



I.S.P.O.
20TH WORLD CONGRESS
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16 - 19 June 2025

Science in Practice
Practice in Science

Collaboration and
innovation towards
sustainable
rehabilitation

**ABSTRACT
BOOK**



INTERNATIONAL
SOCIETY FOR PROSTHETICS
AND ORTHOTICS

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Preface

This abstract book represents the work of contributors to the 20th World Congress of the International Society for Prosthetics and Orthotics (ISPO), held in Stockholm, Sweden from 16 to 19 June 2025. The ISPO World Congress provides a unique platform for the global community to discuss leading edge scientific and clinical advances, research on technologies, techniques, materials and innovations, that aim to improve quality of care and quality of life for persons who may benefit from prosthetic, orthotic, mobility, and assistive devices. As sustainability is a worldwide topic of interest and concern, the 20th World Congress theme '*Science in Practice, Practice in Science: Collaboration and innovation towards sustainable rehabilitation*' invites reflection on this critical aspect of prosthetic, orthotic and mobility care. The Science refers to the scientific part of the world congress programme and the Practice refers to the novel technical track part of the programme. The Science incorporates innovation, evidence, and knowledge translation across the spectrum of prosthetic, orthotic and mobility services to enable end-users to receive appropriate services at the right time, the right place, and the right cost. The Practice entails education about practical applicability of new materials, manufacturing or assembling techniques for prosthetic, orthotic and mobility devices. In both Science and Practice, sustainability deserves more attention in order to be careful with restricted resources, such as materials needed to compose assistive devices, energy or manpower. The interdisciplinary programme features invited keynote lectures, symposia, instructional courses, free paper and poster presentations, as well as exhibitor workshops. New in this world congress are the 3 Minute Thesis (3MT) student competition and the technical track that aims to promote the fabrication arts through demonstration and hands-on instructions. Through its scope the congress delivers the latest achievements, scientific and technological developments in the field and offers delegates a unique opportunity for continued development through discussion and knowledge exchange.

Review procedures and abstract compilation: Abstracts submitted for symposia and instructional courses were reviewed by the World Congress Scientific Programme Committee (SPC) for quality and relevance. Symposia present thematically related research addressing significant problems or controversies in prosthetics, orthotics, mobility and assistive devices, and aims to present differing perspectives through scientific debate. Instructional courses present information on practical applications of specific topics at a level suited to the practitioner.

Abstracts for the Technical Track were reviewed by the World Congress Technical Track Committee (TTC) on relevance, appropriateness and practical applicability of fabrication techniques and materials. Abstracts submitted for free paper and poster presentations and for the 3MT competition were peer reviewed by experts invited by the World Congress SPC for relevance, appropriateness of method and conclusions, and overall quality. Abstract reviewers are acknowledged in this abstract book for volunteering their time and expertise. No remuneration or incentive was provided for their efforts. The abstract book was compiled using Oxford Abstracts. In each abstract, the name of the presenting author is underlined. A limitation of the electronic submission of documents is that Figures are often compressed or minimised in size at various times in the process of upload from the authors and compilation into the final abstract book. As such, we apologise in advance where Figures have not been depicted clearly in this final compilation.



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Keynote lectures

1.01 Overcoming challenges to transform lives: innovation in Prosthetics, Orthotics, wheelchairs and beyond - Knud Jansen Lecture

Ritu Ghosh

Mobility India Rehabilitation Research and Training Centre, Bengaluru, Karnataka, India

Summary

A few decades ago, Prosthetics and Orthotics (P&O) were largely unknown as a “career choice” in the developing world. Often viewed as a charitable platform, particularly in developing countries, the remarkable field faced challenges to reach the level of recognition it enjoys today.

When I embarked on my career as a P&O student 33 years ago in India, I quickly realised that the field was far different from my assumptions. Disability was primarily symbolized by a wheelchair or crutches, and services were largely charity driven. I, an Indian woman, chose to become a professional, navigating not only a new subject, but also confronting sexism in a predominantly male-dominated field.

My career began with Mobility India, where I noticed the significant need for trained professionals. There was also a pressing demand for cost-effective solutions, improved last-mile connectivity, better infrastructure, stronger collaborations among various stakeholders including ISPO, and increased awareness among the general public, community and family engagement. And more trained women P&Os were required. In my lecture, I will talk about innovative solutions and strategies that integrate real-world rehabilitation and assistive technology that have impacted individuals, families and communities significantly.

The frontiers of technology are expanding daily to benefit individuals needing services. We must focus on leveraging these advancements to build services and strong networks. This will provide better support to both communities and the workforce with knowledge, skills, attitudes, and humanity. By doing so, we can collectively contribute to the ecosystem to enable access and inclusion for all.



Keynote lectures

1.02 Challenging limits, creating opportunities – IC2A Inspirational Lecture

Christoffer Lindhe

Momentum Sweden, IC2A, Lindhe Xtend, Halmstad, Sweden

Summary

At the ISPO World Congress 2025, I will share a journey that defied the odds – from a 1% chance of survival to mastering two above-knee prostheses and a prosthetic arm. My story is not just about survival; it is about reclaiming my future and pushing the boundaries of what is possible.

When I first woke up after the accident, my life had changed forever. The medical prognosis was grim, but I made an early decision that my situation would not define me. Rehabilitation was brutal, but through persistence, I gradually regained my independence.

Osseointegration and Hanger Bilateral Above Knee Protocol became a turning point – Yet, despite these advancements, challenges remained. The available prosthetic feet were simply not good enough for my lifestyle and ambitions. So, I took matters into my own hands and developed my own prosthetic foot – designed to simplify my daily life and enable an active lifestyle.

My talk is about transforming adversity into motivation, about daring to challenge limitations, and about creating new opportunities. I aim to inspire others – patients, researchers, and engineers – to think bigger, to look beyond obstacles, and to push the development of prosthetic technology forward together. Join me as I share my journey, and let's shape the future together!



Keynote lectures

1.03 Prosthetic and orthotic science is the key to sustainable rehabilitation and beyond

Chapal Khasnabis

Assistive Technology, Asian Development Bank, Geneva, Switzerland

Summary

Prosthetic and Orthotic science is a very diverse and versatile scientific field. It builds and organises knowledge and skills, evolves, innovates and develops newer technology continuously over time and with context. At the same time, and based on scientific evidence, this field predicts future changes that are needed in relation to prosthetics, orthotics, mobility aids, assistive technology, various health care interventions including rehabilitation and beyond. Prosthetic and orthotic science is a very important field of rehabilitation science – a key that makes the apparently impossible, possible by optimizing the benefit of rehabilitation and other healthcare interventions and, unlocking human potential, assisting an individual to do what he or she wishes to do.

Twenty-first century health care needs are quite different and becoming more challenging considering the population growth, especially the ageing population. Needs are increasing faster than the available financial and human resources. However, the silver lining is the emergence of digital technologies, artificial intelligence, advanced materials, machines and equipment. Today, professionals in the prosthetics and orthotics field are much more scientific and tech-savvy than ever before. While maintaining the human touch.

It needs to be noted, what happens outside the hospitals and clinics is as important as what happens inside, especially to ensure sustainable rehabilitation and prosthetic and orthotic services. Hence, prosthetic and orthotic science needs to look beyond and establish strong linkages with other development sectors, especially public health and the world of economics. In fact, all health care services need to look beyond and establish its power within the country's development agenda to become sustainable. Prosthetic and orthotic science has all the power and potential; an important key to open the gate of development, especially Sustainable Development Goals (SDGs) – leaving no goals and no one behind.



Keynote lectures

1.04 Implantable and wearable modular neuroprostheses to understand and restore neural functions

Silvestro Micera

Scuola Superiore Sant'Anna, Pisa, Italy and Translational NeuroEngineering, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland

Summary

Neuroengineering is a novel discipline combining engineering including micro and nanotechnology, electrical and mechanical, and computer science with cellular, molecular, cognitive neuroscience with two main goals: (i) increasing our basic knowledge of how the nervous system works; and (ii) developing systems able to restore functions in people affected by different types of neural disability. Several breakthroughs have been reached by neuroengineers, in particular in the development of neurotechnologies able to restore sensorimotor functions in persons with disabilities.

In this presentation, I will provide several examples on how implantable interfaces can be used to restore sensory (tactile, position and thermal feedback for hand prostheses, vision), motor (grasping, locomotion), and autonomic functions (for type 2 diabetes and cardiovascular problems) and how they can be used also to understand cognitive functions such as language and decision making.



Keynote lectures

1.05 Rolling together: collaborative approaches to sustainable wheelchair education

Paula Rushton

School of Occupational Therapy, Faculty of Health, Dalhousie University, Halifax, Nova Scotia, Canada

Summary

All people deserve access to appropriate mobility devices, as noted by the United Nations Convention on the Rights of Persons with Disabilities, Article 20. Regrettably, this expectation is yet to be achieved. With 80 million people worldwide requiring a wheelchair for mobility, it is imperative that sustainable and equitable processes are established to facilitate access. It is time to confront how structures of our academic, educational, and health systems create unintended inequities and harm!

One advancement would be to improve sustainable, high-quality training for those who serve on the front line of wheelchair service provision across the globe. To achieve this goal, we need collaborative research approaches, such as participatory action, patient-oriented, and Indigenous decolonizing approaches, which have proven vital to developing best and sustainable practices. While the importance of creating research processes that are conducted with participants rather than on participants has been recognized since the 1940s, there are barriers to overcome at both the system- and researcher-levels to fully embrace end-user engagement in research.

To demonstrate the possibilities of honouring collaborative approaches, three examples will be described involving the development of a Wheelchair Educators' Package, wheelchair skills training resources, and research priorities. The speaker will share experiences about how genuine engagement with those for whom the research outcomes are intended can contribute to sustainability. Lessons learned, recommendations, and calls to action will be offered. As the African proverb tells us, "If you want to go fast, go alone; if you want to go far, go together".



Keynote lectures

1.06 Fundamentals of human movement translated into P&O practice, and back

Han Houdijk

University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

Summary

Human Movement is as self-evident as it is complex. While we are generally able to perform a large range of tasks in daily life with limited effort, our understanding of how movement is brought about is far from complete. In the multidisciplinary field of Human Movement Sciences, we use principals and methods from several scientific disciplines, to understand the fundamental laws governing human movement. Moreover, we aim to apply these insights to find solutions for movement related problems in (clinical) practice.

In this presentation I'll discuss how we used fundamental principles from exercise physiology, biomechanics, and motor control to understand and improve walking impairments in people with lower limb amputation. I'll demonstrate how these fundamental principles have been translated to innovations in prosthetic design and rehabilitation, and conversely how these practical applications translate back to validate and update theoretical knowledge



Symposium | Prosthetics lower limb: transtibial, ankle, foot

2.01 More than Mobility: The Impact of Prosthetic Mobility on Well-Being, Fall Risk, and Employment

Phillip Stevens^{1,2}, Bretta Fylstra¹, Shane Wurdeman^{1,3}

¹Hanger Institute for Clinical Research and Education, Austin, USA. ²Department of Physical Medicine and Rehabilitation, University of Utah, Salt Lake City, UT, USA. ³Department of Biomechanics, University of Nebraska at Omaha, Omaha, USA

Abstract

The modern-day emphasis on value-based healthcare requires readily accessible measures of the cumulative benefits associated with a given treatment modality or course of care. Several years ago, we began collecting prosthetic mobility values using the 12-item short form of the patient-reported Prosthesis Limb Users Survey of Mobility (PLUS-M). The indexed nature of this measure facilitates awareness of a given individual's prosthetic mobility relative to their peers. However, through a series of analyses and subsequent peer-reviewed publications we have determined that this relatively quick assessment of prosthetic mobility also yields valuable insights into additional meaningful constructs.

For example, correlations have been observed between prosthetic mobility and the related constructs of satisfaction with life, quality of life and well-being. Further, we have observed below average prosthetic mobility scores to be associated with a two-fold risk of injurious falls over the preceding 6 months. By contrast, in a separate analysis we observed that above average mobility was associated with more than 3.5 times greater likelihood of post-amputation employment. In this symposium we will describe the observed relationships between prosthetic mobility and well-being, injurious fall risk, and likelihood of employment.

Statement of the objective / learning objectives

1. Attendees will be able to integrate prosthetic mobility assessment into standard clinical practice.
2. Attendees will understand the relationship between prosthetic mobility and well-being, quality of life, injurious fall risk and employment capacity.



Symposium | Outcome Measurements

2.02 The Importance of Paying Attention: How Measuring Cognitive Load and Effort Could Inform Your Clinical Practice

Benjamin Darter¹, Nerrolyn Ramstrand², Susan Hunter³

¹Virginia Commonwealth University, Richmond, USA. ²Jönköping University, Jönköping, Sweden. ³University of Western Ontario, London, Canada

Abstract

Individuals with limb amputation/difference learn to use prostheses that cannot fully replicate the innate control and function of an intact limb. The resulting reduced automaticity of coordinated movement associated with prosthesis use can lead to increased cognitive load and perceived effort. Theoretically, more complex tasks or trying to divide attention between multiple tasks can tax the available cognitive resources to the extent that task performance is impacted negatively. Therefore, measuring cognitive load and effort has a potentially important place in a comprehensive analysis of task performance. A variety of methods have been described in the literature, including physiological, performance-based, and self-report measures. However, use of the methods and their application within clinical decision-making is limited. This symposium will overview the underlying anatomy and physiology involved in cognitive load during physical activity and then focus on recent research measuring the effort required to perform ambulatory activities in persons with lower limb amputation/difference. Insights will be shared highlighting how the measures could be used in clinical practice and rehabilitation research, including how cognitive load may be influenced by personal characteristics, the type of prosthesis used, and the task(s) involved.

Statement of the objective / learning objectives

1. Overview theory and relevance of cognitive load in person with limb amputation/difference
2. Describe evidence for different methods to assess cognitive load and effort
3. Discuss how the measures could inform clinical decision-making



Symposium | Education

2.03 Next Steps in Evidence-Based Practice in Education for Prosthetic Orthotic Occupations

Helen Cochrane, MSc. CPO (c)^{1,2}, Ashley Mullen, PhD, MSAT, CPO/L³, David Rusaw, PhD⁴, Sue Ewers⁵

¹University of Pittsburgh/ISPO, PA, USA. ²ISPO, Brussel, Belgium. ³Baylor College of Medicine, Houston, USA.

⁴Jönköping University, Jönköping, Sweden. ⁵University of Washington, Seattle, USA

Abstract

Following on from the symposium at the 2023 World Congress and the 2024 Global Educators Meeting this symposium will present evidence-based practice in education for prosthetic orthotic occupations.

Presenters will share the current evidence, best practices and ongoing development of a research plan for prosthetic orthotic educators.

Presented by educators aimed at educators this symposium offers an opportunity to learn, contribute and discuss how to get the most out of educational time.

Confirmed Presenters include:

- Helen Cochrane, MSc. CPO (c) - Assistant Professor, University of Pittsburgh
- Ashley Mullen, PhD, MSAT, CPO/L - Associate Professor, Baylor College of Medicine
- David Rusaw, PhD, - Associate Professor, Jönköping University
- Sue Spaulding, MS, CPO/L, FAAOP - Associate Teaching Professor, University of Washington

The Education Committee will provide an updated abstract following the Global Educators Meeting (October 22-24).

Statement of the objective / learning objectives

To help educators in prosthetic orthotic occupations:

1. become more aware of the current evidence, best practices in education research.
2. cultivate collaborations with educator peers.
3. develop and diversify educational practices to stimulate an effective learning environment.



Symposium | Prosthetics: lower limb transfemoral

2.04 The importance of participation and how this can be achieved in all aspects of life following major lower limb amputation

Fiona Davie-Smith¹, Heather Batten², Chantel Ostler³

¹WestMARC, NHS, Glasgow, United Kingdom. ²Queensland Health, Brisbane, Australia. ³Portsmouth Enablement Centre, NHS, Portsmouth, United Kingdom

Abstract

Major lower limb amputation (MLLA) affects the patient both physically and psychologically as they lose mobility and often become dependent on others until they have progressed through rehabilitation. For those who achieve prosthetic limb fitting, rehabilitation focuses on gait and reducing hospital readmission. Literature often focuses on the populations who achieve bipedal mobility and their componentry, but this is not the experience of the majority. A prospective cohort study of patients with MLLA in UK will be presented which demonstrates the stark reality of this life saving surgery as mortality at 10 years is >80%. Follow up of this cohort identifies the association between quality of life and participation, which is improved greatly in those who achieve prosthetic limb fitting and regain bipedal mobility.

Considering the limited life expectancy of this population, understanding patient priorities is key. A large qualitative study followed by a qualitative evidence synthesis will be presented which describe meaningful outcome domains of prosthetic rehabilitation from the patients perspective. The ECLIPSE model, developed from these studies, highlights the ability to participate in important activities is most meaningful to patients, indifferent of level of MLLA. Rehabilitation is key to enabling patients to participate in their important activities, and how this is integrated within patient specific treatments can be challenging. A global overview of various rehabilitation programs will be showcased to inspire AHPs to support patients to participate fully in their lives following MLLA. This is vital for those with this life altering and life limiting condition.

Statement of the objective / learning objectives

1. To understand the impact of major lower limb amputation in dysvascular populations
2. To realise the importance of participation from a user's perspective
3. Inspiration for rehabilitation to support the transition to living well in the community



Symposium | Education

2.05 Your ISPO Scientific Committee: Serving the research, development and knowledge translation needs of the global ISPO membership

Matthew Major^{1,2}, Arezoo Eshraghi³, Kengo Ohnishi⁴, Alix Chadwell⁵, Cleveland Barnett⁶, Ulla Hellstrand Tang⁷, Manunchaya Samala⁸, Dick Plettenburg⁹, Helena Burger¹⁰

¹Northwestern University, Chicago, USA. ²Jesse Brown VA Medical Center, Chicago, USA. ³West Park Healthcare Centre, University Health Network, Toronto, Canada. ⁴Tokyo Denki University, Tokyo, Japan. ⁵University of Southampton, Southampton, United Kingdom. ⁶Nottingham Trent University, Nottingham, United Kingdom. ⁷Sahlgrenska Universitetssjukhuset, Göteborg, Sweden. ⁸Mahidol University, Bangkok, Thailand. ⁹Delft University of Technology, Delft, Netherlands. ¹⁰University of Ljubljana, Ljubljana, Slovenia

Abstract

The ISPO Scientific Committee is a standing committee that is responsible for coordinating science-related matters of ISPO, namely research, development and knowledge translation. The Scientific Committee represents an integral part to the global role of ISPO regarding its impact on informing P&O rehabilitation science and practice. In particular, we engage in ongoing efforts to strengthen ISPO's contribution to the creation and dissemination of science in P&O; oversee the scientific activities of ISPO as directed by the Executive Board; and propose recommendations to the Executive Board on the scientific policy of ISPO. A focus of our work is to support early-stage investigators through mentorship and foster collaboration amongst researchers, clinicians, and industry to promote advancements in P&O clinical practice and technology. Please join us for this symposium as the current members of the Scientific Committee discuss our mission, ongoing efforts, and vision for the future of the Committee. We will highlight ongoing efforts including the online ISPO Dictionary of P&O Terms, science webinars, identification of research priorities, special interest groups, the early-stage investigator mentorship program, and management of achievement awards, as well as present means by which you as an ISPO member can become involved in the Committee and support our important mission. We will conclude the symposium with a question and answer session as your voice is needed to help ISPO be a leading voice in shaping the science of the P&O profession.

Statement of the objective / learning objectives

Attendees will learn about the ISPO Scientific Committee and its ongoing efforts to address the research, development and knowledge translation needs of ISPO and the global P&O community.



Symposium | Education

2.06 Establishing a Prosthetist-Orthotist Profession - The Case of Ukraine

Antonina Kumka^{1,2}, Jonathan Batzdorff^{3,4}, Serhii Ubohov⁵, Anton Johannesson⁶, Olena Kulchytska²

¹Chief Director, CO CF "Protez Hub", Lviv, Ukraine. ²Advisor to the Minister, Ministry of Social Policy of Ukraine, Kyiv, Ukraine. ³CPO and President, Prosthetika Foundation, Santa Rosa, USA. ⁴Chair, Expert Committee, CO CF "Protez Hub", Lviv, Ukraine. ⁵Head of Education Department, Ministry of Health of Ukraine, Kyiv, Ukraine. ⁶Manager of Clinical Education, Ossur, Stockholm, Sweden

Abstract

Ukraine's prosthetics and Orthotics industry has seen rapid development since 2014. However, when the full-scale war broke out, the country faced new challenges, as many war related traumas resulted in limb loss. Since February 2022 there are about 20,000 new amputees in Ukraine, most of whom are young individuals, who will require lifetime prosthetics and orthotics services.

Establishing a formal profession and a formal education in order to accredit practicing professionals and provide opportunities for education of the new generation of professionals became critical.

A Ukrainian NGO "Protez Hub" stepped up to the task with the support from the Ministry of Social Policy, the Ministry of Health and the Ministry of Education and Science of Ukraine.

First, a "Prosthetist-Orthotist" professional standard was developed. The standard was aligned with ISPO recommendations and the team working on the standard consisted of Ukraine's local experts and of the international experts.

Once the professional standard was adopted, the process of accreditation of practicing professionals based on the established criteria has started. Thanks to the support of the Embassy of Switzerland and the American Board for Certification in Prosthetics, Orthotics and Pedorthics, in partnership with CO "Patients of Ukraine" and "Prosthetika" and together with Kharkiv National Medical University (under the Ministry of Health of Ukraine), Protez Hub has developed examinations. 36 professionals have already been accredited.

For those new to profession, a Master of Prosthetics and Orthotics program was established.

A National Educational Curriculum for the program has been developed by Ukrainian and international experts.

Statement of the objective / learning objectives

The session will provide an overview of how the Prosthetist-Orthotist profession was established in Ukraine. This experience is transferrable to other countries and can help improve existing P&O education programs globally.



Symposium | Gait and balance

2.07 Evidence-based Amputee Rehabilitation: Identifying and Treating the Physical limitation to Improve Success of Prosthetic Gait

Robert Gailey¹, Ignacio Gaunard^{1,2}, Lisan Scheepers³

¹University of Miami Miller School of Medicine, Coral Gables, USA. ²Bruce W. Carter VA Medical Center, Miami, USA. ³Ossur, Eindhoven, Netherlands

Abstract

The power of using outcome measures (OM) and selected assessment tools extends beyond simple documentation to the ability for treatment prescription. This presentation will focus on the use of selected standardized outcome measures that can identify physical limitations and the subsequent prescription of a targeted exercises for prosthetic training of people with lower limb loss. Presenters will discuss the importance of pre-prosthetic training and what patient characteristics may be employed to predict candidacy for prosthetic fitting and successful ambulation with a prosthesis. Once a person is walking with a prosthesis specific performance-based and patient-report OM (Amputee Mobility Predictor (AMP), Functional Lower-limb Amputee Gait (FLAG) assessment, Prosthetic Lower-limb Users Survey-Mobility (PLUS-M), Activity Balance-specific Confidence (ABC) scale) may be administered to identify physical limitations, gait deviations and/or patient concerns that can be barriers to prosthetic success. Every OM item or task is correlated to a systematic treatment approach that can modify movement patterns to improve function and reduce or eliminate each gait deviation. Each exercise can be modified to accommodate the patients' improvement or decline. The specific treatment recommendations for each associated gait deviation will be presented with the best-known evidence to support the rationale for why each exercise can be effective. A systematic progression of assessment and the specific exercises designed to enhance prosthetic use and improve a patient's functional capabilities during prosthetic gait will be the common thread throughout the presentation. Finally, how OM can objectively document the change over time to demonstrate prosthetic value will be discussed.

Statement of the objective / learning objectives

Upon completion of this presentation attendees will be able to apply throughout prosthetic gait training rehabilitation process a standardized approach for treatment prescription with the use of selected outcome measures.



Symposium | Rehabilitation medicine and surgery

2.08 Global meeting of the Special Interest Group Bone Anchored Limbs (SIGBAL)

Jan Paul Frölke^{1,2}, Jason Stoneback³, Laurent Frossard⁴, Ruud Leijendekkers¹

¹Radboudumc, Nijmegen, Netherlands. ²AOFE Clinics, Rozendaal, Netherlands. ³University of Colorado Limb Restoration Program, Aurora, USA. ⁴Griffith University, Brisbane, Australia

Abstract

This meeting is an opportunity to meet professionals who share an interest in bone-anchored prostheses for persons with limb amputations and to become familiar with the SIGBAL as a starting network under the flag of ISPO International.

The agenda will include an update on membership, website content, development of a core-outcome set, and future developments.

The current SIGBAL (founding) president will resign and the new president will be installed.

More information about SIGBAL can be found on the ISPO Website: <https://www.ispoint.org/special-interest-groups/bone-anchored-limbs/>

Statement of the objective / learning objectives

1. How to become a member and what to expect
2. What content should be expected on SIGBAL website
3. How can centers that offer treatments be found worldwide
4. Can we define core outcome measures



Symposium | Prosthetics and Orthotics: in less resourced settings

2.09 The importance of understanding cultural and social context in low resource setting P&O research

Sisary Kheng¹, Maggie Donovan-Hall^{2,3}, Alan Maddock^{4,3}, Nerrolyn Ramstrand^{5,3}, Amos Channon^{2,3}, Alex Dickinson^{2,3}

¹Exceed Worldwide, Phnom Penh, Cambodia. ²University of Southampton, Southampton, United Kingdom.

³Exceed Research Network, Lisburn, United Kingdom. ⁴Royal College of Surgeons in Ireland, Dublin, Ireland.

⁵Jönköping University, Jönköping, Sweden

Abstract

P&O services enable individual and state benefits, by improving a person's independence, reducing care responsibilities and enabling return to work or education, delivering 9:1 return-on-investment (ATscale). However, collaborative innovation is required to maximise effective funding use and deliver sustainable rehabilitation, especially for vulnerable people in LRS.

The Appropriate Technologies concept is often interpreted as functional robustness and environmental, material sustainability; cultural appropriateness and sustainable implementation are prioritised less. Social and cultural factors present very different challenges between nations and communities, so cultural competence and a detailed understanding of context are crucial both to appropriate conduct of research and to accurately interpreting the collected data.

We will describe example studies conducted in Cambodia with the Exceed Research Network, which demonstrate the importance of contextual awareness to three very different research methodologies. We will reflect on challenges in:

- Qualitative research to understand P&O service user needs and experiences:
 1. Assessing users' needs to co-develop research aims;
 2. Utilising a co-researcher ethos
- P&O patients' mental health: research and intervention:
 1. Addressing broader psychosocial health needs of P&O users
 2. Tackling the qualified mental health professionals shortage by training P&O clinicians to perform mental health screening and referral, and facilitate peer support groups
 3. Translating, adapting and validating self-report instruments and
- Learning from routinely-collected P&O service provision data:
 1. Responsibly accessing data and extracting insights from clinic management systems
 2. Developing research questions that provide value to service providers and how ERN enabled interdisciplinary collaboration to address them.

Statement of the objective / learning objectives

This session will provide examples of challenges of conducting meaningful research in a low-resourced setting, and insights into good practice and practical approaches to identify and navigate around them



Symposium | Health care, policy, sustainability

2.10 Health Economic Evaluation in prosthetics: innovative solutions to method design challenges

Leigh Clarke, Michael Dillon

La Trobe University, Melbourne, Australia

Abstract

Health Economic Evaluations (HEEs) evaluate the costs and benefits of one healthcare intervention over another and thereby provide the necessary evidence to inform policy and investment decisions. Those policy and investment decisions influence the type of healthcare available to consumers, such as the type of prosthetic interventions available.

There are challenges to conducting high-quality HEEs. For example, to capture the costs and benefits over the useful life of the prosthetic intervention, a long time-horizon is required (e.g., 5+ years for a microprocessor controlled prosthetic knee). Similarly, there are challenges to measuring the benefits that are most important to prosthesis users and funders.

To address these challenges, we propose the following innovative solutions:

- *Synthetic Cohort Method*: participants are recruited into sub-groups reflecting the different years since prosthetic fitting. Assuming the parameters that significantly affect the costs and benefits are similar between sub-groups, these data might be sufficiently representative to estimate the costs and benefits for each intervention.
- *Prosthetic Interventions Core Outcome Set (PI-COS)*: describes the outcomes that prosthesis users and funder consider to be most important. The 14-items of the PI-COS can best be measured using a combination of PROMIS instruments (i.e., PROMIS Physical Function with Mobility Aid short form and the PROMIS-29+2) to estimate both effectiveness and utility.

In the symposium we will describe these innovative solutions in the context of a HEE comparing passive- and vacuum-assisted suction suspension for transtibial prosthesis users.

Statement of the objective / learning objectives

In this session, attendees will learn more about the:

1. Challenges to conducting high-quality HEEs in prosthetics
2. Innovative solutions to make HEE more feasible
3. The steps ahead to pilot these innovative solutions



Symposium | Orthotics: lower limb and footwear

2.11 Microprocessor Stance and Swing Phase controlled Orthotics (MPSSCO): The current state of the evidence

Andreas Hahn¹, Merkur Alimusaj², Rüdiger Rupp², Bea Hemmen³, Russ Lundstrom⁴

¹Ottobock Healthcare Products GmbH, Vienna, Austria. ²University of Heidelberg, Heidelberg, Germany. ³Adelante Kenniscentrum, Hoensbroek, Netherlands. ⁴Ottobock LTD, Austin, USA

Abstract

Microprocessor- stance and swing phase controlled orthoses are an important option in the treatment of patients suffering paralysis of the knee-stabilizing muscles. The introduction of the technology has from very early on been accompanied by biomechanical analysis and clinical research [1,2]. Following a first randomized controlled x-over trial at the Research Institute of Chicago [3], two further independent randomized controlled trials are able to present their results: An international multicenter, randomized X-over study in a cohort of 108 patients with increased risk of falling, conducted in Europe and the USA shows significant and clinically relevant improvements in fall risk [Fig1], number of falls, mobility, and quality of life [4]. A third RCT, conducted in France and Germany, including 38 patients with higher mobility emphasized improvements in mobility, endurance, participation and health utility [5]. Long term results from an international registry complete the findings from the controlled trials [6]. The symposium introduces the technology and the application in clinical practice. It discusses clinical experience as well as recent clinical evidence. The symposium hopes to spark debate on appropriate patient selection, the role during rehabilitation and practical treatment aspects.

- Schmalz et al., POI, 2016
- Pröbsting et al., POI, 2016
- Deems-Dluhy et al., APM&R 2018
- Ruetz et al., Disability and Rehabilitation, 2022
- Submitted
- Lundstroem et al., Disability and Rehabilitation, 2024

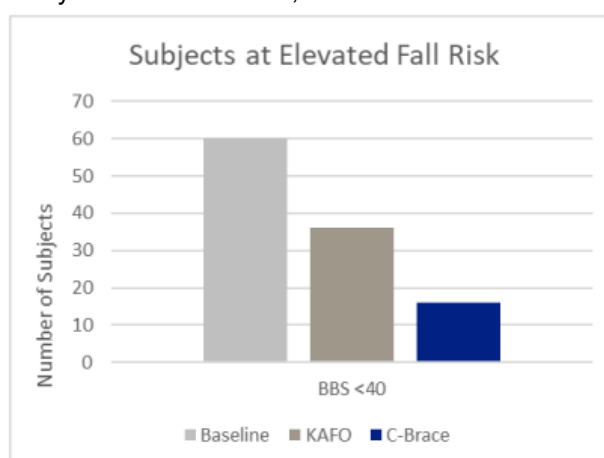


Fig.1: Results from Ruetz et al. indicate significant reduction of fall risk.

Statement of the objective / learning objectives

We will describe this new treatment method, the underlying functional principles and report on experiences from clinical practice. We will provide insight the latest results of the extensive clinical research in this rapidly developing area.



Symposium | Device fabrication and design

2.12 Navigating Diverse Challenges in O&P's Digital Landscape

Jan Andrysek^{1,2}, Dan Blocka³, Alex Dickinson⁴, Calvin Ngan¹

¹Holland Bloorview Kids Rehabilitation Hospital, Toronto, Canada. ²University of Toronto, Toronto, Canada. ³Boundless Biomechanical Bracing, Mississauga, Canada. ⁴University of Southampton, Southampton, United Kingdom

Abstract

With the ongoing emergence of increasingly sophisticated technologies and the continuous expansion of data accessibility, various sectors within healthcare are transitioning towards digitally driven practices. In Orthotics and Prosthetics (O&P), digital technologies such as 3D scanning, computer-aided design, and 3D printing hold great promise for improving the quality and standardization of both devices and workflows. However, a survey conducted in 2020 found that over half of O&P clinicians do not incorporate digital technology into their practice. Further interviews with O&P clinicians in 2022 revealed that technological barriers, economic factors, and the steep learning curve associated with transitioning to digital workflows raise significant concerns about adoption. Compounding these issues is the scarcity of reporting on clinicians' workflows and challenges—both conventional and digital—which has long been recognized as a critical gap.

To overcome these obstacles and facilitate the widespread adoption of digital technologies in O&P, a collaborative effort involving research and clinics is essential. This effort must begin with an open dialogue to share knowledge and address these challenges. Therefore, this presentation aims to discuss the unique needs of clinical populations and device types in integrating digital technologies. We will explore the role of educational programs and how current research advancements and innovations can assist clinicians in navigating this new digital era. By contrasting these perspectives, we seek to provide a comprehensive understanding of the challenges and solutions for adopting digital technologies in O&P.

Statement of the objective / learning objectives

Participants will gain insight into the challenges and opportunities of integrating digital technologies in Orthotics and Prosthetics, and learn how education and research advancements can facilitate the widespread adoption of digital workflows.



Symposium | Health care, policy, sustainability

2.13 The Impact of Psychosocial issues on the Professional Performance of Female Prosthetists Orthotists (Both Educators and Clinicians): Is It Substantial?

Stephney Weerasinghe¹, Dilani Vithanage², Khin Thantzin³, Dilini Atygalla Tennakoon⁴

¹International committee of the red cross, Sanaa, Yemen. ²Sri Lanka School of Prosthetics and Orthotics, Ragama, Sri Lanka. ³Exceed Worldwide, Cambodian School of Prosthetics and Orthotics, Phnom Penh, Cambodia.

⁴Rheumatology and Rehabilitation Hospital, Ragama, Sri Lanka

Abstract

The contribution of female Prosthetists and Orthotists (POs) to the disability sector is immense and cannot be overstated. Their expertise and dedication significantly enhance the quality of life for individuals with disabilities. It is crucial to recognize and celebrate the positive impact these professionals have on the lives of their patients.

However, despite their invaluable contributions, female POs face unique challenges that are often more pronounced compared to their male counterparts. The rapid advancements in the field, coupled with varying cultural contexts, diverse age groups, and health-related issues, mental health issues related with work stress present significant obstacles to their work performance. These challenges can hinder their ability to deliver optimal care and support. This presentation aims to highlight some of these pressing issues and provide a safe platform for female POs to voice their concerns. It seeks to create a supportive environment where these professionals can share their experiences, discuss the challenges they face, and collaboratively find effective solutions. By fostering open dialogue and mutual support, we can help female POs navigate the complexities of their profession and continue to excel in their vital roles.

The presenters are from different contexts and currently work in for different organizations. This unique diversity can be a benefit in identifying common challenges yet managed in different strategical ways.

Statement of the objective / learning objectives

The attendees are expected to identify the challenges faced by female Prosthetists and Orthotists and to collaboratively discuss solutions that could be helpful in addressing these common challenges in various contexts.



Symposium | Health care, policy, sustainability

2.14 ATscale: Reflections on investment and action to create change and improve access for prostheses, wheelchairs and other assistive technology.

Satish Mishra¹, Henri Bonnin¹, Friedbert Kohler², Sarah Sheldon³, Karen Reyes¹

¹ATscale, Global Partnership for Assistive Technology, Geneva, Switzerland. ²Conjoint Professor, SWS Clinical School, UNSW, Sydney, Australia. ³ATscale, Global Partnership for Assistive Technology, London, United Kingdom

Abstract

ATscale's vision is to ensure every person can access and afford the assistive technology (AT) they need, enabling a lifetime of potential. ATscale's mission is to catalyze action, amplify existing work, and coordinate and mobilize global stakeholders with unified strategies to increase availability of and access to AT. This symposium will reflect on lessons learned by ATscale in investing in catalyzing change. Opportunities to collaborate on current projects will be detailed and insights shared to help others seeking to initiate change and promote evolution in the prosthetics, orthotics, wheelchair and AT spaces.

This includes a future implementation research project, to explore the barriers and opportunities for translating prosthetic related research and development into implementable solutions for affordable and high-quality lower limb prostheses in low- and middle-income countries. This project will examine novel fitting technologies, components and the service delivery system through an implementation research lens.

A second project to develop guidance on local wheelchair production, repair and reuse models along with the integration of wheelchair services into the health system will follow. There will also be an overview of ATscale's work on humanitarian preparedness, including a recent large-scale logistics initiative within the UN humanitarian system along with logistics and supply chain management reflections. An update on the LEAD and COMPASS pilot will follow, including the development of a custom app for data collection and opportunities for collaboration as possible pilot sites. Finally, an update of national system investments and opportunities for AT sector transformation will be presented.

Statement of the objective / learning objectives

To share the scope of ATscale's work portfolio, possibilities for collaboration and key learnings in creating systems change to improve access for people in need of lower limb prosthetics, orthoses, wheelchairs and other assistive technology.



Symposium | Prosthetics lower limb: transtibial, ankle, foot

2.15 Bridging the Knowledge Gap in Paediatric Prosthetic Care and Rehabilitation: An Evidence Based Call for Action and Innovation

Anthony Bull¹, Caitlin Edgar¹, Claudia Ghidini¹, Sibel Basaran²

¹Imperial College London, London, United Kingdom. ²Çukurova University, Adana, Turkey

Abstract

Since October 7th, 2023, over ten children per day on average have lost a limb in Gaza. They join a cohort of paediatric patients generated by an increasing prevalence of humanitarian disasters such as the earthquakes in Türkiye/Syria and conflict zones world-wide as well as infectious diseases, cancer, and congenital deformities. Each of these individuals will require complex long-term rehabilitation and prosthetic limb provision. This is a demand no health-care system in the world is currently being supported to meet due to the lack of knowledge and minimal paediatric prosthetic innovation.

The aim of this symposium is to present novel findings on the unique challenges children with lower limb loss face, propose actionable areas for improvement and identify additional gaps in knowledge for further research. This will be achieved by harnessing results from paediatric clinical case files in Cambodia and Türkiye; listening to the voices of children and relevant stakeholders through questionnaire and interview results from multiple global locations; and presenting recent work on appropriate strength and durability testing for paediatric prosthetics.

Work will be presented on:

1. Challenges related to growth, socket fit and residual limb health.
2. Durability of current paediatric componentry.
3. Hierarchy of prosthetic user needs from all relevant stakeholders – child, parent/guardian, and prosthetist.

The session will conclude with an interactive discussion between the presenters and the audience focusing on identification of other unaddressed research gaps and the next steps to improve rehabilitation outcomes and prosthetics for this vulnerable cohort.

Statement of the objective / learning objectives

By the end of this symposium, participants will have a clear appreciation of the most pressing challenges in paediatric prosthetic care, including current research and innovation priorities.



Symposium | Device fabrication and design

2.16 Personalisation of lower limb assistive devices; how Human-in-the-loop optimization can revolutionize prosthetic and orthotic care

Niels Waterval¹, Merel Brehm¹, Han Houdijk², Thijs Tankink², Juha Hijmans², Rifko Kurnianto²

¹Amsterdam UMC, Amsterdam, Netherlands. ²UMC Groningen, Groningen, Netherlands

Abstract

In clinical populations lower limb assistive devices, such as orthopedic shoes, orthoses or prostheses are provided to improve functioning in daily life. Despite technological developments, the effectiveness of these devices often does not live up to expectations. Key to this problem is the lack of tuning of these devices to the individual user. Currently, such tuning is a time- and labor-intensive process that relies on the subjective expertise of the provider, which oftentimes results in suboptimal outcomes. A novel approach towards individualized tuning of assistive devices is Human-in-the-Loop optimization (HILO). Using HILO, properties of assistive device, for example orthosis stiffness or prosthetic alignment are continuously changed. Simultaneously, objective measurements of relevant performance criteria during walking and an AI optimization algorithm efficiently guide the selection of the properties towards maximal performance.

In this mini-symposium we will demonstrate the potential of HILO optimization for prosthetic and orthotic care. After a general introduction about HILO optimization and how this may revolutionize prosthetic and orthotic care, three use cases in different clinical populations will be presented. The use cases consist of how HILO can be used to 1) optimize rocker shoes apex parameters for plantar pressure distribution (Juha Hijmans & Rifko Kurnianto), 2) optimize ankle-foot orthosis stiffness in neuromuscular diseases (Merel Brehm & Niels Waterval) and 3) tune stiffness and alignment of a prosthetic foot (Han Houdijk & Thijs Tankink). The symposium will be finished with time for questions and panel discussion on steps to take to revolutionize prosthetic and orthotic care through HILO.

Statement of the objective / learning objectives

1. Understand the potential of Human-in-the-Loop optimization for individualized tuning of lower limb assistive devices.
2. Gain insights into the current developments of Human-in-the-Loop optimization in tuning of rocker shoes, lower limb orthoses and prostheses.



Symposium | Prosthetics: bone anchored limbs

2.17 Advancing Prosthetic Care: Integrating Osseointegration Technology into Clinical Practice

Atiya Oomatia^{1,2}, Munjed Al Muderis^{1,3,4}, William Lu^{1,2}, Christopher Hoyt¹, Warrick Heald¹

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Abstract

Osseointegration has revolutionized prosthetics, providing a promising alternative for patients facing challenges with traditional socket-mounted systems. This innovative approach enhances functional mobility, osseoperception, comfort, and gait, while reducing pain and offering improved biomechanical alignment, leading to a significantly enhanced quality of life. Advances in implant design, surgical techniques, and rehabilitation have contributed to over 1,300 successful surgeries, with the adoption of streamlined protocols reducing recovery time from 8–12 months to just 4–6 weeks.

Despite these advances, challenges such as the risk of ascending infection and the limited data on bone-anchored prostheses in amputee rehabilitation remain. This advanced symposium will cover the history, current practices, and future directions of osseointegrated implants, drawing on experiences from the Osseointegration Group of Australia. Key topics include implant design, patient screening, surgical techniques, rehabilitation procedures, and post-operative care, alongside insights into standardized global clinical protocols.

Participants will gain a comprehensive understanding of the prosthetist's critical role in patient assessment, long-term care, and troubleshooting issues, as well as practical instruction on selecting and applying appropriate connectors, achieving precise alignment, and ensuring maintenance. Attendees will leave equipped to incorporate this cutting-edge technology into their clinical practice, offering improved outcomes and quality of life for patients who have struggled with traditional prosthetic solutions.

Statement of the objective / learning objectives

Participants will develop a comprehensive understanding of osseointegration as a revolutionary alternative to socket prostheses. They will explore foundational principles, advanced fitting techniques, and standardized protocols to integrate this technology into clinical practice.



Symposium | Orthotics: lower limb and footwear

2.18 Nowhere without footwear: evidence-based solutions of custom-made footwear for people with diabetes

Sicco Bus, Isabella Gigante

Amsterdam UMC, Amsterdam, Netherlands

Abstract

Diabetes affects 537 million people globally, with up to 34% developing a foot ulcer in their life, creating a major health challenge with high risk of recurrence and lower limb amputation. Foot ulceration has a significant impact on multiple levels; individual (i.e. quality of life), societal (i.e. ulcer treatment costs), and planetary (i.e. resources), highlighting the need for effective and sustainable solutions. Therapeutic or custom-made footwear is recommended for people at high risk of foot ulceration, mainly due to its biomechanical offloading features. Despite these features, footwear use adherence remains challenging, necessitating transdisciplinary collaborations to design effective footwear that is used and help reduce ulcer incidence. For such footwear to be effective and used, both biomechanical and user-related aspects need to be considered in the design

In this symposium, presenters will engage the audience in discussions about biomechanical optimization of footwear and patient-centered usability by addressing challenges and solutions for improving footwear adherence, combining scientific evidence and clinical expertise. This problem-solving discussion, being a scientific and clinical challenge, aims to create a more effective and sustainable rehabilitation footwear practice. After the session, participants will understand the state-of-the-art evidence on biomechanical and user-related principles in footwear design, be able to evaluate factors influencing patient adherence, and identify strategies for translating scientific evidence into clinical practice, while future research directions will be presented. Participants will gain practical and scientific knowledge on footwear design that helps improves efficacy and adherence, thereby making a direct contribution to clinical practice

Statement of the objective / learning objectives

Participants will understand the state-of-the-art evidence on biomechanical and user-related principles in footwear design, be able to evaluate factors influencing patient adherence, and identify strategies for translating scientific evidence into clinical practice.



Symposium | Education

2.19 Closing the Global Workforce Gap in Assistive Technology Provision

Johan Borg¹, Chapal Khasnabis², Kylie Shae³

¹Dalarna University, Falun, Sweden. ²ADB, Geneva, Switzerland. ³WHO, Geneva, Switzerland

Abstract

In a survey of preparedness for assistive technology provision, only 10% of the 70 responding countries reported having adequate and trained human resources (WHO & UNICEF Global Report on Assistive Technology, 2022). This significant workforce gap is a major barrier to accessing assistive technology, contributing to the concerning reality that in some countries, as few as 2% of people in need can access the assistive products they require. To address this situation, this symposium seeks to bring together experts from various disciplines to explore strategies, innovations, and solutions for developing a skilled and sustainable global workforce in assistive technology provision.

Presenters and topics:

- Johan Borg, Dalarna University, Sweden – *Knowing the gaps: Estimates of the required global workforce*
- Kylie Shae, World Health Organization, Switzerland – *Bridging the gaps: Global initiatives for local capacity*
- Chapal Khasnabis, Asian Development Bank, Switzerland – *Filling the gaps: Policy frameworks and local initiatives for workforce development*

The presentations will be followed by a collaborative exploration of next steps.

Statement of the objective / learning objectives

This symposium offers an opportunity to explore pathways to a sufficient and trained global workforce in assistive technology provision.



Symposium | Orthotics: spinal

2.20 Digital Assessment, Design and Fabrication for Orthotic Management of Adolescent Idiopathic Scoliosis

Man Sang Wong, Babak Hassan Beygi, Linjing Shang, Lok Yi Ho, Lejun Zhou

The Hong Kong Polytechnic University, Hong Kong, China

Abstract

Scoliosis is a 3-dimensional (3-D) spinal deformity with lateral curvature of the spine and vertebral rotation. Most cases are with unknown cause and found in adolescence, therefore, it is termed as adolescent idiopathic scoliosis (AIS). For severe cases, surgeries will be considered but for moderate AIS, the conventional treatment method is to apply rigid spinal orthoses to patients during their puberty to mechanically support the spine and prevent further deterioration. The outcome of orthotic treatment for AIS is generally considered being associated with the orthosis design and patient's compliance. Although scoliosis is a 3-D spinal deformity, there is lack of non-invasive, inexpensive and accurate assessment method to allow clinicians to reveal the change of deformity during the processes of orthotic design and patient fitting. Moreover, the current orthotic methods and techniques are lack of enough scientific evidence although there are some studies demonstrated the spinal orthosis being effective. In this symposium, the speakers will share with delegates their research studies, clinical experiences and scientific evidences to better understand the science behind the phenomenon that orthoses appear effective and go further for evidence-based practice. Moreover, application of the state-of-art ultrasound technique to the assessment of spinal deformity and flexibility, as well as in the design and fitting of spinal orthosis will be discussed and the relevant clinical results will be reported.

Statement of the objective / learning objectives

The advanced technology of 3D assessment, design and fabrication of spinal orthosis to AIS will be introduced and updated clinical findings will be discussed in the symposium.



Symposium | Outcome measurements

2.21 The importance of a global longitudinal database platform for collection of big data related to amputations, prosthetics and outcome

Bengt Soderberg^{1,2}, Shawn Murphy³, Ruud Leijendekkers⁴, Kenton Kaufman⁵

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Abstract

The theme “Practice in Science, Science in Practice” is exactly what a national quality register stand for. Daily practice is recorded in the clinic to preserve the team joint experiences. On this data we can do research/science and disseminate back the results to clinics for use in daily practice.

The Swedish registry for lower extremity amputations and prostheses (SwedeAmp) was based 2011, and is one of 100 other Swedish registries providing data for quality improvements and research. All these registries are funded by the government and are connected to a competence center for data storing and analyses.

SwedeAmp has experienced a growing international interest for national registries on lower limb amputations, prostheses and outcomes. The COMPASS and LEAD project lead by ISPO have identified parameters of importance for a global registry. However, a joint global platform for data storing and handling is yet missing.

By identifying the scope of amputations, prosthetics and outcome a global platform would speed up and improve the service provided to patients faster than any other method. The results could be compared both domestic and internationally and provide governments and payers a good base for decisions on future investments in the P&O field.

In this symposium four presenters will present their on-going process of setting up a national quality register in their country and highlight the need for a joint data platform. The discussion hope to involve user organizations such as IC2A, WHO and AT scale to form a way forward for further progress.

Statement of the objective / learning objectives

To gain knowledge in the organization of a national health registry such as SwedeAmp, to share experiences in the effort to set up new registries and to discuss the need of a global platform.



Symposium | Robotics, soft robotics, exoskeletons

2.22 From concept to clinical prototype, a multidisciplinary approach for the development of a paediatric ankle exoskeleton

Luiza Muraru¹, Roy Sevit¹, Tom Saey¹, Kaat Desloovere^{2,3}, Laure Everaert²

¹Thomas More University of Applied Sciences, Mobilab & Care, Geel, Belgium. ²KU Leuven, Department of Rehabilitation Sciences, Leuven, Belgium. ³University Hospitals Leuven, Clinical Motion Analysis Laboratory, Leuven, Belgium

Abstract

This symposium covers the development and testing of an ankle exoskeleton to assist gait in children with cerebral palsy. We will present different stages of the collaborative process between engineers and clinicians, from concept to clinical prototyping, pilot study results, and future directions for rehabilitation.

The first presentation describes the design of the paediatric ankle exoskeleton consisting of a 3D-printed personalized ankle module and an actuation unit integrated into a wearable backpack. An in-house automated digital design algorithm was used to create patient-specific cuffs from 3D scans and to align the mechanical axis on the ankle. The device provides variable bilateral assistance throughout the gait cycle mimicking concentric and excentric muscle work of plantar- and dorsiflexors. The assistance is customized to the patient's needs based on typical gait normalization supplemented with clinical input.

The second presentation discusses the results of the initial clinical testing, focused on verifying the working mechanism and the assistance concept. We will present the immediate effect on different gait parameters in a group of children with cerebral palsy, to assess the ankle exoskeleton's functionality and clinical efficacy. Further directions for refining the device were defined based on the observations and results of the clinical pilot study.

The third presentation reviews paediatric rehabilitation exoskeletons at different development stages from experimental models to medical devices and their application in rehabilitation. We will discuss the potential for transferring the present technology beyond the clinical gait lab to rehabilitation clinics, and home environment, to broaden the impact on paediatric rehabilitation.

Statement of the objective / learning objectives

Participants will gain insights into the multidisciplinary development and implementation of a paediatric ankle exoskeleton, evaluate its clinical effectiveness, and explore strategies for improving access to robotic-assisted rehabilitation for children with cerebral palsy.



Symposium | Prosthetics: bone anchored limbs

2.23 A Patient-Centered and Evidence-Based Approach to Bone-Anchored Limb Care for Patients with Lower-Limb Amputation

Jason Stoneback^{1,2,3}, Danielle Melton^{1,4,2,5}, Daniel Milius^{1,4,2,3}, Brecca Gaffney^{1,2,6}

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Abstract

Bone-Anchored Limbs (BAL, i.e., osseointegrated prostheses) are a promising alternative to socket-suspended prostheses for the third of individuals who abandon their prosthesis due to dissatisfaction. Early evidence has shown greater satisfaction and quality of life, reduced disability, and improved physical activity, balance, osseoperception, and biomechanics. We believe that BAL have the potential to radically improve the quality of life and mobility in individuals suffering from severe socket-related issues.

The University of Colorado Limb Restoration Program is an interdisciplinary collaboration of experts that is unique in its comprehensive approach to state-of-the-art care. It is one of the leading centers for osseointegration implant procedures worldwide, combining the talents of many specialists and sub-specialists located at the Anschutz Medical Campus. We are partnered with the Bone-Anchored Limb Research Group (BALRG) to lead the United States in clinical research across the translational research spectrum, from preclinical feasibility to population outcomes. Together, our mission is to advance clinical research knowledge regarding the process of osseointegration surgery and rehabilitation and to perform impactful, translational research that can improve the lives of patients.

In this symposium on clinical care and updated outcomes in BAL, team members from across the patient care pipeline will share their insights on their roles providing a patient-centered and evidence-based approach to BAL care. We will discuss how patient feedback guides our research and how our research feeds back into our patient care. Finally, we will host an open dialogue with symposium attendees about the challenges and opportunities of providing patients with BAL.

Statement of the objective / learning objectives

Attendees will learn about the clinical care after osseointegration, prosthetic prescription and alignment considerations for patients with bone-anchored limbs, and updated evidence for the benefits of bone-anchored limbs for patients dissatisfied with socket-suspended prostheses.



Symposium | Orthotics: lower limb and footwear

2.24 Guideline-based orthotic practice to improve the (cost-)effectiveness of lower limb orthoses in neuromuscular rehabilitation

Merel-Anne Brehm¹, Fieke Koopman¹, Elza van Duijnhoven¹, Tobias Goihl²

¹Amsterdam UMC, Amsterdam, Netherlands. ²Norwegian University of Science and Technology, Trondheim, Norway

Abstract

The application of lower limb orthoses is one of the core areas of neuromuscular rehabilitation expertise (Hsu 2008). However, despite their widespread provision, there is a lack of evidence-based knowledge on the selection of orthoses to best promote patients' mobility. In the absence of evidence-based knowledge, the choice of orthotic design appears to depend primarily on the preferences and experience of the prescribing rehabilitation physician and/or orthotist. This leads to variation in orthotic practice and differences in the effects of lower limb orthoses, with both positive and negative outcomes being reported (Brehm 2008, Waterval 2019), obviously limiting cost-effectiveness. This situation highlights the need to standardise and optimise the orthotic provision process to guide and inform decision making. Providing lower limb orthoses based on multidisciplinary orthotic expertise and with guidance on how to select the best orthosis for the individual patient using objective gait analyses can lead to an improvement in treatment outcomes and cost-effective lower limb orthotic care in neuromuscular rehabilitation (Duijnhoven 2024). In this symposium, we will:

- Provide insight into the steps of guideline-based orthotic practice for lower limb orthoses in neuromuscular disorders.
- Demonstrate the value of guideline-based orthotic practice in improving the cost-effectiveness of lower limb orthoses in neuromuscular disorders.
- Describe current orthotic practice for children with cerebral palsy in Norway and outline the process of developing the Norwegian National Quality Register for prescribing ankle-foot orthoses in children with cerebral palsy.

Statement of the objective / learning objectives

To provide healthcare professionals with an understanding of guideline-based orthotic practice in patients with neuromuscular disorders and cerebral palsy, and show how this approach can be used for the indication and selection of leg orthoses.



Symposium | Orthotics: lower limb and footwear

2.25 Measuring sustainability in healthcare and assistive technology: methods and examples for preventing and treating foot ulcers in people with diabetes

Ulla Hellstrand Tang^{1,2}, Göran Malmberg³, Isabella Gigante⁴

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Abstract

Sustainable development (SD) presents challenges for healthcare and highlights the importance of effective preventive measures. Healthcare costs account for 10% of GDP in Sweden and globally, with diabetes-related expenses making up 10% of total healthcare costs. Preventive treatments can reduce diabetic foot ulcers (DFUs) and amputations by half, offering significant ecological, economic, and social benefits to patients, healthcare providers, society, and ecosystems. We present methods to measure sustainability in healthcare, providing quantitative estimates of the ecological, economic, and social benefits of efficient prevention for patients with a foot at risk. Two case studies are discussed.

Case 1: A new approach to providing insoles for diabetes patients reduced costs by half. A software tool was developed to help Prosthetics and Orthotics Departments register, analyze, and report the sustainability effects of different choices. The results highlight the impacts on patients, employers, healthcare providers, society, and ecosystems.

Case 2: The sustainability of materials used in footwear to prevent DFUs, such as polyurethane and ethylene vinyl acetate, is examined. Environmental impacts, biomechanical properties, and clinical performance are explored, identifying research gaps and future directions for sustainable footwear design. Key research gaps and future directions for footwear design, in the prevention of DFUs, including sustainability aspects, will be presented.

Join us to discuss how to enhance and develop sustainability measurements for assistive devices in DFU prevention and care.

Statement of the objective / learning objectives

Attendees will understand methods to measure sustainability in healthcare, particularly in prevention of foot ulcers and gain insights into ecological, economic, and social benefits of sustainable solutions in prosthetics and footwear design.



Symposium | Health care, policy and sustainability

2.26 Patient-centred approaches to healthcare data in prosthetic rehabilitation

Chantel Ostler^{1,2}, Lisa Hodgson², Cleveland Barnett³, Maggie Donovan-Hall²

¹Portsmouth Hospitals University NHS Trust, Portsmouth, United Kingdom. ²University Of Southampton, Southampton, United Kingdom. ³Nottingham Trent University, Nottingham, United Kingdom

Abstract

It is widely acknowledged data will play an increasingly important role in future healthcare design, delivery and review. There is increasing awareness of the benefits of using data related to patients and their health conditions to improve healthcare (Goldacre and Morley, 2022). Examples in prosthetics being the development of national registries in Sweden and the USA.

However, despite the intent and popularity of registries, few have realised their full potential and struggle to evidence impact on patient outcomes, leading to calls for more patient-centred approaches (Nelson et al., 2016). Large scale patient-centred data systems which include patients in development and leadership, and collect data which matters to patients, which patients and clinicians can use, have been shown to improve healthcare (Crandall et al., 2012).

This symposium consists of four short presentations seeking to explore patient centred data collection in prosthetic rehabilitation. The first will outline a scoping review, synthesising evidence for and examples of patient-centred data collection systems. The second will present findings from a large UK qualitative study exploring patient and stakeholder views on the value, utilisation and sharing of data, articulating patient-centred data collection requirements in prosthetic rehabilitation. The third will describe the development of a patient core outcome set, the ECLIPSE model, which could inform the collection of meaningful outcome data from the patient's perspective. The final presentation will provide a real-world example of how patient-centred approaches in research and design informed the development of a digital app allowing patients to collect and monitor socket comfort data.

Statement of the objective / learning objectives

Symposium attendees can expect to:

1. Gain an understanding of current evidence for patient-centred data systems.
2. Understand stakeholder views on data use in prosthetic care settings.
3. Describe patient-centred outcome domains in prosthetic care.



Symposium | Prosthetics lower limb: transtibial, ankle, foot

2.27 Lower Limb Prosthesis Prescription Guided by Precision Rehabilitation and Patient-Centered Care Strategies

David Morgenroth^{1,2}, Daniel Norvell^{2,1}, Elizabeth Halsne^{2,1}, Alison Henderson²

¹University of Washington, Seattle, USA. ²VA Center for Limb Loss and Mobility (CLiMB), Seattle, USA

Abstract

An optimal prosthesis prescription is vital for restoring mobility and societal participation in people with lower limb loss. Clinicians try their best to choose prosthetic components that best match each individual user's needs, abilities, and goals, yet there is insufficient empirical evidence to guide prosthesis prescription. Further, there are limited tools to facilitate patient engagement in this process. In this symposium, we propose a new paradigm for prosthetic component selection and prosthesis prescription with a focus on prosthetic feet. Guided by precision rehabilitation and patient-centered care approaches, we will discuss thematically related, innovative research areas aimed at developing evidence-based tools and methods for providers and patients to enhance prosthetic foot selection and prescription. Our interdisciplinary group of presenters (physician-scientist, prosthetist-scientist, PT-epidemiologist, and psychologist with expertise in implementation science) will discuss the following innovative solutions that overcome some of the limitations and challenges in the current prosthesis prescription paradigm: an evidence-based clinician-facing decision support tool to aid in matching patients to a prescription that aligns with their future mobility level (including demonstration of use of the tool); a complimentary patient-facing decision aid that helps patients understand various prosthetic foot features to allow them to participate in a shared decision that aligns with their priorities and preferences; a patient-centered 'test-drive' strategy for prosthetic prescription using a programmable robotic prosthetic foot to emulate commercial feet; and implementation science methods used to determine barriers and facilitators to translating these innovations to clinical practice.

Table 1: Proposed symposium topics, speakers, and timing

Topic	Speaker	Presentation time
Brief introduction to thematically related new research directions for prosthesis prescription	David Morgenroth, MD	5 minutes
Prosthetic mobility prediction model translated into a point of care decision support tool	Daniel Norvell, PT, PhD	15 minutes
A patient decision aid for shared decision-making in prosthetic foot prescription	Elizabeth Halsne, CPO, PhD	15 minutes
'Test-drive' strategy for prosthetic foot prescription	David Morgenroth, MD	15 minutes
Implementation science methods for translating these research projects to clinical practice	Alison Henderson, PhD	10 minutes

Statement of the objective / learning objectives

1. Identify prosthetic foot prescription challenges.
2. Engage with a clinician-facing decision support tool to assist in mobility prediction.
3. Understand how patient-facing decision aids facilitate shared decision-making.
4. Discover methods of incorporating prosthesis user input into foot selection.



Symposium | Robotics, soft robotics, exoskeletons

2.28 The use of soft-robotic gloves in ADL and rehabilitation: a scientific, clinical and manufacturing point of view

Johannes Rietman^{1,2,3}, Corien Nikamp^{1,2}, Corry van der Sluis⁴, Annika Rydgard⁵

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Abstract

Recent technological developments enable the use of advanced soft-robotic devices for people with loss of hand function due to etiologies like trauma, neurological diseases or orthopedic conditions. Intended to be light-weight, wearable and comfortable to use in everyday environments, they potentially enable users to assist with daily tasks for prolonged periods.

Besides direct supportive effects during daily life tasks, these soft-robotic devices might be suitable to provide therapeutic effects as well, just by using the devices as a training tool at home, enabling users to perform more daily life activities for longer periods of time.

Within this symposium, we will start with a general introduction of soft-robotics in the field of rehabilitation. Second, we will present a scientific point of view on the use of soft-robotic gloves by presenting results of the iHand-study, a multicenter powered intervention trial to evaluate the therapeutic effects of a grip-supporting soft-robotic glove as an assistive device at home during daily activities. Results include grip and pinch strength, hand function and glove use time. The symposium will continue with the clinical perspective on the use of such devices for people with impaired hand function. Both experiences of a clinician and quotes of end users, who participated in the iHand-study, will be included. Finally, the manufacturer perspective will be presented. Examples of how clinical research drives further development of products will be described. Recent policy changes within the field of soft-robotics will also be presented which impacts the availability of these kind of products for patients.

Statement of the objective / learning objectives

The objective of the symposium is to learn about the different perspectives on the use of soft-robotic gloves both for use as an assistive device during ADL and as a rehabilitation training tool.



Symposium | Education

2.29 Disrupting P&O Education: Blended Learning as a Sustainable Solution for P&O Training - Lessons Learned in War Zones

Christian Schlierf¹, Irena Kranjac², Luai Alhallaak³, Andrii Vilenskyi⁴

¹HUMAN STUDY, School of rehabilitation Sciences, Nürnberg, Germany. ²HUMAN STUDY, School of rehabilitation Sciences, Istria, Croatia. ³HUMAN STUDY, School of rehabilitation Sciences, Hatay, Turkey. ⁴Charitable Organization "Charitable Fund Superhumans", Lviv, Ukraine

Abstract

In conflict and post-conflict situations, there are multiple barriers to the sustainable delivery of P&O education. These include lack of local teachers, language, varying education levels and closed borders preventing students from training overseas. Blended Learning enables us, as educators, to overcome these obstacles and take ISPO-accredited training to the students, building sustainable P&O capacity from the ground up.

Blended Learning Education delivers academic / theoretical content through interactive, multimedia modules; enhanced by onsite, hands-on clinical training. While they are learning, students are active practitioners delivering P&O services - immediately implementing their newly-acquired skills with their patients. On-the-job training is the cornerstone of this delivery model.

Human Study first piloted our Blended Learning model in Southeast Europe in 2005, as an innovative solution for building sustainable capacity in P&O services after the war in the former Yugoslavia. Over 20 years, we have utilised technological advances and progressive didactic models to develop Blended Learning Education in P&O into an incredibly powerful tool that meets international standards and delivers impact that is sustainable.

This symposium will present the successful development and implementation of Blended Learning Education in P&O in more than 50 countries over the past 20 years. We will reflect on lessons learned, using case studies from Syria, Iraq and Ukraine; demonstrate the sustainable, scalable impact of this method; and provide a future perspective showing how the Blended Learning model - developed as a humanitarian intervention - has the potential to revolutionise P&O education everywhere.

Statement of the objective / learning objectives

An overview of the development, implementation, process, advantages and impact of Blended Learning as a method of delivering P&O education to international standards. Case studies will illustrate Blended Learning's innovative, scalable and sustainable aspects.



Symposium | Prosthetics and Orthotics: upper limb

2.30 ISPO Special Interest Group Upper Limb (SIGUL) discuss sustainability

Alix Chadwell¹, Corry van der Sluis²

¹University of Southampton, Southampton, United Kingdom. ²University of Groningen, Groningen, Netherlands

Abstract

The 2025 World Congress theme explores the ways we can collaborate and innovate to bring about a more sustainable approach to rehabilitation. Members of SIGUL and invited speakers will discuss ideas around reuse of componentry in upper-limb prosthetics and the legal implications, more sustainable approaches to manufacture and maintenance, what a sustainable service may look like in a low-resource setting, and device afterlife.

Join us to learn more about the aims of the newly formed SIGUL, one of 2 new ISPO International Special Interest groups and what we have accomplished since we last met in Guadalajara. This interactive session will be an opportunity for you to feed back about what you want the SIGUL to look like as it develops. We will then open a discussion around sustainability in upper-limb prosthetics. Learn more about SIGUL and join our mailing list at www.ispoint.org/special-interest-groups/upper-limb/

Founding members: Corry van der Sluis (Netherlands), Alix Chadwell (UK), Dick Plettenburg (Netherlands), Kengo Ohnishi (Japan), Liselotte Hermansson (Sweden), Sandra Ramdial (Canada).

Statement of the objective / learning objectives

- Introduce the SIGUL to a broader ISPO audience
- Update on progress
- Develop ideas which drive us towards a more sustainable future in upper-limb prosthetics



Symposium | Orthotics: lower limb and footwear

2.31 Optimising motor recovery post stroke – Exploring the role of lower limb orthotic interventions

Paul Charlton¹, Nerrolyn Ramstrand², Youssef Salam³, Miriam Golding-Day⁴, Aideen Steed⁵

¹Peacocks Medical Group, Newcastle Upon Tyne, United Kingdom. ²Jönköping University, Jönköping, Sweden. ³ISPO, Beirut, Lebanon. ⁴University of Nottingham, Nottingham, United Kingdom. ⁵London North West University NHS Trust, London, United Kingdom

Abstract

The use of lower limb orthotic devices to support motor recovery during the subacute (7 days to 3 months) stage post stroke is a controversial topic with practices varying greatly both within and across country borders. Current evidence supporting lower limb orthotic use is limited, with varying results. While some report positive effects of orthotic use on functional outcomes, others report contrasting results (Daryabor et al, 2022).

Few orthotists are fully integrated into early stroke rehabilitation yet biomechanical principles and interventions familiar to orthotists can have a significant impact on the principles of stroke rehabilitation. Stroke rehabilitation of gait is mainly based on motor learning and neuroplasticity.

This symposium will explore the role that lower-limb orthotics may play in supporting motor recovery goals following stroke. The symposium will begin with a review of the current state of evidence and theory supporting the use of lower limb orthotic interventions during the motor recovery phase post-stroke together with a discussion of current practices from a UK and Scandinavian perspective. Speakers will then present examples of practical application of the principles discussed and examples of how this has already been shared with the international community.

The symposium will culminate with an example of how information related to orthotic management post stroke can be disseminated to the wider rehabilitation community.

References

1. Daryabor et al (2022) Effect of ankle-foot orthoses on functional outcome measurements in individuals with stroke: a systematic review and meta-analysis. *Disabil & Rehabil.* 22:2:6566-6581-

Statement of the objective / learning objectives

Understand the impact of orthotic intervention on Motor learning and stroke rehabilitation. Orthotists should feel empowered to become more actively involved in leading and advising on stroke rehabilitation as an active member of an MDT.



Symposium | Health care, policy and sustainability

2.32 Regional Approaches for Professional Development, Recognition and Accreditation of Prosthetists and Orthotists - Reflection from Cambodia, Thailand and Myanmar

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Abstract

A cause of absence of PO care in many situations is the lack of qualified and trained Prosthetists/Orthotists to provide the care. The lack of professional recognition and accreditation in specific settings hinder the awareness of other professionals or accessibility of users to their entitled services.

PO professional integration into the government employment cadre with other relevant issues around CPD, career-pathway, and professional council registration remain an issue for some countries. The interactions from policy makers, institutional implementation of interdisciplinary practice to public awareness are emergent to promote the professional recognition through system thinking, investment in professional resource development, capacity enhancement and standardized quality service provision in prosthetic and orthotic services. Long-term vision of pre-service education, in-service training, and career development in the national strategic plan for PO and health professionals with actionable priorities, government budget investments, review and monitoring plan for capacity development and enhancement are eminent.

The coverage and provision of prosthetic and orthotic services within the roadmap toward UHC and Rehab 2030 agenda. Nevertheless, these cannot be attained without adequate PO workforce where triple-layers challenges may lie around absorption of PO into government system, recognition level of PO in healthcare system, and accreditation of professional practice in formal employment sector.

Both, training programme and local professional association play essential roles in advocating and promoting professional recognition and accreditation. The case study of Thailand, Cambodia and Myanmar present three diverse experiences on the journey toward professional integration into local government cadre from challenges to progress and success.

Statement of the objective / learning objectives

Share and exchange experiences of success, journey toward, and challenges facing PO professional accreditation in Thailand, Cambodia, and Myanmar through the intersections of significant roles of training programme, investment and the professional national policy.



Symposium | Prosthetics and Orthotics: upper limb

2.33 Providing Sensory Feedback and Reducing Phantom Limb Pain Using Innovative Surgical Techniques of Targeted Sensory Reinnervation and Novel Medical Technology

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Abstract

The loss of the hand can lead to a considerable reduction in personal and professional quality of life. Myoelectric prostheses can restore many of the prehensile patterns of the hand with the exception of tactile sensitivity. Additionally, phantom limb pain and neuromas pain affect many amputees, compromising their quality of life. Their treatment remains a challenge, and in most cases, is limited to symptomatic treatment. A new therapy combining a unique surgical approach, Targeted Sensory Reinnervation (TSR), and a non-invasive vibrotactile sensory feedback system has been developed. This method has dramatically reduced phantom limb pain and improved prosthesis functionality and embodiment, helping patients regain a more natural interaction with their environment.

Following TSR, the skin of the forearm is reinnervated, enabling these patients to draw a phantom limb map of all 5 fingers on the forearm. In addition, these patients can distinguish between hot and cold. The genuine feeling of touch can be restored when vibrotactile feedback is applied to the phantom hand. Sensors on the prosthetic hand record touch and transmit this information as vibrations to the reinnervated area of the residual limb.



In this symposium, we will present the TSR technique that allows sensations to be perceived precisely at the level of the residual limb and give insight to the impact of using non-invasive sensory feedback. The method and its applications are discussed from both reconstructive surgical and clinical perspectives, focusing on how TSR significantly improves quality of life and reduces pain, providing a holistic improvement for amputees.

Statement of the objective / learning objectives

Following this symposium, the attendees will understand the TSR surgical technique for the upper limb and will know different applications of sensory feedback for upper limb prostheses and their impact on patient's daily life.



Symposium | Gait and balance

2.34 Anatomy of a Fall: Is the microprocessor knee the only suspect?

Robert Gailey¹, Christopher Wong², Kurt Gruben³

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Abstract

People with transfemoral amputations (TFA) stumble 2.5-4.5 times per month with 1-2 falls per month. Microprocessor knees (MPKs) have been attributed to the reduction of falls in people with TFA and as a result, the prescription for these devices are expanding to K2 patients. However, the anatomy of falls is complex. In fact, most falls are not exclusively prosthetic related but rather, they can be correlated to physical limitations, such as impaired balance related to comorbidities, decreased strength and gait limitations. Moreover, other pre-existing factors such as cognition, motivation and medication interactions combined with environmental factors and decreased social participation can play a significant role in falls. Identifying the characteristics of patients at risk can assist with prosthetic prescription and treatment. This evidence-based presentation will discuss a series of relevant published systematic reviews performed by various working groups from other professions. Presenters will outline mechanisms of falls with and without a prosthetic knee and patient characteristics from the best-known evidence. The biomechanics of when and how falls occur with a prosthesis and the different recovery mechanisms employed by people with TFAs will be described. Additionally, the falls assessment and outcomes measures recommended by allied health professionals and their application to the field of O&P will be discussed. Finally, a brief overview of evidence-based, multi-disciplinary treatment approaches for MPK users will be discussed. Comprehensive care plans for MPKs and fall safety for our patient's well-being can have positive effects for patients, clinicians, providers and the profession.

Statement of the objective / learning objectives

Participants will be able to:

1. Describe the mechanism of trips and falls and influence of the MPK characteristics.
2. Identify the most common falls outcome measures use by health professionals.



Symposium | Outcome measurements

2.35 Advancing measurement in lower limb orthotics: development, testing, and clinical implementation of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) survey instrument

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Abstract

Patient-reported outcome measures (PROMs) can be used to evaluate important aspects of health that may be improved by a lower limb orthosis. Existing PROMs have been used to measure the effects of orthoses but have limitations like a broad population focus, scores that are difficult to interpret, and less relevant content. To address these issues, our interdisciplinary research team developed the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M), a new PROM designed to measure mobility of lower limb orthosis users. The development process involved a review of existing items, focus groups, item generation and selection, and cognitive interviews. A pool of candidate items was administered to more than 1,000 lower limb orthosis users in the United States. Survey responses were used to calibrate the instrument using item response theory methods and establish initial evidence of validity for the item bank. Both 12- and 20-item short forms, and a computerized adaptive test (CAT) were created to facilitate administration in clinical care and research studies. A repeated measures study was then conducted to evaluate the validity and reliability of the OPRO-M short forms and CAT. Collectively, these studies resulted in a PROM that is easy to administer and interpret, psychometrically robust, and targeted to activities of importance to lower limb orthosis users. In this symposium, presenters will share their motivations for developing OPRO-M, describe an overview of its development, summarize evidence of its reliability and validity, and demonstrate how it can be integrated into routine clinical practice and used to advance orthotic care.

Statement of the objective / learning objectives

The goals of this symposium are to familiarize clinicians and researchers with OPRO-M, describe its development and psychometric testing, share how it is being implemented clinically, and offer suggestions for its use in the future.



Symposium | Prosthetics lower limb: transtibial, ankle, foot

2.36 A multidimensional approach merging cutting edge technology and patient's insight to empower prosthetists in residual limb assessment and socket design

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Abstract

The socket is a crucial component for lower limb amputees, significantly influencing comfort, fit, and overall prosthesis function. Current clinical approaches to managing socket fit and suspension issues primarily rely on patient feedback and visual inspections during clinic visits. This system leaves gaps between appointments, offering no continuous record of changes in the residual limb, which could provide valuable insights.

Although tools for monitoring the residual limb exist—from traditional methods to modern smartphones—there is still no real-time system to support self-management and enhance clinical care. Advances in digital applications present opportunities for patients to monitor and document changes at home, capturing critical information that can help prosthetists refine socket adjustments.

In this symposium, we will explore various approaches to residual limb monitoring. This will include a breakdown of key factors to track (shape, comfort etc...), the frequency of monitoring, how data can be stored, and how to ensure the information is valuable for prosthetists in their daily tasks of designing and adjusting sockets. We'll discuss state-of-the-art, user-friendly, and affordable systems that allow for continuous monitoring, including a new app designed to empower users to record their residual limb conditions.

The session will feature perspectives from technology experts, prosthetists, and patients, providing a comprehensive look at how modern monitoring tools can bridge the gap between clinical visits and improve prosthetic care through enhanced data collection and patient engagement. Insights from patient and public involvement (PPI) activities will also be included, offering a deeper understanding of user experiences and needs.



Statement of the objective / learning objectives

Attendees will learn how to combine the latest technologies available to gather information about the residual limb over time, what are the key elements to record for the benefits of the patients and the clinicians.



Symposium | Education

2.37 Quality and Sustainability of Prosthetics and Orthotics Education in the South and Southeast Asia Region

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Abstract

Access to P&O education is needed globally for sustainable rehabilitation services, particularly, where there is a striking shortage of P&O professionals. The South and Southeast Asia region is one of the most densely populated and plays a major role in global demographics. The ratio of P&O professionals is drastically lower in this region compared to high-income countries. P&O education programmes often encounter many challenges that hinder their quality and sustainability. These challenges range from awareness, recognition of professionals, missing infrastructure, expensive componentry, lack of trainers, and low faculty/student ratio, to the difficult integration of the P&O workforce and weak professional associations. ICRC has supported the P&O School of the Bangladesh Health Professional Institute created in 2014 and its partner the Center for the Rehabilitation of the Paralysed since 2003. It will present its experience at the time of the ICRC phase-out process, sharing lessons learnt and recommendations as an employer, educator and from a funding viewpoint. Exceed's experience of maintaining international standards of education as a gateway to national/international collaboration rely on diverse funding, maximizing potentials of faculty and resources and supply-chain management. Stakeholder engagement, co-creation, and co-ownership in both South-South and North-South corporations could be encouraged. Mobility India will share key factors and findings influencing the sustainability of P&O education, drawing on its two decades of experience in workforce development for the Global South and providing functional strategies to address challenges and enhance the sustainability and effectiveness of education.

Statement of the objective / learning objectives

The participants will gain understanding of regional experiences, recommendations, and actionable strategies towards access to sustainable quality education and services in less resourced/conflict affected countries aiming for improved rehabilitation outcomes.



Symposium | Rehabilitation medicine and surgery

2.38 Pros and Cons using National Registry Data for research - examples from SwedeAmp

Kerstin Hagberg^{1,2}, Cleveland Barnett³, Lina Sjödin^{4,5}, Maria Glemne^{6,7}

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Abstract

There is a growing international interest in national registries on lower limb amputations, prostheses and outcomes. In Sweden, a system of about 100 National Quality Registries provides the Swedish health care system with the opportunity to monitor quality and outcomes, and to provide data for registry-based research. SwedeAmp, the Swedish registry for lower extremity amputations and prostheses, was established in 2011. Any Swedish National Registry is connected to a competence center for data storing/handling, and each registry is annually monitored for financial support from the government.

In SwedeAmp data is registered voluntarily and on-line by clinicians, and registrations contain individual patient level data for amputations, prostheses and outcomes. The data is stored at the competence center and all users have access to data from their unit. Up to 2023, SwedeAmp contained data for around 12 000 patients, 17 000 surgical procedures, 7 000 prosthetic devices and 4 500 outcomes.

Access to data for research purposes requires a formal process including ethical approval. The aim of this symposia is to describe the pros and cons inherent with research performed on registry-based data by describing examples evolving from the SwedeAmp dataset.

In this symposium, three researchers will briefly present their currently on-going research and especially reflect on their experiences using registry data, pros as well as cons. The presenters represent different disciplines, units and countries and they applied for SwedeAmp data between year 2021 and 2024.

Statement of the objective / learning objectives

To gain knowledge in the organization of a national health registry such as SwedeAmp, and to gain a deeper understanding of factors that will influence research based on registry based-data.



Symposium | Rehabilitation medicine and surgery

2.39 Post-amputation pain: 100 years of progress

Jackson Linke¹, Jack Devonshire², Sam Williams¹, Andrew Rice³

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Abstract

Post-amputation pain is a burdensome condition characterised by either pain in the residual limb or pain perceived in the missing limb after an amputation, or phantom limb pain. Approximately 80% of people who have undergone an amputation experience post-amputation pain during their life. The consequences of post-amputation pain can be profound, often delaying the use of prostheses, leading to reduced mobility and quality of life.

This topical session will use a historical perspective to gain insights into contemporary evidence-based management strategies, prosthesis use, and outcome measurement. The speakers will explore the impact of post-amputation pain and the history of prosthetics use by examining the long-term outcomes of amputations that occurred during the First World War. Recent advances in surgical, pharmacological, and rehabilitation treatments for post-amputation pain will be presented and evaluated. Finally, outcome measurement for this population will be described and evaluated.

The aim of this workshop is to provide a platform for discussion about the history of post-amputation pain and prosthetics use, the current evidence for post-amputation pain management, and methods for measuring outcomes for people with post-amputation pain.

Statement of the objective / learning objectives

1. Understand the impact and natural history of post-amputation pain and prosthetics use.
2. Evaluate surgical, pharmacological, and rehabilitation treatments for post-amputation pain.
3. Engage in discussion about methods for measuring outcomes for people with post-amputation pain.



Symposium | Education

2.40 Dynamic tools to advance sustainable workforce development for prosthetists and orthotists in alignment with the Rehabilitation 2030 agenda

Cheryl Footer¹, Shala Cunningham^{2,1}, Angela Patterson^{3,1}, Martina Lukin¹, Neelum Zehra^{4,1}, Herbert Omoding^{5,1}, Rachael Lowe¹, Yara Peterko^{6,1}, Larisa Hoffman^{7,1}

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Abstract

Rehabilitation workforce development is a global priority to meet diverse demands for rehabilitation services. Around 100 million people globally need prosthetic or orthotic devices, yet 80-90% lack access to these services due to shortages of trained personnel, service facilities, and health rehabilitation infrastructure. Access is particularly limited in low- and middle-income countries (LMICs), where individuals are often younger and face greater physical demands.

The International Rehabilitation Education and Training Toolkit (IRETT) offers practical tools designed to assist stakeholders in executing key workforce development activities. These tools focus on enhancing entry-level education, continuing professional development, and professional regulation and are adaptable to all rehabilitation professions emphasizing the use of shared resources and efforts to strengthen the rehabilitation workforce. Implementation activities in Pakistan, Uganda and Ukraine demonstrate how the IRETT bolsters PO services through innovative approaches combining shared content development, local context adaptation, and contemporary learning technologies. Each tool emphasizes a quality improvement framework—plan, do, assess, and adjust—empowering local leaders to drive meaningful change.

The success of these initiatives relies on effective interprofessional collaboration, with POs playing a crucial role within rehabilitation teams. By providing a cohesive structure, the IRETT promotes alignment among stakeholders, facilitating coordinated efforts to integrate rehabilitation services into healthcare systems. In this presentation, we will introduce the IRETT tools and demonstrate their practical implementation through international case studies, exploring how POs can adapt these resources within their specific contexts.

Statement of the objective / learning objectives

Participants will gain practical insights into tools developed for supporting sustainable rehabilitation workforce development fostering inclusivity, collaboration, and culturally sensitive approaches to address the evolving needs of diverse populations.



Symposium | Therapy, physical activity, sports

2.41 Using knowledge of lived experiences to improve rehabilitation services for lower limb amputees

Jette Schack¹, Linn Reed-Schwanborg¹, Nerrolyn Ramstrand², Ulla Riis Madsen^{3,4}, Inger Lise Sørensen⁵

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⁴Holbæk Sygehus & REHPA, Holbæk, Denmark. ⁵Sørlandet sykehus HF, Kristiansand, Norway

Abstract

People with a lower limb amputation undergo profound and irreversible changes that impact their physical, social and mental health, permanently altering their lives. The path through amputation and rehabilitation varies from individual to individual and much can be learned through an increased understanding of personal experiences.

In this symposium, we will explore the various stages of the amputation journey through the perspectives of patients. We will consider whether certain factors influencing the lived experience of lower limb amputation deserve more focus in both research and clinical practice. We will highlight how research on patient perspectives can provide valuable insights for clinicians aiming to improve prosthetic rehabilitation practices.

Researchers will present findings on how Scandinavian patients experience the amputation process, including stages such as the perioperative phase and early prosthetic rehabilitation. The symposium will also address the barriers and facilitators that experienced prosthetic users face in their everyday lives. By examining the diverse experiences of prosthetic users at different stages of their journey, participants will gain a deeper understanding of challenges encountered by their patients. This knowledge will help practitioners better understand patients' reactions and decisions, ultimately supporting them in leading more fulfilling lives as prosthesis users.

Statement of the objective / learning objectives

Gaining insight into patient perspectives is essential for clinicians aiming to improve prosthetic rehabilitation. By understanding patients' experiences and challenges, clinicians can tailor rehabilitation approaches to better support functional outcomes and overall quality of life.



Basic instructional course | Paediatrics

3.01 Interdisciplinary approach in the treatment of children with congenital malformations of the upper extremity

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Abstract

Congenital malformations of the upper extremities can be accompanied by significant functional deficits. In clinical terms, the body parts missing from birth are looking in many cases similar to amputations. In comparison to children with amputations, children with congenital malformations do not feel any physical loss of the missing extremity.

The treatment regime is therefore very much based on the functional gain and benefit that can be achieved through surgical or conservative measures.

The speakers of the instructional course have been working together for many years in an interdisciplinary consultation for children with congenital malformations and convey ideas about both surgical and conservative options for functionally expanding treatments.

Children's hands can benefit from the surgical options of syndactyly separations, opponensplasties, pollicizations and toe transfers in terms of the everyday suitability of their malformed hand. Where this is not possible there are purpose-oriented aids in the field of prosthetics and functional aids, especially for the compensation of larger defects.

All efforts focus on supporting the gripping function, which comes into play in the diverse situations of children's everyday lives (e.g. personal hygiene, sport, play, music and leisure).

The child is the focus of these efforts and must be taken into account with all of his or her feelings, inclinations and reactions.

Statement of the objective / learning objectives

From an interdisciplinary perspective, participants are introduced to and taught both new care approaches and existing care solutions with prostheses and functional aids for dealing with these special situations.



Basic instructional course | Orthotics: lower limb and footwear

3.02 Ecological Footprint: Does the shoe fit? How to perform a Life Cycle Assessment of Orthotic Footwear

Chantal Bakker¹, Demi Lammers², Jolien Kommers², Kadir Omar³, Nicolaas (Nick) Toornend³

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Abstract

In the Netherlands, roughly half a million people have a condition that warrants wearing orthotic shoes. Over 80% of these shoes are produced abroad, and around 40% overseas. In addition to worldwide transportations, the production process itself has an environmental impact due to the assembly, energy consumption and raw materials used. We estimate that the average person with orthotic shoes has 2 adequate pairs at home, that are actively worn approximately half of the time. People may use their shoes in suboptimal ways for reasons of comfort, convenience, or ignorance. They probably own at least one additional pair that has become idle due to health changes. Currently, options for recycling are sparse in our country.

In conclusion, this shows ample room to improve the climate burden of orthotic shoes. But where to start? To guide choices for more sustainable prescription of orthotic shoes, we present the application of a Life Cycle Assessment (LCA). An LCA splits the life cycle of a product in phases and categorises its environmental impact. As such, it gives a broader view than carbon footprint alone.

In this instructional course we discuss the steps involved in an orthotic shoe LCA according to ISO norms 14040/44 and its possible impact on daily health care. The LCA can be initiated and performed by any stakeholder (in our case, respectively: the medical specialist and orthotic shoe technician) but relies on cooperation between all parties involved, to provide the necessary information and to evaluate and implement the outcomes.

Statement of the objective / learning objectives

Attendees will have an understanding of the phases of an LCA and the type of data that form an inventory specifically for orthotic shoes. They will gain insight into the environmental impact and possible choices.



Basic instructional course | Education

3.03 Academic Workplaces as a linkage between science and practice; working towards innovative and sustainable rehabilitation in prosthetics and orthotics

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Abstract

In healthcare, growing care needs and increasing complexity of health issues require a multidisciplinary approach. These societal challenges also impact prosthetic, orthotic and footwear care. To address these challenges, a reciprocal integration of science and practice is essential. An academic workplace in the field of assistive devices is a collaborative research infrastructure that connects healthcare practice, research, education, industry, and end users, who have a central position as patient research partners. Research questions, originating from end users and professionals, are jointly collected and addressed, while the acquired knowledge is shared and implemented among all stakeholders. This approach reduces research waste, adds value and stimulates/facilitates the implementation of research results. Our academic workplaces, 'the ProsthesisAcademy' and 'Academic Workplace HOMELAND' focus specifically on mobility aids in Dutch rehabilitation medicine. The ProsthesisAcademy aims to improve the use of arm and leg prosthetics at home. HOMELAND focuses on improving offloading devices for people with neuropathy, such as custom-made footwear. In this instructional course, we will explain the organization, methods and experiences of these academic workplaces. Participants will then be challenged to think about opportunities such networks can have in their own practice, and discuss potential implementations in their countries. Subsequently, we will address how and what type of practice-oriented research takes place within our academic workplaces and how we organize the path to implementation. Participants will share their own experiences with performing and implementing practice-oriented research in collaborative networks. The course will give insight into the benefits of sustainable collaboration within academic workplaces.

Statement of the objective / learning objectives

Participants will:

1. Understand how academic workplaces respond to societal changes in rehabilitation medicine; 2.
2. Learn to involve all stakeholders in research through academic workplaces; and
3. Discuss their potential for collaboration and innovation.



Basic instructional course | Paediatrics

3.04 Rebuilding Lives: A Multidisciplinary Approach to supporting children with amputations after sepsis

Val Jacques-Robinson, Jennifer Fulton, Amy Arnott

Royal National Orthopaedic Hospital, Stanmore, United Kingdom

Abstract

Children who suffer from sepsis that results in multi limb loss are a small and unique population within paediatric prosthetic rehabilitation. They present many challenges to the rehabilitation team over the years as they develop and grow from children to young adults

As clinicians our aim is to enable each child to be able to participate fully with their siblings and peers at each stage of their development. We believe this is best achieved through a team approach, which works to minimise the impact of the pathology and maximise the child's ability through rehabilitation and considered prosthetic provision

During the course we will discuss the need for:

- Early surgical /rehabilitation team collaboration
- Consideration of amputation level and impact on rehabilitation
- Rehabilitation principles and strategies for managing children
- Prescription choice at different stages of development
- Prosthetic challenges and solutions in multi limb loss
- Minimising impact of complications for long term musculoskeletal health
- Collaborative team working throughout childhood

Case studies will be used to demonstrate management of cases in everyday clinical practice

This course aims to provide clinicians with an opportunity to explore and exchange solutions for their paediatric patients with an experienced MDT

Statement of the objective / learning objectives

1. Understand the importance of collaborative MDT working throughout childhood.
2. Impact of level of amputation on rehabilitation outcome
3. Explore rehabilitation strategies and prosthetic prescription choices unique to multi limb loss children



Basic instructional course | Prosthetics and Orthotics: upper limb

3.05 Practical application of pattern recognition myoelectric control in powered upper limb prosthetics

Blair Lock

Coapt, Chicago, USA

Abstract

There is a confusing amount of information flooding into our field about how AI and Machine Learning are impacting today's clinical solutions. It is difficult for practicing clinicians to determine what is a promising research project from what is available in commercial applications. Nowhere is this challenge more prevalent than powered upper limb prosthetics. For over 10 years, "pattern recognition" myoelectric control has been a Machine Learning option for upper limb devices, but many practitioners have had limited formal education on how it is differentiated from conventional myoelectric approaches. This instructional course aims to fill the gap for the experienced or beginning practitioner, covering the pattern recognition myoelectric control topic that receives limited coverage in undergraduate curricula.

Attendees will be taught the practical application of pattern recognition myoelectric control, including how this form of Machine Learning acts as a decoder of neurological intent to provide the modern-technological approach to prosthesis control personalization. The course will also cover the underlying aspects of AI that work to benefit the users' learning process as well as foster the user-clinician relationship. Attendees who have used, or understand, pattern recognition myoelectric control will gain advanced knowledge on the future direction of the commercial applications and attendees who are new to the concept will come away with a solid understanding and confidence in applying the solution to their patients. The presenters will welcome any, and as many, questions as time permits.

Statement of the objective / learning objectives

Attendees will gain a solid understanding of pattern recognition myoelectric control, learn how it is differentiated from conventional myoelectric control, and leave with the confidence to apply the solution for the benefit of their patients.



Basic instructional course | Therapy, physical activity, sports

3.06 Leveling the playing field: The secrets to coaching athletes to run with a prosthesis

Robert Gailey¹, Peter Harsch², Eric McElvanney³

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³USA Paralympic Triathlon Team, Pittsburgh, USA

Abstract

Running with a prosthesis is no longer a novelty but rather has become a part of the rehabilitation process by the current generation of prosthetic users. In the United States, approximately 15% of K3-K4 active LLA have a secondary activity-specific prostheses. Since 1978, 183 journal articles focused on running and LLA athletes have been published, however 73% were published after 2010. Likewise, since 2010 the instructors of this presentation have taught over 100 running clinics globally. Participating athletes include juniors, adults, elite athletes and military populations. The range of the athletes' goals span from play ball with their kids to competing in the Paralympics or Ironman triathlons. This presentation will be taught by the three coaches of the Challenged Athletes Foundation Running Clinics who will share the program's structure and instructional methods in three sections. Section one, will describe the Five-steps for running with a prosthesis with an emphasis on assessing the novice runner in real-time and the corrective tips used to improve technique and build confidence. Moreover, agility techniques for running sideways, backward, and changing direction smoothly will be offered. Section two, will focus on the athletes who have running experience and want to improve on their abilities for distance running by learning a series of drills designed to minimize effort and improve performance. The third section will discuss training tips, nutritional information, and other insights that the athletes can incorporate into their training routines. Finally, the obstacle course designed to demonstrate the athletes' skills will be shown.

Statement of the objective / learning objectives

Participants will be able to:

1. Host a running clinic teaching lower-limb amputees to run with a prosthesis.
2. Instruct accomplished athletes to more effectively train and use of their prosthesis for sports.



Basic instructional course | Orthotics: lower limb and footwear

3.07 AFO Training in Practice and Innovative Strategies for Optimal Adaptation in Neuromuscular Disorders

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Abstract

Ankle-foot orthoses (AFOs) are widely prescribed to improve walking in various neuromuscular disorders. To maximally benefit from an AFO, individuals need to adapt their gait to the AFO and gain confidence in walking with the AFO. While physiotherapy sessions are often planned to provide explicit instructions for safe and intended use of AFOs, full gait adaption is typically assumed to occur naturally through daily use. However, spontaneous adaptation to the AFO may not (always) take place, especially for individuals with fear or low balance confidence. This might prevent individuals from fully utilizing the AFO capabilities. A better understanding of the AFO adaptation process, alongside the role of gait training and innovative training strategies, is essential to ensure AFO users to achieve the best possible outcomes.

In this symposium, we will focus on the role of gait training following provision of AFOs. We will begin by emphasizing the importance of standardized AFO training to help patients become familiar with AFO use during daily activities in real-world settings, using our expert center experience and results of a national survey on current training practices. We will then discuss the AFO adaptation process and the role of exploratory variability in learning, drawing on current scientific literature and results of our recently conducted analysis on AFO adaptation. Lastly, we will share promising findings from a pilot study that utilized principles of motor learning to enhance AFO adaptation and overall functioning through an innovative training approach.

Statement of the objective / learning objectives

By attending this session, participants will gain insights into adaptation to AFOs, the role of gait training following AFO provision, and innovative training strategies to enhance treatment outcomes in neuromuscular disorders supported by scientific concepts.



Basic instructional course | Outcome measurements

3.08 Children's Amputee Mobility Predictor: Functional assessment for children with leg length discrepancy requiring a prosthesis or Extension-prostheses (Orthoprosthesis)

Sharon Eylon^{1,2}, Nurit Stern^{1,2}, Anat Kristal³

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Abstract

A child with a leg length discrepancy requires a prosthesis or Extension-prosthesis to participate in home, school, and community activities. Typically, the functional status evaluation of children with leg length discrepancy includes physical examination (e.g., range of motion and manual muscle testing) and observational assessment of functional capabilities such as transitioning from sitting to standing, maintaining standing balance, or hopping on one leg. Additionally, clinicians may enhance their evaluation using functional assessment tools or mobility and balance performance-based measures. Nevertheless, these assessments for the pediatric/adolescent population are not specifically designed to assess the unique age-specific functional challenges children with leg length discrepancies face. The Children's Amputee Mobility Predictor (CAMP) is a new functional assessment developed specifically to assess the functional capacity of children with leg length discrepancy requiring a prosthesis or Extension-prosthesis. The CAMP assessment aims to provide sustainable rehabilitation by equipping clinicians with the skills to accurately evaluate the functional challenges of children with leg length discrepancies, ensuring they achieve long-term mobility and participation in daily activities. The purpose of this instructional course is to present the 26 tasks of the CAMP assessment, provide instructions and guidance on administering and scoring each task, and explain how to calculate the total score. Additionally, attendees will participate in an interactive session scoring the CAMP while observing patient videos.

Statement of the objective / learning objectives

1. Learn how to administer and score the CAMP assessment.
2. Learn how to calculate CAMP's total score.
3. Use CAMP assessment to evaluate the functional capacity of children and adolescents with leg length discrepancy



Basic instructional course | Education

3.09 Revolutionizing P&O Practice and Education: Artificial Intelligence and Large Language Models for Clinicians and Educators

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Abstract

This course invites P&O clinicians and educators worldwide to explore the transformative synergy of artificial intelligence (AI) and large language models (LLMs) in clinical practice and education. Designed to empower clinicians and educators alike, this course provides practical tools for integrating AI and LLMs and AI into clinical workflows and teaching methodologies, enhancing patient care, educator productivity, and student learning.

Presenters will address ethical considerations related to the use of AI and LLMs and make practical applications to clinical and education settings, with special attention to less resourced settings. The session will include a brief overview of AI and LLMs, followed by live demonstrations and active participation, showcasing how these technologies can be used in both clinical and educational settings. Examples of incorporating AI in formulation, documentation, professional communication, and patient education will be included, and insights offered into how these innovations can improve practice and learning.

Join us in shaping the future of orthotics and prosthetics by embracing AI-driven advancements, preparing clinicians, educators, and students to excel in a rapidly evolving technological landscape.

Statement of the objective / learning objectives

Explore practical applications of AI and LLMs in P&O, develop skills to enhance their use, collaborate with peers, and address ethical considerations such as privacy, bias, and equity.



Basic instructional course | Outcome measurements

3.10 Advancing Observational Gait Analysis: Unlock the Collaborative Power of the Functional Lower-limb Amputee Gait Assessment Tool

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Abstract

After a patient is fitted with a prosthesis and begins walking, physical therapists and prosthetists conduct observational gait analysis (OGA) to assess their gait and identify deviations. Using an OGA-tool, which includes a list of prevalent gait deviations and their causes, can guide their evaluation in determining the presence of gait deviations, provide insight into intervention, and measure change over time. Current OGA tools are typically tailored to either physical therapists or prosthetists, focusing primarily on exercise interventions for the former and prosthetic adjustments for the latter. The Functional Lower-limb Amputee Gait (FLAG Assessment) is a new OGA-tool developed specifically to promote communication and collaboration between physical therapists and prosthetists. It outlines the most probable causes for each gait deviation (i.e., body function impairments and patient and prosthetic-related issues). The FLAG Assessment supports sustainable rehabilitation practices by providing a platform for team-based, patient-centered care, where each profession contributes a unique skill set to mitigate observed gait deviations. In this instructional course, attendees will dive deep into the gait deviations featured in the FLAG Assessment and master the skills needed to identify each one. Additionally, they will participate in an interactive session analyzing patient videos to apply their new knowledge.

Statement of the objective / learning objectives

By the end of the course, attendees will be able to describe gait deviations included in the FLAG Assessment, determine their probable causes, and analyze the gait of individuals with lower-limb prostheses using this tool.



Basic instructional course | Device fabrication and design

3.11 Digital Workflow for Prosthetic Socket Production – Clinical and Workshop Practises

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Abstract

This instructional course aims to provide practitioners with basic knowledge of current digital workflow practices for the creation of prosthetic sockets. The course will discuss a flowchart of a digitalised workflow in comparison to traditional production, and explain basic knowledge and practices surrounding each digitalised step for further context. This course aims to further practitioners understanding of how they can implement digital workflows into their current practises, and how this will affect their outputs on resource, material waste, storage capacity and time. Recommendations will be given on types of additive manufacturing solutions are available and most relevant to the production of transtibial prostheses, as well as what may be out of scope in a digitalised workflow compared to traditional practises. Insight into realistic implementation of digitalised workflows will be given through case study examples and first-hand advice from the managing director of a European prosthetic and orthotic company.

Statement of the objective / learning objectives

Understand traditional against digitalised workflows for socket production; How to create a prosthetic socket using a digitalised workflow; What current additive manufacturing solutions are available for sockets; Challenges present when adopting digitalised workflows.



Advanced instructional course | Orthotics: lower limb and footwear

4.01 Orthotics and Gait Rehabilitation for Persons Poststroke as Evidence-Based Practice

Hiroshi Hashimoto^{1,2}, Sumiko Yamamoto³, Soji Tanaka⁴

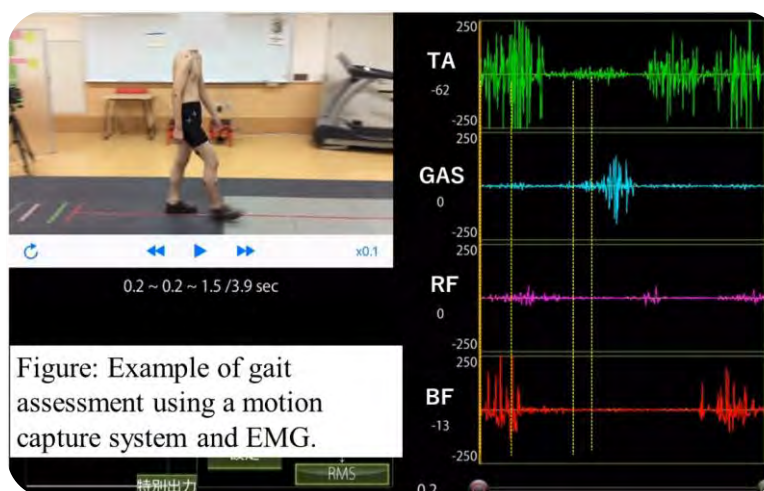
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Abstract

One important goal of rehabilitation for persons poststroke is gait reconstruction. Movement of lower limb during stance phase can be considered as an inverted pendulum. To reconstruct gait, it is crucial to inhibit excessive and irregular muscle contractions, promote harmonious muscular activities, and control adequate range of motion of joints of the lower limb as early as possible. Orthoses are indispensable for gait re-learning both in the acute and sub-acute periods.

Orthoses can help compensate for both kinematic and kinetic disorders of the ankle, the knee, and the hip, as long as the orthotic functions, stiffness and range of motion, are appropriately adjusted for each individual. Moreover, orthoses can be adjusted to the difficulty levels of each individual in order to enable more ideal gait training. Therefore, both appropriate selection of the AFO' functions and interventions are essential for good orthotic therapy.

In this instructional course, the basic knowledge of orthotic function and how AFOs can improve pathological gait are explained in detail. Also, some clinical cases are introduced to support this knowledge including examples of evidence-based practice. Furthermore, clinically beneficial ways of assessment and effective interventions using orthoses will be demonstrated with objective information including kinematic and kinetic data measured by 3D motion capture systems including EMG data.



Statement of the objective / learning objectives

1. To provide an overview of gait rehabilitation using orthoses for persons poststroke.
2. To better understand effective manner of evaluation, intervention, and adjustment of orthotic functions specific to persons poststroke in gait rehabilitation.



Advanced instructional course | Prosthetics: bone anchored limbs

4.02 Bone-anchored Lower Limb Alignment: Reestablishing Normal

Christopher Hoyt

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Abstract

Osseointegration provides significant advantages for individuals with limb loss, including the elimination of the skeletal/socket pseudo-joint, enhanced range of motion, and the restoration of normal anatomical alignment.

This instructional course will explore the various factors influencing lower limb build height and tri-planar alignment, presenting a systematic approach to fitting patients with bone-anchored prosthetics. By differentiating between 'acceptable' and 'optimal' alignment, practitioners can achieve the best possible patient outcomes.

Course topics will cover pre-surgical measurements, bench alignment, static acute fitting, dynamic and long-term alignment strategies, and subjective observational gait analysis. Additionally, we will examine radiographic and LASAR-guided posture alignment.

Participants will also benefit from specific troubleshooting cases, including non-invasive prosthetic solutions for addressing bone-anchored limb pain.

Statement of the objective / learning objectives

By the end of the session, participants should have a thorough understanding of the variables encountered in bone-anchored alignment and with a scientific view, more confidently achieve optimal patient outcomes.



Advanced instructional course | Prosthetics: lower limb transfemoral

4.03 Innovative Socket-design And Digital Processes In AK-Prosthetics

Michael Schaefer¹, Malte Prof. Dr. Bellmann², Marlo Ortiz³, Tim Baumeister¹, Jason Kahle⁴

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Abstract

Technological advances in the design of modern AK prostheses have led to significant improvements in recent years. Increasingly safer and more adaptive prosthetic componentries in both the area of prosthetic knee joints and feet enable a wider range of applications, but also require consistent input of the required information by the users. The prosthetic socket technology for AK-amputees must, on the one hand, be based on adequate management of the different anatomical Situations (Joints, bone, muscle and soft tissue), and, on the other hand, the corresponding biomechanical information from the most diverse everyday situations must also be adequately input and processed. The following advanced instructional course will introduce the biomechanical requirements and necessities of a contemporary supply of a AK-socket. The requirements for a modern, physiological and sustainable socket design will be addressed. Using systematic approaches and the latest material-technologies, their implementation in practical care is conveyed.

The current state of studies shows the knowledge gained to date from proven care systems, but still leaves a clear gap for discussion on the latest experiences presented here in this field of care. The fact that sophisticated care is increasingly benefiting from the influence of digital media and the resulting processes is demonstrated by the implementation of digital workflows.

The advantages that result from the digitalization of processes and the use of modern socket materials for orthopedic technology can lie in a faster transfer of specific specialist knowledge but also in a systematic continuous learning from the care provided.

Statement of the objective / learning objectives

Experienced prosthetists and biomechanists convey experiences for the treatment of modern AK prosthetic socket systems. They provide specific advice on individual design variants and the influence of digital procedures in this treatment process.



Advanced instructional course | Education

4.04 Structuring Interventions for Children with Neuromotor Impairments – A Multidisciplinary and Family-Centered Approach

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Abstract

Caring for children with neuromotor impairments requires an interdisciplinary, goal-oriented approach that actively involves the family in the treatment process. Training should focus not only on assessment, planning, and implementation, but also on engaging these children in active motor behavior. A course should empower families and treatment teams in decision-making while supporting the child's motor capacities for optimal participation in everyday life.

Human Study developed and piloted a Specialised Course called "Interventions for Children with Neuromotor Impairments – Interdisciplinary and Family-Centered" designed to meet the specific needs of this complex care.

The programme targets professionals from various fields such as physiotherapy, occupational therapy, orthotics, and medicine, enhancing their skills in interdisciplinary collaboration and family-centered treatment planning.

This advanced instructional course demonstrates how to design and implement an interdisciplinary, family-centered intervention program. Participants gain insights into course development, including goal setting, handling classifications with family involvement, utilising a multidisciplinary approach, including paediatric and functional assessments, conducting observational gait analysis, making indications for orthotic care and aid testing, leading to objective outcome measures.

Statement of the objective / learning objectives

The course emphasizes how different health care disciplines can closely collaborate in order to learn from each other regarding working methods and perspectives.



Advanced instructional course | Prosthetics: bone anchored limbs

4.05 Towards optimal prosthetic alignment of transtibial bone-anchored limbs

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Abstract

Bone-anchored limbs (BAL) using a transcutaneous osseointegration implant are gaining popularity as a solution for socket-suspended prosthesis users suffering from socket-related problems.

Appropriate alignment is crucial in transtibial prosthetic fitting, involving the positioning of the prosthetic foot in relation to the residual limb. The alignment of a transtibial BAL has consequences for the moments around the joints and implant. Due to the absence of a pseudo-joint (i.e. socket-residual limb interface), suboptimal alignment of a BAL can lead to serious moments on both adjective joints and the BAL components (e.g. the osseointegration implant and the connector). These moments may lead to negative long-term effects such as osteoarthritis and excessive wear of BAL components. A clear understanding of the relationship between transtibial prosthetic alignment and moments around the joints and BAL components for bone-anchored prosthetic users is still lacking. Presentations will be given by a multidisciplinary team with experience in BAL rehabilitation care up to 15 years. The team consists of a physical therapist, a prosthetist, and a human movement scientist. Topics covered include instruments used to evaluate alignment (e.g. LASAR Posture 3D, x-rays, instrumented gait analysis), the relationship between static and dynamic measures, and responsiveness of dynamic measures.

Statement of the objective / learning objectives

Attendees will enrich their knowledge about the applicable methods to optimize transtibial BAL's and the impact of alignment on joints, BAL components, and gait. The philosophy behind the methods and lessons learned will be discussed.



Advanced instructional course | Orthotics: lower limb and footwear

4.06 Rocker Profile Shoes: Design parameters & Biomechanics

Juha Hijmans, Rifko Kurnianto, Alexandra Millar

University Medical Center Groningen, Groningen, Netherlands

Abstract

A rocker bottom shoe is defined as a shoe with a contoured outsole that creates a curved anteroposterior profile. These rocker shoes are commonly used in clinical practice for various conditions, including diabetic neuropathy and foot pain. However, design parameters are rarely specified in detail.

In this course, we will explain how different design parameters of rocker profiles impact gait biomechanics. Specifically, we will explore the relationship between factors such as apex position, apex angle, rocker angle/radius, and longitudinal bending stiffness (see fig 1) with the kinetics and kinematics of the lower limb, as well as plantar pressure distribution during gait. The process of producing rocker profile shoes with individually optimized design parameters will also be discussed.

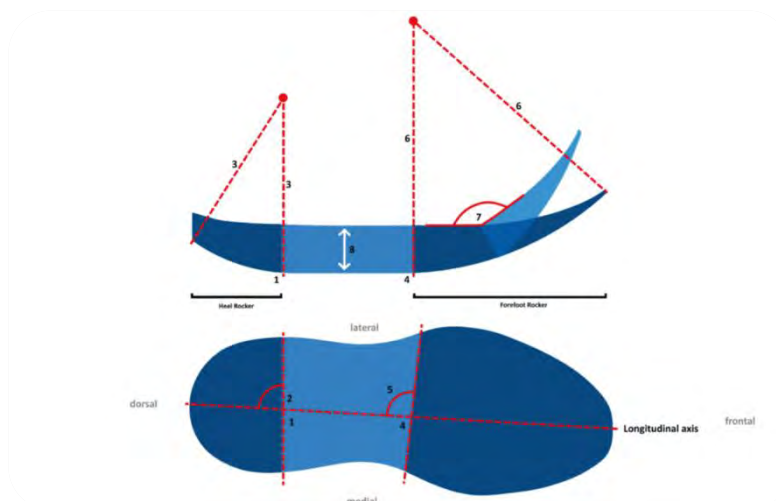


Fig 1: Design parameters of rocker profile shoes

Two topics will receive special attention:

We will specifically focus on the use of rocker profiles for targeted pressure redistribution in diabetic neuropathy and explore how to optimize the design when multiple areas on the plantar side of the foot require offloading. Both optimization algorithms based on current literature and human-in-the-loop approaches for individualized rocker profiles will be presented.

The second topic to be discussed in depth is AFO tuning through the optimization of rocker parameters. We will demonstrate how rocker shoe designs can influence shank kinematics.

Statement of the objective / learning objectives

Attendees will gain knowledge about the relation between design parameters of rocker profile shoes and biomechanics of gait. Emphasis will be on individualization of the rocker parameters in diabetes and tuning of AFOs with rockers.



Advanced instructional course | Orthotics: lower limb and footwear

4.07 Aligning the ankle-foot orthoses

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Abstract

To increase gait capacity, Ankle-Foot Orthoses (AFOs) are commonly prescribed in people with neurological impairment such as stroke and incomplete SCI patients. AFOs aim to minimize gait deviations by providing stability during stance and facilitating toe clearance during swing. To further improve the efficacy of AFOs for optimizing gait capacity, several influential factors have been investigated. One of the most important factors is AFO alignment, which corresponds to the orientation of the ground reaction force (GRF) in relation to the joint rotation centers. By making small adjustments to the heel height of the AFO-footwear combination or the angle between the ventral shell and footplate of the AFO, the orientation of the GRF can be manipulated until optimal AFO alignment is achieved. The first part of this mini symposium will focus on the clinical importance and current clinical practice of AFO alignment by presenting several show cases. The second part of the symposium will focus on new technological developments that can be used for optimal AFO alignment. The validity, reliability and responsiveness of the use of inertial movement sensors in assessing Shank to vertical angle for AFO alignment will be presented. The second technological method is the automated localization of human joints in figures and videos by artificial intelligence (AI). The results of this technique in 20 patients will be presented. In the final part of the symposium, we will discuss the steps that are needed for a better implementation of AFO alignment in current practice of rehabilitation centers.

Statement of the objective / learning objectives

1. Importance and current clinical practice of AFO alignment
2. New technological developments to improve AFO alignment



Advanced instructional course | Prosthetics and Orthotics: upper limb

4.08 Advances in Upper Extremity Prosthetic Suspension Technology and Techniques

Gerwin Smit¹, Robert Radocy^{2,3,4}, Debra Latour^{5,6,7}, Joe Mahon⁸, David Rotter⁹, Rolanas Balcaitis¹⁰

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Abstract

A comfortable and optimal fitting socket is the cornerstone of successful upper limb prosthesis provision. Socket discomfort, which is a major reason for prosthesis rejection, can be caused by factors such as poor fit, pressure points, and problems with perspiration and temperature regulation. This workshop provides an overview of new approaches to socket design, using the newest technologies. The different techniques will be illustrated with a series of actual cases from daily practice.

The workshop will start with a brief overview of the history of upper limb socket development, describing the evolution of fitting methods and socket materials being used, towards comfortable self-suspending sockets.

We will demonstrate the application of dial driven laces, to create user adjustable sockets, allowing for supra-olecranon suspension, volume adjustment as well as maintaining optimal electrode pressure, to create stable myo-signals and prevent muscle fatigue.

Both low- and high-level limb absence will be covered. A new approach will be presented, which uses a telescopic socket, to create a very lightweight and highly functional shoulder level prosthesis.

The application of CAD design and 3D-printing of sockets will be examined. This has opened up new possibilities in socket design, with new materials and new open design. We will show how open socket design, with adjustable features, can improve ventilation and volume management, to increase user comfort, as well as easier donning and doffing.

The presenters of the workshop are experts with decades of experience in the field, who have been working in the clinic, in industry and academia.

Statement of the objective / learning objectives

After attending the workshop, the participants can:

1. Describe the challenges involved in creating a comfortable, high performance upper extremity prosthesis.
2. Describe how new advanced socket techniques can solve common socket problems and improve socket comfort.



Free paper session | Prosthetics: bone anchored limbs – Review, consensus, and patient selection

5.011 Ideal Patient Selection for Osseointegration Reconstruction – Based on 800 Cases

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BACKGROUND

Osseointegration has been established as a promising alternative for patients who suffer from problems associated with the traditional socket mounted prosthesis. This radical approach is often reported to provide improved functional mobility, better osseoperception, improved comfort, reduced pain, better biomechanical alignment and better gait, which all lead to a less restricted lifestyle and significantly improved quality of life. However, the success of osseointegration is heavily dependent on patient selection. This study aims to identify the ideal patient characteristics for successful osseointegration reconstruction based on an analysis of 800 cases.

AIM

To enable our audience to:

1. Understand the new osseointegration technology as an alternative to socket prosthesis for optimal rehabilitation of the war injured and failed socket users suffering with limb loss.
2. Develop a good understanding on the risk and benefit considerations when assessing patient suitability for osseointegration surgery.
3. Explore the future prospects and outcomes of potential amputation rehabilitation through osseointegration.

METHOD

A retrospective analysis was conducted on 800 cases of osseointegration reconstruction using the Osseointegrated Prosthetic Limb (OPL) and early IPL (integral leg prosthesis) system between November 2010 and November 2022. Patient demographics, medical histories, comorbidities, surgical interventions, and outcomes were carefully evaluated. In this research study, the Osseointegration Group of Australia shares their experience and the future directions on how to better select patients for successful outcomes after osseointegration reconstruction.

RESULTS

The overall success rate of osseointegration reconstruction in this study cohort was 76%. The key to patient selection is dependent on assessment from a highly cross functional team which includes psychologists, pain specialists, physiotherapists, prosthetists, rehabilitation physicians, biomedical engineers, primary treating orthopaedic surgeon specialised in Osseointegration procedure along with orthopaedic surgeon's experts in other treatment areas. Our analysis revealed several factors associated with successful outcomes, including the presence of comorbidities, the type of surgical intervention (single stage or two stage surgery), how the amputation was sustained and time from amputation to osseointegration.

DISCUSSION AND CONCLUSION

By far this is the largest group of osseointegration patients comprising of 800 cases providing valuable insights into ideal patient selection. Comorbidity profiles were identified as critical factors influencing the success of the procedure. These findings contribute to the development of evidence-based guidelines for selecting candidates who are most likely to benefit from osseointegration reconstruction, ultimately improving patient outcomes and enhancing their quality of life. Further prospective studies are warranted to validate these findings and refine patient selection criteria.



5.012 Promoting Osseointegration during Rehabilitation with Bionic Bone-Anchored Prostheses: Technology and Knowledge Gaps

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BACKGROUND

The efficacy and safety of rehabilitation programs leading to the fitting of bone-anchored prostheses (BAP) must be improved prior to collegial acceptance as a standard of care. Efforts are required to prevent load-related adverse events due to mechanical stresses surrounding sites of bone integration. During rehabilitation exercises, increasing axial loads are applied onto the implant until the full bodyweight can be tolerated. However, little is known about pain-free Goldilocks loading zones.

AIM

This study aims were (A) to review the literature on biomechanical aspects of rehabilitation load bearing exercises for transfemoral BAP and (B) to identify technology and knowledge gaps.

METHOD

The literature review focused on the design and monitoring of mechanical load applied during load bearing exercises following the four-phase PRISMA framework. We used MeSH keywords associated with BAP and rehabilitation programs to search for references published between 2000 and 2023 in PubMed and Web of Science according to modified PICO methods: Population (e.g., lower and upper extremities), Intervention (e.g., design of implants, static and dynamic exercises), and outcomes (e.g., bone remodelling, adverse events). Data extraction included the quantitative and qualitative characterization of publications.

RESULTS

196 (100%) references screened focusing on: lower (192,98%) and upper (11,6%) limb; press-fit (95,48%) and screw-shape (49,25%) design; static (34,17%) and dynamic (17,9%) exercises, periprosthetic cortical thickness (9,5%) and bone mineral density (34,17%); and adverse events (103,53%). Three cohort studies focused on the design of apparatus, loading reliability and compliance.^[1-3] The ways to perform loading exercises are generally practical (e.g., low-tech bathroom scale) but partially efficient (e.g., reliance on pain). The monitoring of bone remodelling (e.g., musculoskeletal modelling, medical imaging, computational models) is efficient (e.g., comprehensive data) but impractical (e.g., resource intensive).

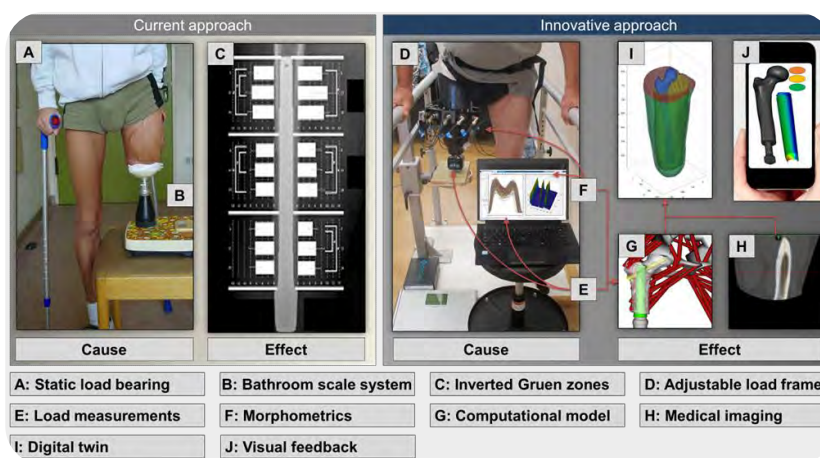


Figure 1. Rehabilitation care approaches for individuals fitted with BAP. A: Aschoff et al. J Bone Joint Surg Am, 2010. 92 Suppl 2: p. 180-6, C: Haket et al. J Orthop Res, 2017. 35(6): p. 1237-1241.

DISCUSSION AND CONCLUSION



Clearly, there are research opportunities to develop smart rehabilitation devices (Figure 1), integrating loading sensors and quantitative ultrasonography and computational modelling to establish the cause-to effect relationship between exercises rehabilitation and bone remodelling.^[1, 4] Innovative monitoring device can productively disrupt rehabilitation pathways and health service delivery of BAP, provided that all relevant technological parts can be integrated and deemed acceptable by clinicians.

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5.013 Prosthesis Prescription Consensus for Case Patients with Transfemoral Bone-Anchored Limbs

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BACKGROUND

Prosthesis osseointegration is an emerging surgical technique that provides direct femoral prosthesis attachment to create a bone-anchored limb (BAL). As the interfaces between the residual thigh and prosthesis differ between socket prostheses and BALs, prosthetic componentry needs also differ. However, there are no clinical practice guidelines (CPGs) for prosthetic component selection specific to transfemoral BALs due to insufficient scientific evidence. As clinical trials have yet to provide sufficient evidence to create CPGs, a first step to support clinicians is obtaining expert consensus.

AIM

We established international consensus amongst 18 worldwide experts for the prescription of prosthetic components for patients with transfemoral BALs.

METHOD

We conducted a three-round Delphi method to establish consensus amongst 18 experts on transfemoral BALs. During the first survey round, Delegates were presented descriptions of 18 case patients and asked to describe their recommended prosthesis prescriptions. From these responses, two evaluators synthesized 20 thematic statements regarding prosthesis prescription recommendations to provide case patients with the best possible prosthetic outcomes. Across two subsequent surveys, Delegates indicated their level of agreement with the thematic statements and their rationale. Consensus was defined as at least 80% Delegate agreement.

RESULTS

Over the course of the 3 surveys, 14 of the 20 thematic statements pertaining to prescription recommendations for case patient examples with transfemoral BALs achieved expert consensus. General recommendations for prosthetic prescription included (1) a microprocessor or hydraulic knee, (2) positional rotator (3) torque absorber, (4) carbon fiber or fiberglass foot with a split toe, and (5) the appropriate connector for the screw-fit or press-fit implant. There was also strong agreement that torsion absorption should be prioritized over shock absorption if build height is a limiting factor, and more general agreement that prescription recommendations should not differ based on sex, gender, age, contralateral amputation, or the use of a press-fit or a screw-fit osseointegrated implant.

DISCUSSION AND CONCLUSION

Most Delegate consensus aligns with current CPGs for transfemoral socket prostheses. However, some findings illuminate areas of uncertainty amongst experts, such as recommended changes for patients with lower activity levels or without local access to prosthetic care. Given increasing interest in BALs, this consensus is crucial to summarize the current state of expert opinion based on Delegates' extensive experience, providing a basis for developing clinical trials and clinical practice guidelines.

ACKNOWLEDGEMENTS

We thank the Steering Committee and Delegates for their time and expertise in establishing this broad and international consensus.



5.014 Prosthesis Prescription Consensus for Case Patients with Transtibial Bone-Anchored Limbs

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BACKGROUND

Prosthesis osseointegration is an emerging surgical technique that provides direct skeletal prosthesis attachment to create a bone-anchored limb (BAL). The interfaces between the residual limb and prosthesis differ between socket prostheses and BAL. However, there are no clinical practice guidelines (CPGs) for prosthetic component selection specific to transtibial BALs due to insufficient scientific evidence.

AIM

We established international consensus amongst 10 worldwide experts for the prescription of prosthetic components for patients with transtibial BALs.

METHOD

We conducted a three-round Delphi method to establish consensus amongst 10 experts on transtibial BALs. During the first survey round, Delegates were presented with descriptions of 17 case patients and asked to describe their recommended prosthesis prescriptions. From these responses, two evaluators synthesized 16 thematic statements regarding prosthesis prescription recommendations to provide case patients with the best possible prosthetic outcomes. Across two survey rounds, Delegates indicated their level of agreement with these thematic statements and their rationale. Consensus was defined as at least 80% Delegate agreement.

RESULTS

Over the course of the 3 survey rounds, 13 of the 16 thematic statements pertaining to prescription recommendations for case patients with transtibial BALs achieved expert consensus. General recommendations for prosthetic prescription included (1) a high-energy return carbon fiber or compliant carbon fiber/fiberglass foot with a split toe, (2) torque absorber, and (3) the appropriate safety connector for the osseointegrated implant. There was strong agreement that torsion absorption should be prioritized over shock absorption if build height is a limiting factor, and more general agreement that prescription recommendations should not differ based on sex, gender, age, access to local quality prosthetic care, or presence of osteoarthritis. Delegates were unable to reach consensus on some topics including prosthetic prescription for patients with bilateral amputation or lower activity levels.

DISCUSSION AND CONCLUSION

Despite the higher incidence of transtibial amputation, BALs are less common for transtibial than transfemoral amputation. Thus, fewer clinician-patient relationships exist to draw consensus from on BAL prosthesis prescription. Our findings show agreement on general recommendations for transtibial BAL prosthetic prescription, but also illuminate several areas of uncertainty amongst experts. Given increasing interest in BALs, this consensus both summarizes the current state of expert opinion based on Delegates' extensive experience and provides a basis for future clinical practice guidelines by identifying knowledge gaps for future research studies.

ACKNOWLEDGEMENTS

We thank the Steering Committee and Delegates for their time and expertise in establishing this broad and international consensus.



5.015 Patients' Preferences Heterogeneity for Bone-Anchored Protheses after Lower-Extremity Amputation; A latent class analysis of a discrete choice experiment

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BACKGROUND

Patients with lower limb amputations and socket-related issues elicited preference for bone-anchored protheses (BAPs) with osseointegrated implant (OI) ¹. To provide patient's and/or subgroup tailored care, that is heterogeneity, phenotypes of patients' preference subgroups need to be revealed. The relative importance of BAP-characteristics per subgroup by quality-of-life points (QOL), expected implant patency (IP), short- and long-term complications (STC and LTC), and out-of-pocket contribution (OOP) can be determined to reveal different patients' phenotypes.

AIM

This study determined number of hidden preference subgroups, the relative importances of BAP-characteristics of the subgroups, and, and preference difference based on background characteristic and BAP-characteristics.

METHOD

A discrete choice experiment was conducted to reveal preferences for BAP-characteristics on a sample of 247 patients from The Netherlands. The choice data were analyzed using a latent class logit model selected based on statistical (consistent Akaike information criterion), minimum class size (class share ≥ 0.20) and theoretical interpretability to unveil heterogeneity between hidden subgroups. Subgroups were characterized BAP treatment characteristics by relative weight for comparability between classes, and by patient background characteristics. Influence of background characteristics on preference were assessed by Bayesian logit models through interactions.

RESULTS

Three different subgroups with homogenous preference were statistically identified. Rescaled estimated show different preferences between the latent classes in magnitude and importance of BAP characteristics. All classes considered opting-out a crucial factor. Patients, in all classes, considered the opting-out option when an option with BAP-characteristics was not favorable. QOL was important for all classes. When opting for BAP, class 1 and 3 had the most balanced importance for all the attributes compared to class 2 (Figure 1). Class 2 cared the most about QOL. All classes had relative equal importance for IP. Class 3 cared the most for LTC. Similar to class 3, but relatively more pronounced, was class 1, which found OOPC important, but less than QOL.

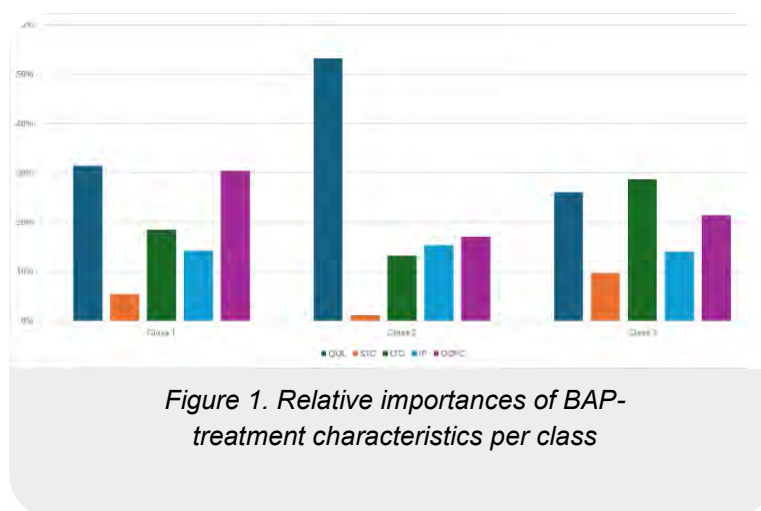


Figure 1. Relative importances of BAP-treatment characteristics per class

DISCUSSION AND CONCLUSION

This study has highlighted the heterogeneity in patient preference on what is important in BAP-care. Three distinct BAP-patients are identified. To accurately value BAP-care a variety of outcomes given the subgroup preference can be considered, both for patients with BAP and during information sessions for new patients by focusing on the phenotype allocation to provide subgroup tailored care.

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5.016 Analyzing research trends and developments in osseointegration in patients with extremity amputations; systematic bibliometric analysis and research recommendations

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BACKGROUND

Bone-anchored prostheses (BAP) by means of osseointegrated implants are increasingly being used in amputees with socket-related issues. Clinical advancements are being published by more and more centers worldwide. Although the number of publications and interest in BAP is growing, a systematic evaluation of scholarly output is lacking.

AIM

To identify scholarly output, understand research trends and make research recommendations in the clinical field of BAP.

METHOD

Systematic searches in Medline All, Embase, Web of Science Core Collection, Cochrane Library and Google Scholar were completed in February 2023. The results were deduplicated, screened, and assessed for quality by independent reviewers. Inclusion criteria were as follows: clinical studies; and BAP in the extremities. Articles were excluded if they were animal or fundamental studies; nonclinical reports; had a study population less than 10 patients or BAP was performed in areas other than extremities.

RESULTS

One hundred twelve articles were included and published between 1993 and 2023. An annual growth rate of 10.3% was found and research was published in 62 different journals. Prosthetics and Orthotics International, Clinical Orthopaedics and Related Research and The Bone & Joint Journal were the most prolific journals. *Hagberg K*, *Aschoff HH* and *Branemark R* were major contributors to BAP research. Collaborations are predominantly among high-income countries. Main research trends were on rehabilitation, questionnaires, complication managements and implant treatment (Figure 1).

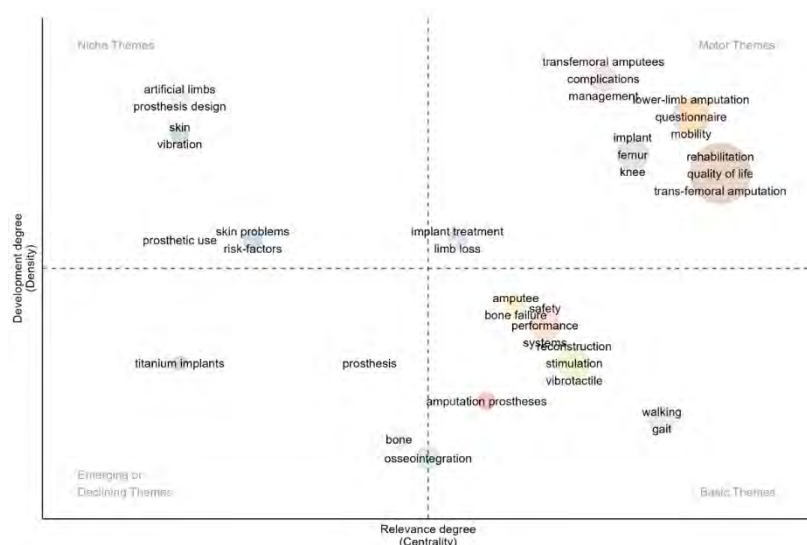


Figure 1. Themes in osseointegration research

DISCUSSION AND CONCLUSION

Research on BAP shows an increasing global trend, highlighting key research areas and authors. A unified global research agenda, stakeholders' collaborations and consensus is essential for addressing knowledge gaps and development future direction of BAP.



5.017 Patient Screening and Selection for Bone-Anchored Limb Implantation in Individuals with Transfemoral Amputation: Eligibility Criteria and Risk Factor Analysis

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BACKGROUND

Osseointegration of a bone-anchored limb (BAL) is an emerging rehabilitation technique offering significant advantages over traditional socket prostheses. Despite these benefits, the patient screening and selection process for BAL remains underdeveloped, with evidence-based guidelines still in their infancy.

AIM

This study aimed to describe eligibility criteria for BAL implantation by retrospectively evaluating anatomical, physiological, psychological, and lifestyle factors from BAL candidates. Specific objectives included comparing eligible, ineligible, and optimization-required groups, and identifying key factors influencing eligibility.

METHOD

From May 2019 to September 2024, eighty individuals with transfemoral amputations were evaluated as BAL candidates through a multidisciplinary screening approach considering anatomical, physiological, psychological, and lifestyle factors. Screening outcomes for eligible and ineligible candidates were compared to identify between-group differences, with significance set at $\alpha=0.05$. The most common causes of medical holds for optimizing modifiable risk factors were documented.

RESULTS

50 candidates were eligible for BAL implantation and 30 were ineligible. Ineligible candidates had higher body mass ($p=0.004$) and body mass index ($p=0.01$), thinner cortical bone thickness ($p=0.01$), greater pelvic asymmetries ($p=0.04$), and a greater number of lifestyle risk factors such as recreational drug use ($p=0.01$), nicotine use ($p=0.04$), higher alcohol dependency ($p=0.04$), unemployment ($p=0.02$), and cognitive impairment ($p=0.01$) than eligible candidates. Additional factors included lower vitamin D levels ($p=0.04$), elevated C-reactive protein ($p=0.02$), higher white blood cell counts ($p=0.03$), unemployment ($p=0.02$), retained hardware ($p=0.03$), skin ulcers/cellulitis ($p=0.0006$), depression ($p=0.006$), peripheral vascular disease ($p=0.001$), and osteoporosis ($p=0.02$). There were no between-group differences in age ($p=0.3$), residual bone length ($p=0.8$), intramedullary canal diameter ($p=0.1$), number of prior socket prostheses ($p=0.7$), daily wear hours ($p=0.6$), previous residual limb surgeries ($p=0.6$), or soft tissue contracture ($p=0.4$). The primary risk factors deemed to be modifiable by the clinical team included elevated BMI, abnormal laboratory findings, nicotine use, financial or insurance constraints, limited post-BAL care providers, active infection, uncontrolled diabetes ($HbA1c >7\%$), prosthetic component adjustments, ongoing corticosteroid therapy, substance use, conflicting personal or family commitments, and home safety considerations. Non-modifiable factors leading to ineligibility included age, skeletal immaturity, insufficient residual bone for implant anchoring, cognitive impairment, limited implant weight-bearing capacity, permanent medications affecting bone healing, and severe peripheral vascular disease.

DISCUSSION AND CONCLUSION

Our findings highlight the results of structured, patient selection for BAL, potentially informing future research for optimizing patient selection, optimizing outcomes and expanding candidate eligibility as BAL technology advances.

ACKNOWLEDGEMENTS

We acknowledge the clinicians, researchers, and support staff at the University of Colorado Bone-Anchored Limb Research Group



Free paper session | Prosthetics and Orthotics: upper limb – Components and rehabilitation

5.021 Developing a Finite Element Analysis Model of the Transradial Amputated Arm-Prosthesis Interface

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BACKGROUND

Upper-limb prosthetics research often addresses advanced hand componentry, but user-reported concerns remain around device weight, function, appearance, and most of all, comfort [1,2]. The lack of focus on comfort may reinforce decisions to not use a prosthesis, and a greater understanding of human-device interface biomechanics is needed. Upper-limb device interfaces have very different biomechanical requirements than lower-limb devices, and experience a wider range of activity loads, including greater priority for suspension while the user carries objects. Finite Element Analysis (FEA) may offer insights into these key biomechanical factors. FEA is established in lower-limb prosthesis research [3] but there is an almost complete absence of published FEA work addressing upper-limb prosthesis-human interfaces.

AIM

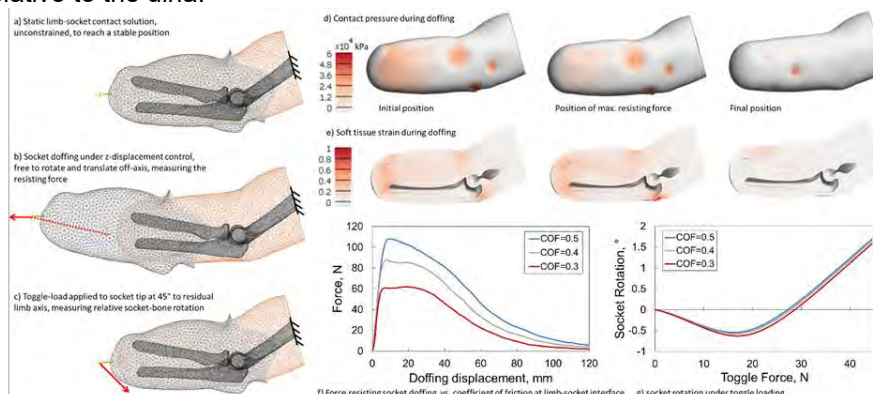
To develop a generic, parameterisable FE model of the transradial amputated arm and prosthesis, building upon a transtibial methodology [4].

METHOD

Soft tissue and bone surface meshes were extracted from published CT and MRI [5] of a 60-year-old male's arm, and virtually amputated. A parameterised socket was generated with overall (e.g. down-scaling) and local rectifications (e.g. supracondylar and olecranon bar). An FE mesh was generated in ANSYS and imported into open-source package FEBio 2.7.0. Linear elastic material properties were assigned to the bone and socket, and compressible neo-Hookean properties were assigned to collected soft tissues. Sliding contact with coefficients of friction (COF) from 0.3-0.5 was assigned at the soft tissue-socket interface. The humerus was fixed, and socket load cases represented i) donning, ii) distraction along the residual limb axis and iii) tip loading to generate an elbow flexion moment.

RESULTS

Simulations predicted residuum-socket conditions consistent with *in vivo* measurements [6]. Socket donning exerted device-limb interface pressures up to 60kPa. Distracting the socket generated suspension force exceeding 100N, indicating the ability to carry such weights with a relaxed, extended elbow, whilst also allowing doffing with the other hand. Increasing COF increased the force resisting socket doffing, but did not influence the coupling stiffness before the socket began to slide. Socket-bone coupling resisted socket tip loading, with 45N rotating the socket by $>2^\circ$, and $>1^\circ$ rotation relative to the ulna.





DISCUSSION AND CONCLUSION

This novel model reveals previously uncharacterised stress distributions at the prosthesis interface for a range of loading conditions, using generic open-access limb anatomy, a simplified socket design and the open-source FEBio platform. This may enable the community to expand their upper-limb prosthetic biomechanics activities and thus support the development of devices which better meet the biomechanical needs of people with upper-limb absence.

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ACKNOWLEDGEMENTS

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5.022 PROMISE: Post-market study of a multi-articulating prosthetic hand, a French national multicenter prospective study in upper limb amputees

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BACKGROUND

A multi-articulating prosthetic hand is reimbursed in France as a prosthetic compensation option for individuals with complete hand amputation. For continued reimbursement by the French healthcare system, additional clinical data demonstrating the device's performance and benefits were required.

AIM

The objective of this prospective multicenter study was to evaluate improvements in the activities of daily living, quality of life, and satisfaction of upper limb amputees fitted with a multi-articulating prosthetic hand compared to their previous single-degree-of-freedom (DOF) prosthetic hand.

METHOD

Persons (18 years+) with unilateral hand amputation who had previously used a single-DOF prosthetic hand, and were indicated for a trial of a multi-articulating hand prosthesis, participated in the before-and-after observational study, approved by a national ethics committee (CPP Sud-Est V N° 18.11.13.96253, 2019). Assessments were carried out with the single-DOF prosthetic hand and with the multi-articulating prosthetic hand at the end of the trial period (~4 weeks), and 8 and 10 weeks after receiving the definitive prosthesis.

The primary outcome was function assessed by the upper limb function component of the Orthotics and Prosthetics Users Survey (OPUS) [1-2]. Secondary outcomes were assessed by the QUICK DASH [3], by the quality of life component of the OPUS [1-2], by the satisfaction component of the OPUS [1-2], and by a numerical scale (0-10). Within-subject comparisons were made using statistical analysis by a t-test or a Wilcoxon test for paired series (p=0.05). Device deficiency incidents were recorded.

RESULTS

Twenty-five upper limb amputees started the multi-articulating hand trials and 22 chose to receive a definitive multi-articulating prosthesis (19 men / 3 women, mean age of 40.8 +/- 16.8 years, 77.3% traumatic etiology, mean time to amputation = 6.5 +/- 11.4 years). Eighteen (18) patients completed the study with full datasets for analysis.

The OPUS function component score significantly increased with the multi-articulating prosthesis hand (+6.2 +/- 10.8 pts, p= 0.01). Significant increases in quality of life (OPUS, p=0.02), upper limb function (Quick DASH, p=0.002), and overall satisfaction (numerical scale, p= 0.0002) were found with the multi-articulating prosthesis hand compared to the single-DOF hand. Device deficiency incidents (n=11, 36.4% (8/22) of patients) were resolved by manufacturer support.

DISCUSSION AND CONCLUSION

This study demonstrates improved function, quality of life, and overall satisfaction in patients using the multi-articulating hand prosthesis despite hand dysfunctions by the resolving manufacturer support compared to their previous single-DOF myoelectric hand. Further studies are needed to assess improvement over a longer period of follow-up.



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ACKNOWLEDGEMENTS

The study was sponsored by Össur Iceland EHF. Additional 10 more authors, but the form only allows 10.



5.023 Influence of Powered Wrist Flexion on Transradial Prosthetic Users Completing the Gaze and Movement Assessment (GaMA) Cup Transfer Task

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BACKGROUND

Previous work has highlighted the importance of wrist dexterity.^[1] However, many functional assessments only evaluate time. The Gaze and Movement Assessment (GaMA) metric evaluates kinematics and timing during the Cup Transfer Task and Pasta Box Task. Tasks are short to allow multiple repetitions and require transporting objects at varying heights across the body.^[2,3]

AIM

We developed a 2-DOF wrist with a single-DOF hand to improve function. We hypothesized that using wrist flexion/extension will slow task time but reduce compensatory trunk and shoulder movements (GaMA metric).

METHOD

Five individuals with transradial limb loss and myoelectric experience were trained with a pattern recognition-controlled custom wrist (rotation and flexion) and a single-DOF hand.^[4] Participants completed two conditions: wrist flexion disabled (noWF) and enabled (WF). Each condition included functional assessments, a home trial (when possible), and GaMA tasks.

For the Cup Transfer task, users grasped cups from the top and side, moving them across a divider. Data compared included movement timing and joint kinematics between conditions and to normative values from individuals without amputation. Statistical analysis has not been performed, conclusions are made on observed trends in the metrics. This study was IRB²/REB³ approved, and participants consented.

RESULTS

Analysis has been completed for four of the participants who have completed the study.

Overall, participants took longer to complete the task in both conditions compared to normative values. Three of four took longer with WF than noWF. Participants utilized WF to pick up the cup closest to the front of the box by the top. For both conditions, participants utilized wrist rotation to assist with prepositioning. Early analysis indicates that there are compensatory shoulder and trunk movements seen for both conditions compared to normative, especially in trunk lateral bend. However, it was hypothesized that there would be reduction in these movements with WF compared to noWF. Improvements are seen with the addition of WF, but the impact on specific movements is less consistent across participants.



Figure 1. Cup Transfer Task



DISCUSSION AND CONCLUSION

As hypothesized, with WF, most participants took longer to complete the task. Compensatory movements are notable with both conditions, especially with trunk lateral bend. However, there are differences in the impact of WF on the shoulder and kinematics between users. Continued analysis of individual task execution strategies will be essential to deepen our understanding of the unique approaches that participants use.

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ACKNOWLEDGEMENTS

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5.024 Can we foresee the pattern of the device usage according to the color choice of the patient

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BACKGROUND

The design of a prosthesis is proven to impact its usage ^[1]. However, it remains unclear whether it is more beneficial to create a prosthesis that resembles a natural hand or to offer a more colorful, customized design ^[2].

AIM

This study aims to evaluate the effect of prosthesis design on the patterns of device usage.

METHOD

A retrospective analysis of data regarding the frequency and duration of prosthesis usage over a 10-month period following prosthetic fitting. The patients were divided into two groups: Group 1 (N=256), who chose active upper limb prostheses that matched skin color, and Group 2 (N=443), who selected colorful prostheses based on their individual preferences.

RESULTS

In Group 1, 57% of patients wore the device daily or several times per week, whereas in Group 2, 62% did. Conversely, 41% of patients in Group 1 chose not to wear the device at all, while only 26% in Group 2 avoided using their prosthesis. Among the prosthesis users in both groups, the duration of device usage showed no statistically significant difference.

DISCUSSION AND CONCLUSION

Based on the data obtained, the choice of a colorful design for the upper limb prosthesis appears to lead to a more consistent pattern of device usage. Patients with colorful prostheses tend to wear the device more frequently and are less likely to avoid using it. However, the design of the prosthesis does not seem to have an impact on the duration of daily use.

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5.025 3D Printing for Manufacturing Upper Limb Prostheses: An International Online Survey

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BACKGROUND

3D printing (3DP) technology is increasingly employed to manufacture upper limb prostheses (ULP) by qualified professionals and volunteers from the private sector and non-governmental organizations (NGOs).^{1,2} However, they each follow various 3DP manufacturing protocols.^{1,2} Indeed, no established guidelines currently exist to guide clinical teams for an optimal implementation and usage of 3DP in their manufacturing workflows of ULP.² Therefore, exploratory studies are required to investigate current practices and expertise to further establish recommendations.

AIM

The aim of this exploratory pilot study was multiple. Firstly, to describe the sociodemographic and professional profiles of qualified professionals (e.g. prosthetists, engineers) and volunteers who employ 3DP to manufacture ULP. Secondly, to investigate their technical and clinical expertise.

METHOD

An international online survey was developed and distributed, using non-probability sampling methods, through Social Media platforms, professional associations and individual contacts. The questionnaire was available in French, English and Spanish and comprised both sociodemographic and technical questions (e.g. 3DP technology, 3DP material, devices componentry, follow-up, etc.). Participation was voluntary and anonymous. Data were analyzed using descriptive statistics.

RESULTS

111 participants from 27 countries enrolled in the study, with a completion rate of 55%. Most participants were male (72; 65%) working in healthcare and technical services (e.g. engineers) (65;59%). 32 (29%) prosthetists participated, and other participants were mainly qualified professionals and volunteers volunteering for NGOs. Most respondents had less than 5 years of experience manufacturing ULP with 3DP. The most used 3DP processes were Fused Deposition Modelling and Powder Bed fusion, which were mainly employed to manufacture either 3D-printed sockets or entire functional ULP. Main prostheses' fragile parts were 3D-printed fingers and joints, and actuation cables. Natural material deterioration and heavy load were reportedly the main causes of ULP failures. Respondents pointed durability, weight and socket fitting as improvement priorities. However, customization of prosthetic designs to fit users' anatomy was marked as difficult stage by participants. Collaboration between stakeholders and follow-ups of recipients were common practice to ensure the quality of prostheses and care.

DISCUSSION AND CONCLUSION

Qualified professionals and volunteers possess non-negligible experience with 3DP applied to ULP manufacturing which this pilot study strived to investigate and underscore. Although 3D Printing brings possibilities, technological improvements are still necessary. Moreover, guidelines are required to support manufacturers and clinicians in their clinical implementation of this technology. Larger similar studies are mandatory to further investigate current practices and facilitate the development of good practice recommendations.

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5.026 Ethnographic Exploration of the Role of Insurance in Prosthetic Device Choice Among American Civilians

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BACKGROUND

In the U.S., access to prosthetics depends on the type of insurance: state-provided insurance/Medicare, private insurance, or Workers' Compensation. Non-veteran insurance providers vary in the frequency and types of devices they approve (Etter et al. 2015). This variability is compounded by some states' "one prosthesis per limb, per lifetime" rule (Amputee Coalition 2015).

AIM

This ethnographic study examines how class and insurance privilege affect prosthesis users' desire for high-tech devices.

METHOD

For my PhD dissertation in Cultural Anthropology, I developed an interview guide with my PIs at the US Armed Forces Institute and FDA. In 2017, I conducted semi-structured ethnographic interviews (2–6 hours) with eleven individuals over 18, with upper-extremity limb loss or difference, who were not injured while serving in the military. Participants were recruited via targeted mail and snowball sampling. Interviews, recorded and transcribed, were analyzed thematically using Daniel Linger's ethnographic principles (2002), focusing on individual responses to and negotiations of situations.

RESULTS

Two participants worked in the prosthetics industry and had unrestricted access to new high-tech devices. One individual, covered by Workers' Compensation, also had easy access to updated prostheses. Two amputees on Medicare/public insurance were limited by the "one prosthesis per limb, per lifetime" rule. Six participants with private insurance were provided prostheses based on coverage and individual payment ability.

DISCUSSION AND CONCLUSION

This presentation explores how insurance companies' presumed approval or rejection of devices shapes prosthesis users' relationships with current devices and their expectations for future ones. By analyzing the role of class and insurance in shaping desires for new high-tech devices, this qualitative data has implications for clinicians, device developers, and policymakers, as understanding amputees' psychological engagement with device access is crucial for their acceptance or rejection of prosthetics.

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Free paper session | Health care, policy, sustainability – Assistive devices, policies and frameworks

5.031 Exploring Competencies for Mobility Assistive Product Provision

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BACKGROUND

Globally, 2.5 billion people require assistive products to improve their independence, participation, and quality of life ^[1]. A significant proportion of the need relates to assistive products for mobility ^[1,3]. As global demand for mobility assistive products rises, there is an increasing need to ensure that professionals, including prosthetic and orthotic professionals possess the necessary competencies to deliver safe and effective services ^[1, 2, 3]. However, the competencies required for mobility assistive product provision are not uniformly defined across education programs and professional frameworks, creating gaps in training and service quality ^[4].

AIM

This study aimed to undertake a global environmental scan of competencies for mobility assistive product provision and compare identified resources with the WHO Rehabilitation Competency Framework (WHO-RCF) [2].

METHOD

The environmental scan consisted of two steps: an internet search to identify global standards documents in the area of mobility assistive products (Step 1) and a consultation with global professional bodies for further information (Step 2). Resources were compared to the WHO-RCF to identify gaps and inconsistencies.

RESULTS

Fourteen global resources outlining competencies for mobility assistive products were identified, from a variety of professions. There were significant differences in the required education levels, competency domains, and curriculum content. While key service steps such as assessment, fitting, and follow-up were common across resources, important competencies like clinical reasoning, cultural competence, and person-centered care were inconsistently integrated.

DISCUSSION AND CONCLUSION

This environmental scan identified several global resources relating to competencies for mobility assistive products. Resources were both profession-specific and multidisciplinary and included education standards, training resources, service guides, and frameworks. Understanding the core competencies required to provide mobility assistive products is crucial to improving the training and practice of professionals who provide them, including prosthetist/orthotists.

This presentation will outline recommendations for next steps to define these competencies such that they can be embedded into education programs, with a focus on harmonizing global standards and preparing future professionals to meet the growing demand for mobility assistive products.

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5.032 Health and economic burden of disability in Bangladesh: Insights from the national perspective

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BACKGROUND

Disability poses a substantial global challenge, significantly affecting social participation and economic productivity. This issue is particularly pronounced in low- and middle-income countries (LMICs) like Bangladesh. Despite the high prevalence of disability within the population, national-level insights into the health and economic burden of disability in Bangladesh are scarce, leading to the unknown need and hindering efforts to improve prosthetics, orthotics, and other rehabilitation services.

AIM

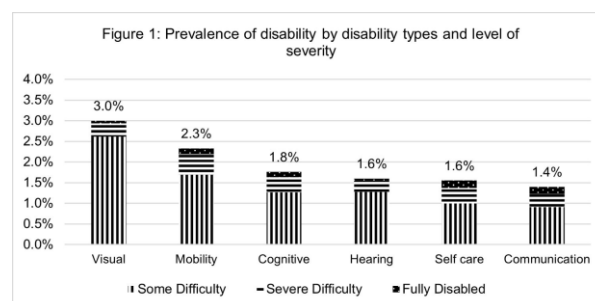
This study aims to estimate the health and economic burden of disability in Bangladesh, highlighting disability prevalence, types, severity, excess healthcare costs, and the incidence of Catastrophic Health Expenditure (CHE).

METHOD

This study analysed nationally representative cross-sectional data from the 2022 Household Income and Expenditure Survey (HIES) of Bangladesh. Disabilities were assessed by identifying difficulties related to vision, hearing, mobility, cognition, self-care, and communication among 62,407 participants from 14,400 households. Disability status was determined through self-reported assessments using the Washington Group's Short Set of Questions, whereas the incidence of catastrophic health expenditure (CHE) was defined as households' healthcare costs exceeding 40% of their non-food expenditure.

RESULTS

National disability prevalence was estimated at 5.7% (CI: 5.48-5.85), with 4.19% reporting "some difficulty", 1.36% "severe difficulty", and 0.16% being "fully disabled". The most common disability prevalence was recorded for visual (3.0%), and the lowest prevalence was found for communication (1.4%) (figure 1). Multiple disabilities were present in 2.26% of the population, with visual and hearing impairments frequently co-occurring (1.16%).



Notably, disability prevalence was higher among the elderly, rural residents, females, lower income groups, and among those suffering from chronic illness, underscoring the presence of inequities. Households with disabled members reported higher healthcare expenditures compared to those without (37% vs. 27% of non-food expenditures) and experienced a higher incidence of CHE (15% vs. 9.6%). The primary coping strategy differed by income level: low-income households mainly relied on donations (42.7%), while higher-income households primarily used their savings (43.1%).

DISCUSSION AND CONCLUSION

Despite improvements over time, the disability burden in Bangladesh remains higher than in many other LMICs. High rates of visual, mobility, cognitive, and hearing disabilities underscore the need for assistive technology (ATs) and rehabilitation services, including the introduction of prosthetic and orthotic services prioritising vulnerable groups within the country. The financial strain on affected households calls for expanding social safety nets and subsidies for ATs to reduce healthcare disparities.

ACKNOWLEDGEMENTS

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5.033 Estimating the Global Workforce Needed for Providing Orthoses and Prostheses: A Modelling Study

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BACKGROUND

Despite being a fundamental human right to lead a dignified, independent and productive life, access to assistive products varies between 3% and 90% globally ^[1]. Barriers for access include policy failures, high costs, limited availability, inadequate support, insufficient services, and workforce shortage ^[1]. Consequently, a vital prerequisite for improving access to orthoses and prostheses is to ensure that adequate and trained human resources for the provision are available ^[2]. However, studies estimating the size of such a workforce are missing.

AIM

This study aims to estimate the global need for a workforce for the provision of orthoses and prostheses to achieve a high level of access.

METHOD

This modelling study uses cross-sectional data on the workforce in full-time equivalents (FTEs) within orthotics and prosthetics and the number of persons in need of orthoses and prostheses from Sweden, a country with a high level of access. Together with estimated global needs for orthoses and prostheses based on WHO rATA data, the required global workforce for providing these products will be estimated and subjected to a sensitivity analysis.

RESULTS

Preliminary results indicate that the total global workforce required for providing orthoses and prostheses at a high level of access corresponds to about 1.1 million FTEs (approximately 140 FTEs per million persons). Of this total workforce, the clinical and technical workforce constitutes about 0.9 million FTEs (approximately 110 FTEs per million persons). The final results from the modelling and sensitivity analysis will be presented at the ISPO Congress 2025.

DISCUSSION AND CONCLUSION

This study is an attempt to quantify the global workforce required for providing orthoses and prostheses based on the situation in a country with high level of access. The results indicate a higher workforce need than proposed in the WHO Standards for prosthetics and orthotics [3]. The findings from this study can be used to inform the planning and development of an adequate and trained workforce as well as policymaking globally.

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5.034 Exploring Orthotists' Perspectives on Facilitators and Barriers to Spinal Orthotic Treatment for Adolescent Idiopathic Scoliosis: A Qualitative Study in Thailand

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BACKGROUND

Adolescent Idiopathic Scoliosis (AIS) is a prevalent musculoskeletal disorder among Thai adolescents ^[1], with orthotic treatment crucial for managing curve progression non-surgically ^[2]. However, access to spinal orthotic care is predominantly restricted to secondary and tertiary hospitals, limiting availability in rural areas. Identifying facilitators and barriers to treatment is essential for optimizing care delivery, promoting innovation, and ensuring equitable access to sustainable rehabilitation across the country.

AIM

To explore **Thai orthotists' perspectives** on facilitators and barriers in spinal orthotic treatment for AIS, to improve treatment outcomes, enhance patient compliance, and identify factors contributing to treatment success.

METHOD

This qualitative study investigated Thai orthotists' perspectives on scoliosis orthotic treatment. Experienced orthotists from hospitals of varying sizes and geographic locations were recruited using purposive sampling to ensure maximum variation. Semi-structured, one-on-one in-depth interviews were conducted in Thai until data saturation was reached. Informed consent and demographic information were collected before the interviews. All interviews were audio-recorded, transcribed verbatim, translated into English, and supplemented with field notes. Data were analyzed using thematic analysis (Braun and Clarke, 2006) ^[3], with findings categorized according to the Social Ecological Model (SEM) ^[4]. Validity was ensured through triangulation, member checking, and participant verification.

RESULTS

Factors influencing scoliosis treatment with spinal orthoses were categorized according to the Social Ecological Model (SEM) ^[4], encompassing five levels: **(i) intrapersonal, (ii) interpersonal, (iii) institutional, (iv) community, and (v) policy**. Barriers identified included insufficient space for patient privacy at the institutional level, limited interdisciplinary coordination at the interpersonal level, a lack of advanced technology and device functionality at both the institutional and policy levels, and inconsistent availability of X-ray services. Facilitators included patient education that emphasized the importance of consistent brace use at the intrapersonal level and customization of devices to individual needs at the institutional level. These findings emphasize the critical need for enhanced interdisciplinary collaboration, comprehensive patient education, and the integration of advanced technologies across multiple levels to optimize the effectiveness and accessibility of scoliosis treatment.

DISCUSSION AND CONCLUSION

This study identified key factors affecting scoliosis orthotic treatment, including limited collaboration and insufficient technological advancements. Consistent with previous studies ^[5], barriers such as discomfort from brace design and passive patient engagement were highlighted. These findings highlight the need for better interdisciplinary cooperation, resources, and patient education. Addressing these challenges could improve treatment outcomes and long-term rehabilitation, with future research focusing on clinical practice and technological advancements.

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ACKNOWLEDGEMENTS

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5.035 Finding the Right Fit: Virtual, Onsite, and Hybrid Accreditation Visits Compared

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BACKGROUND

In response to pandemic challenges, ISPO accreditations transitioned to a fully virtual format, offering cost savings but also new challenges. While on-site visits have advantages, logistical constraints may necessitate virtual or hybrid options. To ensure effective site visits-regardless of type, it's vital to implement strategies that facilitate objective and accurate assessments of schools against ISPO education standards, supporting informed accreditation decision-making.

AIM

This research aims to assess on-site, virtual, and hybrid site visits for ISPO accreditations, utilizing empirical data and feedback to identify effective strategies for objective school assessments and improved accreditation decision-making.

METHOD

This study utilizes auditor experience and survey data from ISPO auditors and schools to highlight effective strategies and potential challenges in conducting different types of site visits. Presenters will clarify successful methodologies and identify areas for improvement based on auditor insights and feedback.

RESULTS

The feedback collected highlights the complexities and nuanced nature of the decision for the best type of site visit between in-person, hybrid and virtual site visits, emphasizing the importance of leveraging auditor experience and strategies specific to the three different types of auditor site visits. By synthesizing insights from virtual, on-site, and hybrid engagements, auditors can navigate future site visits with greater proficiency and adaptability.

DISCUSSION AND CONCLUSION

As the debate over the best mode for site visits continues, insights from on-site, virtual, and hybrid audits provide crucial guidance for the ISPO education committee. These insights help identify the most feasible site visit format given the current context and inform strategies for conducting meaningful assessments. This, in turn, supports informed decision-making regarding accreditation by ensuring that the chosen approach effectively evaluates the schools' adherence to education standards.



5.036 Advocating for Global Recognition of Prosthetics and Orthotics Professionals in ISCO: Ensuring Alignment by 2028 for Sustainable Growth

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BACKGROUND

Despite the global significance of prosthetics/orthotics, key policies like the ISCO document only recognize prosthetic technicians, leading to inadequate recognition and resources, especially in low-income countries. This prompts some to leave the field. To address, ISPO is collaborating with the ILO to update the ISCO document by 2028, aiming to recognize the prosthetist/orthotist, associate and technician levels based on demonstrated sustainable growth, as highlighted by the 2024 ISPO workforce study.

AIM

To advocate for the recognition of all prosthetics and orthotics professionals in the ISCO document by 2028, ensuring proper occupational alignment for the prosthetist/orthotist, associate and technician's levels.

METHOD

For six years, ISPO has provided the International Labor Organization (ILO) with documented evidence on the prosthetics and orthotics profession. Recently, ISPO identified the need for an updated workforce study to highlight growth since 2017. This data will assist the ILO in making informed decisions about aligning prosthetics and orthotics occupations in the International Standard Classification of Occupations (ISCO) document. A survey was distributed to stakeholders in the ISPO database to collect this information.

RESULTS

The workforce survey was distributed to 1,100 ISPO members, yielding 685 responses and a 62% response rate. Among these, 291 respondents confirmed their ability to address workforce-related queries, with 40% representing national member societies. Since 2017, there has been a notable global increase in prosthetic and orthotic professionals across three levels: Prosthetists/Orthotists, Associate Prosthetists/Orthotists, and Technicians. This sector has seen a remarkable 58% growth (see table 1), with a projected additional increase of 34% over the next five years. Moreover, 96% of the 82 surveyed countries now recognize "Prosthetists/Orthotists" and "Prosthetic/Orthotic Technician." Notably, the term "Associate Prosthetist/Orthotist," previously unrecognized in our 2017 survey, is now acknowledged in 63% of countries, indicating significant progress in seven years.

Table 1: Comparison of Global Survey Results 2017 vs 2024

ISPO Survey	Prosthetists/ Orthotists	Associate Prosthetists/ Orthotists	Prosthetic/ Orthotic Technician	Total
2024	52,240	27879	31,884	112,003
2017	35,785	No results	13,730	47,474

DISCUSSION AND CONCLUSION

The 2024 ISPO survey findings indicate substantial growth and evolution in the global prosthetic and orthotic profession. With a 58% increase in the workforce since 2017, the demand for these services is clear. Moreover, the broad acceptance of standardized occupational terminology demonstrates the profession's commitment to aligning with international standards set by ISPO and WHO, highlighting the need for realignment of the prosthetics and orthotics occupation in the ISCO document.

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ACKNOWLEDGEMENTS

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5.037 Healthcare Professionals' Perspectives on Facilitators and Barriers to Adolescent Idiopathic Scoliosis Orthotic Treatment: A Qualitative Study in Thailand's Tertiary Hospital

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BACKGROUND

Multidisciplinary healthcare professionals are essential to delivering orthotic treatment for adolescent idiopathic scoliosis (AIS), a complex condition that benefits from a coordinated, patient-centered approach ^[1]. Understanding their perspectives on the facilitators and barriers in treatment delivery is essential for identifying challenges and promoting sustainable rehabilitation practices. However, limited research examines these factors across diverse healthcare roles, restricting insight into collaborative care dynamics crucial for effective, long-term management of AIS.

AIM

This study aims to identify facilitators and barriers in AIS orthotic treatment, enhancing interdisciplinary collaboration, optimizing protocols, and promoting sustainable, patient-centered outcomes from healthcare professionals' perspectives at Siriraj Hospital, Thailand.

METHOD

This qualitative study purposively sampled 10 healthcare professionals (three rehabilitation physicians, three orthopedic surgeons, three orthotists, and one physical therapist) from Siriraj Hospital, Thailand's leading tertiary care center, each with over two years of experience in AIS management. Informed consent was obtained, and demographic data were collected. Semi-structured, face-to-face, in-depth interviews were conducted in Thai until data saturation, audio-recorded, transcribed verbatim, and supplemented with field notes. Transcripts were translated into English for analysis using Braun and Clarke's (2006) thematic analysis ^[2], organized by the Social Ecological Model (SEM) ^[3]. Validity was ensured through triangulation, member checking, and participant verification.

RESULTS

Themes analysis at each SEM level identified facilitators and barriers

- (I) **Intrapersonal**: Providers' motivation, knowledge, and skill development enhanced care; however, limited patient health literacy, motivation, and financial constraints hindered treatment adherence.
- (II) **Interpersonal**: Team support, positive patient-provider relationships, and effective communication facilitated care, but conflicts and lack of multidisciplinary collaboration were barriers.
- (III) **Institutional**: Access to resources and patient-centered care models supported service delivery, while limited funding for advanced tools, lack of supportive workplace policies, device-related challenges, and delays in care-affected outcomes.
- (IV) **Community**: Community supports, like local initiatives and school screenings, aided early intervention, but transportation issues and limited local resources impacted adherence.
- (V) **Policy**: National supportive policies, and expanded insurance improved access, but restrictive coverage and lack of standardized guidelines limited care effectiveness.

DISCUSSION AND CONCLUSION

This study identifies facilitators and barriers across SEM levels, aligning with similar interdisciplinary challenges in healthcare, such as in dementia care ^[4]. Findings emphasize that collaboration, effective communication, and resource availability are critical for sustainable AIS treatment. To address issues such as financial/resource limitations and protocol inconsistencies, future research should explore targeted interventions, while policy changes supporting standardized protocols and resource allocation are essential to improve long-term AIS outcomes.

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ACKNOWLEDGEMENTS

This study was supported by the Faculty of Medicine Siriraj Hospital, Mahidol University, Grant No. R016732019, Thailand.



Free paper session | Therapy, physical activity, sports – Therapeutic approaches

5.041 Patient Education in Healthcare: Exploring Strategies for Effective Comprehension, Recall, and Compliance

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BACKGROUND

In orthotics and prosthetics, we create devices to assist people in their day to day lives. However, effectiveness of treatment is limited if patients cannot properly utilize their devices. While patient education is an essential part of orthotics and prosthetics treatment, there are currently no standardized methods of providing education to these patients. Current methods of educating patients include verbal instructions, written materials, visual aids, online resources, videos, or a combination of techniques.

AIM

This literature review looked at the most effective current methods of educating patients in terms of comprehension, recall, and compliance.

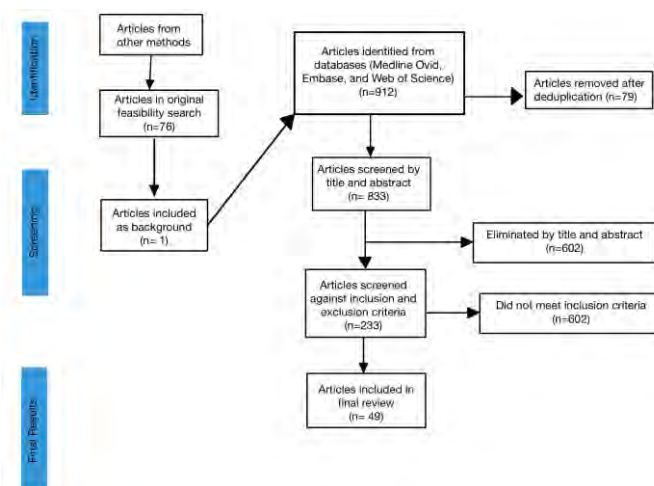
METHOD

Inclusion and exclusion criteria for articles were determined. Search strategy was developed using keywords, MeSH terms, and Boolean operators and applied to three online databases (Medline Ovid, Embase, and Web of Science). The final strategy was subsequently translated to the other databases to ensure validity of the search.

RESULTS

After searching on Medline Ovid, Embase, and Web of Science, 833 articles were found after deduplication, with 49 articles included in the final review. Of the 49 articles selected, four articles were found relating to comprehension, five articles were related to recall or self-management, 33 were related to compliance, and seven had mixed themes.

A total of 3.8% (n = 2) of articles were related to written instructions, 7.7% (n = 4) of articles were related to verbal instructions, 7.5% (n = 4) of articles were related to audio-visual, 22.6% (n = 12) of articles were related to group sessions, 9.6% (n = 5) of articles were related to app/online instructions, 40.4% (n = 21) were related to multimodal interventions, and 7.5% (n = 4) articles were related to other methods.





DISCUSSION AND CONCLUSION

The review found that delivering the education in terms of behavioral advice, like using cognitive behavioral therapy techniques and improving self-efficacy, and multimodal methods were the most effective in improving compliance. Additionally, structured education sessions and multimodal interventions (written, verbal, and visual) can assist in comprehension, recall, and compliance. Patients' preference of education delivery, mood, attitude toward their condition, and relationship with their provider also need to be considered.

The challenge for implementing these findings will be developing standard processes, training clinicians, and finding time to apply them during patient appointments. Further research needs to be done on effective methods of delivering patient education specifically related to orthotic and prosthetic interventions.

ACKNOWLEDGEMENTS

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5.042 Transtibial amputees' perspective on information and shared decision-making

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BACKGROUND

Lower extremity amputees desire to take an active part in decision-making. A new care program for transtibial amputees were developed by an interprofessional team and implemented at large acute hospital in 2017. The care program featured new pre- and postoperative education, recommendations for the sagittal surgical technique, a rigid removable dressing, early liner treatment, and interdisciplinary team follow-up three weeks after the amputation.

AIM

The primary aim was to explore patient's experiences of the care trajectory and the information provided following the introduction of a new care program. The secondary aim was to explore patients' perceptions of their involvement in the care process.

METHOD

In this qualitative study, using content analysis was used to explore the patient's perception of a new standardized surgical technique and care program for transtibial amputees.

Fifteen participants with a previous transtibial amputation were included and interviewed two to three months post-surgery. A semi-structured interview guide, developed by the authors, was used and all interviews started with an open-ended question. Purposeful sampling was used, to catch a wide variety of experiences and opinions.

RESULTS

We identified three themes: (1) The mixed experience of becoming an amputee; (2) The need to be seen during the amputation process; and (3) The importance of being involved in care. Participants wanted to take a more active role in the decision-making process, and our interdisciplinary team visit was an excellent example of shared decision-making (SDM). The printed information was appreciated, but the most crucial aspect was the oral communication, given the gravity of the subject. Participants experienced a lack of continuity throughout the trajectory of care.

DISCUSSION AND CONCLUSION

In summary, participants undergoing transtibial amputation expressed a strong desire for more active involvement in decision-making and highlighted a lack of continuity in their care. Individualized oral information and interaction with dedicated healthcare professionals are essential.

An interprofessional team consultation prior to the amputation decision, accompanied by a contact nurse can improve SDM and continuity of care. This approach may substantially improve the overall quality of patient care.

ACKNOWLEDGEMENTS

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5.043 A Multi-Level Meta Analysis of Therapeutic Treatment Programs for People with a Lower Limb Amputation

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BACKGROUND

Lower limb amputation (LLA) compromises key functional areas such as gait, balance, functional mobility, increased falls risk and fear of falling ^(1,2). Training interventions have been developed to improve mobility and balance confidence, broadly classified into prosthetic (e.g. microprocessor knees, energy storing feet) and therapeutic (e.g. exercise, virtual reality). Despite the range of treatment, previous reviews ^(3,4) have not clearly differentiated the effects of specific treatment types, limiting clinicians' ability to make informed decisions to improve these key functional outcomes.

AIM

To determine the effectiveness of different treatments designed to improve gait, balance, functional mobility, falls incidence, and fear of falling in people with LLA.

METHOD

A systematic review was conducted across 6 databases. Inclusion criteria encompassed therapeutic treatment of the identified outcomes. A multi-level meta-analysis accounted for correlations between multiple effect sizes from the same study, allowing for a more comprehensive evaluation both within and between studies. This approach is appropriate when studies report multiple outcome measures assessing the same underlying construct (e.g., gait), leading to correlated effect sizes within studies. Subgroup analysis determined differences in treatment type effectiveness. Effect sizes were calculated as standardized mean differences (SMDs) using Hedges' g, which corrects for small sample bias. SMDs can be interpreted using Cohen's benchmarks (small = 0.2, moderate = 0.5, and large = 0.8 effects).

RESULTS

Of 4,220 articles, 16 were analyzed. Treatments included proprioceptive neuromuscular facilitation (PNF, n = 2), exercise (n = 8), computerized balance training (CBT, n = 1), cognitive training (n = 3), and virtual reality (n = 4). Most studies were randomized controlled trials (n = 15), with sample sizes from 5 to 154 participants (73% male overall).

Collectively, treatments moderately improved gait (SMD = 0.54) and balance (SMD = 0.47), and had small to moderate improvements in functional mobility (SMD = 0.30) and fear of falling (SMD = 0.27). Table 1 characterizes treatment effects.

*Table 1: *indicates statistically significant association*

	Gait (SMD)	Balance (SMD)	Functional Mobility (SMD)	Fear of Falling (SMD)
Virtual reality	0.32	0.85*	0.08	0.39
PNF	0.82	NA	1.16	NA
Exercise	0.40	0.38	0.32	-0.08
Cognitive training	1.66*	0.30	NA	NA
CBT	-1.02	0.34	0.35	NA

DISCUSSION AND CONCLUSION

Cognitive training and virtual reality statistically significantly improved gait and balance respectively. Despite these promising results, further research is needed to align statistical improvements with meaningful patient benefits. Understanding the factors that modulate intervention effectiveness will be crucial for developing optimized rehabilitation protocols tailored to individual needs.

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5.044 EXOPULSE MOLLII SUIT – a new multi-site transcutaneous electrical stimulation device : technical aspect, mechanisms of action and effects on fibromyalgia

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BACKGROUND

Fibromyalgia is a multifaceted and complex illness characterized by chronic and widespread pain in the musculoskeletal system, pressure sensitivity, and a low threshold for painful stimuli. In addition to pain, patients may have fatigue, sleep disturbance, physical, emotional, and cognitive symptoms, as well as a reduced quality of life. Fibromyalgia is third among the most common musculoskeletal conditions, making its management a public health problem. The present approved pharmaceutical treatments for fibromyalgia are frequently insufficient, they often end up being unsatisfying with partial beneficial outcomes and many side effects. Thus, alternative therapeutic strategies are highly needed in this context.

AIM

This trial evaluated the effects of a multisite transcutaneous electrical nerve stimulation device, the EXOPULSE Mollii Suit, on fibromyalgia pain, fatigue, emotional symptoms, disease impact, and quality of life.

METHOD

Adults with a confirmed diagnosis of fibromyalgia were enrolled. This trial consisted of two phases. Phase 1 implied a randomized, sham-controlled, cross-over, double-blind experiment with daily one-hour sessions of active or sham intervention over two weeks (separated by a two-week washout interval). Once phase 1 was completed, patients were asked to rest for two additional weeks (washout interval) before entering phase 2 (an open-label phase). During the latter, all participants were given daily active intervention for four weeks. Comparisons on pain, fatigue, illness impact, emotional symptoms, quality of life, clinical impression, and comfort ratings were performed using Friedman, Wilcoxon signed rank, and Chi2 tests.

RESULTS

Thirty-three patients completed the study (93.9% female). The active intervention significantly reduced pain (as measured by a visual analog scale) compared to the sham condition (pre-active: 6.9 ± 1.4 , post-active: 5.9 ± 1.8 , pre-sham: 6.8 ± 1.4 , post-sham: 6.6 ± 1.5 ; $p = 0.014$). This also applies to the other secondary endpoints (fatigue, anxiety, and illness impact), except depression and quality of life. After phase 2, significant beneficial effects were identified for most outcomes, and 78.8% of patients reported improvement in their condition according to the clinical global impression scale.

DISCUSSION AND CONCLUSION

This is the first randomized controlled experiment to examine the effects of EXOPULSE Mollii Suit on fibromyalgia. It shows that multisite stimulation has beneficial effects on fibromyalgia-related pain, fatigue, emotional symptoms, and disease impact. The mechanisms underlying this method analgesic efficacy could be located at the peripheral (impulse blockage, or gate control theory), segmental (spinal), and/or extra-segmental (supraspinal descending inhibition) level. The results are promising and point to a potential place for this method in the therapeutic arsenal of fibromyalgia.



5.045 Motion Analysis System Supported Telerehabilitation and Home Therapy for DMD (Duchenne Muscular Dystrophy) and MS (Multiple Sclerosis) Disease Applications

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BACKGROUND

Patients with Duchenne muscular dystrophy (DMD) and multiple sclerosis (MS) experience mobility challenges that can significantly affect their daily functioning and overall quality of life ^{[1]-[3]}. Musculoskeletal system is important public health concerns that contribute the highest number of applications to physical therapy and increase the wait times in hospitals due to their high prevalence.

This research presents a “Motion Analysis System Supported Telerehabilitation and Home Therapy” application. Initially, it employs IMU sensors, camera-based motion analysis for accurate, real-time assessment ^{[4]-[10]}.

AIM

To develop an advanced telerehabilitation system integrating IMU, flex sensor and camera data for precise motion analysis and classification, enhancing remote therapy options for DMD and MS patients.

METHOD

The system design includes a combination of wearable motion tracking devices equipped with inertial sensors, and a frame system with flexible sensors integrated into a custom-designed wearable jacket to detect motion. Additionally, camera-based angle estimation is achieved using MediaPipe. The IMU sensors capture raw accelerometer and gyroscope data, while joint positions are calculated from extracted landmarks using MediaPipe. The data collection process was carefully conducted to capture signals simultaneously, ensuring synchronized data. The processed data were then fed into a machine learning pipeline. It is worth mentioning that MediaPipe landmark points were validated using the Opti-Track motion system to ensure reliable data accuracy.

RESULTS

The collected dataset was evaluated using various traditional ML models. A variety of ML models were used for evaluating the datasets. The LR model achieved 92% accuracy for IMU data and 91% for MediaPipe data. The SVM model demonstrated significant improvement, with an increase in accuracy of 4% for IMU data and 5% for MediaPipe data. The use of Random Forest model, utilizing 100 ensemble trees, achieved a remarkable accuracy of 100% for both IMU and MediaPipe datasets. Detailed results from different ML models are summarized in Table1.

Table1: Performance metrics for different ML models

Model	F1- Score Accuracy	
	IMU Data	MediaPipe
LR	92%	91%
SVM	96%	96%
RF	100%	100%
MLP	92%	96%
CNN	96%	100%

DISCUSSION AND CONCLUSION



The evaluation of data collected from the custom-designed IMU sensor and the MediaPipe angle system demonstrated significantly high classification performance across all tested models. The RF and CNN models achieved remarkable accuracy. Future studies will explore a sensor fusion approach, integrating data from both IMU and MediaPipe, to investigate how these sensors correlate with each other. The proposed system provides precise feedback for the assessment and rehabilitation of patients.

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5.046 Developing BACPAR's "Clinical guidelines for the pre and post operative physiotherapy management of adults with lower limb amputations" (3rd edition)

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BACKGROUND

The British Association of Chartered Physiotherapists in limb Absence Rehabilitation (BACPAR) is a professional network in the United Kingdom (UK). The previous editions of these guidelines were published in 2006 and 2016, the latter of which was accredited by National Institute for Health Care Excellence (NICE). This third edition seeks to integrate new scientific evidence and current best practice into the original recommendations following similar methodology.

AIM

To identify and incorporate new published evidence into the guidelines recommendations, to facilitate best practice for the physiotherapy management of amputees during the pre-operative and immediate post-operative phase of care.

METHOD

A comprehensive literature search was undertaken by an information specialist from Southampton Health Technologies Assessments Centre of the following databases: AMED, Cinahl, Cochrane Library, DARE, Embase, Medline, PEDRO. Articles that matched the inclusion criteria were then critically appraised by a guideline update group using Critical Appraisal Skills Programme (CASP) tools. The articles included to support the updated recommendations were classified using the SIGN grading tool, and a Delphi technique was undertaken for any recommendations where literature was lacking, as well as all of the good practice points (which are local implementation points for the guidelines recommendations).

RESULTS

Significant additions and changes have been made to the pre and post-operative guidelines, introducing new supporting evidence and updating current practice. New sections were created to reflect the current physiotherapy management of this population. The format of the document was also updated, ensuring it flows through the patients journey, to better support the physiotherapist utilising the guidelines.

DISCUSSION AND CONCLUSION

This update of the pre and post-operative guidelines was significantly delayed due to the global pandemic of Covid-19. Health services throughout the UK were heavily disrupted and physiotherapy rehabilitation spaces continue to be affected. However, this provided opportunity for innovation, and significant service changes across the UK. Developing guidelines such as these, demonstrates the need for strong, clear evidence to address the wide variation nationally in the quality, type of service and care offered by physiotherapists to adults with lower limb amputation.

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5.047 The Effects of Basic Body Awareness Therapy on Clinical Parameters of Scoliosis and Body Awareness in Adolescents with Idiopathic Scoliosis

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BACKGROUND

One of the most effective approaches in scoliosis management is scoliosis-specific exercises (PSSE). A good level of body awareness in individuals facilitates more effective exercise during scoliosis rehabilitation. Basic body awareness therapy, which aims to increase postural alignment awareness by integrating breath with slow movements, seeks to improve body awareness, movement quality, posture, coordination, balance, postural control, and physical-social functions. This approach is expected to enhance the benefits that individuals with scoliosis gain from the rehabilitation process.

AIM

Our research explores the impact of adding basic body awareness exercises to scoliosis-specific rehabilitation, assessing improvements in posture, body awareness, quality of life, and trunk proprioception.

METHOD

14 participants were included in the experimental group, and 14 in the control group. Demographic characteristics, Cobb angle, anterior trunk rotation (ATR) and the Body Awareness Questionnaire (ABC), results were recorded for all subjects. The control group underwent only the Scientific Exercise Approach to Scoliosis (SEAS) under the supervision of a certified physiotherapist, while the experimental group received both SEAS and Basic Body Awareness Therapy (BBAT) for 16 weeks. Cobb angles, ATR and ABC results were evaluated before and after the exercise intervention. The Mann-Whitney U test was used to compare the parameters between the groups in the statistical analysis.

RESULTS

The mean age of participants was 14.14 ± 2.74 years in the control group and 14.36 ± 2.24 years in the experimental group. At baseline, the Cobb angle was 31.79 ± 20.40 in the SEAS group and 24.21 ± 6.14 in the BBAT group. Post-treatment, Cobb angles were 24.79 ± 17.88 for SEAS and 28.50 ± 15.35 for BBAT. Initial anterior trunk rotation (ATR) was 7.64 ± 2.90 for SEAS and 7.07 ± 2.50 for BBAT, decreasing to 5.07 ± 3.02 and 5.21 ± 2.36 , respectively, after treatment. The ABC scores were 3.54 ± 0.56 for SEAS and 3.55 ± 0.77 for BBAT at baseline, increasing to 3.79 ± 0.53 and 4.50 ± 0.46 post-treatment. No significant differences in Cobb angle, ATR, or ABC score were found before treatment ($p > 0.05$). Post-treatment, a significant difference was observed in the ABC scores ($p < 0.05$).

DISCUSSION AND CONCLUSION

The addition of body awareness therapy to scoliosis rehabilitation has been found to be effective in increasing individuals' body awareness. However, no significant effect was observed on scoliosis parameters. Larger sample studies are needed to further investigate these findings.



Free paper session | Outcome measurements – Development and integration

5.051 Consensus development of a core outcome set for rehabilitation management of individuals with upper limb amputation

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BACKGROUND

Assessing people who have undergone a major upper limb amputation (ULA) with standardized measurement tools is essential to identify their needs and monitor their progress throughout the rehabilitation process. However, there is currently no consensus on which assessment tools should be used for evaluating rehabilitation outcomes in this population. As a result, it is difficult to determine the impact of interventions on patients' functional status and quality of life at the end of the rehabilitation process.

AIM

The objective of this study was to develop a core outcome set (COS) for use in routine clinical care and research to enhance rehabilitation management for people with ULA.

METHOD

The project comprised three phases: 1) The identification of priority domains affected by ULA from the perspective of individuals with ULA and healthcare professionals (HCPs); 2) A review of existing measurement tools for these domains, including both generic and specific tools for ULA; 3) The use of a nominal group technique (NGT) to achieve consensus on a COS and outcome measures with HCPs and patient partners.

RESULTS

A total of 40 clinicians and 33 individuals with ULA completed questionnaires to identify the priority domains that are affected by an ULA. Forty potential measurement tools were identified from systematic reviews and matched to the priority domains. The nominal group technique (NGT) resulted in the consensus of eight specific or generic outcome measures, which encompass upper extremity function, pain interference, depression, anxiety, psycho-social illness impact, satisfaction with prosthesis, and quality of life.

DISCUSSION AND CONCLUSION

This COS provides a standardized set of tools that can facilitate shared decision-making and enhance the consistency of outcome evaluation for ULA rehabilitation. The implementation of these tools will allow rehabilitation teams to ensure that patient assessments align with both clinical priorities and individual needs.



5.052 Exploring meaningful outcome domains of recovery following lower limb amputation and prosthetic rehabilitation in low-and-middle-income (LMIC) settings: A Systematic review

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BACKGROUND

Delivering effective healthcare in low- and middle-income countries (LMICs) presents an on-going challenge due to increasing demand and limited resources. Understanding the definition of a successful outcome from the patient's perspective can help prioritise limited resources and improve service delivery. While several studies have started to explore outcome domains of importance following lower limb amputation from the patient's perspective, none have focused on patients in LMICs. This gap highlights the need for research in these settings to guide appropriate and efficient resource allocation and service provision.

AIM

To undertake a systematic review and qualitative synthesis of studies exploring the views and experiences of individuals undergoing prosthetic rehabilitation and living in LMICs, to identify outcome domains of importance specific to these settings.

METHOD

CINAHL, PsycInfo, Web of Science, and Tric databases were searched for papers from inception to April 2024. Two reviewers screened 3067 records, selecting 62 for full-text review. Papers were included if they used qualitative methods, and explored the experiences of adult lower limb prosthetic users in LMICs (as defined by the World Bank). Five papers underwent thematic synthesis. Data were extracted from results, study design, and sample sections. Study quality was assessed using the Critical Skills Programme (CASP) checklist. No studies were excluded based on quality.

RESULTS

Five studies involving 55 participants from Nepal, Kenya, Cambodia, Bangladesh, and Kiribati were thematically analysed. Four key themes emerged:

1. **The importance of a prosthesis:** Highlighted issues like socket comfort, durability, and prosthesis functionality.
2. **Valued activities:** Emphasised the need to engage in work and daily living activities.
3. **Acceptance following limb loss:** Participants valued social acceptance and community integration for fostering self-acceptance.
4. **Independence:** Participants expressed anxiety over being able to meet their basic physiological, safety, and security needs. This fear drove their desire for independence, which they saw as achievable through access to a prosthesis.

DISCUSSION AND CONCLUSION

These findings reflect the complex, multifaceted nature of recovery and the significance of access to a prosthesis, the ability to work, and community acceptance for patients living with limb loss in LMIC settings. These insights could inform prosthetic service provision and outcome measure selection in LMICs. However, findings were limited by the inclusion of only five studies with 55 participants from five LMICs, underscoring the need for further research on patients' experiences, and their perspectives on what constitutes a successful outcome, across diverse LMIC contexts.

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5.053 The effect of walking with a dynamic ankle foot orthosis on attentional demand

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BACKGROUND

Dynamic orthoses such as Dictus band are known to be effective in improving walking ability in various conditions [1]. Nevertheless, the underlying reasons for the benefit of such a device has not yet been fully understood. Research has shown that people with gait deviation experience an increased attentional demand. The effect of the use dynamic orthosis on the attentional resources during gait in people with drop foot is lacking.

AIM

The aim is to explore the effect of walking with the Dictus band on attentional demand in people with drop foot.

METHOD

Crossover Design was used. 28 participants with drop-foot and using Dictus band (Erimed Dictus DS02) on a daily basis were included. Participants performed a 2-minute walk test(2-MWT) with and without the orthosis in a random order. Functional near-infrared spectroscopy(fNIRS) was used to quantify the attentional demand while walking. The Borg CR10 scale was also used as a subjective estimation of perceived need of concentration during walking.

RESULTS

The attentional demand, measured as concentration level changes in oxygenated haemoglobin, indicated an increased brain activity when walking without the Dictus band (Mean(SD)= -0.035 (0.295) μM) compared to walking with (Mean(SD)= -0.108(0.249)) μM) (Figure 1). However, this increase was not significant ($t(24) = 0.982, p = .336$). A significant increase (Median(range)=4.0 (0.0-9.0,) ($p=.001$)) was seen in the Borg score of perceived need of concentration when walking without the Dictus band compared to walking with it (Median(range)=3.0 (0.0-8.0)). The participants also walked significantly faster (Median(range)=1.11 (0.38-1.86) m/s) ($p=.005$), when using the Dictus band compared to walking without it (Median(range)=0.96 (0.27-1.47) m/s).

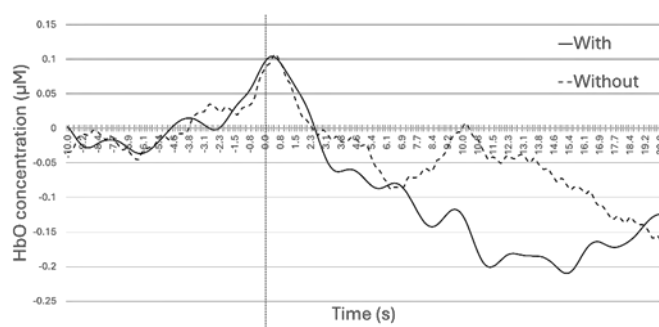


Figure 1: Graph of the concentration level changes in oxygenated haemoglobin under the two testing conditions for 10 seconds of baseline and 20 seconds of walking.

DISCUSSION AND CONCLUSION

In line with earlier research, clinical measures showed that walking ability significantly improved while using the Dictus band. Despite the decrease in brain activity while using the Dictus band, the high variability in the data undermined the statistical significance. However, to the authors' knowledge, this is the first study exploring attentional demand while walking with a Dictus band in persons with drop foot.

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ACKNOWLEDGEMENTS

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5.054 Awareness, Needs, and Uses of Outcome Measures in Thai Prosthetists and Orthotists: A Mixed-Methods Study

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BACKGROUND

Outcome measures (OMs) are standardized tools to assess intervention impacts ^[1]. In addition to its application in research, it is also imperative for routine clinical practice in prosthetics and orthotics (PO) as recommended by International Society for Prosthetics and Orthotics (ISPO) and World Health Organization (WHO) ^[2]. However, in Thailand, the use of PO OMs in Certified Prosthetists and Orthotists (CPOs) including their awareness and needs of OMs remains unknown.

AIM

To explore the awareness, need, and use of outcome measures among Thai CPOs.

METHOD

A mixed-methods study ^[3] was conducted to explore the awareness, need, and use of OMs in Thai CPOs. Quantitative data was collected through a validated web-based survey in 88 CPOs, and qualitative data was collected using the virtual semi-structured in-depth interviews with 13 CPOs. Quantitative data was analyzed using descriptive statistics, while qualitative data were examined using thematic analysis ^[4]. Subsequently, quantitative and qualitative data were integrated, synthesized, and interpreted using concurrent/convergent triangulation ^[3].

RESULTS

Findings from the quantitative survey showed that 79.6% of respondents were aware of OMs, with 94.3% expressing the need for knowledge and skill development and availability of OMs. Although 84.1% had experienced the use of OMs in research and clinical practice, only 34.1% reported themselves as routine users. In addition to performance-based OMs (i.e., TUG, 6MWT, 10mWT), which were frequently mentioned by respondents when asked about their awareness and use, patient-reported OMs were indicated when asked about their needs. The qualitative approach highlighted the high awareness of the importance and application of OMs in clinical and research contexts. Various needs of OMs were identified for seminars/workshops, availability and accessibility of tools/equipment, and standardized OMs in the Thai language. Additional insights on current OMs use, barriers/facilitators, and recommendations were also indicated.

DISCUSSION AND CONCLUSION

This study provided comprehensive information on the present situation of awareness, need, and use of OMs among Thai CPOs. Despite contextual differences, overall findings align with those of previous studies conducted in other countries ^[5-6]. Additionally, recommendations for strategies to raise awareness, promote OMs use, and fulfill the needs of the Thai PO profession were proposed. Addressing these areas could enhance evidence-based practice and improve PO service and research in Thailand.

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ACKNOWLEDGEMENTS

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5.055 Use of outcome measures in prosthetics clinical practice: a survey of prosthetists in the United States and Canada

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BACKGROUND

Outcome measures (OMs) are standardized instruments designed to quantify aspects of patients' health. As such, they can be used to guide treatment decisions and evaluate interventions designed to improve patient outcomes.¹ Despite this potential, integrating OMs into practice is challenging as they require knowledge, skill, and time to administer effectively. Some also require space and equipment. Understanding how prosthetists use OMs in day-to-day practice can help guide efforts to address barriers.

AIM

The goals of this study were to assess the extent to which prosthetists in the United States and Canada use OMs for patients with lower limb amputation, and to identify barriers and facilitators to outcomes measurement in day-to-day clinical practice.

METHOD

A cross-sectional survey was developed to solicit information about prosthetists' use of OMs, resources available to administer OMs, and opinions on the utility and value of OMs in clinical practice. Participants were recruited via national professional associations. The survey was administered in the U.S.² and Canada³ between July 2020 and July 2021. Descriptive statistics were used to characterize the samples and present survey results.

RESULTS

A total of 375 U.S. and 49 Canadian practitioners completed the survey. More respondents from the U.S. than from Canada were encouraged or required to use OMs (79% U.S. and 49% Canada). However, less than half from either country indicated they used OMs routinely for clinical purposes. Respondents from both countries generally perceived value in OMs, but few (30% U.S. and 23% Canada) thought they were administered in a standardized way across the profession. Respondents from the U.S. were willing to spend more time administering OMs than respondents from Canada, but less than 40% of respondents from either country said they would spend more than 10 minutes measuring outcomes at any appointment. Space was also limited but more than half of all respondents agreed they had sufficient space to administer OMs.

DISCUSSION AND CONCLUSION

Use of OMs among prosthetists is greater in the U.S. than in Canada. However, use of OMs for clinical reasons (e.g., informing clinical decisions or evaluating treatment effectiveness) in either country is still not routine. Time and space for administering OMs is clearly limited in both countries, so efforts to select or design OMs that can be administered quickly and require little space should be undertaken. Lastly, work is needed to improve standardization of OMs so that results can be combined, compared, and used to advance patient care.

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ACKNOWLEDGEMENTS

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5.056 Content comparison of utility and effectiveness instruments aligned to the Prosthetic Interventions Core Outcome Set (PI-COS)

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BACKGROUND

The Prosthetic Interventions Core Outcome Set (PI-COS) describes the outcomes that are most important to prosthesis users and funders [1].

The PI-COS was developed according to the international core outcome set development efforts based on the *International Classification of Functioning, Disability, and Health* (ICF) framework [2,3] and therefore its 14 items are described using ICF categories. Given the content of many outcome measures (e.g., instruments) have been linked to ICF categories, it is possible to use this linking research to determine which instruments best measure the items of the PI-COS; a process known as content comparison.

AIM

The study aimed to compare the content of existing instruments used to evaluate lower-limb prosthetic interventions against the PI-COS

METHOD

This study involved two literature searches and data extraction, followed by the comparison of extracted content to the PI-COS (e.g., content comparison).

First, a comprehensive literature search was undertaken to identify utility (e.g., Health-Related Quality of Life measures, such as the EQ-5D) and effectiveness (e.g., Amputee Mobility Predictor) instruments used to evaluate prosthetic interventions. Using the identified instruments, a second literature search was conducted to determine those instruments that had instrument content linked to the ICF. For each instrument that had been linked to the ICF, the linking results were extracted and used to compare instrument content to the PI-COS. Standard content comparison metrics, such as bandwidth (i.e., the percentage of items in an instrument linked to the PI-COS), were used to support analysis and description of the content comparison results for each instrument.

RESULTS

Of the 130 identified instruments used to evaluate prosthetic intervention studies, 24 had previously been linked to ICF. The instrument with the greatest bandwidth was the SF-36 given it linked to 6 of the 14 items (43%) of the PI-COS. It was possible to achieve higher bandwidth by combining the PROMIS-29+2 and the PROMIS Physical Function with Mobility Aid short-form to create a bespoke instrument that measured 9 of the 14 items (64%) of the PI-COS.

DISCUSSION AND CONCLUSION

While there is no perfect fit instrument providing coverage of the PI-COS, we recommend using the PROMIS 29+2 and the PROMIS Physical Function with Mobility Aid short-form to create a 42-question instrument that best measures what is most important to prosthesis users and funders.

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ACKNOWLEDGEMENTS

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Free paper session | Prosthetics: lower limb transfemoral – Gait

5.061 Improvements in pain and gait regardless of time since amputation using the Suralis Feedback System

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BACKGROUND

Vibrotactile feedback has been shown to improve gait performance and alleviate phantom pain in lower limb amputees (Khajuria & Joshi, 2020; Lauretti et al., 2017). Self-assessed and functional mobility also improve with time since amputation (TSamp) (Seth et al., 2022). However, whether the benefits of vibrotactile feedback vary by TSamp remains unexamined.

AIM

The objective of this study was to investigate whether improvements in gait and phantom pain using the vibrotactile Suralis Feedback System (FBS) depend on TSamp.

METHOD

Nineteen participants (five female, age: 63.78 ± 8.78 years) with lower limb amputation (LLA) used FBS for 37 ± 10.5 days. The Timed Up and Go (TUG), Four Square Step Test (FSST) and ten meter walk test (10m) were conducted pre- and post-treatment. Participants recorded daily phantom pain levels using the Numerical Rating Scale (NRS). Data analysis was performed in Matlab (Mathworks, Natick, MA). The mean difference in TUG, FSST, and 10m per subject was calculated as well as average NRS from the first and last seven days. Post-pre differences were analyzed with Shapiro-Wilk for normality and Wilcoxon for improvements. Spearman correlation assessed relationships between TSamp and improvements.

RESULTS

Average difference between pre- and post-data was -2.47 ± 2.63 s for TUG, -2.47 ± 2.54 s for FSST and -1.93 ± 2.54 s for 10m. Overall, gait assessments had an average improvement of -2.29 ± 1.92 s. Although one participant had a deterioration in gait assessments, only FSST worsened (4.44 s), while TUG and 10m improved (-0.58 s and -2.75 s). Average reduction in pain was -1.66 ± 1.65 NRS points. One participant's pain increased by 0.34 points but the daily amount of analgesics was halved. One-sided Wilcoxon tests indicated significant improvements in FSST ($p = 0.007$), 10m ($p = 0.045$) and pain ($p = 0.003$) but not for TUG ($p > 0.05$). Spearman's correlation revealed no significant relationship between improvements in investigations with FBS supply and TSamp ($p > 0.05$) (Fig. 1).

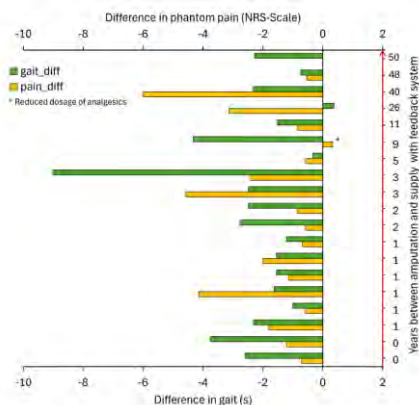


Figure 1: Post-pre-difference in gait and phantom pain after using FBS. Negative results describe improvement



DISCUSSION AND CONCLUSION

Seth et al. (2022) showed that gait speed and endurance are independent of TSamp, supporting our findings. Amputees often display reduced adaptability and altered sensorimotor learning for new gait patterns (Kannape et al., 2016). Our positive results indicate that FBS can help to return to their pre-amputation gait through muscle memory training and sensory adaptation. In conclusion, improvements in gait and phantom pain are independent of TSamp, which means all individuals with LLA can benefit from FBS.

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5.062 Walking on different inclines: How do transfemoral amputees adapt their gait? – a biomechanical study

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BACKGROUND

Compared to walking on level ground, walking on ramps requires an adaptation of the gait pattern, which is associated with increased muscle strength and an increased range of motion (ROM) in the lower extremity^{1,2}. In addition, walking on slopes requires greater balance and increases the risk of slipping³. These factors can pose a particular challenge for transfemoral amputees (TFAs) due to the lack of sensitive feedback as well as unfavourable lever ratios and functional limitations of the prosthetic components⁴.

AIM

To identify inclination-dependant gait adaptations for transfemoral amputees when walking up and down slopes with state-of the-art prosthetic components.

METHOD

Eight unilateral TFAs and a reference group of 12 non-amputated persons participated in this study. All TFAs used the prosthetic knee joint Genium or Genium X3 (Ottobock) and a conventional energy-storing and returning foot. Walking on level ground, 2.5°, 5°, 7.5°, and 10° (up and down) with self-selected gait speed was analysed. Kinematic and kinetic parameters were recorded with an optoelectronic camera system and piezoelectric force plates.

RESULTS

Functional limitations of the prosthetic fittings lead to altered gait patterns and compensation strategies that showed inclination-dependent systematics. The lack of adaptation of the prosthetic knee joint at prosthetic side initial contact and the limited ROM of the prosthetic foot led to various compensation mechanisms when walking upslope, such as a decreasing stride length, an increasing contralateral plantar flexion in late stance and an increasing vaulting movement of the contralateral leg. These compensations are accompanied by overloading of the contralateral side. When walking downslope, the yielding gait strategy is more frequently used as the inclination increases. The inclination from which yielding is used varies between the subjects. The knee and hip dynamics are significantly altered by this strategy compared to the reference group.

DISCUSSION AND CONCLUSION

The study shows that there is still room for improvement in the functionality of prosthesis fittings in order to further reduce compensatory movements and overloading of the contralateral side when walking on inclines. Future studies with adaptable and active prosthetic components could provide interesting insights into the extent to which prosthesis users could benefit from these systems.

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5.063 Reactive balance and stepping strategy in persons using a transfemoral prosthesis

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BACKGROUND

Persons with a transfemoral amputation (TFA) have poorer balance compared to able-bodied persons (AB)^[1,2]. Research shows additional contributions of the intact leg to compensate for the loss of an active ankle strategy on the prosthetic limb side^[2]. Currently, it is unknown whether a) reactive balance is also affected in persons with TFA, b) whether this is influenced by the type of prosthetic suspension, and c) which leg they prefer to recover from perturbations. Insight into reactive balance may ultimately help to identify who has an increased fall risk.

AIM

Determining whether reactive balance differs between persons with TFA and AB, and between types of prosthetic suspension (i.e. socket-suspended (SSP) versus bone-anchored (BAP)); and to identify which leg is used for stepping to recover from a perturbation.

METHOD

Experienced transfemoral SSP- and BAP-users and AB were recruited. Participants stood on a platform that moved at increasing perturbation intensities in forward, backward, prosthetic/non-preferred leg and intact/preferred leg stepping directions. Participants were instructed to recover their balance with a maximum of one step. The multiple stepping threshold was recorded (i.e maximum perturbation intensity (m/s²) at which one could still recover with one step), as well as the stepping leg used.

RESULTS

We included 10 AB persons (age: 57±11years) and 20 persons with TFA; 10 BAP-users (age: 59±15years, time since amputation: 25±17years) and 10 SSP-users (age: 56±13years, time since amputation: 27±14years). Balance confidence (ABC-questionnaire) and balance capacity (Brief-BEST) were significantly lower in TFA compared to AB (90vs97% and 18vs24points, p<.001 and p<.001), with no significant differences between BAP and SSP. TFA achieved a significantly lower multiple stepping threshold in the backward direction (3.5m/s², p=.005) and towards the prosthetic/non-preferred leg (2.5m/s², p<.001) compared to AB (both: 4.5m/s²); no significant differences between BAP and SSP. In the backward, forward, and towards the intact side, the majority of TFA used side steps with their intact leg (90, 80, and 100%). Toward the prosthetic side, mainly the prosthetic leg was used (90%).

DISCUSSION AND CONCLUSION

Results suggest reduced reactive balance in persons with TFA, which might be a result of reduced sensory feedback and delayed responses^[3]. No difference between type of prosthetic suspension were found. In contrast to the stepping strategy of stroke patients^[4], people with TFA prefer using their affected leg to recover from a sideways perturbations towards the prosthetic side. These findings underpin the cautious behaviour of prosthetic-users during disturbances.

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ACKNOWLEDGEMENTS

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5.064 The Effect of Passive Mechanical Prosthetic Knee and Ankle-Foot Components on Gait Safety in Transfemoral Prosthesis Users

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BACKGROUND

Studies report that the majority of falls in transfemoral prosthesis users (TFPUs) occur during walking ^[1]. To facilitate gait safety during walking, TFPUs must achieve certain objectives during the two phases of gait: 1) prevent knee buckling while weight-bearing during stance ^[2] and 2) avoid limb collision with the ground during swing phase ^[3]. TFPUs must rely on their intact hip and leg prosthesis, comprised of a prosthetic knee joint and ankle-foot mechanism, to achieve these objectives. However, it is not evident how different combinations of prosthetic knee and foot designs affect gait safety in TFPUs.

AIM

The purpose of this study was to examine the interaction effects of prosthetic knees and feet on the gait safety of TFPUs.

METHOD

This study was approved by the Jesse Brown VA Medical Center IRB and participants provided written informed consent.

Participants: Ten TFPUs (3F/7M, 50.7±13.3 years, 83.7±18.0 kg; 1.70±0.10 m)

Apparatus: Participants were randomly fitted with each of four different combinations of prosthetic knees (OttoBock 3R60 polycentric and 3R95 single-axis) and ankle-foot components (College Park Odyssey K3 hydraulic and Horizon non-articulated). Kinematic and kinetic data were collected using a digital motion capture system and six floor-embedded force plates.

Procedures: Participants walked on level ground at their freely-selected speed.

Data Analysis: Two variables were analyzed to determine changes in gait safety during stance phase (PKAI: Knee Moment Angular Impulse and PSKM: Pre-Swing Knee Moment) and one variable during swing phase (TC: Toe Clearance). Gait data were analyzed using Visual 3D and custom software in MATLAB. Linear mixed models were used to analyze data with two repeated factors (prosthetic knee and foot).

RESULTS

Results suggest that gait safety was improved for the prosthetic configurations that included the polycentric knee ($p<.001$), reflected by more negative KMAI, smaller PSKM, and increased TC. Though there are believed to be advantages to using either the polycentric knee or hydraulic foot when considered independently, the effects of adding the hydraulic foot to the polycentric knee did not consistently improve gait safety.

DISCUSSION AND CONCLUSION

These results suggest prosthetic knee type affects gait safety, but few differences were observed between prosthetic foot designs. The inconsistent effect of combining a hydraulic foot with a polycentric knee on gait safety may be due to gait compensations. The results indicate that the polycentric knee provides substantial benefits over the single-axis knee, regardless of foot type, for most outcome measures during both stance and swing phases.

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ACKNOWLEDGEMENTS

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5.065 Load on the musculoskeletal system of lower limb amputees - depending on the level of amputation

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BACKGROUND

The gait characteristics of lower limb amputees with a prosthesis deviate from normal gait patterns. Generally, lower limb amputees walk slower including a prolonged stance phase duration on their contralateral limb compared to the prosthetic side and to able-bodied individuals [1, 2]. It is shown that amputees compensate the loss of one or more joints by increased joint moments and power output at their contralateral ankle, knee and hip compared to able-bodied individuals. [1, 3]. In general, the level of amputation influences these gait deviations but by knowledge of the authors no study analysed the contralateral load for more than two different amputation levels.

AIM

Analysing the load on the musculoskeletal system for all major lower limb amputation levels.

METHOD

The data collection for this study was performed retrospectively. Gait analysis data from 44 TTs, 30 TFs and 8 HDs could be used for the analysis.

Selected knee loading parameters of the sound side (peak knee adduction moment, maximum knee flexion and extension moment, maxima of vertical ground reaction forces, force rate) were evaluated statistically between the different amputation levels.

RESULTS

As the level of amputation increases, walking speed decreases and asymmetry of stance duration increases. Vaulting TFs tend to walk faster than those without vaulting.

The knee adduction and flexion moments increase, and the knee flexion moments decrease with increasing amputation level by tendency. The higher the amputation level, the significantly steeper the force rate during the first 5%GC.

DISCUSSION AND CONCLUSION

With increasing amputation level on the one hand, the tendentially higher loading acts over a significantly longer time on the contralateral limb. On the other hand, the load transmission is significant faster. Thus, it can be assumed that in summary the loading of the contralateral limb increases with increasing amputation level. This higher load may explain the higher prevalence of knee osteoarthritis [4] with increasing amputation level.

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5.066 Kinematic and kinetic parameters of prosthetic knee joints during walking – Comparison of gait analysis results and internal sensor data

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BACKGROUND

Accurate and valid gait analysis parameters of prosthetic knee joints are essential to evaluate the functionality and safety of these components. A methodological problem for determining these measures has been that standard models for calculating kinetic and kinematic parameters were developed for analyzing movement in able-bodied people. In the present study, essential gait parameters characterizing functionality of prosthetic knee joints, such as the sagittal knee angle and moment, were determined using different gait models and validated by comparing them with internal sensor data of the prosthetic knee joint.

AIM

Which gait model provides the most reliable data?

METHOD

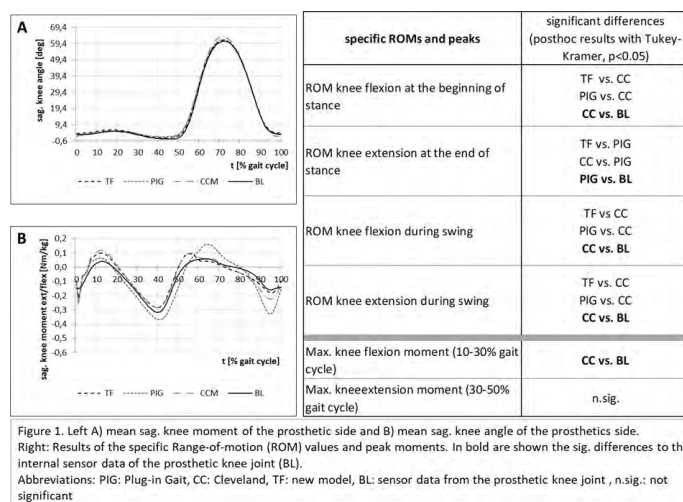
Measurements took place in two gait laboratories. In total, level walking of 19 persons with a transfemoral amputation at their usual speed (1.23 ± 0.17 m/s) was biomechanically analyzed. All participants used microprocessor-controlled knee joints (Genium or X3, Ottobock). Optoelectronic cameras (VICON, GB) and force plates (KISTLER AG, CH or AMTI, US) were used for gait analysis. Prosthetic knee moment and angle were calculated with three different models: Plug-in Gait (PIG) [1], adapted Cleveland (CC) [2], and a new model specifically developed for the analysis of transfemoral amputees (TF).

During the gait analysis, sensor data of the prosthetic knee joint (BL, knee angle and moment) were recorded simultaneously.

RESULTS

Mean value curves normalized to gait cycle of all participants (knee angle and knee moment) showed only small differences, which are also visible at the small root mean square error between the models and BL: sag. knee moment: TF: 0.05 ± 0.02 Nm/kg, CC: 0.06 ± 0.02 Nm/kg, PIG: 0.12 ± 0.04 Nm/kg; sagittal knee angle: TF: 1.6 ± 0.5 deg, CC: 3.2 ± 1.4 deg, PIG: 3.2 ± 1.1 deg. Here, both values for the TF model are the lowest.

When comparing the specific range-of-motion and peak moment values, there are significant ($p < 0.05$) differences between the models. The only model without significant differences from BL is TF (Fig. 1)



DISCUSSION AND CONCLUSION

Relevant parameters of the prosthetic knee joint can be determined using gait analysis, but not all models have the level of accuracy required for evaluating prosthetic knee joints.

The new model, specifically developed for the analysis of above-knee amputees, shows the most reliable data.

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Free paper session | Prosthetics and Orthotics: upper limb – Outcomes

5.071 A patient decision aid about terminal devices for people with upper limb absence: the PDA-TULA

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BACKGROUND

To select an upper limb prosthesis can be challenging, especially for novice users. Users need to become aware of their demands and wishes and they need to be informed properly, before they know what type of prosthesis fits best for them. Patient decision aids can be helpful in supporting choices for prostheses.

AIM

To develop a patient decision aid for choosing upper limb terminal devices and implement and pilot-test this PDA-TULA (Patient Decision Aid-Terminal devices for Upper Limb Absence).

METHOD

A systematic co-creation process involving users, clinicians, researchers, and implementation- and ICT-experts was used to develop the PDA-TULA. Literature meta-synthesis, focus groups, and surveys were used to determine stakeholder needs. Detailed features of included terminal devices (prosthetic hands, hooks and accessories for cosmetic, body-powered as well as myoelectric prostheses) were collected and refined in a nationwide meeting. End-user feedback supported the drafting and testing of the PDA-TULA. Barrier/facilitator analyses with stakeholders guided the tailored implementation strategies. The PDA-TULA was pilot-tested nationwide.

RESULTS

The PDA-TULA challenges the users to think about their wishes and demands regarding their upper limb prosthesis. It also informs patients about available TD options and allows comparison of the users' preferences with available options. 'Knowledge brokers', dedicated occupational or physical therapists, were appointed in each clinical institution, which facilitated the implementation of the PDA-TULA at the different workspots. Users indicated that the PDA-TULA helped them to realize what was important for them regarding their choice for a prosthesis. Clinicians stated the PDA-TULA supported the shared-decision making between the team and the users.

DISCUSSION AND CONCLUSION

Discussion: Both users and clinicians were satisfied about the way the PDA-TULA supported the selection of the terminal devices. Implementation strategies, applied with the help of an implementation expert, were essential to implement the innovation at the workplace. Co-creation appeared to be crucial to develop and implement this innovation to align with user needs.

Conclusion: The PDA-TULA is a valuable tool for clinicians and users to support a personalized and well-informed choice for an upper limb prosthesis. Although the PDA-TULA is currently only implemented in the Netherlands, this innovation might also be interesting for other rehabilitation teams worldwide.

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ACKNOWLEDGEMENTS

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5.072 A Pilot Study on the Use of Virtual Reality to Introduce Transradial Amputees to Myo-Electric Prostheses

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BACKGROUND

The benefits of myo-electric prostheses can be difficult to grasp without lived experience with such technology. This can be costly and challenging due to the need to build trial sockets and loan terminal devices. Virtual reality (VR) offers a more accessible alternative to help clients understand the benefits of myo-electric prostheses, whilst allowing for functional training.

AIM

Here, we present a pilot study on the use of VR to introduce transradial amputees to myo-electric prosthetic devices.

METHOD

Participants: 7 transradial amputees (4 male, 3 female) with no previous experience with myo-electric prostheses (2 cosmetic prosthesis users, 5 body-powered prosthesis users).

Apparatus: Myo-Hand XP VR training and rehabilitation system (Virtetic) was used in this study. The system simulates myo-electric prosthetic devices and common training scenarios for upper-limb prostheses. The system includes a Quest 2 VR headset (Meta) and a MyoCuff myo-electric pattern recognition sensor (Ottobock).

Procedure: Participants involved in a single 1-hour session in the clinic, delivered by a trained prosthetist. The session procedure was as follows:

- Participants were verbally introduced to the Myo-Hand XP system and the procedure for the session.
- Participants had the MyoCuff fitted and calibrated using the MyoPlus Android app (Ottobock).
- Participants wore the VR headset with the Myo-Hand XP software.
- Participants were guided through the following activities in VR:
 - Perform basic prosthetic hand movements (open/close)
 - Grasp objects with the virtual prosthesis
 - Train muscle contractions through a paintball game
 - Train pick-and-place tasks through a cooking game
- Participants were asked about their experience with the Myo-Hand XP and their thoughts on myo-electric prostheses.

Data Analysis: Subjective feedback from all participants was compiled and summarised.

The study was approved by the University of Melbourne HREC (No.23319).

RESULTS

All participants showcased excitement and enthusiasm throughout the VR experience. Participants were able to perform basic grasping tasks in the virtual environment within the session time. All participants reported a good understanding of the potential benefits of transitioning to a myo-electric prosthesis and a willingness to make the transition.

DISCUSSION AND CONCLUSION

The key benefit we observed from participants after the VR session was that they built self-belief and motivation. Self-belief that a myo-electric prosthesis will be beneficial for their lifestyles and to achieve their goals. And motivation to prepare for a myo-electric prosthesis. This behavioural change has the potential to bring a positive impact in the journey of people adopting myo-electric prostheses and may provide meaningful, subjective and objective information for clinical report writing.

ACKNOWLEDGEMENTS

We would like to acknowledge the support provided by Ottobock Australia in the execution of this pilot.



5.073 Development of a Virtual Reality Environment for the Assessment of Prosthetic Functional Outcome Measures

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BACKGROUND

Approximately 8% of the U.S. population lives with upper limb absence, significantly impacting daily activities and quality of life. This highlights the need for prostheses that are functional and user-friendly, but current methods for evaluating prosthesis control and function require time- and cost-intensive fittings. Previous research suggests that virtual control may predict a user's ability to control a prosthetic device [1], enhancing clinicians' and researchers' ability to assess user suitability and predict functional outcomes prior to fitting.

AIM

The aim of this study is to develop an immersive virtual reality (VR) system in which users perform clinical outcome assessments that allows comparison to physical upper limb prosthesis performance

METHOD

The VR software package was built using the Unity engine for deployment to Meta Quest devices. Meta Quest devices track user movements to enable immersive gaming experiences. A key feature of the system is a generic software asset, which translates control signals from our custom-developed pattern recognition controller (Control Algorithms for Prosthetics, CAPS) into VR hand and wrist control inputs. Currently, Bluetooth Low Energy (BLE) is used to transmit data from the controller to the application on the headset.

RESULTS

We have developed an immersive VR platform integrated with our internal controller allowing for evaluation of various control strategies, including 2-site EMG control with various switching algorithms and with pattern recognition control. Though the system is modular and can be expanded to evaluate various control calibration strategies and functional tasks, it is currently being used to create virtual versions of clinical assessments commonly employed to evaluate myoelectric prosthetic control, including the box-and-blocks test (Figure 1A), the clothes pin task (1B), the Southampton Hand Assessment Procedure Abstract Objects (SHAP; 1C) and the Target Achievement Control (TAC) test—a Fitts' Law posture matching task (1D). These measures are now being used to understand how performance in VR correlates with performance using a physical prosthesis using both 2-site EMG control and pattern recognition control.

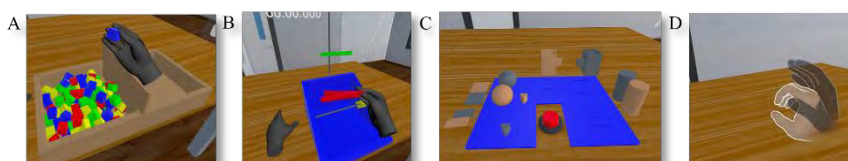


Figure 1. Virtual Reality Box and Block (A) Clothespin Relocation Task (B), SHAP Abstract (C) and TAC test (D)

DISCUSSION AND CONCLUSION

The new immersive VR system enables individuals with upper limb absence to test and predict their prosthetic control abilities before using a physical device, providing valuable data to optimize prosthesis function and personalization. Along with reducing costs and creating a more optimized prosthesis for the user, a VR prediction platform will provide useful tools to evaluate new control algorithms, training protocols, and prosthetic devices.

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5.074 Refining Criteria in the Assessment of Capacity for Myoelectric Control for Multi-articulating Hands

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BACKGROUND

Multi-articulating hands offer increased functionality compared to single degree of freedom prostheses. While users prefer their enhanced features¹, mastering these hands presents challenges. The Assessment of Capacity for Myoelectric Control (ACMC), originally designed for single-DOF hands, evaluates myoelectric control in bimanual activities. However, it lacks items to assess the nuanced control required for multi-articulating hands, such as grip-switching. New assessment items are needed to capture these advanced control skills.

AIM

We developed three new ACMC items to assess multi-articulating hand control skills. Video analysis and expert consensus was used to evaluate these items across individuals with various multi-articulating hand prostheses.

METHOD

Four experienced raters (occupational therapists and researchers) developed new ACMC items for multi-articulating hands: (1) Ability to switch grips; (2) Positioning the hand appropriately for grasping; and, (3) Choosing a secure grip for function. Two additional certified raters provided feedback based on their research experiences. The process involved:

- I. Initial meetings to refine item definitions
- II. Ethical approval for sharing ACMC videos.
- III. Independent scoring of videos by raters.
- IV. IV. Compilation of scores and justifications by a facilitator.
- V. Group discussions of results led by the facilitator.

This collaborative approach aimed to create comprehensive assessment items for advanced prosthetic hand control.

RESULTS

During consensus meetings, raters discussed individual scores in relation to item wording and rating scale definitions. For instance, the initial definition of "Ability to switch grips" focused on mechanics of switching and accessing available grips consistently and accurately. Video analysis revealed instances of unintended or delayed grip switching due to unfamiliarity with the prosthetic hand, limited control ability, or missed opportunities to switch grips. Initially, raters scored these instances as 1 or 2 on the 0-3 point rating scale. Through collaborative discussions, raters with diverse experiences refined their understanding of the assessment criteria. This process led to a more unified interpretation of the rating scale. After deliberation, all raters reached a consensus, agreeing on a score of 2 for the examples discussed, reflecting a shared understanding of the assessment criteria.

DISCUSSION AND CONCLUSION

We refined new ACMC item definitions for evaluating multi-articulating hand control using video analysis and consensus methods. This process, involving raters with diverse backgrounds, strengthened the definitions and clarified assessing multi-articulating hand function. The improved definitions include more comprehensive language, examples, and specific scoring details, enhancing item interpretability. The next step is validating these new items alongside existing ones with multi-articulating hand users in an international, multi-center study.

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5.075 Parents expectations before prosthetic fitting: meeting reasonable criteria or chasing the unicorn

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BACKGROUND

A key component of prosthesis acceptance is consideration of the user's needs^[1,2]. However, there is a big gap between meeting detailed and motivated goals and wrongly formed expectations that can not possible be satisfied.

AIM

The purpose of the study is to assess the typical expectations parents might have before a prosthetic fitting.

METHOD

Quantitative prospective study by the method of questioning (02.2021- 09.2024). At the time of the survey, all study participants were about to receive an active upper limb prosthesis. The questions were open, so the parents were able to share any idea on the topic they might have.

RESULTS

173 parents were interviewed. The main expectations were: improve general health, widen functional abilities, provide future comfort/ability to use prosthesis, psychological comfort, aesthetics, random try, no expectations. 60 respondents (34,5%) mentioned 2 or more types of expectations, while 98 (57%) named only 1. Among the last group, the most common expectation were to widen functional abilities (40%) and to improve general health (40%). However, out of 60 parents who aimed to improve the child functional abilities, only 17 people (28%) managed to name specific functional goals. Psychological comfort was named as the only reason for prosthetics only in 9 cases (5%). But it was commonly named as a second expectation. Parents hope that the child will "feel normal", "believe in himself", "socialize", "stop hiding hand". Meanwhile, none of the children have ever received psychological help. 5 respondents (3%) mentioned the future opportunity to get a modern device as a current reason for prosthetics. 7 respondents (4%) were receiving a device to «give it a try», while 15 (8,5%) - did not have any expectations.

DISCUSSION AND CONCLUSION

Parents might have different expectation regarding prosthetic. Thought the improvement of functionality is one of the most common one, most of the parents don't set specific functional goals. Therefore, they might be unaware of further steps and may lack training motivation. Also, parents have high expectations regarding the effect of the prosthetic on the child's psychological comfort. Some of the kids might need psychological help, however they don't receive any. Parents put their hopes on the prosthesis to completely solve the issue. There is a group of people who do not have any expectations that can be caused either by the lack of information or by the lack of motivation. The future research on the expectations, effects on the device usage and preparation for prosthesis fitting is needed.

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5.076 Exploring the creation of illusions of phantom limb movements using cutaneous vibrations in the population with upper limb absence

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BACKGROUND

Previous studies have shown that the proprioceptive sense can be manipulated using vibrations over the skin [1,2]. Vibrating muscles with the correct stimulation characteristics can induce illusory movements of the connected joints [3,4,5]. However, research has focused on able-bodied participants. Hence, it was not known if people with limb absence similarly experience the phenomenon although two studies suggested it [6,7]. Evoking these phantom limb movements can then be used to further explore this methodology as intuitive and genuine sensory feedback for prosthetic limbs.

AIM

This study investigated if illusions of arm movements can be induced in people with upper limb amputation or congenital upper limb loss.

METHOD

Sixteen participants with upper limb absence were recruited (age 24-79, 8 females, 9 transhumeral / 7 transradial limb level, 8 congenital / 8 acquired limb difference). The biceps of their shorter arm was stimulated using a vibration motor multiple times. After every stimulation, the subjects were asked to describe any illusions of a movement and rank their characteristics (vividness, duration, range of movement). The vibration frequency (50Hz, 70Hz, 90Hz, 110Hz), the stimulation site (muscle belly, proximal and distal tendon if available) and the arm position (extended next to the body and fixed in a frame) were changed randomly. A three-way ART ANOVA was performed to evaluate the effect of frequency, stimulation site and arm position.

RESULTS

Overall, 14 out of 16 participants (87.5%) reported feeling an illusion. The hanging arm position led to the experience of longer, more vivid illusions of arm movements with a greater range of movement than when the arm was fixed in its position. Also, the interaction of the hanging arm and the muscle belly led to significantly more vivid illusions than the proximal tendon. Interaction of 70Hz and the hanging arm position resulted in significantly longer illusions than when the fixed arm was stimulated at 110Hz. However, higher frequencies of 110Hz evoked illusions of movements with a greater range while the arm was hanging than using 50Hz.

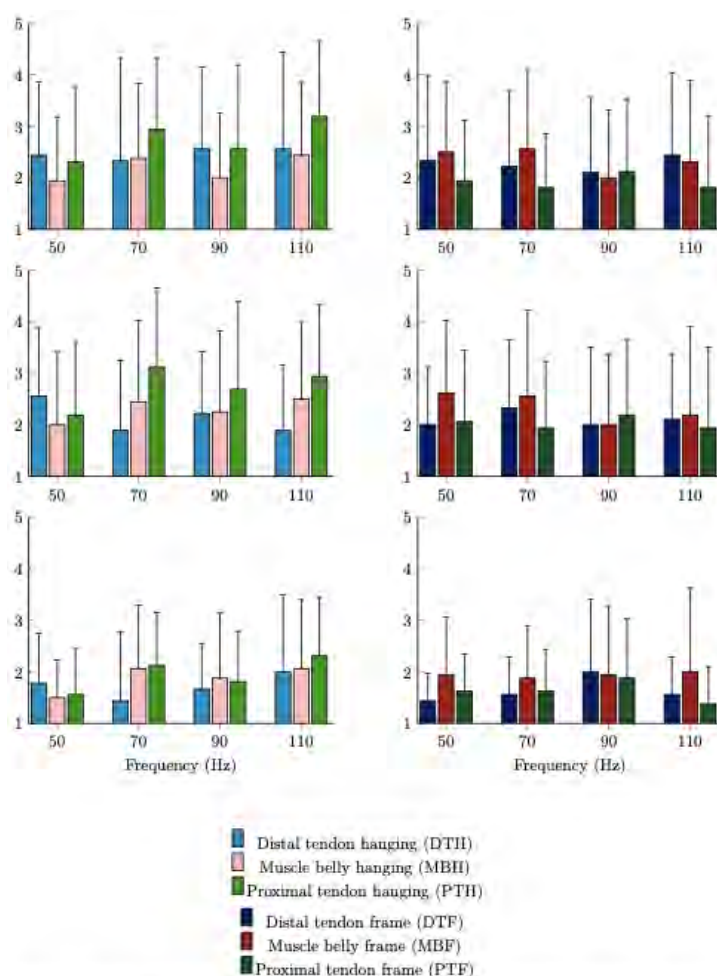


Figure 1 : Means and standard deviation for the ranked factors (vividness, duration, range of movement) of the illusion across all frequencies for the different stimulation sites and both upper arm positions



DISCUSSION AND CONCLUSION

It was possible to create illusions of arm movements in participants with an upper limb amputation and a congenital upper limb absence. A comparison to studies investigating this phenomenon in unimpaired subjects revealed that the percentage of participants feeling an illusion was in the same range (87.5% compared to 70-100%). Remarkably, a person who never possessed an elbow felt the movement of a phantom elbow.

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Free paper session | Orthotics: lower limb and footwear – Foot Orthoses

5.081 The Effect of Medially Wedged Foot Orthoses on Peroneus Longus and Tibialis Posterior Muscle Activities - A Literature Review

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BACKGROUND

Medially Wedged Foot Orthoses are a common orthotic prescription in the conservative management of symptomatic flatfoot, amongst other conditions. Limited information is available regarding their effects on the muscle activities of the foot's main pronators and supinators.

AIM

To evaluate all available literature relating to the effect of Medially Wedged Foot Orthoses on Peroneus Longus and/or Tibialis Posterior muscle activities.

METHOD

Literature searching was carried out across four databases (Medline, Embase, CINAHL, Cochrane Library). Publications were screened and chosen according to their relevance to the literature review's aims. Scottish Intercollegiate Guidelines Network (SIGN) checklists were used to grade the quality of each included publication.

RESULTS

A clear relationship exists between the decrease in Tibialis Posterior peak values and Medially Wedged Foot Orthoses, but the effects on muscle timing and activation are unclear due to poor publication results. Results pertaining to Peroneus Longus timing, activation, and peak values are conflicting—some indicating an increase, and others a decrease—with medial wedging.

DISCUSSION AND CONCLUSION

There is strong evidence regarding the effects Medially Wedged Foot Orthoses have on Tibialis Posterior activity and the minimum inclination level required for a meaningful change in its activity. However, more high-quality research relating to the effects on Peroneus Longus is required to unlock the devices' full potential and maximise its impact across various treatment pathways.



5.082 Predictors of Effective Treatment with Customized Foot Orthoses for Adults with Flexible Flatfoot – Pilot study

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BACKGROUND

Flexible flatfoot is a postural deformity characterized by subtalar joint pronation and a collapsed medial longitudinal arch (MLA) during weight-bearing, which reappears in non-weight-bearing. Our study demonstrated that customized foot orthoses (FO) significantly improve MLA support and rearfoot alignment.¹ Identifying variables that predict treatment effectiveness could assist health professionals in designing foot orthoses. However, few studies have investigated kinematic variables predicting responses to FO.

AIM

This study aims to investigate which variables predict improvements in MLA support and rearfoot alignment following one month of FO use in adult males with flexible flatfoot.

METHOD

Data for this study were sourced from the published article.¹ The participants included 12 adult males with flexible flatfeet. Gait motion analysis was performed under two conditions: (1) without insole (Flat) and (2) over one month after using FO (FO1m), using Vicon motion capture system. Multiple linear regression models, based on kinematic parameters in the Flat condition — including static navicular drop (StNdrop), dynamic navicular drop (DyNdrop_Flat), dynamic navicular drift (DyNdrift_Flat), and maximum rearfoot angle (RFAMax_Flat). The dependent variables were dynamic navicular drop (Δ DyNdrop) and maximum rearfoot angle during stance phase (Δ RFAMax), calculated as difference between Flat minus FO1m condition.

RESULTS

In this study, data from 12 participants (age: 20.75 ± 3.02 years, body mass index: 21.59 ± 1.87) were analyzed, with left and right foot measurements treated as independent sample. The standardized histogram of residuals showed an approximately normal distribution, supporting the regression model's assumptions. The multiple regression model predicting Δ DyNdrop was statistically significant, $F(4, 19) = 2.977$, $p = .046$, with DyNdrop_Flat as a significant predictor ($\beta = .310$, $p = .004$). The model explains 38.5% of the variance in Δ DyNdrop ($R^2 = 0.385$), indicating a moderate fit. In contrast, the multiple regression model predicting Δ RFAMax was not significant, $F(4, 19) = 1.367$, $p = .283$, $R^2 = .223$. However, DyNdrift_Flat approached significance ($\beta = .553$, $p = .062$), suggesting a possible relationship (Table 1).

Table 1: Multivariable linear regression models for improvements in MLA support and rearfoot alignment.

Dependent variable	Independent variable	B (SE β)	t-value	P-value
Δ DyNdrop $F(4, 19) = 2.98$, $p = 0.046$	StNdrop	-0.01(0.13)	-0.02	0.982
	DyNdrop_Flat	0.31(0.09)	3.28	0.004*
	DyNdrift_Flat	0.09(0.17)	0.53	0.604
	RFAMax_Flat	-0.02(0.12)	-0.18	0.861
Δ RFAMax $F(4, 19) = 1.37$, $p = 0.283$	StNdrop	0.25(0.21)	1.19	0.249
	DyNdrop_Flat	-0.14(0.15)	-0.93	0.365
	DyNdrift_Flat	0.55(0.28)	1.98	0.062
	RFAMax_Flat	0.28(0.19)	1.44	0.165

Abbreviations: SE, standard error.

* Statistical significance P-value < 0.05.



DISCUSSION AND CONCLUSION

Our results suggest that the effectiveness of foot orthotics on medial longitudinal arch (MLA) support in adult males with flexible flatfoot, as represented by $\Delta\text{DyNdrop}$, is significantly predicted by DyNdrop_Flat . While rearfoot alignment, indicated by ΔRFAMax , was not significantly impacted, DyNdrift_Flat approached significance, suggesting a potential predictive factor. Future studies with larger samples could improve prediction models and potentially enhance foot orthotic design for flexible flatfoot management.

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5.083 In-Depth Design and Plantar Pressure Analysis of Indoor versus Regular Custom-Made Footwear in People with Diabetes at High Ulcer Risk

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BACKGROUND

Custom-made footwear specifically designed to use indoors increases adherence to prescription footwear in people with diabetes, peripheral neuropathy and high ulcer risk, compared to using only regular custom-made footwear. A pilot study also showed similar peak pressures with regular footwear, a quality requirement considering the indoor footwear replaces the regular footwear for indoor use. A more in-depth analysis of the pressure distribution and design characteristics of this indoor footwear in a representative sample of subjects is yet to be conducted. Such investigation can certify if indoor footwear is a biomechanically safe replacement for regular custom-made footwear for indoor use.

AIM

To compare indoor and regular custom-made footwear for design and pressure distribution in people with diabetes at high risk of ulcer development.

METHOD

Custom-made indoor footwear was provided to 36 participants with diabetes, peripheral neuropathy, and a recently healed plantar foot ulcer or (partial) foot amputation. All participants were in possession of regular pressure-optimized custom-made footwear and the indoor footwear was designed based on the last of the regular footwear. Both regular and indoor footwear were assessed for shoe design elements and agreement in design was calculated using Cohen's Kappa. In-shoe plantar pressures were measured during walking in both shoes, from which multiple peak plantar pressure parameters were calculated. Peak pressure distributions in spatial and temporal domains were assessed between footwear types using paired t-tests and statistical parametric mapping.

RESULTS

A total of 132 shoes, 66 per footwear type, of 36 participants were analyzed. Cohen's Kappa for agreement on design elements was highest for the insole top cover ($\kappa=0.72$), insole heel cup ($\kappa=0.51$), insole heel lift ($\kappa=0.47$) and insole transmetatarsal bar ($\kappa=0.42$), and lowest for outsole heel lift ($\kappa=-0.17$). Agreement for other shoe and insole design elements ranged from $\kappa=0$ to $\kappa=0.37$. Outcomes for all peak pressure parameters were non-significantly higher in the indoor compared to regular footwear. Maximum difference in the forefoot regions was 10.14 kPa for maximum peak pressure, 1.22 kPa.s for pressure time integral and 0.13 kPa/mm for the pressure gradient.

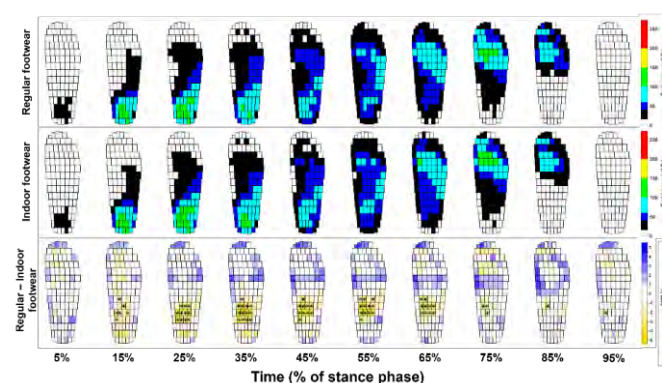


Fig. 1: Peak plantar pressure distribution of regular and indoor custom-made footwear in a pressure time map. The bottom row shows the statistical comparison between both types of footwear. Blue = peak plantar pressure regular > indoor footwear, yellow = peak plantar pressure indoor > regular footwear.

Overall pressure distribution over time for all participants is shown in Fig.1.

DISCUSSION AND CONCLUSION

No significant differences were found in pressure distribution using different pressure analysis methods between footwear types, despite differences found in footwear design. The results show that custom-made indoor footwear is a biomechanically safe alternative for use indoors to regular custom-made footwear in people with diabetes at high risk for foot ulceration.



5.084 Exploring Unknowns in Footwear Design for People with Diabetes at Moderate-to-High Risk of Foot Ulceration: a Knowledge Gap Analysis

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BACKGROUND

Custom-made footwear can help prevent foot ulcers in people with diabetes at moderate-to-high ulceration risk. Current footwear designs however appear largely based on principles not focused on this target population, likely misrepresenting the true biomechanical and user needs for footwear for this group at risk. To better guide future research on footwear design effectiveness, insight is needed on the extent to which design features are investigated in different populations.

AIM

To identify knowledge gaps in footwear designs for people with moderate-to-high risk of foot ulceration.

METHOD

We conducted a knowledge gap analysis through a systematic search of PubMed and EMBASE, focusing on footwear interventions and biomechanical and user-related outcomes. Only experimental studies in English were included. Two reviewers screened titles, abstracts, and full texts for eligibility. Publications were categorised into direct evidence (studies done in the target population) and indirect evidence (other populations), covering 16 footwear design interventions, 4 biomechanical and 3 user-related outcomes. Each included paper was labelled with its population, one or more intervention(s) and outcome(s). The publication count per combination identified the extent of the knowledge gaps.

RESULTS

Of the 5813 papers identified, 289 were included. Of these, 10% provided direct evidence, and 90% indirect evidence (see table 1). Biomechanical and user-related outcomes were studied in 72% and 19% of publications, respectively, and 9% studied both biomechanical and user-related outcomes. For 75% of the interventions, none or <5 studies were done in the target population.

Table 1: Study volumes (n) by footwear interventions and outcomes, categorised as direct and indirect evidence

Notes 1: Colour codes represent study label volume: red = 0, orange = 1 - 4, yellow = 5 - 20, light green = 21 - 40, and dark green = 41 - 55; Footwear type numbers may overlap with footwear components, as some studies fall into both categories

			FOOTWEAR											
			components									type		
DIRECT EVIDENCE	Biomechanical outcomes	Pressure, shear stress, center of pressure, balance	Midsole	Outsole (not specified)	Outsole (rocker sole)	Insole (not specified)	Insole (metatarsal pad)	Insole (heel or forefoot wedge)	Insole (medial arch support)	Insole (cover material)	Upper	Pre-fabricated medical grade	Custom-made	Pre-fabricated
			0	1	3	11	0	0	0	0	0	5	18	0
	User-related Outcomes	Usability & experience, quality of life, adherence	0	0	1	1	0	0	0	0	0	1	9	0
	Biomechanical outcomes	Pressure, shear stress, center of pressure, balance	7	8	52	67	8	13	10	41	7	141	63	45
INDIRECT EVIDENCE	User-related Outcomes	Usability & experience, quality of life, adherence	6	0	7	30	0	14	5	1	3	45	27	10

DISCUSSION AND CONCLUSION

Design principles for footwear for people with diabetes at moderate-to-high risk of foot ulceration are primarily based on indirect evidence, with significant gaps in studies made in the targeted population. There is a particular need for research on user-related outcomes, specific biomechanical principles such as shear stress, and shoe upper designs. We therefore stress the need to prioritise footwear research done in the target population and, based on these identified limitations, obtain more valid outcomes and knowledge on footwear design and, with that, help reduce ulceration risks in the target population.



5.085 Experiences of Parkinson's patients using peroneal nerve functional electrical stimulation: a qualitative study within a feasibility randomized control trial

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BACKGROUND

Public and Patient Involvement and Engagement (PPIE) and embedded qualitative research are increasingly valued in both feasibility and full trials. Well-planned PPIE fosters active partnerships in research design and management. Embedding qualitative research provides insights into participants' everyday experiences with interventions, capturing aspects beyond typical trial outcome measures.

AIM

To present a series of PPIE and qualitative studies embedded within a feasibility trial evaluating the effectiveness of Peroneal Nerve Functional Electrical Stimulation in reducing bradykinesia in Parkinson's disease.

METHOD

Study Design: A longitudinal qualitative study, informed by PPIE, using semi-structured telephone interviews with pre- and post-interviews for control and intervention groups in a multi-centred feasibility trial.

Participants and Recruitment: All eligible candidates meeting RCT criteria were invited via study information packs. Convenience and purposive sampling ensured diverse perspectives, balancing representation across groups. Ethical approval covered invitations to those declining or withdrawing from the study.

Data Collection: An independent researcher conducted 20-50 minute interviews, primarily by telephone. Recordings were taken for analysis.

Data Analysis: Thematic analysis was used, involving five steps: 1) identifying an initial analytical framework, 2) generating initial codes, 3) identifying and reviewing themes, 4) defining and naming themes, and 5) verifying final themes. Pre- and post-interviews were analyzed separately to capture all aspects of study participation and FES use.

RESULTS

A total of 58 interviews were conducted: 1) pre-study interviews before randomisation (n=24), 2) post-study interviews with the intervention group (n=12), 3) post-study interviews with the control group (n=12), 4) interviews with participants who withdrew (n=5), and 5) interviews with eligible participants who declined (n=5). Key themes from pre-study interviews provided insights into living with Parkinson's, motivations for trial participation, and initial trial experiences. Post-study interviews with the FES group revealed perceived improvements in walking and mobility, psychosocial benefits of enhanced mobility, daily experiences with FES, and suggestions for trial improvements.

DISCUSSION AND CONCLUSION

The key themes provide valuable insights into living with Parkinson's disease, complementing the growing body of qualitative research. Key issues included the impact of reduced mobility and falls on daily life and the importance of controlling symptoms. The study offered clear insights into participants' motivations for joining and the perceived value of the intervention, contributing to the evidence base. The longitudinal approach enabled an in-depth understanding of experiences throughout the trial. The study also highlighted key areas for future research on FES's impact on individuals with Parkinson's.

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Free paper session | Orthotics: spinal – Treatment

5.091 Trunk Appearance Perception and Quality of Life of the Patients with Adolescent Idiopathic Scoliosis undergoing Orthotic Treatment: A Pilot Study

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BACKGROUND

Orthotic treatment is a non-operative approach for managing moderate adolescent idiopathic scoliosis (AIS) to prevent from further deterioration. The severity of spinal deformity & application of orthosis could affect trunk appearance perception, and potentially disturb quality of life (QoL) [1]. Some research studies showed that female patients generally report lower QoL than male patients [2]. However, the specific impact of trunk appearance perception on QoL in the females and males with AIS undergoing orthotic treatment remains inadequately addressed.

AIM

To investigate the correlation between trunk appearance perception and QoL of the females and males with AIS and undergoing orthotic treatment.

METHOD

The patients with moderate AIS and undergoing orthotic treatment were included and the QoL evaluations were conducted before treatment, in the 1st month, and the 7th month of orthotic treatment. The evaluations included the Trunk Appearance Perception Scale (TAPS), Scoliosis Research Society-22r (SRS-22r), and Brace Questionnaire (BrQ). The study time points were to capture baseline conditions, initial adaptation and longer-term treatment effects. Gender differences in questionnaire responses were evaluated using the Mann-Whitney U test. Spearman's rank-order correlation coefficients were used to examine the correlations between TAPS, SRS-22r, and BrQ results and clinical characteristics for both genders.

RESULTS

Twenty-nine females and ten males were included in this study. There was no significant difference between females and males in TAPS and SRS-22r scores before and at the early stages of orthotic treatment. In males, lower treatment compliance and shorter treatment duration correlated with better TAPS results ($p < 0.05$), whereas such a correlation was not observed in females. By the 7th month, females demonstrated higher BrQ scores than males, particularly in the general health perception and physical functioning (Figure 1). In males, BrQ scores initially showed significant correlations with TAPS scores ($p < 0.05$), but this correlation diminished after 7 months. In females, the SRS-22r total scores were consistently associated with the self-esteem and aesthetics scores in BrQ throughout the treatment period. Both genders reported challenges with self-image, self-esteem and aesthetics.

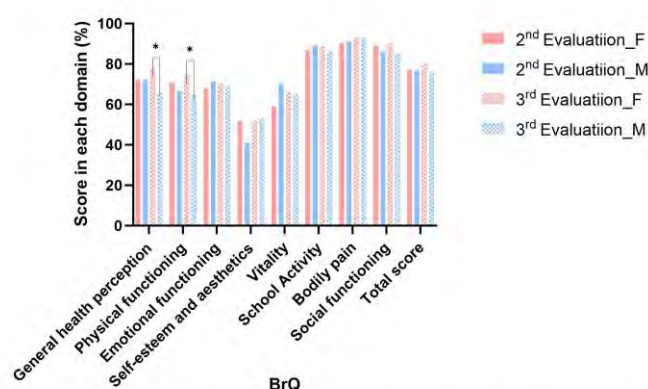


Figure 1. BrQ scores for females (F) and males (M) in the 2nd and the 3rd evaluation time points. * significant level at $p < 0.05$.

DISCUSSION AND CONCLUSION



This study could not support the previous findings for the females with lower QoL than males. Both genders showed lower self-image and self-esteem during the orthotic treatment. Enhancing trunk appearance perception may improve QoL for both. The QoL of females was more correlated with self-esteem and aesthetics, while the QoL of males correlated with orthosis wearing compliance and treatment duration. Future research with larger samples and longer durations is deserved for a comprehensive understanding.

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5.092 Comparison of Plane of Maximum Curvature (PMC) and Non-PMC Oriented Controlling Force Applications in Spinal Orthoses for Adolescent Idiopathic Scoliosis

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BACKGROUND

Adolescent Idiopathic Scoliosis (AIS) is a common spinal deformity in adolescents with unknown causes, often managed with spinal orthoses [1]. The traditional 2D Cobb angle assessed via coronal radiography may not adequately reflect the 3D complexity of AIS for effective orthotic design. The Plane of Maximum Curvature (PMC), defined as the vertical plane between the sagittal and coronal planes that presents the maximum spinal curvature [2], could provide valuable 3D insights for understanding spinal deformities and optimizing orthotic controlling force application [3].

AIM

This study evaluates the effectiveness of PMC-oriented group (controlling forces acting within $\pm 15^\circ$ of the PMC) versus non-PMC-oriented group (controlling forces acting outside $\pm 15^\circ$ of the PMC) in the designs of spinal orthosis for managing AIS.

METHOD

This study included the participants with progressive AIS and primary curves between 21° and 45° treated with rigid underarm spinal orthoses. CAD/CAM-modified torso models were used for orthosis fabrication. Radiographic data included pre-orthosis X-rays and initial in-orthosis X-rays. The primary outcomes were the changes of the coronal Cobb angles and apical vertebral rotation (AVR) from the pre-orthosis to the immediate in-orthosis conditions of the two groups.

RESULTS

Both the PMC group ($n = 30$) and non-PMC group ($n = 40$) showed significant reductions in coronal Cobb angles from pre-treatment to in-brace conditions: from $32.3^\circ \pm 6.8^\circ$ to $19.5^\circ \pm 8.5^\circ$ ($\downarrow 12.8^\circ \pm 6.5^\circ$, $p < 0.05$) for the PMC group, and from $31.7^\circ \pm 6.1^\circ$ to $20.9^\circ \pm 7.8^\circ$ ($\downarrow 10.8^\circ \pm 6.7^\circ$, $p < 0.05$) for the Non-PMC group. However, comparisons between the groups showed no statistically significant differences in mean reductions ($p > 0.05$). AVR changes were minimal, with the PMC group showing a decrease of $0.7^\circ \pm 0.3^\circ$ and the non-PMC group showing a decrease of $0.4^\circ \pm 0.3^\circ$, both non-significant ($p > 0.05$). Between-group comparisons for AVR changes also indicated no significant differences ($p > 0.05$).

Table 1. Comparison of Pre-Brace and In-Brace Outcomes with Within-Group and Between-Group p-values for PMC and Non-PMC Groups in AIS Management

Parameters	PMC Group (n=30)	Non-PMC Group (n=40)	Within Group p-value	Between- Group p-value
Pre-brace Coronal Cobb Angle ($^\circ$)	32.3 ± 6.8	31.7 ± 6.1	$p < 0.05$	
In-brace Coronal Cobb Angle ($^\circ$)	19.5 ± 8.5	20.9 ± 7.8		
Change in Coronal Cobb Angle ($^\circ$)	$\downarrow 12.8 \pm 6.5$	$\downarrow 10.8 \pm 6.7$		$p > 0.05$
Pre-brace AVR ($^\circ$)	24.2 ± 3.0	25.5 ± 2.7	$p > 0.05$	
In-brace AVR ($^\circ$)	23.5 ± 3.3	25.1 ± 2.7		
Change in AVR ($^\circ$)	$\downarrow 0.7 \pm 0.3$	$\downarrow 0.4 \pm 0.3$		$p > 0.05$

DISCUSSION AND CONCLUSION



The study showed that the PMC and non-PMC oriented groups had similar correction effects, with both demonstrating comparable reductions in coronal Cobb angles and minimal impact on AVR. The PMC-oriented design did not demonstrate a better clinical outcome than the non-PMC-oriented design at the initial stage of treatment. Consistent applications of controlling forces at the optimal orientations remain essential for long-term management of AIS. Future studies should focus on identifying the optimal corrective force direction tailored to individual patient characteristics to enhance personalized AIS management and improve the final treatment outcomes.

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5.093 The Impact of Self-Stretching vs 3D Machine-Stretching Exercises on the Efficacy of Orthotic Treatment for Patients with Adolescent Idiopathic Scoliosis

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BACKGROUND

Adolescent idiopathic scoliosis (AIS) is a common spinal deformity affecting adolescents, generally managed with spinal orthosis for moderate cases [1]. Previous research showed that greater spinal flexibility strongly correlates with initial in-orthosis correction [2]. Self-stretching and 3D machine-stretching have been used for improving spinal flexibility [3-4]. However, the effect of self-stretching and 3D machine-stretching exercises in enhancing orthotic treatment remains underexplored.

AIM

To compare the effect of self-stretching and 3D machine-stretching exercises in preparation of orthotic treatment for patients with AIS.

METHOD

This prospective study recruited participants with AIS, age 10-16, Risser 0-2, Cobb 20-45° and no prior treatment, and those with contraindications to exercise/traction or other spinal pathology were excluded. The eligible participants were randomly divided into two groups: one performing one month of daily 30-minute self-stretching exercises (SE) and the other receiving 14 days of daily 28-minute 3D machine-stretching exercises (MS) between the orthosis prescription and the first orthosis fitting. The primary outcome measures were the curve flexibility (CF) and Cobb angle (CA). Independent t-tests were used to compare baseline and outcome measures between groups, and paired t-tests were used to assess pre- and post-intervention differences within groups.

RESULTS

A total of 15 subjects were enrolled in the SE and 19 subjects in the MS. For the subjects of SE, the CF was significantly increased from 0.63 to 0.75, and the CA was reduced from 25.50 to 14.31 in the orthosis ($p<0.001$). For ST subjects, the CF was significantly increased from 0.59 to 0.79, and the CA was significantly decreased from 20.4 to 7.54 in the orthosis ($p<0.05$). When comparing the CF after the self-stretching exercises (0.75) and after machine-stretching exercises (0.79), there was no significant difference between two groups ($p=0.07$). However, when comparing the in-orthosis CA and in-orthosis correction rate, the MS was significantly better than SE with a lower CA and a higher correction rate ($p<0.05$). The comparison of the two groups is presented in Table 1.

Table 1. The comparison of the two groups			
Characteristics	SE (N=15)	MS (N=19)	P value
Age	13.60±1.12	13.68±1.16	0.83
Gender (female, %)	13 (86.7%)	14 (73.7%)	0.43
BMI	17.35±1.85	17.17±1.81	0.77
ATI	0.98±1.01	0.86±0.73	0.68
AVR (no, %)			0.44
0	2 (13.3%)	4 (21.1%)	/
1	5 (33.3%)	9 (47.4%)	/
2	8 (53.3%)	6 (31.6%)	/
Risser sign (no, %)			0.70
0	3 (20.0%)	5 (26.3%)	/
1	1 (6.7%)	0	/
2	3 (20.0%)	4 (21.1%)	/
3	8 (53.3%)	10 (52.6%)	/
Curve type (cases, %)			0.23
Single	4 (26.7%)	10 (52.6%)	/
Double	11 (73.3%)	9 (47.4%)	/
CA (degrees)	25.50±8.48	20.43±4.01	0.06
Kyphosis (degrees)	27.10±9.35	28.07±11.97	0.83
Lordosis (degrees)	32.50±11.66	34.80±8.86	0.58
Pre-CF	0.63±0.21	0.59±0.25	0.45
Post-CF	0.75±0.15	0.79±0.18	0.07
In-orthosis CA (degrees)	14.31±8.59	7.54±2.94	0.002*
In-orthosis Cobb correction rate (%)	0.46±0.22	0.63±0.16	0.003*

DISCUSSION AND CONCLUSION

The CF was significantly improved after self-stretching exercises, which was consistent with our previous published work [5]. However, only initial in-orthosis corrective outcomes were acquired in this study, which may limit the generalization of the findings. A longer-term follow-up is needed. In conclusion, both methods are beneficial for the corrective outcomes of patients with spinal orthotic treatment, but the use of 3D machine-stretching system appears to offer a superior outcome in terms of Cobb angle correction when compared to self-stretching exercises.

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5.094 Strategies for successful 3-D printed spinal brace application to Cancer survivor through accurate assessment and evaluation – Clinical case study

G Pandian

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BACKGROUND

After evaluating the effects of Leg Length Discrepancy, (LLD) on her body, aside from walking difficulties, a 17-year-old girl with 4" of left LLD reported that her left hip joint and 4 inches of her proximal femur had been removed due to cancer, the cause of LLD. She also developed non-structural scoliosis with a Cobb's angle of 28°. The best action was to prescribe 3D-modified spinal brace and shoe compensation.

AIM

The objective of the clinical approach is to compensate LLD and maintain horizontal pelvic alignment to provide maximum corrective impact on the spine, correcting scoliosis.

METHOD

It became difficult to get her to stand and walk and to correct her scoliosis because she lacked an anatomical hip joint. With the aid of AI Enabled Reverse Engineering Software, the spinal brace was Digitally Designed and then printed with the help of 3D Printer, and footwear was created. Wearing shoes helped to keep the forces applied by the spinal brace and pelvis in the right places. The anterior horns Customised 3D Printed spinal brace allowed for a snug fit. The effectiveness of the pressure pads was tracked and modified, benefits for correction included client support and effective suspension.

RESULTS

Posture analysis using GAIT ON software was conducted after a year of continuous use, and the results demonstrated a significant improvement in both postural correction and scoliosis. To maintain the pelvis in the desired position, the girl's height has increased over the past three years, so the shoe height compensation has also been carefully adjusted for both indoor and outdoor footwear. The curvature was reduced to less than 15° after three years of consistent, ongoing rehabilitation. A reassessment revealed that modified TLSO is better suited to maintaining posture and correcting curvature. Thus, on November 1st, 2024, the girl is fitted with LTTP TLSO. The deformity will be better controlled by the TLSO's effect.



Figure 1. Post analysis of 3D Spinal brace

DISCUSSION AND CONCLUSION

In order to control the spinal deformity and correct posture, the treatment plan was carefully planned. A successful rehabilitation depends on a methodical approach and careful considerations. The clinical results and analytical results assist us in determining the best course of treatment. The treatment approach planned using Industry 4.0 Tools made it simple to get the best possible outcome in a shorter amount of time than anticipated.

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5.095 Exploring the spinal kinematics of hyperextension brace

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BACKGROUND

Thoracolumbar spinal bracing is commonly used to treat stable spinal fractures in patients. However, the use of spinal bracing remains controversial (NICE 2022). Arguments for and against spinal bracing use qualitative measures such as healing time, complications, and pain scales. There is a distinct lack of quantitative evidence concerning the kinematics of spinal bracing due to the difficulty in performing such studies and the lack of standardisation between experiments. In addition, no previous studies have examined the kinematic effects of different brace fits, brace during gait.

AIM

This pilot study was designed to report the kinematic effects of a thoracolumbosacral orthosis (TLSO) hyperextension spinal brace during ambulation. Additionally, the study examined the kinematic differences between wearing a well-fitted brace and a poorly-fitted brace during gait.

METHOD

Following ethical approval, six healthy participants were recruited for this study. The study assessed the range of motion in the thoracic, lumbar, and pelvic segments during level ground walking under three conditions: wearing a properly fitted brace, an ill-fitting brace, and no brace. Kinematic data were collected using a novel 3-D cluster-based marker set in conjunction with the standard IOR marker set. Data reduction was conducted using a vector coding approach, allowing analysis of segmental coordination, coordination variability, and range of motion.

RESULTS

Statistically significant differences were observed across the three conditions. Specifically, differences were noted between the lumbar and pelvis in the coronal plane (when comparing the no-brace condition to both brace conditions), between the thorax and pelvis in the transverse plane (no-brace vs. brace condition), and between the ill-fitting brace and no-brace conditions in the coronal plane. Notably, despite the small sample size, the data demonstrated a clear pattern of decreased range of motion when participants wore a brace compared to when no brace was worn.

DISCUSSION AND CONCLUSION

These findings build on previous research demonstrating the restrictive nature of TLSO bracing, extending this understanding by showing restriction across all three planes during gait. Importantly, the study highlights that, in certain circumstances, an ill-fitting brace may reduce the intended restrictive function of the TLSO, underscoring the need for professional fitting and appropriate training for non-specialist fitters. This information may guide future research into the practical utility of TLSOs and inform healthcare policy.

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Free paper session | Prosthetics and Orthotics: in less resourced settings – User interface and education

5.101 What Do Young Nigerian Users of Upper Limb Prostheses Really Need?: A Qualitative Study

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BACKGROUND

Upper limb differences(ULD) have physical and psychosocial effects on children.¹ Pediatric UL prostheses(ULP) aim to restore some degree of functionality and anthropomorphic appearance.¹ However, studies reported frequent inadequacy between general-purpose ULP and young individuals' needs.¹ Their understanding is essential to provide pediatric patients with adequate ULP.¹ Limited research was undertaken to understand children with ULD living in African countries where needs and demands vary due to socio-cultural differences.

AIM

The aim of this study is to explore and understand the needs and expectations from young Nigerian users of ULP to determine the characteristics of an ideal prosthetic device.

METHOD

A qualitative approach was followed: twenty-five Nigerian children, adolescents and young adults with ULD, enrolled in the prosthetic care program of The IREDE Foundation in Nigeria, participated in focus groups (n=11) or an individual interview (n=14). All participants used only cosmetic ULP. Questions investigated two aspects: satisfaction with current ULP and expectations of ideal ULP. We followed a thematic analysis method to conduct this research and data were recorded, transcribed and analyzed accordingly. The research question was to determine the necessary elements to consider in the design and manufacture of an ULP meeting participants' daily functional and psychosocial needs within their specific socio-cultural environment.

RESULTS

Participants were aged between 6 and 22 years old, had either transhumeral (16;64%) or transradial (9;36%) amputations, and the main etiology was traumatic (16;64%). The thematic analysis yielded in five major themes. The main themes were function, comfort, aesthetics, manufacture and psycho-social impacts. Participants strongly highlighted the lack of functionalities of their prostheses causing their inability to be self-reliant, to engage socially and to meet family and cultural expectations. They all demanded for anthropomorphic and skin-colored ULP in order to feel "normal" again, to blend in with peers and limit strangers' judgmental look. Weight, inadequate sizing of socket and unbreathable material were the main cause of discomfort and abandonment. Ability to perform house chores and bimanual tasks, to play, and to grasp and carry objects are indispensable functionalities required for an ideal prosthesis. Finally, ULP provided a sense of self-completeness and normality to most young participants.

DISCUSSION AND CONCLUSION

Young Nigerian users of ULP expressed valuable specific needs and demands anchored in their socio-cultural realities. Manufacturers and clinicians are to explore and integrate those to provide prosthetic devices meeting recipients' daily functional and psycho-social needs. Similar works should be undertaken in other comparable environments as cultures and needs differ.

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5.102 Enhancing Mobility and Quality of Life for Nigerian Children with Limb Differences: A Study of The IREDE Foundation's Prosthetic Program

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BACKGROUND

Upper Limb differences are devastating conditions for pediatric patients as such impairments can derange their psychomotor development and limit their self-reliance.¹ Therefore, to hinder those consequences, prostheses can be provided.² Nevertheless, costs of commercial prostheses are expensive and might represent a limitation in low-resource areas.³ For example, many African countries are affected by scarce accessibility to healthcare. Numerous non-governmental organizations (NGOs) strive thither to dispense adequate prosthetic solutions.³ Among these NGOs, the IREDE Foundation (IF), founded in 2012 in Nigeria, attempts to provide prosthetic care to Nigerian children.⁴

AIM

This study aims to retrospectively document the demographics of the pediatric recipients enrolled in the prosthetic care program of the IF and report its management strategy.

METHOD

This retrospective, single-centre study reviewed the records of all pediatric recipients who benefited prosthetic care from the IREDE Foundation between January 2012 and October 2024. Collected data included demographics, etiologies of limb differences, levels of impairment, ages of first prosthetic fittings, and follow-up details. The latter included reported injuries, components failures and functional assessments. Data were analyzed using descriptive statistics.

RESULTS

The IREDE Foundation fitted a total of 602 children (343 male; 57%) with prostheses, with a mean enrolment age of 3 years old. The etiologies of the limb differences were amputation (374; 62%), congenital (138; 23%), illness (60; 10%) and bone fractures mismanagement by traditional healers (30; 5%). The majority (80%) of recipients had lower limb impairments, with 42% being above-the-knee amputees and 38% below-the-knee, all of whom received locally manufactured endoskeletal prostheses. All 120 (20%) children with upper limb differences were provided with passive prostheses. All recipients have access to follow-ups by prosthetists, physiotherapy sessions and psychological support, free of charge until their 18th birthday. Results found that recipients developed self-reliance, built their self-esteem, engaged socially and culturally, and performed tasks (e.g. walking, running, playing) with their prostheses. Most reported injuries included skin irritations and allergic reactions. Main causes of repairs were components breakdown due to overuse, water expose, and overgrowth of recipients.

DISCUSSION AND CONCLUSION

The IREDE Foundation's model of providing prosthetic and psychosocial support has sustained high prosthesis usage rates among recipients. Moreover, families' access to counselling also fostered their children's trust in the prosthetic care provided, positively influencing their prostheses usage. Locally sourced materials and in-house prostheses manufacturing allowed affordable and timely repairs and adjustments, contributing to the NGO's sustainable support model. Despite these efforts, a significant unmet need for pediatric prosthetic devices remains in Nigeria.

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5.103 Longevity and Effectiveness of 3D-Printed Transtibial Prosthetic Sockets in Rural Sierra Leone: a pilot study with 2.5-year follow-up

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BACKGROUND

Prosthetic care is limited in low- and middle-income countries (LMICs). Finding solutions to improve prosthetic accessibility is commendable, and 3D printing presents a potential solution.

AIM

This longitudinal study examines the longevity, usage, participants' functioning, and health-related quality of life (HRQoL) of 3D-printed transtibial prosthetic sockets over 2.5 years of follow-up in rural Sierra Leone.

METHOD

Participants received a locally manufactured transtibial prosthesis with a 3D-printed prosthetic socket at the 3D Lab at Masanga Teaching Hospital in Sierra Leone. Baseline, ten-week, nine-month, 1.5-year, and 2.5-year follow-up assessments included: a) quantifying prosthetic longevity, b) prosthetic use using activity sensors, c) Lower Extremity Functional Status (LEFS) using the adopted Orthotics and Prosthetics User's Survey (OPUS) (range: 0-60), d) Disease-specific HRQoL using the adapted OPUS survey (range: 0-36) and, e) Generic-HRQoL using EQ-5D-3L (range: -0.145-0.9) and the VAS score (range: 0-10).

RESULTS

Nine participants participated in the study. Six prosthetic sockets exhibited damage after 361, 398, 399, 553, 641, and 756 days. One participant used the prosthesis for 2.5 years, another had their socket replaced due to socket size problems, and one was lost to follow-up. At 2.5 years, the median (IQR) wear time was 12.4 hours (11.4-13.5) daily, with 6,906 steps (4277-9792), 65% (51%–82%) while wearing the prosthesis. Median scores at follow-up compared to baseline were as follows: OPUS Function (47 to 55 points), OPUS D-HRQoL (17 to 34 points), EQ5D-3L (0.741 to 0.744), and VAS (6 to 10 points).

DISCUSSION AND CONCLUSION

This study revealed the potential of 3D-printed prosthetic sockets to enhance the functioning and health-related quality of life of people with a transtibial amputation in Sierra Leone. However, the durability of 3D-printed sockets using Tough PLA raised significant concerns. The eventual breakage of prosthetic sockets among a notable portion of participants underscores the urgent need for improved methods in 3D printing for prosthetic socket production.

ACKNOWLEDGEMENTS

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5.104 Effectiveness of locally produced AI-designed transtibial prosthetic sockets in rural Sierra Leone – a prospective cohort study

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BACKGROUND

There is a massive unmet global need for prostheses. Artificial Intelligence (AI) trained on large datasets from experienced prosthetists offers a promising solution to streamline prosthetic socket design, enhancing efficiency and consistency in prosthetic socket fit for low- and middle-income countries (LMICs).

AIM

This prospective cohort study evaluates the effectiveness of locally produced transtibial prosthetic sockets in rural Sierra Leone, created with user-friendly software incorporating AI-based socket shape design.

METHOD

Local coworkers at the 3D laboratory of Masanga Teaching Hospital in Sierra Leone autonomously produced transtibial prosthetic sockets using 3D scanning, user-friendly design software (including AI prosthetic socket shape prediction), and production by laminating 3D-printed socket molds. Baseline and ten-week follow-up assessments included the following measures: (1) satisfaction with the device and service using the adapted Orthotics and Prosthetics User's Survey (OPUS); (2) functioning by quantifying prosthetic wear time and step count (before and after receiving the prosthesis) with activity sensors and the Lower Extremity Functional Status (LEFS) using the adapted OPUS survey (range: 0-60); (3) disease-specific Health-Related Quality of Life (D-HRQoL) using the adapted OPUS survey (range: 0-36) and Generic Health-Related Quality of Life (G-HRQoL) using the EQ-5D-3L and the VAS score; (4) participants' personal goals were evaluated.

RESULTS

From March 2023 to May 2024, 34 participants received a prosthesis through the self-developed software (Figure 1). At follow-up, 28 participants were reached; 27/28 reported using the prosthesis, confirmed by the activity sensors. Median (IQR) prosthetic wear time was 8.9 (1.7-11.4) hours per day, with a median (IQR) of 4243 (1762-7019) steps per day, of which 39% (17-73%) with the prosthesis. Median (IQR) scores indicated a significant improvement in OPUS LEFS from 45 (40-50) to 52 (48-54) and OPUS D-HRQoL from 26 (21-31) to 32 (25-35). EQ-5D-3L and the VAS score did not significantly change, 57% achieved their desired predefined activity goal.

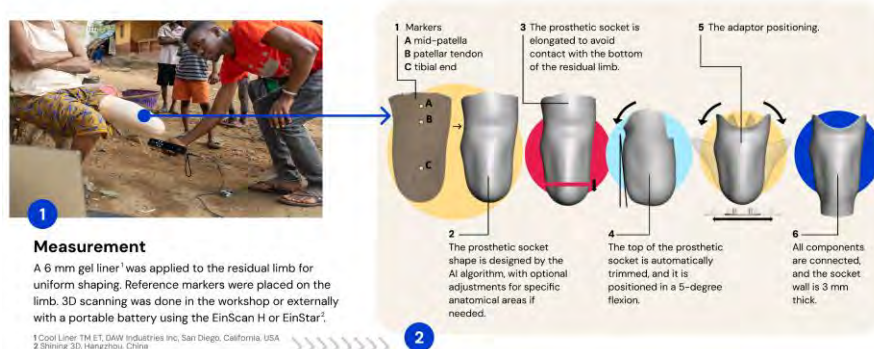


Figure 1: Measurement through 3D scanning and socket shape design using the in-house developed standardized design workflow in 3DMedX® (3D Lab Radboudumc, Nijmegen, the Netherlands)

DISCUSSION AND CONCLUSION



This study demonstrates that simple software for prosthetic socket design can empower local trainees in training to become more independent in developing transtibial prosthetic sockets, thereby enhancing functioning and health-related quality of life for individuals with transtibial amputation in Sierra Leone. While manual adjustments are still required for more complex cases, the AI-generated socket shape design is a suitable starting point. Continued validation will support the potential expansion of this approach to other countries worldwide.

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5.105 Predictors of Mobility in Cambodian Lower Limb Prosthesis Users

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BACKGROUND

Impaired mobility in prosthesis users is associated with a reduction in quality of life ^[1], increased symptoms of depression ^[2] and reduced labour force participation ^[3]. To date, research on mobility predictors in lower limb prosthesis users has focused on high-income country contexts. More research is needed to identify determinants of mobility for prosthesis users in low-to-middle income countries.

AIM

The objective of this cross-sectional study was to provide a greater understanding of mobility in Cambodian lower-limb prosthesis users and to identify factors which predict levels of mobility in this population.

METHOD

Lower-limb prosthesis users attending 3 clinics in Cambodia were requested to participate by completing a comprehensive survey. The survey comprised of demographic information, social determinants known to influence health outcomes (e.g. education, marital status, employment status), psychological factors (anxiety/depression, PTSD), information related to the amputation and prosthesis use, and the experience phantom pain. Mobility levels of participants were measured using a validated Khmer version of the LCI-5 and the mobility dimension of the EQ-5D-5L. Regression analyses were performed to identify significant predictors of mobility.

RESULTS

347 lower limb prosthesis users responded to the survey. The majority were male (n=306), aged between 55 and 63 (n=114), married (n=292) and lived in a rural area (n=213). Most respondents were unilateral transtibial prosthesis users (n=242). Average scores on the LCI-5 were 19.5/20 (SD=1.3) for basic activities and 18.4/20 (SD=3.2) for advanced activities. Higher scores represent a superior ability to perform mobility related activities. The average score on the mobility dimension of EQ-5D-5L was 1.5/4 (SD=0.62), with a lower score reflecting fewer perceived mobility problems. Factors identified as being significant predictors of mobility were sex, amputation level, PTSD score, anxiety and depression (p<0.05).

DISCUSSION AND CONCLUSION

Prosthesis users in this study can be considered to have a high level of mobility. This result may reflect differences in the physical status of clients who are able to access prosthetic services in contrast to those who cannot. Results indicate that both physical and psychosocial variables should be used to predict mobility outcomes in lower limb prosthesis users in Cambodia.

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5.106 Capacity Building in Prosthetic & Orthotic Education in Tanzania: A Collaborative Approach to Improving Services for People with Disabilities

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BACKGROUND

Over 1.3 billion people live with disabilities globally, with 80% residing in low- and middle-income countries. Of the 35-40 million people needing prosthetics and orthotics (P&O) services, 90% lack access. In sub-Saharan Africa, the shortage of trained professionals exacerbates this issue. Tanzania's TATCOT (Tanzania Training Centre for Orthopaedic Technologists), a key P&O education provider, faces significant gaps in educator capacity, making local training and development a critical solution.

AIM

This project aims to enhance the skills of P&O educators at Tanzania's TATCOT through practical training, enabling them to pass on this knowledge to Africa's future P&O workforce.

METHOD

The ReSciO-TATCOT collaboration delivers practical, hands-on training to P&O educators at TATCOT faculty. The project includes three courses annually, focusing on affordable, locally available materials and "appropriate technology" for prosthetic and orthotic solutions, with a strong emphasis on durability, functionality, and cost-effectiveness. Courses are tailored to the specific needs of TATCOT faculty and integrate theoretical learning with practical, patient-centered application. The curriculum covers key topics such as assessment, casting, fitting, and observational gait analysis. ReSciO's collaboration with local and international experts ensures that teachers gain knowledge in both technical skills and teaching methods.

RESULTS

To date, 11 courses have been completed, covering topics such as upper and lower limb orthotics for various patient groups, diabetic management, and a focus on assessment and realistic prognosis. These workshops have increased motivation and enhanced teaching effectiveness among TATCOT's faculty. Teachers report significant improvements in both practical and theoretical knowledge, which they are now applying to improve the quality of education for P&O students. The courses also emphasize patient-centered care and the use of locally available materials, ensuring sustainability in low-resource settings. TATCOT has gained recognition from both the Ministry of Education and ISPO, validating the quality of the training. Graduates are better equipped to meet the growing P&O needs across Africa, ultimately benefiting the broader patient population and improving care outcomes.

DISCUSSION AND CONCLUSION

This project highlights the need for local capacity building in P&O education. By strengthening educators, it ensures the next generation of P&O professionals can meet the growing demand for services in low-resource settings.

The ReSciO-TATCOT initiative provides a sustainable model for improving P&O education. By enhancing educator capacity, it supports the UN Convention on the Rights of Persons with Disabilities, improving global access to rehabilitation services and quality care for people with disabilities.

ACKNOWLEDGEMENTS

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Free paper session | Device fabrication and design – Orthotic application

5.111 Preliminary effectiveness and production time and costs of three-dimensional printed orthoses in chronic hand conditions: an interventional feasibility study

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BACKGROUND

In chronic hand conditions, orthoses can reduce impairments and improve the use of the hand to perform activities of daily living (ADL). Over the past decade, three-dimensional (3D) printing has been increasingly used to manufacture hand orthoses, as a promising alternative to conventional custom-fabricated orthoses. However, evidence on the effectiveness, production time and costs of 3D-printed orthoses for chronic hand conditions is scarce.^{1,2}

AIM

To assess the preliminary effectiveness of 3D-printed orthoses compared to conventionally custom-fabricated orthoses for permanent use in persons with chronic hand conditions on ADL performance, quality of life, satisfaction, and production time and costs.

METHOD

In this interventional feasibility study, chronic hand orthotic users received a 3D-printed orthosis of the same type as their previously worn conventional thumb, wrist or wrist-thumb orthosis. Outcomes were assessed 2 weeks before the intervention and at baseline for the conventional orthosis, and at 1 and 4 months follow-up for the 3D-printed orthosis. The primary outcome, ADL performance, was assessed using the Dutch Flemish Patient-Reported Outcomes Measurement Information System – Upper Extremity (DF-PROMIS-UE) custom short form at 4 months follow-up. Secondary outcomes were satisfaction (Dutch Client Satisfaction with Device (D-CSD) questionnaire) and quality of life (EuroQol 5-Dimension 5-Level (EQ-5D-5L)). Production time and costs were also calculated. Linear mixed models and Wilcoxon signed-rank tests were used to analyze the results.³

RESULTS

Twenty-one persons were included. Nineteen completed the 4-month follow-up assessment. At 4-month follow-up, no difference was found between the 3D-printed orthoses and conventional orthoses in ADL performance and quality of life. Satisfaction with the 3D-printed orthosis was significantly higher than with the conventional orthosis (mean difference (SD) D-CSD: +5.11 (2.29) 95%CI: 0.62-9.59). Production time (labor time) and costs for 3D-printed orthoses (production time: median 129 min, IQR: 109-148 min, costs: median €187, IQR: €143-206) were significantly lower compared to conventional orthoses (production time: median 269 min, IQR: 241-311 min; costs: median €398, IQR: €380-436).⁴

DISCUSSION AND CONCLUSION

This was the first study to compare 3D-printed orthoses with custom-fabricated orthoses for permanent use in chronic hand conditions. ADL performance and quality of life were similar for both orthoses. Satisfaction with the 3D-printed hand orthoses was higher. Production time and costs for the 3D-printed orthoses were more than halved compared to conventional orthoses. A future randomized cost-effectiveness study should investigate whether the 3D technique is efficient for the production of hand orthoses.

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5.112 Estimation of Biomechanical Responses of Scoliotic Spine under Different Control Strategies via Finite Element Modelling

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BACKGROUND

Scoliosis is a three-dimensional spinal deformity with lateral curvature and vertebral rotation. It may affect patients' cardiopulmonary function ^[1] in severe cases. Cobb angle is commonly used to assess spinal deformity, and orthotic treatment is generally prescribed for patients with Cobb angle between 20-45° with growth potential. Among different advanced technologies, Finite Element Modeling (FEM) has been developed to improve the understanding of 3D spinal deformity and its responses to orthotic treatment.

AIM

This study aims to (1) reconstruct a patient-specific scoliotic spine; (2) simulate different controlling forces on the spinal model, and (3) identify the optimal control strategy.

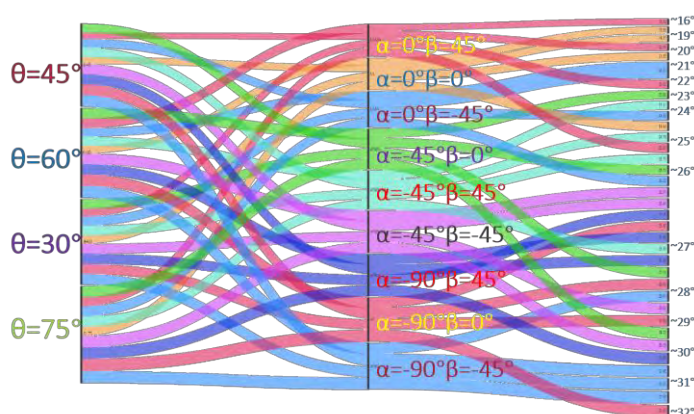
METHOD

A 3D spine model was first reconstructed from the CT data of a patient. The spine model was rectified and constructed with grids using Geomagic Design X. Both the soft tissues and torso were also reconstructed. All established models were meshed in ABAQUS. The mesh size was determined by different convergence tests. The controlling forces were applied at the apex of the curve with different configurations. The simulation results were exported. Cobb angle, stress distribution, and displacement were used to identify the optimal controlling effect. The torso model was designed as an orthosis according to the simulation result.

RESULTS

A finite element patient-specific model has been reconstructed including bony structures, soft tissues, and torso. The lumbar spine (L1-L5) was validated for six motions (forward-backward bending, left-right bending, and left-right twisting) under the moment of 10 Nm. The range of motion (ROM) was compared to the previous in-vitro experiments. The force configurations were conducted with sensitivity tests under three different angles. The force location (θ) is moved from the posterior to the lateral from 30 to 75°. The force direction is controlled by α and β angles.

The α angle in the transverse plane controls the medio-lateral and antero-posterior directions while the β angle controls the vertical direction. Totally 36 deformed models were exported and analyzed for optimal controlling force and the corresponding Cobb angles are shown in Figure 1.



DISCUSSION AND CONCLUSION

The FEMs not only could provide 3D optimal controlling forces, but also avoid flat back and hyper-lordosis of the spine. In this study, the biomechanical responses showed that pad location at $\theta=45^\circ$ has better correction. The α angle that controls the transverse plane significantly affects the correction and the sagittal curvature. The findings could provide theoretical insight into the design of an effective spinal orthosis for the management of scoliosis.

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5.113 An Auto-Adjusting Dynamic AFO to Manage Ankle Range of Motion during Running

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BACKGROUND

The stiffness of the posterior strut in a dynamic AFO determines the patient's ankle range of motion (ROM) during ambulation. Patients may prefer a low stiffness strut while they are walking about the house or other settings so that they can easily maneuver, and a high stiffness strut during running or other sports so that they do not exceed their acceptable ROM and experience pain. A technology that adjusted stiffness automatically to maintain a consistent ROM may improve outcome in patients wearing dynamic AFOs.

AIM

Develop a motor-driven variable stiffness strut and control system to maintain a selected ankle ROM during stance phase. Test the controller's performance on a group of participants running on a treadmill.

METHOD

Participants above 18 years of age with no lower-limb injury or disability were included in this study. They were casted, and an AFO footplate and proximal cuff were fabricated [1]. Custom sensors were attached to the footplate to measure AFO sagittal plane bending [2] which was converted to stance phase ROM using a computational model verified in a physical testing system. A custom, 200-mm, motor-driven, adjustable stiffness strut system was used (Fig. 1). In this system, a motor drove gears and a coupler that adjusted the positions of two clamps surrounding the inner and outer carbon-fiber struts. Moving the clamps inward increased the stiffness of the strut system, and moving the clamps outward decreased the stiffness. Participants walked and ran on a treadmill following a scripted protocol while the control system adjusted strut stiffness to achieve a target set point ROM. Participants were asked to relax their ankle as much as possible during testing to simulate a lower-limb disability.

RESULTS

The system's strut stiffness ranged from the low to medium level of commercially available struts (posterior dynamic element 1 to 4). Testing on three participants (1 male, 2 females) demonstrated that the controller took less than 20 s to achieve an initial set point ROM. It maintained that ROM within less than 2 degrees during running.

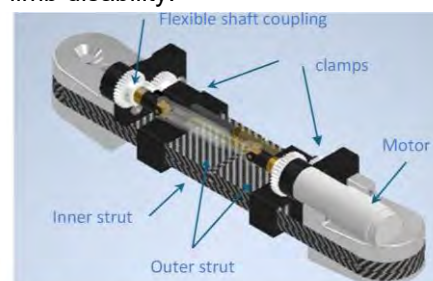


Fig. 1. Motor-driven adjustable stiffness strut system.

DISCUSSION AND CONCLUSION

The results from this study suggest that the sensors in the footplate provide an effective feedback signal for the controller to properly adjust strut stiffness to maintain a consistent ROM during running. We conclude that the technology is ready for testing outside of the lab to determine if it improves clinical outcome in participants with ankle disability wearing dynamic AFOs.

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5.114 Application of a Novel Low-Cost 3-Dimensional Postural Measurement System and Scoliosis Casting Apparatus in Scoliosis Assessment: A Case Study

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BACKGROUND

Scoliosis is defined as a lateral deviation of the spine that exceeds 10° [1]. Radiography, a standard method for quantifying spinal outcomes [1], can be harmful and cannot provide a three-dimensional description. A motion capture system is another option [2]; however, current systems are expensive. Orthotists perform conventional casting using their hands, which requires skill and teamwork. Casting frame is another option; however, current systems are expensive and mainly correction in one plane.

AIM

The study aimed to develop a low-cost 3D postural measurement system for assessing spinal parameters, along with a scoliosis casting apparatus to aid in optimal correction.

METHOD

We developed a postural measurement system and scoliosis casting apparatus. This study involved a single participant. Ethics was approved by Mahidol University. The inclusion criteria were AIS patients aged 10–18, with 25°–40° Cobb angles and apical vertebra at T8 or below. The participant obtained radiographs without braces. Before data collection, the markers were attached to the spinous processes of C7, T7, T12, L3, and L5. The participant stood inside the system, and spinal parameters (SP) were recorded. The researcher then positioned the participant on a bar, adjusted manipulators to correct deformities and recorded data.

RESULTS

Participant was a 16-year-old boy with AIS. He presented a double-curve pattern with apical vertebrae at T8 to the right side (25°) and L1 to the left side (35°), with the left trunk leaning. Table 1 shows a change in the coronal spinal angles (the angle respected to the horizontal plane) before and during the application of forces created by the apparatus, bringing them closer to 90°. There was an improved trunk balance from 23.7mm leaning to the left side to 11.60mm leaning to the same side. There was a change in the translation from C7, T7, T12, and L3 to the reference point at L5. The translation was closer to the central sacral line (CSL) or midline, with a 56.81 percent reduction between assessment and optimal correction.

Table 1. Results of spinal parameters in the coronal plane obtained from the developed system.

Spinal Parameters	Developed system result	
	Assessment	Optimal Correction
Coronal-upper-thoracic angle, degree	94.82	95.99
Coronal-lower-thoracic angle, degree	83.53	83.31
Coronal-upper-lumbar angle, degree	96.35	88.56
Coronal-lower-lumbar angle, degree	108.16	93.78
Trunk balance, mm	-23.70	-11.60
Translation from C7 to L5, mm	-23.70	-11.60
Translation from T7 to L5, mm	-7.20	9.50
Translation from T12 to L5, mm	-20.80	-4.50
Translation from L3 to L5, mm	-15.40	-3.30

Note: mm = millimeter. (-) values = translation to the left side of CSL. (+) value = translation to the right side of CSL.

DISCUSSION AND CONCLUSION

A developed system assessed SP before and during the forces applied. The apparatus was able to correct the deformities to their optimal position. Applying the forces resulted in the angles approaching 90° or the spinal sections becoming straighter. Trunk balance was improved. The entire spinal column shifted closer to the CSL, resulting in a reduction percentage that exceeded 50. The researchers should recruit more participants for future research to validate the system in clinical practice.

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5.115 Adapting the International Lower Limb Prosthetic Strength and Durability Testing Standard ISO 10328 for Paediatric Use

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BACKGROUND

The safety and performance of lower limb prosthetic components are evaluated using ISO standard 10328:2016 [1]. This provides static and cyclic loading protocols in two offset configurations to replicate the lifetime loading for 5 bodyweight levels (60-175kg; P3-P8) in heel strike and toe off. However, this standard omits appropriate testing levels for young children who present with lower bodyweight but higher activity [2]. This limits innovation in smaller, durable, and sustainable componentry for younger children. While a heavier bodyweight category, P8 (175 kg), and case specific paediatric testing has previously been extrapolated, a comprehensive paediatric adaptation is required.

AIM

This study aims to investigate ISO 10328 loading values and fatigue test parameters for paediatric application and implement a new appropriate testing protocol.

METHOD

Loading levels were investigated according to body mass. Two new categories were extrapolated from existing levels P3 and P4. A linear fit equation was calculated from the resultant knee moment (M_{res}) for the cyclic range force (F_{cr}) in each offset configuration. Configuration offsets from level P3 were maintained for the lower levels and F_{cr} was calculated using the fit and vector cross-product. All other required test forces (proof and ultimate) were derived from F_{cr} . Fatigue testing cycles were calculated using literature on yearly step count for able-bodied children and adults. The ISO adult value of 3 million cycles for 3 years of use was scaled appropriately.

RESULTS

Table 1 presents the linear fit equations. Two new loading levels were created for body masses <30kg (P1) and <45kg (P2) with F_{cr} values provided (Table 1). The peak daily step count for able-bodied children was 14,000 steps/day for 10-year-old males [3], yielding a scaling factor of 1.4 compared to the adult target of 10,000 steps/day [4].

Table 1: ISO 10328 loading values and cycles for two new representative paediatric body mass levels

Parameter	Condition 1 (Heel-Strike)		Condition 2 (Toe-Off)	
	P1 (30kg)	P2 (45kg)	P1 (30kg)	P2 (45kg)
Cyclic Range Force (F_{cr}) (N)	533	726	475	635
Prescribed number of cycles	4.2×10^6			
Linear Fit of P3 and P4 M_{res} (x =Body Mass (kg))	$Y = 0.09243x + 10.533$		$Y = 0.858x + 12.276$	

DISCUSSION AND CONCLUSION

The developed lower loading levels support innovation in smaller paediatric componentry. However, extrapolation of loading values from levels created using adult gait data and offsets is a limitation. Fatigue analysis suggested the current standard under-assesses durability for 3 years of paediatric use. The absence of available activity level data for young children with limb loss may mean current cycle estimation is conservative. This adapted ISO 10328 is now available for broader paediatric use.

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ACKNOWLEDGEMENTS

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5.116 Developing a Finite Element Model of the Cervical Collar-Head Interface

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BACKGROUND

Cervical collars provide external support to the upper spine, aiding rehabilitation and reducing the risk of damage. The mechanical loading that cervical collars put on the skin causes discomfort, pain, and damage in the form of pressure ulcers^[1]. To date, there has been limited design innovation through bioengineering approaches to improve device design and interfaces.

AIM

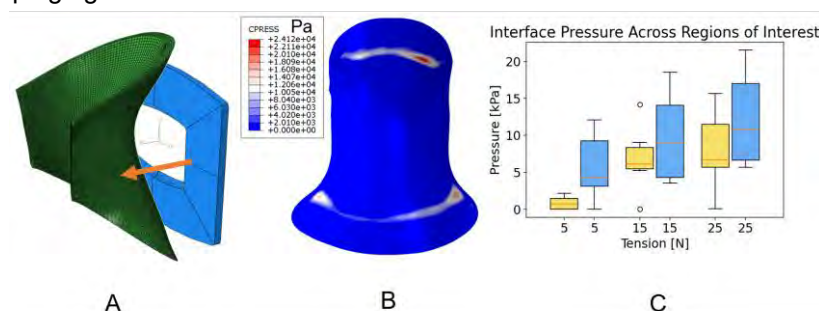
This study aims to evaluate cervical collar design through observed and predicted contact pressures at the device interface through finite element (FE) modelling and a phantom physical model.

METHOD

A finite element and in vitro physical model were developed to evaluate the application of the rear of a cervical collar onto a phantom head shape. The FE model (fig. 1a) includes a uniform soft tissue with a thickness of 8 mm, and linear elastic modulus $E = 200$ kPa, $\nu = 0.45$. The collar was modelled with linear elastic shell elements for the stiff support material ($E = 600$ MPa, $\nu = 0.3$). A first-order Hyperfoam model was fitted to material test data for the foam padding. A friction coefficient of 0.6 was used at the collar-skin interface. The collar was pulled from either side onto the head. This was replicated in the physical model with pressure recorded at the device-skin interface in key locations while a load cell monitored tension.

RESULTS

Initial contact was made with the edge of the collar foam resulting in the highest interface pressures (fig. 1b). Both the FE and physical models show an increase in the interface pressure with increasing tension. Contact pressure values were in a similar order of magnitude according to strap tension between FE and physical model testing, though the FE model generally underpredicts the interface pressures (fig. 1c). As more tension was applied a greater contact area was observed, while the pressure peak at the occiput moved down corresponding to stiffer plastic of the collar impinging on the foam material.



DISCUSSION AND CONCLUSION

This study presents the first step in developing an FE model that can be used as a preclinical in-silico evaluation of cervical collar design. While these specific results have limited generalisability, future developments will evaluate collar fit across a population of head shapes and collar designs. This may enable the evaluation of new collar designs that better suit the needs of all users and help reduce device-related pressure ulcers.

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ACKNOWLEDGEMENTS

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5.117 Investigation of Upper Extremity Proprioception and Shoulder Head Position in Adolescents with Idiopathic Scoliosis Wearing Cheneau Orthosis

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BACKGROUND

Scoliosis is a three-dimensional deformity characterized by lateral deviation, rotation, and hypokyphosis of the spine. It is noted that shoulder girdle asymmetry occurring in individuals with scoliosis could alter the axis of scapular movement and shoulder kinematics [1]. These biomechanical impacts suggest a potential change in proprioception [2].

AIM

The aim of this study is to investigate the effects of brace use on upper extremity proprioception and shoulder head position in individuals with adolescent idiopathic scoliosis.

METHOD

The study included 20 primary thoracic idiopathic scoliosis individuals using the Cheneau orthosis, with a Cobb angle of $31.32^{\circ} \pm 8.68^{\circ}$ and ages of 14 ± 2.3 years. Upper extremity proprioception and shoulder position were evaluated both in-brace and out of brace conditions. Participants were asked to remove their braces 24 hours prior to out-of-brace measurements. The Laser Pointer Assisted Angle Repetition Test for proprioception was conducted for shoulder flexion and abduction at angles of 55° , 90° , and 125° , and deviation from the target angle was recorded as a score. Shoulder position was evaluated under two conditions for each shoulder: in neutral and internal rotation positions, using the photographic method to calculate the anterior displacement.

RESULTS

In upper extremity shoulder proprioception, a statistically significant difference was found between in-braced and non-braced measurements in terms of deviation from the target angle at 90° shoulder flexion ($p=0.01$). In the angle reproduction test, no difference was found between the two conditions at 55 degrees and 125 degrees ($p>0.05$). For shoulder head position, no significant difference was observed between in-brace and out-of-brace conditions, neither in neutral nor in internal rotation ($p>0.05$).

DISCUSSION AND CONCLUSION

For upper extremity proprioception at 90 degrees of shoulder flexion, a significant decrease was observed on the convex side in the out-of-brace condition compared to the in-brace condition. The distinct effects observed on the convex and concave sides are suggested to result from the corrective mechanism of the brace and potential alterations in position sense. Additionally no significant result was found in the amount of anterior displacement of the shoulder head under these conditions. We believe that this study can provide a foundation for future research on the effects of braces on upper extremity proprioception, and that these findings about shoulder head position may be further expanded through more comprehensive studies.

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Free paper session | Orthotics: lower limb and footwear - Knee

5.121 Fall and Fall-risk Reduction with Increased Walking Speed after One Year of C-Brace Use: Results from the C-Brace Registry

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BACKGROUND

Reducing falls for orthosis users is an important goal for health care professionals in treating these patients¹. The C-Brace is a microprocessor-controlled Stance and Swing Controlled Orthosis (MP-SSCO) providing Stumble Recovery. Previous studies have shown that C-Brace reduces fall frequency and fear of falling, improves gait, walking speed and endurance^{2,4} and improves patient-perceived safety³.

AIM

A prospective, multicenter registry was designed to gather real-world safety and effectiveness data from patients fit with a C Brace.

METHOD

51 O&P clinics in the United States and Europe agreed to participate in the registry. IRB or Ethics Committee approval was obtained, and all subjects provided informed consent.

Outcome measures included a timed walking test (25ft or 10m) at fast walking speed (FWS), the Timed Up and Go (TUG) and the Activity-specific Balance Confidence scale (ABC). In addition, the number of falls in the previous 6 months was collected. Assessments were done at baseline with the existing orthosis and at 6 and 12 months with the C Brace.

Means and standard deviations were calculated at baseline and follow up. 6-month data were carried forward in the case of missing 12-month data. Changes of +0.1 m/s, -3.6 s, +13%, and -25% compared to baseline were considered clinically meaningful for FWS, TUG, ABC, and Fall Frequency, respectively. Paired t-tests were used if data were normally distributed and Wilcoxon Signed Rank if not.

RESULTS

91 subjects were enrolled, and 46 subjects had both baseline and follow-up data for this analysis: 17 female/29 male, mean age of 51.8 (22-83) yrs. and mean weight of 174 (58-270) lbs. 9 subjects were bilateral users. Most common diagnoses were incomplete spinal cord injury (15), polio (9), trauma (3), and iatrogenic (3), but many other causes (16) also led to paralysis of the knee stabilization muscles and a KAFO indication. The mean scores and changes vs. baseline by outcome are summarized in Table 1.

Table 1. Results

Outcome	Sample size	Baseline (BL)	C-Brace (6-12M FU)	Change	p-value C-Brace vs. BL
FWS [m/s]	n=40	0.73 ± 0.34	0.99 ± 0.42	+0.26 ± 0.33	0.000014
TUG [s]	n=40	23.7 ± 17.5	15.5 ± 10.2	-8.1 ± 14.6	0.00007*
ABC [%]	n=46	45.1 ± 21.1	70.0 ± 17.5	+24.9 ± 25.8	<0.00001
Falls	n=42	33 ± 77 median: 3	3.0 ± 5.6 median: 1	-30 ± 74 median: -2	0.00048*
Falls (multiple fallers)	n=28	50 ± 90 median: 6	4.4 ± 6.4 median: 1	-45 ± 87 median: -4.5	0.00051*

* Wilcoxon signed rank test used, since the data was not normally distributed; all other p-values are for t-tests.

** Unpaired t-test all other p-values are for paired t-tests.



DISCUSSION AND CONCLUSION

The majority of subjects showed clinically meaningful average improvements in FWS, TUG, ABC and Fall Frequency. The median number of falls dropped from 3 at baseline to 1 at follow up. These results suggest a reduced risk of falling confirmed by a reduction in reported fall frequency for most subjects.

Interim results from this prospective registry revealed that most C-Brace subjects demonstrated clinically meaningful improvements in walking speed and in both objective and subjective measures of the risk of falling and fall frequency.

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5.122 Comparison of Plantar Pressures in Healthy Adults Using Two Designs of Removable Cast Walkers with and without a Contralateral Raise

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BACKGROUND

Removable Cast Walkers (RCWs) are commonly used in diabetic foot care to offload diabetic foot ulcers. However, their use introduces a leg length discrepancy and can impact gait mechanics. Understanding how different RCW designs the Aircast® XP Diabetic Walker and the Ossur Rebound™ Diabetic Walker affect gait parameters can inform clinical practices to improve patient outcomes, particularly in diabetic foot management.

AIM

This study compared gait parameters in healthy adults using two different RCW designs utilizing the Pedar® pressure system to measure plantar pressure and gait dynamics, with and without the EVENUP® contralateral raise.

METHOD

Eight healthy adults participated in gait analysis under five conditions: standardised shoes, Aircast® XP Diabetic Walker with and without the EVENUP®, and Ossur Rebound™ Diabetic Walker with and without the EVENUP®. Gait parameters including plantar pressure, stride time, and gait symmetry were measured. Descriptive statistics were used to analyze pressure distribution and force patterns for each condition.

RESULTS

The use of the EVENUP® contralateral raise improved gait symmetry across both RCWs by reducing leg length discrepancy. The Ossur Rebound™ Walker showed a more balanced pressure distribution compared to the Aircast® XP, particularly without the EVENUP®, suggesting that design variations impact gait.

Table 1: The average of gait parameters of all participants

		Mean Stride (Seconds)	Mean Step (Seconds)	Mean Stance (Seconds)	Mean Swing (Seconds)	Speed (m/s)	Mean Force (N)	Mean Pressure (N/m ²)	Stance %	Swing %
Standard shoe	Left	1.23	0.65	0.77	0.46	0.71	365.32	343.94	61.56	38.44
Standard shoe	Right	1.21	0.63	0.76	0.46	0.71	366.04	357.40	60.94	38.33
Aircast® without EVENUP®	Left	1.29	0.64	0.76	0.53	0.72	233.67	261.02	58.93	41.07
Aircast® without EVENUP®	Right	1.31	0.67	0.81	0.50	0.72	374.90	357.30	61.50	38.50
Aircast® with EVENUP®	Left	1.27	0.61	0.74	0.53	0.75	246.95	261.40	58.10	41.90
Aircast® with EVENUP®	Right	1.23	0.65	0.75	0.47	0.75	356.55	340.85	61.64	38.36
Ossur without EVENUP®	Left	1.24	0.61	0.73	0.51	0.75	241.63	257.89	59.22	40.78
Ossur without EVENUP®	Right	1.20	0.70	0.71	0.47	0.75	335.46	349.55	61.16	38.84
Ossur with EVENUP®	Left	1.25	0.60	0.72	0.52	0.73	244.25	272.01	58.03	41.97
Ossur with EVENUP®	Right	1.20	0.64	0.74	0.47	0.73	320.20	327.12	61.36	38.64

DISCUSSION AND CONCLUSION

This study indicates that the EVENUP® contralateral raise, when used with RCWs, improves gait mechanics. These findings support its use in clinical settings to enhance patient outcomes. Further research in diverse populations is recommended to confirm these findings.

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5.123 Validation of a simulation framework to analyze the effects of a novel knee extension assist brace

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BACKGROUND

A new design of brace exists that purports to reduce patellofemoral (PF) pain and dysfunction by providing a knee extension torque assist, thus reducing the necessary action of the quadriceps and reducing PF compression.^{1,2} The potential effects of such a brace on PF joint loading can be evaluated through musculoskeletal modeling and simulation techniques. However, it is necessary to validate a simulation workflow prior to examining how the brace may affect PF joint loading.

AIM

To validate a simulation workflow to examine the effect of a knee extension assist brace on PF joint loads and examine preliminary results.

METHOD

Torque-angle data for 4 different tension levels of a knee extension assist brace was obtained from the manufacturer² and fit to exponential functions in Matlab. A previously established OpenSim model³ was altered with an actuator representing a right knee brace and applied to data of an individual squatting to ~59 degrees. Knee flexion moments (KFM) were calculated using OpenSim's Inverse Dynamics (ID) tool for 5 conditions: one without any brace and with the actuator's assistance defined by the calculated exponential functions of each of the 4 tension levels. The expected knee extension assistance based on the exponential functions and the KFM from ID were calculated and compared to validate the brace's representation. PF joint compression was calculated using standard OpenSim methods for each of the 5 brace conditions.

RESULTS

Each of the progressively higher levels of tension of the brace was expected to produce knee extension torque assistance ranging from 5.87 n·m to 8.89 n·m (Table 1). These values matched the reductions in KFM compared to the No Brace condition as calculated by ID. Additionally, increased levels of brace knee extension assistance appeared to progressively reduce PF joint loading. The highest level of tension reduced loading by approximately 230 N.

Brace Condition	Brace Torque Assistance (n·m)	KFM (n·m)	Diff. from No Brace (n·m)	PF Joint Force (N)
No Brace	0	32.65	0	1476.81
Tension 1	5.87	26.78	-5.87	1321.84
Tension 2	6.76	25.89	-6.76	1298.20
Tension 3	8.14	24.51	-8.14	1261.54
Tension 4	8.89	23.76	-8.89	1245.90

Table 1. Brace knee extension assistance, KFM, difference in KFM to No Brace condition, and PF joint compression.

DISCUSSION AND CONCLUSION

These results suggest that the described workflow may be valid to represent a knee extension assistance brace to examine the effect on PF joint loading. Additionally, preliminary results support the notion that such a brace may decrease PF joint compression. These results can inform future studies examining the effects of knee extension bracing on PF joint loading in patient populations.

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5.124 A comparative evaluation of two commercially available stance-control knee-ankle-foot orthoses on safety, gait function, walking ability and satisfaction outcomes

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BACKGROUND

Stance-control knee-ankle-foot orthoses (SCKAFOs) provide knee stability during gait by locking during the stance phase and allowing free knee flexion during swing. Commonly used knee-joints for SCKAFOs are the E-MAG Active knee joint® and the NEURO TRONIC® knee joint. Differences in functioning between the knee joints and KAFO design principles may affect their effectiveness in daily life.

AIM

To compare the effectiveness of the NEURO TRONIC SCKAFO and the E-MAG Active SCKAFO in terms of safety, gait function, walking ability and satisfaction outcomes.

METHOD

Ten subjects with proximal leg muscle weakness, who were already using an E-MAG Active SCKAFO, were provided with a newly fabricated NEURO TRONIC SCKAFO. We compared knee joint locking and unlocking failures (percentage of steps the knee joint failed to lock/unlock) when walking under challenging conditions on an instrumented treadmill; net energy cost (J/kg/m) assessed with a 6-minute walk test; 3D gait analysis outcomes; and patient-reported outcomes of perceived walking ability (16 items rated on a 7-point scale), satisfaction and reported number of falls with paired samples t-tests.

RESULTS

No differences were found between SCKAFOs for knee joint locking failures (both devices 0%) and unlocking failures (NEURO TRONIC 9.9% vs. E-MAG Active 13.9%, $p=0.408$). Net energy cost was not significantly reduced with the NEURO TRONIC SCKAFO at 8.2% ($p=0.123$) compared to the E-MAG Active SCKAFO (Table 1). Significant improvements with the NEURO TRONIC SCKAFO were found for ankle power ($p=0.003$) and perceived walking effort ($p=0.014$), while all other items, as well as overall perceived effectiveness, satisfaction and falls did not differ between SCKAFO types.

Table 1

	E-MAG Active	NEURO TRONIC	Delta	p-value
Knee joint securing				
%locking failures	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	N.A.
%unlocking failures	13.9 (11.6)	9.9 (8.6)	-4.0 (13.8)	0.408
Energy cost				
Walking speed [m/s]	0.86 (0.18)	0.86 (0.18)	0.01 (0.11)	0.870
Net energy cost (J/kg/m)	3.68 (0.81)	3.38 (0.75)	0.30 (0.52)	0.123

Data presented as mean (SD), N.A.: not applicable, *Significant at $p < 0.05$

DISCUSSION AND CONCLUSION

Our small study in adults with knee instability due to proximal leg muscle weakness indicates that the NEURO TRONIC SCKAFO and the E-MAG Active SCKAFO are comparable in terms of knee joint safety. Net energy cost was reduced by 8.2% with the NEURO TRONIC SCKAFO but not significantly, and ankle power and perceived walking effort were in favor of the NEURO TRONIC SCKAFO.



5.125 Optimization of hindfoot loading and running economy with Foot Orthoses (FO) in people with flatfoot deformity

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BACKGROUND

An intact windlass mechanism (WM) is essential for energy-efficient locomotion and physiological loading during the propulsion phase (PP) of running. In functional flatfoot deformity, WM is inadequately developed. This can result in overstraining. In addition, energy efficiency is reduced when running. A new 3d-printed bionic Foot Orthosis (BFO) is intended to improve hindfoot loading and energy efficiency during running.

AIM

The aim of the presented study was to examine the influence of the BFO on hindfoot loading during PP and running economy.

METHOD

The study involved 13 people with flatfoot deformity (39 ± 7 J, 8m). The tested conditions were treadmill walking without support (oFO), with supportive FO (CFO), sensorimotor FO (SMFO) and BFO in randomized order. Data was recorded using the vebitoScience measurement system (120 Hz). The maximum supination moments at the midfoot and hindfoot during PP were analyzed. The ratio of PP to absorption phase (AP) was analyzed to evaluate running economy. Statistical analysis was performed using single-factorial ANOVA and Pearson correlation.

RESULTS

Without FO, a maximum supination load of -0.3 ± 0.6 Nmm/(kg*m) occurs during PP. With CFO the load is 0.2 ± 0.8 Nmm/(kg*m), with SMFO -0.3 ± 0.7 Nmm/(kg*m) and with BFO 2.4 ± 0.5 Nmm/(kg*m). Negative signs indicate an opposite load. BFO differs significantly from the other conditions.

The ratio of PP to AP for oFO is 1.1 ± 0.1 , CFO 1.1 ± 0.1 , SMFO 1.2 ± 0.2 and BFO 1.6 ± 0.2 . BFO differs significantly from all other conditions. For both oFO and BFO, there is a significant correlation between the supination load and the ratio of PP to AP.

DISCUSSION AND CONCLUSION

Supination during PP is increased with BFO. AP is demonstrably shortened and PP prolonged using BFO. The intrinsic muscles actively perform work during AP. Mechanical energy is generated during PP. Shorter AP and longer PP mean that there is more time to generate mechanical energy and less energy has to be provided by muscle activity. This can therefore be seen as an optimization of running economy. The significant relationship between supination load and the ratio of PP to AP in BFO shows that greater supination is associated with shorter AP and longer PP. In conclusion, it can be said that BFO has a positive influence on hindfoot loading and running economy in runners with flatfoot deformity.

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Free paper session | Rehabilitation medicine and surgery – Population inventions

5.131 Long-term follow-up, Quality of Life and Function of patients with lower limb discrepancies mobilizing with Extension-prosthesis

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BACKGROUND

When a baby is born with lower limb deficiencies (LLD), a lifetime of functional limitations is predicted. It is common to plan surgery, but in some cases conservative treatment is chosen, meaning the child will mobilize with a shoe lift or a personally-fitted Extension-prosthesis. Limited research describes the long-term implications of LLD and use of Extension-prosthesis. This presents a challenge when discussing prognoses with newly diagnosed patients' families.

AIM

To evaluate the long-term quality of life (QoL) and functional capabilities of adults with LLD mobilizing with an Extension-prosthesis.

METHOD

We reviewed medical records of patients aged above 18 years who were prescribed an Extension-prosthesis between 2000-2020. Data included demographics, diagnoses, surgeries and prosthetic prescriptions. Telephone interviews were conducted, including data on living conditions, family status, education and employment, prosthetic use and mobility, pain, participation, and QoL. Questionnaires included: Katz ADL, adapted Hoffer for mobility, QoL Short Form-12, Prosthesis Evaluation Questionnaire- Mobility Scale (PEQ-MS), Trinity Amputation and Prosthesis Experiences Scales-Revised (TAPES-R) and Visual Analog Scale for pain. Non-parametric tests were used to compare group ranks and associations between variables of interest.

RESULTS

Eighty-five patients met the inclusion criteria; 35 replied (43%). Twenty-six males (72%); mean age 51.36 (SD=15.90). Twenty-one (61%) report having pain. All live independently although some need assistance in dressing and bathing. Some are active in sport; many attended some level of tertiary education, married and work. Regarding QoL, many reported that their psychological health was better ('very good') than their physical health ('good'). As shown in the table, there were many significant correlations between indoor and outdoor mobility and the SF-12, PEQ-MS and TAPES-R scores.



Table: Associations between indoor and outdoor activity measures and SF-12, PEQ-MS and TAPES-R scores

	Scores	With Extension-prosthesis	
		Indoor activity	Outdoor activity
SF12	Physical	0.64***	0.68***
	Psychological	0.48**	0.40*
PEQ-MS	Ambulation	0.39*	0.42*
	Appearance	-0.15	-0.16
	Residual Limb Health	-0.35*	-0.45**
	Sounds	0.23	0.20
	Utility	0.41*	0.48**
	Transfer	0.60***	0.60***
TAPES-R	General adjustment	0.33	0.33
	Social adjustment	0.18	0.02
	Adjustment to limitation	-0.46**	-0.50**
	Athletic activity restriction	-0.54**	-0.49**
	Functional activity restriction	-0.50**	-0.53**
	Social activity restriction	-0.34	-0.40*
	Aesthetic	0.07	0.14
	Functional	0.26	0.27

DISCUSSION AND CONCLUSION

The study results include key data towards providing more informed patient education and decision-making on treatment recommendations when the patients and families are at a crossroad concerning the selection of treatment options. Additional research is needed to broaden our understanding of critical evidence concerning short- and long-term implications of alternate treatments.

ACKNOWLEDGEMENTS

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5.132 Recovery beyond mortality and morbidity in humanitarian settings: practical use of a measure of independence in daily activities

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BACKGROUND

In humanitarian settings, patients after injury have a vital need to recover their independence in daily activities, which is a primary objective of rehabilitation interventions. However, trauma care interventions in these settings tend to focus on reducing mortality and morbidity. Rehabilitation is therefore often not prioritized and/or is seen as a post-acute health intervention. The lack of research on rehabilitation in humanitarian settings further hinders its more systematic and early integration within trauma care.

AIM

This study aimed to describe recovery of independence in activities during the first six months after injury and to identify its associated factors, including early physiotherapy.

METHOD

This prospective cohort study was conducted from June 2020 to January 2022 in four hospitals run or supported by Médecins Sans Frontières and located in Burundi, Cameroon, Central African Republic, and Haiti. This study included patients above 5 years old, admitted for acute orthopedic and/or visceral injury. The independence in activities was measured using the Activity Independence Measure-Trauma (AIM-T)^[1], defining independence depending on the level of human and/or material assistance (i.e. assistive products) required to perform the AIM-T activities. The AIM-T was collected at hospital admission and discharge, and at three and six months after injury. The change in independence between each time point was assessed using the Wilcoxon signed rank test. A multivariable logistic regression model was used to identify factors associated with independence in activities at three follow-up time points (i.e. discharge, three and six months after injury).

RESULTS

Overall, 554 patients were included, with 86% and 87% followed up at 3M and 6M, respectively. Two-thirds of the patients were discharged from hospital while being dependent on human assistance in several AIM-T activities. The independence in activities improved significantly between each of the time points ($p < 0.001$). At six months, 55% of patients were independent from human and material assistance in most AIM-T activities. Having received early physiotherapy (i.e. within 48h of admission) was associated with independence at discharge and three-month, when adjusted for other injury-, personal-, functioning- and trauma care-related factors ($p < 0.05$).

DISCUSSION AND CONCLUSION

Almost half of patients still experienced difficulties in functioning at six months; calling for trauma care along the continuum. Early physiotherapy was significantly associated with recovery of independence in the present study. Its early integration as part of trauma care could therefore have the potential to increase the quality of care and the outcomes of patients after injury in humanitarian settings.

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5.133 Phantom Limb Pain Treatment With At-Home Phantom Motor Execution Therapy for Individuals with Upper or Lower Limb Loss

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BACKGROUND

Phantom limb pain (PLP) is a common issue among individuals with amputation, with recent studies estimating a prevalence of 59-64% [1, 2]. Conventional treatments, including pharmaceuticals, mirror therapy, and motor imagery have shown varied success rates. Phantom motor execution (PME), where electromyographic (EMG) signals measured from the residual limb muscles are used to control a virtual limb, has recently gained attention as a promising, non-invasive approach to managing PLP [3].

AIM

To evaluate the effectiveness of a portable Phantom Limb Pain Management System (PLP-MS) that enables at-home PME therapy and remote therapeutic monitoring.

METHOD

Individuals with upper or lower limb loss and minimum PLP intensity of 4 on a 0-10 scale, occurring at least twice monthly, were recruited. Participants were trained to use the PLP-MS which consists of an electrode-embedded cuff with an EMG pattern recognition controller and a Bluetooth-connected mobile application (app). Participants used residual limb muscle contraction patterns to calibrate the system to control a virtual limb and play games in the app during an 8-week home trial, which was remotely monitored by study personnel. PLP intensity, interference with daily activities, and sleep disturbance were assessed at baseline, post-trial, and 16, 24, and 32 weeks follow-up.

RESULTS

Out of 48 enrolled participants, 3 dropped out and 45 have completed the 8-week home trial (18 male, 27 female; 5 transhumeral, 13 transradial, 11 transfemoral, 16 transtibial; age range 22-78 years). Significant reductions were observed in PLP intensity, daily activity interference, and sleep disturbance from baseline to post-trial.

Table 1: Pain outcomes, mean $\pm$ SE. For all outcomes, lower scores indicate a lower level of the measured metric (ie, less pain intensity, less pain interference, less sleep disturbance). All differences from baseline to post-home trial were statistically significant with t-test $p < 0.001$.

	Pain Rating Index (Short Form McGill Pain Questionnaire)	PLP Intensity (PROMIS Pain Intensity 1a)	PLP Interference (PROMIS Pain Interference 4a)	Sleep Disturbance (PROMIS Sleep Disturbance 4a)
Baseline	16.1 $\pm$ 1.0	5.9 $\pm$ 0.2	9.0 $\pm$ 0.5	13.2 $\pm$ 0.6
Post-Trial	11.2 $\pm$ 0.9	3.8 $\pm$ 0.3	6.1 $\pm$ 0.4	10.3 $\pm$ 0.6

DISCUSSION AND CONCLUSION

PME therapy using the PLP-MS was shown to be an effective at-home PLP treatment for individuals with upper or lower limb loss. The consistent improvements seen across outcomes measures suggest that individuals can achieve meaningful improvement outside clinical settings. This study highlights the potential of a portable PLP-MS that promotes at-home PME therapy as a safe, accessible therapy for individuals with PLP.

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5.134 Surgical protocol for Regenerative Peripheral Nerve Interface for a Randomized Controlled Trial in Postamputation Pain

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BACKGROUND

Over the past decade, nerve reconstruction and end-organ muscle reinnervation have gained prominence in prosthetic care. Originally aimed at improving prosthetic limb functionality, these procedures also reduce postamputation neuropathic pain and are now often performed primarily for pain management. The Regenerative Peripheral Nerve Interface (RPNI) is a notable procedure in this field. The RPNI technique addresses nerve regeneration at the nerve end to prevent painful neuromas. Retrospective studies demonstrate RPNI's efficacy in managing postamputation pain, though variations in the technique have emerged with its rising use.

AIM

This work aims to provide a step-by-step protocol of the RPNI technique, serving as the standardized procedure in the international randomized controlled trial (RCT; ClinicalTrials.gov, NCT05009394)¹, and to make it accessible for those interested in implementing RPNI surgery into amputation care practices.

METHOD

An anatomical cadaveric study was conducted to define each surgical step, followed by comprehensive discussions among all surgeons involved in the RCT to refine procedural consistency.

RESULTS

This step-by-step protocol for RPNI surgery was developed and validated by a consortium of expert surgeons specializing in the technique. RPNI surgery entails longitudinal dissection of the distal nerve into main fascicles, which are then implanted within denervated, devascularized muscle grafts (Figure 1). The protocol is structured into four main phases: 1) Presurgical Preparations, 2) Recipient Site Preparation, 3) Donor Site Preparation, and 4) RPNI Construct Fabrication. Each phase is thoroughly detailed in the written protocol and supplemented by an instructional video. Key critical steps include muscle harvesting aligned with muscle fibers to maintain fiber integrity and ensuring an optimal nerve-to-muscle graft ratio to prevent central necrosis and the formation of new neuromas within the RPNI construct.

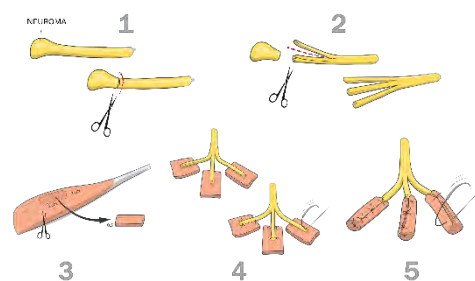


Figure 1. Schematic representation of the Regenerative Peripheral Nerve Interface (RPNI) technique.

DISCUSSION AND CONCLUSION

The RPNI surgery is a simple, safe, and reliable treatment approach for postamputation pain related to neuroma formation. While studies support RPNI's efficacy, no comparative studies have yet evaluated RPNI against other nerve reconstruction techniques, such as Targeted Muscle Reinnervation (TMR) and standard treatment including no reconstruction, thus motivating this RCT. The increased use of the surgery has led to increased variations in the technique. In this work we manage to align expert contributions to propose a standardized RPNI surgical protocol to be used in the RCT and to facilitate for professionals who would like to implement the technique in their amputation care.

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5.135 Specialized rehabilitation including early MPK mobilization: Impact on Mobility and Quality of Life of limited community ambulators after transfemoral amputation

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BACKGROUND

Early functional rehabilitation is essential for optimizing mobility and enhancing the overall quality of life for amputees, yet it is often constrained by structural and financial challenges. In Germany, national care guidelines recommend direct transfer from acute to specialized rehabilitation centers for prosthetic fittings, particularly with microprocessor-controlled knee joints (MPK), to maximize rehabilitation outcomes ⁽¹⁾.

AIM

This study aims to evaluate the effectiveness of early, specialized rehabilitation including the Kenevo (Ottobock), a knee joint with specific features adopted to rehabilitation requirements, adhering to German care guidelines.

METHOD

This prospective, multicenter observational study compares outcomes between a study group receiving specialized rehabilitation and a control group from seven rehabilitation centers in Germany. A total of 125 participants with transfemoral amputation (K1-2 mobility level) are included.

The primary outcome is mobility, measured by the PLUS-M K2 score 24 weeks after rehabilitation begins (t8). Secondary outcomes include quality of life (EQ5D-5L), falls, fear of falling, and functional aspects. The rehabilitation duration is 6 weeks for the study group and 4 weeks for the control group.

RESULTS

To date, 67 participants have been enrolled (study group: n=50, mean age 64 ± 12 years, control group: n=17, mean age 68 ± 8 years). At t8, the study group demonstrated higher mobility PLUS-M T-score: 40.2 ± 5.9 (CI: 40.3 – 44.5) compared to the control group (T-score: 36.9 ± 7.0 (CI: 28.1 – 48.5)). The study group also reported a higher quality of life (EQ5D-5L health utility score: 0.810 (CI: 0.729 – 0.891)) versus the control group (EQ5D-5L health utility score: 0.630 (CI: 0.257 – 1.014)).

Regarding falls, none of the participants in the study group experienced fall-related hospitalization, while 25% of falls in the control group required hospitalization. Notably, 100% of falls with a non-microprocessor knee (NMPK) required hospitalization, whereas none of the falls with the MPK resulted in hospitalization.

DISCUSSION AND CONCLUSION

Early and specialized rehabilitation with a specialized MPK, aligned with national care guidelines, significantly enhances both mobility and quality of life for individuals with transfemoral amputation. The study also demonstrates that MPKs reduces the severity of falls. These findings highlight the benefits of early and specialized rehabilitation with MPKs, which may also contribute to long-term cost savings by reducing fall-related complications.

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5.136 Optimized early Functional Rehabilitation after transfemoral amputation: A prospective observational trial

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BACKGROUND

The early functional rehabilitation process in amputee patients is crucial for their mobility but is hindered by structural and financial challenges. According to German care guidelines, direct transfer from acute care to specialized rehabilitation centers should occur, where prosthetic fittings with microprocessor-controlled knee joints (MPK) are performed ⁽¹⁾.

AIM

This study aims to assess the impact of early and specialized functional rehabilitation using the Kenevo knee joint (Ottobock) on mobility in transfemoral amputees, in alignment with evidence-based national rehabilitation guidelines.

METHOD

This prospective, multicenter, exploratory study compared outcomes between a study group receiving early and specialized rehabilitation with the MPK joints and a control group from seven German rehabilitation centers. A total of 125 transfemoral amputees with K1-2 mobility levels are enrolled. The primary outcome measurement is mobility (PLUS-M K2), assessed 24 weeks after rehabilitation initiation (t8). Secondary outcome measures include locomotor capabilities, quality of life, falls, and fear of falling. The rehabilitation duration is six weeks for the study group and four weeks for the control group.

RESULTS

So far, 67 participants have been included in the short-term analysis (study group (n=50): 64 ± 12 years, 36% female; control group (n=17): 68 ± 8 years; 29% female). The study group showed higher mobility scores (PLUS-M T-score: 40.2 ± 5.9) compared to the control group (36.9 ± 7.0). Additionally, the study group showed superior locomotor capabilities across both basic and advanced tasks, with an advanced locomotor capability index (LCI 5) of 21.4 ± 2.3 compared to the control group (14.7 ± 10.2).

DISCUSSION AND CONCLUSION

The study shows that early and specialized rehabilitation with the MPK, strictly following national guidelines, enhances mobility and locomotor capability compared to conventional rehabilitation practices. The improved mobility highlights the Kenevo's potential in supporting greater independence and autonomy in transfemoral amputees, underscoring the benefits of early and specialized intervention with MPKs.

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5.137 Innovations in Trauma-Related Primary Below-Knee Amputation

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BACKGROUND

Soft tissue coverage is often a limiting factor in prosthetic rehabilitation following below-knee amputation. Surgical techniques such as myodesis, myoplasty, and myopexies aim to refixate muscles in the residual limb (RL), providing cushioning for the distal bone and muscular guidance. Rupture or dislocation of muscle transpositions can lead to inadequate soft tissue coverage, ulcerations, pain and biomechanical limitations

AIM

We aim to assess the long-term impact of the Agonist-Antagonist-Myoneural-Interface (AMI) in primary below-knee amputation on RL volume changes, walking ability and amputation-related pain.

METHOD

The Agonist-Antagonist Myoneural Interface (AMI) represents a novel surgical approach that selectively connects agonist (e.g. the tibialis anterior) and antagonist (e.g. the gastrocnemius) muscles through a tenorrhaphy. Perioperative data, modifications of the surgical technique, complication rates, longitudinal RL volume changes, walking ability, balance, amputation-related pain, and embodiment were analyzed.

RESULTS

Over a 24-month follow-up, 20 patients underwent a primary below-knee amputation utilizing AMIs. Of these, 14 were unilateral and 6 bilateral. 75% of the AMI-candidates lost their lower leg due to acute trauma (n=6), sepsis (n=5) or late failure of limb salvage (n=4). The remaining 25% were non-trauma related amputations (n=5). Complications included two early and one late infection requiring resection of AMIs. RL volume analysis showed a consistent increase at six of seven measurement points. Muscle functionality was reliably preserved in all patients, resulting in palpable contractions at the RL. Only 15% reported life-altering amputation-related pain.

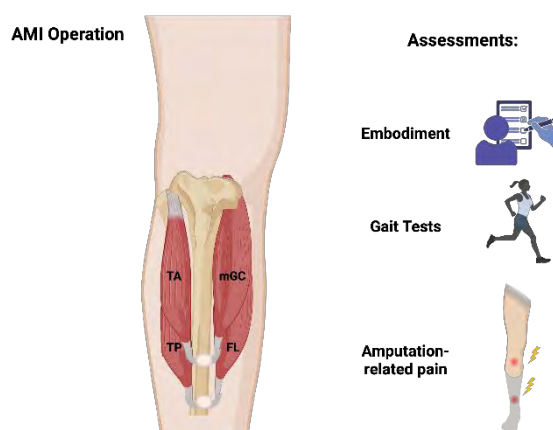


Figure 1: Surgical procedure for AMI. TA = Tibialis anterior muscle, mGC = medial part of gastrocnemius muscle, TP = Tibialis posterior muscle, FL = Fibularis longus muscle. Created with BioRender.com

DISCUSSION AND CONCLUSION

AMIs were successfully used across various indications during primary amputations, with no documented dislocations as experienced after standard amputation. RL volume reductions remained <10%, compared to 17-35% observed after standard amputations at 100 days follow-up. Incidence of amputation-related pain was lower than after standard amputation. Object of future investigations remains the agonist-antagonist relationship and whether preserving proprioceptive structures enhances motor control and ambulation capabilities of the RL and prosthesis.



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5.141 Exploring the rationale for prescribing ankle-foot orthoses and supra-malleolar orthoses for children with cerebral palsy amongst paediatric orthotists in Australia

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BACKGROUND

To help improve outcomes for children with cerebral palsy (CP), both ankle-foot orthoses (AFOs) and supra-malleolar orthoses (SMOs) are often prescribed [1]. However, based on a recent narrative review [2] the rationale for prescribing AFOs was clearer than that for SMOs. By contrast, the rationale for prescribing SMO was not clear given the rationale was often vague, and not aligned with the aim, nor the outcome measure(s) used [2].

AIM

To explore the rationale for prescribing ankle-foot orthoses and supra-malleolar orthoses in children with cerebral palsy amongst paediatric orthotists in Australia.

METHOD

Purposive, convenience, and snowballing sampling were used to identify paediatric orthotists providing care to children in both hospital- and community-based facilities across Australia. Semi-structured interviews were conducted virtually. All were recorded and transcribed. The data were independently coded by two researchers. Themes and subthemes were presented with illustrative first-person quotes.

RESULTS

Participants (n=16) in the sample were diverse in terms of their age, years of clinical experience, and state of residence. Two themes were generated: *rationale for orthotic prescription*, and *alignment of prescription rationale with child/family goals*. Experienced clinicians could clearly articulate the key factors that influence their orthotic prescription aligned to the reasons why children/families sought orthotic intervention. Early to mid-career clinicians found this more challenging.

DISCUSSION AND CONCLUSION

Given the observations of experienced clinicians, early- and mid-career clinicians might adopt a similar approach whereby the prescription was based on a couple of primary factors (e.g., presence of crouch gait) that determined the most appropriate type of orthotic intervention (e.g., type of AFO), and then optimised the prescription using a range of secondary factors (e.g., body mass) to tailor the orthotic design (e.g. choice of material).

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ACKNOWLEDGEMENTS

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5.142 A National Population-based Study of AFO Provision to Children with Cerebral Palsy

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BACKGROUND

AFOs are the most common orthosis provided to children with cerebral palsy. Sweden's national follow-up programme records data on every orthosis given to people with CP, including the aim of providing the orthosis and how it is intended to affect the user's body. To have access to the whole population provides unique opportunities for research.

AIM

To investigate potential correlations between patient characteristics such as age, GMFCS level and contractures and AFO design.

METHOD

3 year's worth of AFO reports were collected from the national database as well as relevant information on the child that received the AFO. Descriptive statistical analysis was performed, as well as correlation analyses

RESULTS

Results are not yet completed since this project is ongoing. 1457 AFOs provided to 894 children are included in the analyses. The mean age of AFO provision was 8.4 years old. Most children who received AFOs were GMFCS I (318), and fewest AFOs were given to children in GMFCS III (96). The most common goal was to affect structures of the foot and ankle, followed by improved walking ability. The most frequent functional requirement stated was to control the affect of increased muscle activity, followed by to correct a flexible deformity.

DISCUSSION AND CONCLUSION

The author reserves discussion and conclusion comments until completion of the project. However, the data set used includes all of the AFOs reported to the national quality register during a fixed time period. This sets the project in a unique position to be able to comment on national trends with more confidence than a randomised sample would allow.

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ACKNOWLEDGEMENTS

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5.143 Functional Comparison and Social Perception of a New Orthotic Intervention for Idiopathic Toe-Walking in Children

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BACKGROUND

Older school-aged children with autism-spectrum disorder (ASD) can continue to present with idiopathic toe-walking (ITW), even after years of continued orthotic intervention¹. Children with ASD who continue to exhibit sensory-seeking (or sensory-avoidant) toe-walking are frequently treated with orthotic intervention from early toddler age, into adulthood². Orthotic compliance can be challenging for both the child and the parents, as traditional rigid orthotic intervention interferes with the sensory-seeking tactile input or exacerbates sensory-avoidant behaviors due to increased stimuli from orthotic contact with the lower extremities³. It is known that toe-walking can cause other postural compensations including equinovarus deformities, excessive genu recurvatum, and hip flexion tightness with increased lumbar lordosis⁴

AIM

To assess children with ASD and toe-walking clinical outcomes in dynamic assistant-resistant orthotic designs, acceptance and rejection rates, social perceptions, and impacts on gait.

METHOD

Twelve subjects diagnosed with ASD and toe-walking, between the ages of 8-12 years old, were recruited for the study. Inclusion criteria included an orthotic history of daily use of bilateral articulated ankle-foot orthoses (AFOs) with plantar-flexion stops since preschool age. Exclusionary criteria included plantarflexion contractures greater than 5 degrees or known additional diagnosis known to cause toe-walking. Outcome measures were taken barefoot, with current orthotic intervention, and with dynamic strut intervention at various time periods.

RESULTS

Subjects' overall wearing refusal decreased by 42% with the dynamic strut AFOs. Subjects chose to wear the dynamic AFOs 83% of the time. Barefoot was able to perform the TUG and TUDS test at faster speeds than with the articulated or dynamic strut AFO designs. At the 1 month and 3-month assessment, the dynamic strut AFO demonstrated longer distances ambulated during the Pediatric 30-Second Walk Test (30sWT) than both barefoot and articulated AFO assessments. There was no difference between the 1-month dynamic strut AFO assessment and baseline articulated AFO assessment of the Pediatric Reach Test. The 3-month dynamic strut assessment demonstrated an improvement in the Pediatric Reach Test. No significant difference in outcome measures found when assessing barefoot walking at the beginning versus end of assessment.

DISCUSSION AND CONCLUSION

Dynamic strut AFO designs have shown improvements in clinical outcomes and compliance for children with idiopathic toe-walking and autism spectrum disorder. For children with sensory processing sensitivities, this strut design may reduce sensory difficulties associated with orthotic intervention by providing stimulus input different than traditional methods.

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5.144 Exploring Progression of Prosthetic Knee Prescription in Paediatric Rehabilitation: A Case Study

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BACKGROUND

Microprocessor knees (MPK's) have been developed to improve the energy efficiency of walking through improved kinetics and to reduce the risk of falls. (Kaufman et al., 2012; McGrath et al., 2022) In 2016, these knees were commissioned by the NHS in England for people that met the inclusion criteria. (Clinical Commissioning Policy: Microprocessor Controlled Prosthetic Knees NHS England, 2016). The limitation for children with unilateral amputations accessing an MPK is the space available to accommodate the build height.

AIM

To consider the opportunities and limitations of progressing from a mechanical knee to a MPK in a child with unilateral femoral transcondylar amputation.

METHOD

This case study describes the initial 2 years of a rehabilitation journey for a child who required a femoral transcondylar amputation due to sarcoma when aged 9. It discusses rehabilitation and prescription choice based on patient characteristics, goals and available components. The progression from a mechanical to a microprocessor knee was done as a trial as set out in the NHS England MPK policy. Quality of life (QOL) questionnaires, functional tests, goal setting and gait analysis on an instrumented treadmill were completed on both knee joints.

RESULTS

The gait analysis observed a wider step width with the mechanical knee compared with the MPK. Both the MPK and mechanical knee has a similar step length but the MPK demonstrated a slight decrease in the left double-support loading time.

Table of results

Outcome Measures	Mechanical Knee	MPK
6 minute timed walk	351m	513m
L test	25 seconds	12 seconds
Number of falls in the past 4 weeks	5	0
Number of stumbles in the past 4 weeks	15	5
Modified Reintegration to Normal Living Index	34	40
EQ5D5L	23222	12121
Activities- specific Balance Confidence Scale - UK	92%	92%
Locomotor Capabilities Index- 5	45	53
Prosthesis Evaluation Questionnaire	82.05	92.15

DISCUSSION AND CONCLUSION

A challenge when evaluating the use of MPK's with children is the lack of validated condition specific QOL questionnaires or functional tests. Initial findings and patient feedback are positive, and suggesting the MPK is beneficial in improving gait and QOL. Further consideration needs to be given to the type of kinetic and kinematic data collected to evaluate the effects of an MPK. Clinicians can consider early transition to MPKs for children when space allows.

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ACKNOWLEDGEMENTS

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5.145 Child-Adapted Investigation for Design Input of a New Prosthetic Device: A Comprehensive Testing Approach

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BACKGROUND

Prosthetic testing in children is limited, most publications conducted before the year 2000 [1]. There are significant gaps and limitations of the research and development of prosthetic components. Structural design testing often assumes children are “small adults” and lacks input on their acceptance [2]. Child-adapted clinical investigations aim to provide design input in formats suitable for children. Patient reported outcomes (PRO) will offer additional information to product designers and clinicians.

AIM

The aim of this study was to align user feedback and expert observations with pre-developed design features of a novel paediatric prosthetic foot, and to compare its performance with that of the participants' current devices.

METHOD

The study included a single event, with a maximum duration of two hours per participant. Each participant was provided with the investigational device, along with variations of this device in different stiffness categories. According to the feedback and expert observation one version was defined as preferred and compared to the current device. The participants were asked to perform various tasks such as incline and decline walking, sidestepping, balancing, running, and playing with a ball, among others. A playground was used to create a more natural environment and motivation. Activities were adapted to the participants' abilities and were observed by attending experts. Baseline data forms and user feedback questionnaires were completed, and expert observations were systematically documented.

RESULTS

All participants could be fitted with a well-accepted device configuration. There was a trend that participants preferred a slight softer category as compared to the predeveloped design. Observations from Certified Prosthetists and Orthotists (CPOs) as well as engineering professionals corroborated these findings. Engineers gathered sufficient feedback to generate data points for the final stiffness curve, thereby allowing for the finalization of the layup and stiffness parameters for the final product. The comparison between the preferred version and the current device underscores the significance of a foot design that incorporates both flexibility and energy return, which are crucial for the activities performed by children.

Mean Age and Range [y]	12.7 (6-21)
Gender	6 female, 7 male
Mean Weight and Range [kg]	38.3 (16-56)
Amputation Levels	8 TT, 4 TF, 1 HD
Amputation Sides	7 right, 4 left, 2 bilateral
Foot Sizes [cm]	18-24

Figure 1: Demographics

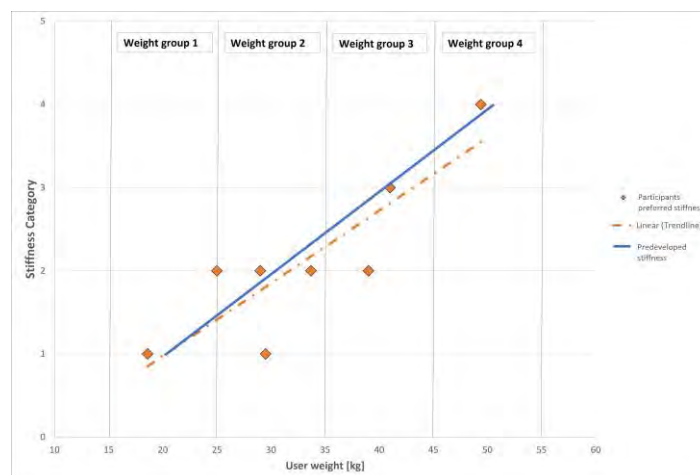


Figure 2: Stiffness Evaluation

DISCUSSION AND CONCLUSION

Testing with children requires more empathy from the researchers and more flexible procedures than for adults. Conducting evaluations in environments that differ from traditional laboratory settings, such as playgrounds, can be beneficial for motivating children and observing their natural behavior. The heterogeneity in deficits and functional levels among pediatric participants reflects the clinical reality. Consequently, intra-subject comparisons were employed to assess device performance through participants' feedback and observation.

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ACKNOWLEDGEMENTS

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5.146 Evaluating Balance and Finger Muscle Strength in Children with Down Syndrome: The Role of Orthotic Insoles and Finger Splints

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BACKGROUND

Down syndrome, the most common chromosomal disorder, results from trisomy 21. The majority of musculoskeletal issues in individuals with Down syndrome (Ds) stem from widespread ligamentous laxity, joint hypermobility, and hypotonia. These factors can contribute to conditions such as atlantoaxial and atlanto-occipital instability, scoliosis, spondylolisthesis, hip dysplasia or instability, patellar instability, pes planus, and hallux valgus. Additionally, individuals often have reduced motor skills, balance, strength, and coordination.

AIM

The aim of the study is to investigate the impact of insole application on balance and the effect of finger splints on pinch strengths and hand dexterity in children with Down syndrome.

METHOD

The study included 15 children with Down syndrome, aged 7-13. Evaluations revealed that these children had foot deformities such as pes planus, hallux valgus, and calcaneal valgus. Custom-made insoles produced with 3D printing were applied to these individuals. Balance assessments were conducted with and without insoles using the Bobo Pro 2 device. For children with joint laxity, particularly hyperextension in the proximal interphalangeal joints, finger splints made from Orficast More thermoplastic material were applied.

RESULTS

The Bobo Pro 2.0 is widely used in physical therapy to improve balance, coordination, and overall motor skills. In a study involving eight children, static balance was assessed using the Bobo Pro 2.0 with and without insoles. The results showed that without insoles, balance scores ranged from 50-70%, while with insoles, the scores significantly improved to 75-89%. Additionally, the effect Orficast More hyperextension blocking finger splints on pinch strength was evaluated in seven children with Down syndrome using the JAMAR pinch dynamometer. The findings indicated no significant change in lateral pinch strength, but an increase in two-point pinch and three-point pinch strengths were observed. These results suggest that insoles can enhance balance, and Orficast More splints may improve certain types of pinch strengths in children.

DISCUSSION AND CONCLUSION

Orthotic devices are commonly used in children with Ds to support lax ligaments and hypotonic muscles. Studies show that custom-made foot orthoses improve foot alignment and gait consistency, while flexible supramalleolar orthoses enhance gross motor skills, contributing to physical function. Our study demonstrated that 3D-printed insoles positively influences balance. Furthermore, the implementation of finger splints was observed to enhance finger strength, although their impact on writing ability exhibited variability.

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5.147 Use of Cranial Molding Orthoses in Positional Plagiocephaly: Family Impact and Satisfaction

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BACKGROUND

Positional plagiocephaly is a common cranial deformity in infants with rising incidence. Untreated cases may lead to cosmetic issues, causing parental concerns about future psychosocial impacts. Recently, cranial molding orthoses (helmets) have proven effective ¹, though families often view helmet use with prejudice due to infants' young age.

AIM

This study aimed to investigate the impact on families, satisfaction with helmet use, and challenges faced during helmet therapy in infants with positional cranial deformities.

METHOD

17 infants using helmets for at least two months, with no neurological issues or surgical history, were included with their caregivers. Initial assessments recorded anteroposterior and mediolateral measurements, diagonal differences, cephalic index (CI), and Cranial Vault Asymmetry Index (CVAI) using Structure Sensor 3D ©. Parents reported average daily helmet-wearing hours. Family impact was evaluated via the "Impact on Family Scale (IPFAM)" (Financial, Social/Familial, Personal Strain, Mastery subscales)² and the "Quebec User Evaluation of Satisfaction with Assistive Technology 2.0 (QUEST-2.0)"³. Helmet-use challenges were assessed using a 7-item Likert questionnaire on topics such as helmet adjustment, hygiene, sleep, duration, activity, feeding, and dressing.

RESULTS

The CI ($88 \pm 9.51\%$), diagonal differences (14.9 ± 3.61), and CVAI ($11.53 \pm 3.48\%$) values were recorded for 17 infants, with an average daily helmet usage of (21.47 ± 1.77) hours. IPFAM scores included financial (6.82 ± 2.09), social/familial (17.29 ± 6.121), personal strain (23.06 ± 6.36), mastery (6.59 ± 1.87), and total (47.18 ± 13.84). QUEST-2.0 results showed device satisfaction (34.82 ± 4.26), service satisfaction (18.71 ± 1.96), and total satisfaction (53.53 ± 5.63). When asked to select the three most important features of helmet use, 13 families chose "effectiveness," 7 chose "durability," and 7 chose "follow-up service." A moderate positive correlation existed between CVAI values and total family impact ($r=0.581$, $p<0.05$), while total QUEST-2.0 scores did not correlate with CVAI ($r=0.060$, $p>0.05$). Families found "getting used to wearing duration" and "sleep" most challenging, while "helmet hygiene" was least challenging.

DISCUSSION AND CONCLUSION

Families are generally hesitant about helmet therapy. Preliminary results suggest low negative impacts on social, personal strain, and financial aspects. Families expressed satisfaction with the helmet's effectiveness, durability, and follow-up service. Future studies with larger samples could examine monthly changes in family impact, providing valuable insights. This study highlights helmet therapy's potential to enhance family satisfaction and support healthy infant development.

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Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Gait and balance

5.151 Gait stability and Balance Strategies of Prosthetic Users in Response to Perturbations

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BACKGROUND

Falls are one of the leading causes of injuries including bone fractures, head injuries, and even deaths¹. Falls are considered as the most common cause of injuries leading to death in people over the age of 75 in the UK. Populations such as those with lower limb loss/absence have an even higher incidence of falls. It has been reported that the up to 50 per cent of subjects with lower limb absence encounter a fall each year². It is essential to understand the stability and the recovery mechanism in order to develop anti-falling programs. A measure by Hof et al called Margins of stability has been reported to be a strong indicator for stability³. MoS along with step length and step width could reveal important insights regarding recovery mechanisms.

AIM

The aim of this study was to assess the stability and determine the biomechanical adaptations to maintain stable when facing unbalance situations.

METHOD

Ten male and five female participants with lower limb amputation (average age 55, time since amputation 19.85 years) participated in the study. Participants walked at comfortable in the Motek CAREN Rehabilitation Environment that has split belts. Sudden speed changes were imposed on each leg by increasing or decreasing the speed. The method adopted from previous work⁴. MoS was calculated in both AP and ML direction along with step length and width.

RESULTS

Table 1: Summary of the perturbation effect on the MoS compared to steps before. () represents significant difference (p<0.05)*

Deceleration		
Step	AP MoS	ML MoS
C1-A	Decreased (intact~3%, prosthetic~20% *)	Increased (intact~12%, prosthetic~16% *)
I1-A	Increased (intact~45% *, prosthetic~55% *)	Decreased (intact~8% *, prosthetic no change)
C2-A	Increased (intact~35% *, prosthetic~37% *)	Decreased (intact~12%, prosthetic~3%)
I2-A	Increased (intact~20% *, prosthetic~16% *)	Decreased (intact~8% *, prosthetic~13%*)
C3-A	Increased (intact~8%, prosthetic~6% *)	No noticeable change
I3-A	Increased (intact~8%, prosthetic~10% *)	No noticeable change
Acceleration		
Step	AP MoS	ML MoS
C1-A	Increased (intact~45%*, prosthetic~65%*)	Decreased (~10% intact * & prosthetic *)
I1-A	Increased (intact~15%*, prosthetic~10%*)	Increased (~10% intact * & prosthetic *)
C2-A	Decreased (intact~15%*, prosthetic~10%*)	Increased (~10% intact * & prosthetic *)
I2-A	Increased (intact~8% *, prosthetic~12%*)	No noticeable change
C3-A	No noticeable change	No noticeable change
I3-A	Intact no change, prosthetic increased~10%	No noticeable change



DISCUSSION AND CONCLUSION

The results indicate that prosthetic users as a group could not return to baseline values and the situation before the slips even after three steps. The involvement of the prosthetic side to retrieve the balance when the intact was being challenged was limited. The Deceleration slips were more challenging than acceleration slips. The acceleration slips were also challenging to the prosthetic users.

Results indicate that walking with wider and faster steps with no significant change in step length, may help prosthetic users to recover from slips and thus avoid falling. It is feasible to provide training and awareness to prosthetic users which may help them react in a similar way to promote recovery, maintain stability and avoid falls. Such training and awareness may be promoted during rehabilitation, prosthesis fitting and delivery and could be valuable throughout entire prosthetic use. If a gait analysis system was available in a prosthetic clinic, this study protocol is useful in evaluating anti-falling training.

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5.152 There are distinctive relationships between dynamic balance during gait and clinical outcomes for elderly individuals with and without transtibial amputation

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BACKGROUND

The frequency of falls in community-ambulating individuals who are elderly (≥ 65 years old) with and without lower-limb amputations are 30 and 50%, respectively [1,2]. Fall risk has been quantified through balance-related clinical tests like the Activities-specific Balance Confidence (ABC) Scale, Amputee Mobility Predictor (AMP), and prospective falls diaries, as well as through biomechanical measurements such as whole-body and segmental angular momenta (H) [1, 3-5].

AIM

Test the hypotheses that relationships exist between clinical fall-related outcome measures and angular momenta during gait for older individuals with and without transtibial amputation (TTA) but differ between these groups.

METHOD

Data including the ABC, AMP and prospective falls (for 12 months via diary logs) were collected from 10 able-bodied individuals and 13 individuals with unilateral TTA who were ≥ 65 years old. Participants were instrumented with a modified Helen Hayes reflective marker set and walked along a 10-m walkway at comfortable self-selected speeds. During five repeated trials, whole-body and body segment (arms, legs and head-abdomen-thorax) H were calculated in 3D. For each participant, the average peak-to-peak range of H was correlated with clinical outcome measures (Spearman's correlation (ρ) for ABC and AMP; Pearson's correlation (r) for prospective falls; $\alpha=0.05$).

RESULTS

Able-bodied individuals had significant positive correlations with ABC and their dominant and non-dominant leg H in the *sagittal* plane (both $\rho=0.66$, $p=0.039$). This group also had correlations with prospective falls in the *frontal* plane with whole-body and dominant arm H ($r=0.66$, $p=0.038$; $r=0.72$, $p=0.02$, respectively). These results suggest that increased fore-aft rotations of the legs are associated with increased balance confidence, but that increased whole-body and arm side-to-side rotation are linked to more falls. TTAs had correlations in all three planes: whole-body H (*frontal*) negatively correlated with AMP ($\rho=-0.57$, $p=0.04$), whole-body H (*transverse*) positively correlated with ABC ($\rho=0.56$, $p=0.49$), and dominant arm (*sagittal*) negatively correlated with prospective falls ($r=-0.6$, $p=0.03$). These differences between groups suggest there are changes in perceived control of balance and associated "ground truth" measures of performance.

DISCUSSION AND CONCLUSION

Greater balance confidence of elderly individuals was reflected by increased angular momentum but differed by plane and body segment in the presence (or absence) of amputation. With amputation, functional outcomes like mobility and prospective falls revealed opposite trends with angular momentum. Specifically, larger frontal-plane body momentum during walking may be a marker of reduced mobility across functional tasks, while larger sagittal-plane arm momentum may protect against community-based fall risk.

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5.153 Validity and reproducibility of Inertial Physilog® sensors for quantitative gait analysis in patients with major lower limb amputation

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BACKGROUND

Gait analysis (GA) plays a key role in prosthetic rehabilitation of persons living with major lower limb amputation (mLLAs) by providing essential data for prosthetic alignment and monitoring of rehabilitation progress ⁽¹⁾. Inertial measurement units (IMUs) offer a promising alternative for accurate, cost-effective, and portable GA ⁽²⁾. Their use in daily practice could improve rehabilitation and assist clinicians in evaluating gait abnormalities.

AIM

To assess the reproducibility of Physilog® gait parameters (PgP) in mLLAs during functional tests (FT) and correlate them with visual observation (VO) and mLLAs perceived and observed mobility (MOB).

METHOD

-FT (repeated twice): 2-minute-walking-test (2MWT), Timed-Up-and-Go-test (TUG), stairs (ST) and on a 5°-slope (5°S).

-PgP: speed, cadence, stride-length, stance, strike-angle, peak-swing (2MWT, ST, 5°S), duration, turn-to-sit (TS), sit-to-walk (SW), U-turn components (TUG).

-VO: flight/stance time asymmetry (FSTA), lateral excursion of amputated limb (LE), and step length asymmetry (SLA) (Yes/No by majority vote of physiatrist, physiotherapist, and prosthetist).

-MOB: Amputee-Mobility-Predictor (AMPPRO), prosthetic-limb-users-survey (PLUS-M/FC-12).

We used: the intraclass-correlation-coefficient (ICC) to assess reproducibility of PgP, the area under the ROC curve (AUC) for estimating VO detection threshold for gait abnormalities (when possible), the Spearman's correlation-coefficient between some PgP and AMPPRO and PLUS-M/FC-12.

RESULTS

Sixteen mLLAs participated (mean age 61[IQR: 63;71], 8/8 male/female, 8/4/2/1/1 transtibial/Gritti-Stokes/transfemoral/syme/hip disarticulation, 7/6/3 ischemic/traumatic/other).

ICC was:

-2MWT: good to excellent (0.69[0.15;0.93] to 0.98[0.89;0.99]) for all PgP, except for stance phase measures of prosthetic side (0.18[-0.8;0.8]).

-TUG: Excellent (0.96 [0.86-0.99]) for duration, poor for TS, SW and U-turn (all<0.4).

-ST: Excellent for peak-swing (0.88[0.54;0.97]), poor to fair for the other parameters (-0.4 to 0.47).

-5°IS: fair to excellent (0.48[-0.23;0.85] to 0.81[0.36;0.95]), the majority being good (0.6-0.74).

VO: AUC was perfect (1.00) for the detection of LE ≥4cm, good (0.74) for of FSTA>15cm and bad for SLA ≥9% (0.63).

MOB: Moderate to good correlation was found between PgP (speed, strike-angle, asymmetry) and AMPPRO and PLUS-M/FC-12 (0.51 to 0.84, p: 0.05 to < 10⁻²).

DISCUSSION AND CONCLUSION

Gait parameters measured by Physilog® sensors are reliable for GA of mLLAs on flat surfaces, but further software improvements and validation are required before suggesting their use on inclined terrain and stairs. IMU have the potential to complement VO. Good correlation of Physilog® measures with person's perceived and measured mobility reinforce the validity of using IMU in clinical practice.

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5.154 Clinical Investigation of Patient Benefits and User Preferences for a Novel ESAR Foot Compared to Established ESAR Feet

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BACKGROUND

Energy storing and return (ESAR) feet are commonly used among community ambulators with lower limb amputations. Recently, a novel ESAR foot, the Ottobock Evanto, has been introduced. Due to a different technical approach, this foot is more compact than traditional ESAR feet, which commonly incorporate an elongated heel and shank.

AIM

To characterize user preference and patient benefits of the novel foot compared to established ESAR feet, a randomized multicentre study was performed. In this study, the novel foot was compared with the current everyday foot of the study participants and the comparator foot, Össur Pro-Flex XC.

METHOD

Transfemoral amputees with a functional level of K3 using ESAR feet participated in the study. They used the study foot and comparator foot in a randomized order for 8±2 weeks. During each visit and 8 weeks after returning to their everyday foot, they completed a questionnaire evaluating multiple parameters. After all test phases, they selected their preferred foot overall and for specific activities (adapted from Morgan et al. 2018) and evaluated how well each foot met their prosthetic needs. Of the twenty participants analysed, eight already used the comparator as their everyday foot.

RESULTS

The novel foot was the overall preferred choice for 55% of participants and was favoured for many activities, with the highest preference rates for walking on inclines (85%) and declines (75%), traversing uneven terrain (70%), and walking quickly (55%). The comparator foot was the preferred choice for 20% of participants, with relatively high preference rates for walking quickly (35%), walking while carrying a heavy load (25%), and running (20%), but relatively low preference rates for walking on inclines (5%) and in sand (5%).

The novel foot was the highest rated among the tested feet in terms of meeting amputees' prosthetic foot needs and in many other outcomes investigated (for details, see Table 1). The improvement in mobility, as measured by PLUS-M, compared to the current everyday feet, was statistically significant ($p=0.0007$).

Table 1. Summary of the Outcome Scores (Mean ± SD)

Outcome	Everyday foot (Baseline)	Comparator	Novel foot	Everyday foot (Final)
Extent of meeting amputees' prosthetic foot needs (0-10)	n.a.	7.5 ± 2.3	8.6 ± 1.4	7.8 ± 2.1
Mobility (PLUS-M T-Score)	60.8 ± 4.7	61.3 ± 3.8	63.1 ± 4.4	62.2 ± 5.7
Balance confidence (ABC)	91.0 ± 7.2	90.8 ± 8.6	91.4 ± 6.8	92.9 ± 6.2
Highest reported pain (0-10)	3.3 ± 2.4	3.6 ± 2.2	2.9 ± 2.4	3.2 ± 2.6
Pain interference (0-10)	0.5 ± 0.8	1.7 ± 2.5	0.8 ± 1.3	1.7 ± 2.4
Health utility value (EQ-5D-5L; 0-1)	0.94 ± 0.09	0.94 ± 0.07	0.97 ± 0.05	0.94 ± 0.12
Current health (EQ-5D-5L; 0-100)	84.7 ± 18.3	88.0 ± 12.7	89.4 ± 9.9	87.0 ± 9.8

Note: Except for the highest reported pain and pain interference, higher scores indicate better outcomes.

DISCUSSION AND CONCLUSION

The study results suggest that the novel foot offers many advantages compared to other state-of-the-art ESAR feet, above all during walking on uneven terrains and slopes. Despite its small height, it has similar preference to the comparator for activities requiring high energy return (walking quickly, running).

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5.155 Feels good to be an amputee: 21-year journey to walking

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BACKGROUND

This work reports a case study of a male patient with congenital deformation of bilateral lower limbs; likely caused by rubella. The patient did not ambulate since birth as a result. He had moved on his knees with pads for protection, dragging his feet behind. With limited infrastructure in his village to accommodate wheelchairs, he was largely housebound. The patient was referred to our hospital after elective bilateral below-the-knee amputation.

AIM

The study aimed to represent an unusual case of non-ambulatory patient to independent walking with bilateral below knee prostheses after a comprehensive rehabilitation therapy at our facility.

METHOD

The patient was a 21-year old male with congenital malformation of all limbs including upper limb. The patient was advised to wait until he turned 18 to undergo a double amputation. The Left lower limb was amputated in Apr 2024 and the right one in May 2024. The patient was admitted to Amputee rehab unit and started with pre-amputation therapy. Once the incision healed, the patient was casted for bilateral lower limb prostheses. The patient ambulated with the bilateral preparatory prostheses for the first time in his life. The rehab team designed the gait training based on the initial evaluation.

RESULTS

The outcome measures were the socket comfort score, 2-minute walk test, and L test. The data were collected during the inpatient therapy, before the discharge and the follow up sessions at 3 weeks, 1 month and 3 months. Two-minute walk test score improved by 63% on the discharge day (after 3 weeks) compared to the initial prosthetic fit and by 37% (126 vs. 79 meters) after 3 months compared to the discharge day. The L-test score reduced to 46 seconds on the discharge compared to initial 1.26 minutes. The patient started in the bars, then progressed to walker and left the hospital with two single-tip canes.

DISCUSSION AND CONCLUSION

Currently, the patient does not need any gait aid. The outcome measures improved over time. The patient is independent in his activities of daily living such as walking up and down the stairs. His perspective on life has changed literally and figuratively. With his new legs, he is taller, which he says offers a much better view. Life opportunities are beginning to open and he wants to find a job.



5.156 Importance of timely decision to undergo Amputation to achieve Cosmetic and Functional Restoration in Tibial Hemimelia cases: A case study

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BACKGROUND

Tibial hemimelia is a rare congenital anomaly with a reported incidence rate of one in one million live births. The tibia may be shortened, dysplastic, partially or completely absent. If the child has no functional ankle joint or is not able to actively straighten his knee, then lengthening becomes more challenging. Preferred option in such cases is amputation, followed by fitment of a prosthesis.

AIM

To present the outcome after transtibial amputation of a tibial hemimelia adolescent patient and to disseminate the importance of timely decision on surgical intervention to achieve cosmetic and functional restoration.

METHOD

Zameer (name changed), 16-year-old boy, was diagnosed with Left Tibial hemimelia within first week after his birth. He had been using extension prosthesis (EP) since he was 8-year-old until 15. Zameer was operated upon in December 2017 for limb reconstruction and lengthening by Ilizarov but did not yield desired outcome. Not satisfied with EP, mainly due to poor function and poor cosmetic appearance, he underwent below knee amputation. Zameer responded very well to gait training due to his previous experience.

The Prosthetic and orthotic centre where Zameer was rehabilitated is supported by the International Committee of the Red Cross, India.

RESULTS

At the time of discharge, three months after amputation, Zameer was able to achieve his goals by regaining efficient mobility, independence and most importantly self-confidence. Significant increase in distance covered was observed in 6-Minute Walk Test on Transtibial prosthesis (341m) compared to extension prosthesis (275 m). Zameer does not fatigue easily now like the way used to, and he relates it to his aspiration of becoming a cardiac surgeon as they have to perform long duration surgeries. Within first month after receiving his prosthesis, Zameer has rejoined his school and has started playing various games like badminton and cricket and his passion for cycling has grown enormously.

DISCUSSION AND CONCLUSION

A multi-disciplinary team approach in which professionals work closely with the user and family to set and attain clear goals is critical to optimizing patient outcomes for this population. Additionally, need of the hour is to disseminate the importance of timely decision on surgical intervention to achieve cosmetic and functional restoration in Tibial Hemimelia cases among various professionals about the best rehabilitation outcomes.



5.157 Exploring transtibial prosthetic coupling (Part 1): Utilising adjustable sockets to influence prosthetic interface stiffness when comparing knee axis estimation methods

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BACKGROUND

Motion capture (MoCap) is widely used to study human ambulation. While optimisation to estimate the knee axis from MoCap markers has been explored in healthy populations¹⁻³, its effectiveness in transtibial prosthesis users remains unclear due to the increased marker artefact generated from prosthetic coupling movements. Adjustable sockets are gaining popularity in research and industry⁴. Their adjustments influence the 'pseudo-joint' interface properties; however, the changes to interface stiffness and coupling are unknown.

AIM

To utilise the variable interface properties of adjustable sockets to investigate knee marker optimisation strategy influence on prosthesis movement measurements.

METHOD

Gait was recorded for a unilateral transtibial participant across two sessions using MoCap for ten walking bouts at five socket tightness's, providing ten interface conditions. Gold standard knee-axis estimation¹ was conducted on knee flexion data with the prosthesis doffed to create a baseline. Three functional methods¹⁻³ were then conducted on gait data, with socket-limb coupling movements calculated in four degrees of freedom (DoFs, Table 1), with an estimated adduction movement⁵. Method accuracy was analysed against the baseline using root-mean-square-error (RMSE) of marker locations¹, pairwise RMSE and cross-correlations of mean-centred coupling results, and Spearman's correlation to analyse within-session coupling range trends.

RESULTS

Sphere fitting with iterative noise reduction² proved to be the most accurate method of knee axis calculation from transtibial walking gait data throughout all tests. Principal component analysis (PCA) performed the worst throughout, probably because it optimises knee axis *orientation* but not *location*, as it retains proximal-distal marker placement error. However, the correlation of within-session trends between interface conditions was very strong. The axis location RMSE was comparable to virtual tests¹ which used smaller ranges of motion than gait (5° and 70°, respectively). The RMSE was largest in the transverse rotation measures for all methods; however, this DoF is known to be least accurate in MoCap.

Table 1: Statistical results on various accuracy measures of three optimisation methods for estimating knee joint axis compared to the baseline.

	Axis Location RMSE (mm)	Pair-wise Coupling RMSE					Pairwise Cross Correlation (p value)	Within Session Trends – Spearman's Correlation (ρ value)
		Displacements (mm)			Rotations (Degrees)			
		A/P	M/L	S/I	Ab/Ad	I/ER		
SARA Algorithm ¹	13.7	4.0	1.4	3.6	0.6	4.9	0.79	1.00
Sphere fitting ²	12.0	1.9	1.3	3.3	0.6	4.9	0.87	1.00
PCA Method ³	45.4	6.5	4.3	12.8	0.6	4.9	0.46	0.97

*(A/P – Anterior/Posterior, M/L – Medial/Lateral, S/I – Superior/Inferior, Ab/Ad – Abduction/Adduction, I/ER – Internal/External Rotation)

DISCUSSION AND CONCLUSION

Two methods produced pairwise S/I RMSE of 3.3-3.6mm, which equates to 15% of pistoning displacement (22.3mm) for this user. Though limited to a single participant, the above results suggest that the sphere fitting algorithm with noise reduction should be used for knee joint axis estimation in transtibial gait analysis. Future work



includes verification that the above stands true for more participants with differing socket, residuum, and gait characteristics and use in secondary data analysis to increase knowledge around prosthesis coupling trends.

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Free paper session | Prosthetics and Orthotics: upper limb – Feedback and control

5.161 Implantable myoelectric sensors improve control of a transradial myoelectric prosthesis: A long-term home-use feasibility study

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BACKGROUND

Myoelectric hand prostheses still rely on surface electromyography (sEMG) sensors with sequential selection of prosthetic hand functions^[1]. Using implants to bypass the troublesome skin-electrode interface and accessing intramuscular signals may be a solution. A new generation of an Implantable Myoelectric Sensor (IMES) system, fully contained in a prosthesis and able to provide 16 implant signals, has been built based on prior foundations^[2,3] and tested by individuals with transradial amputation.

AIM

To evaluate the feasibility of the new IMES system to control a motorized wrist and multiarticulating hand (IMES Transradial Prosthesis, IMES-TP) compared to a surface myoelectric multiarticulating hand (sEMG-TP).

METHOD

A within-subject feasibility study comparing IMES-TP to sEMG-TP was conducted. Two males with transradial amputation and prior sEMG-TP experience were implanted with 11 (P1) and 15 (P2) wireless IMES sensors. Six implants were configured for direct proportional control of 3 physiologically relevant (e.g. m.supinator for supination) prosthetic hand/wrist functions: Hand open/close, thumb rotation and wrist supination/pronation. Ten assessments were planned after IMES-TP fitting; 6 configuration/training sessions (T1-T6) and 4 during a long-term home use period (T7-T10). Functional assessment included Assessment of Capacity for Myoelectric Control (ACMC), and Clothespin Relocation Test (CPRT). sEMG-TP assessment occurred at baseline pre-implant and after T10.

RESULTS

All implants provided quality intramuscular signals after successful implantation. IMES-TP device was fit 30-/31-days post-implant (P1/P2). Simultaneous control was observed at T1 and good control capability lead to IMES-TP home-use starting earlier than expected (T3). Performance on ACMC showed a rapid improvement with a ceiling effect, so task difficulty was increased at T6/T5. At T10 (16-/9-months after starting home-use) IMES-TP clearly showed increased capability for control (ACMC) and improvements on CPRT compensatory movement score compared to sEMG-TP (Table 1).

Table 1. Functional outcomes comparing sEMG-TP to IMES-TP. Values shown as P1/P2 (average)

	Baseline (sEMG-TP)	After T10 (sEMG-TP)	T10 (IMES-TP)
ACMC (score)	58.2/69.8 (64.0)	66.4/62.0 (64.2)	87.8/100 (93.9)
CPRT (s)	23.6/29.1 (26.3)	24.0/22.1 (23.0)	15.3/22.5 (18.9)
CPRT (compensation)	2.8/2.3 (2.5)	1.7/2.0 (1.9)	3.6/3.9 (3.8)

DISCUSSION AND CONCLUSION



Two users of the new IMES system have been simultaneously controlling 3 degrees of freedom (DoF) using 6 implants and direct control, providing improved prosthetic wrist/hand function. Outcomes indicate intuitive control and demonstrate the potential of IMES. Two participants still limit generalizability of the results. Future work will explore more advanced control, use additional implant signals (7+) and test 4+DoF functions to evaluate the full capability of IMES.

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5.162 Improvement of Hand Prosthesis Function with Vibrotactile Feedback

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BACKGROUND

Amputation significantly impacts daily life, and despite advancements in prosthetic technology, many users reject their prosthesis due to unnatural sensations, imprecise control, and limb pain, making embodiment challenging. Research over the last decades has explored various sensory feedback methods to address these issues, including invasive and non-invasive approaches. However, developing a feedback system that is both suitable for daily use and provides feedback within physiological time limits remains challenging.

AIM

This work's goal was to evaluate the effectiveness of vibrotactile feedback in enhancing daily life for upper limb prosthesis users with unimpaired vision.

METHOD

Touch feedback from pressure sensors in a silicone glove - wearable over any myoelectric prosthesis - was delivered via a vibrotactile cuff with a 100ms delay. A 30-day pilot study with one participant was conducted to assess whether sensory feedback improves prosthetic control, ultimately increasing the user's sense of embodiment. The study employed performance-based and patient-reported outcome measures, including Box and Block Test (BBT), Southampton Hand Assessment Procedure (SHAP) and Assessment of Capacity for Myoelectric Control (ACMC) as well as Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) questionnaire, Patient-Specific Functional Scale (PSFS) and Short Form-36 (SF-36). Embodiment was measured using the Prosthesis Embodiment Scale for Upper Limb Amputees (PEmbS-ULA).

RESULTS

The study demonstrated significant improvements in the participant's prosthetic control, with notable enhancements in both gross and fine motor skills. Measurements on the first and 30th day, revealed a 66.6% increase in the BBT score and a 41.88% rise in the SHAP score. Additionally, the ACMC result showed an improvement of 15.53%, and the QuickDASH score increased by 25%. The PSFS score rose by 23.53%, and the SF-36 result by 10.26%. The participant reported increased confidence in using the prosthesis and better embodiment, as shown by an 81.82% improvement in the PEmbS-ULA.

DISCUSSION AND CONCLUSION

The results suggested that vibrotactile feedback significantly improved the functionality and acceptance of a hand prosthesis. However, the one participant study design limits the strength of conclusions, as individual learning effects may have influenced outcomes. But the feedback transmission delay did not pose any significant issues. Compared to previous research, this study incorporated a broader set of outcome measures for better evaluation and, to our knowledge, it is the only add-on vibrotactile feedback system in that form. Findings from this pilot study will inform future research involving a larger participant group and further explore the potential of regular sensory feedback use to reduce phantom limb pain.

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5.163 A Review of Rehabilitation after Upper Limb Amputation: Trends and opportunities

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BACKGROUND

Since 2018, several comprehensive reviews focusing on rehabilitation programs after upper limb amputation (ULA) highlighted the importance of early intervention, the use of advanced prosthetic technology, the critical role of patient-centered care^[1, 2]. Publications focusing on the rapid advances in prosthetic technology and rehabilitation techniques have proliferated over the last 5 years. Therefore, there is a need to characterize holistically the current body of literature focusing on rehabilitation of ULA.

AIM

This review aims to synthesize the latest evidence, identify emerging trends, and pinpoint opportunities for future research and clinical practice improvements in rehabilitation for ULA since 2018.

METHOD

Following the PRISMA framework, MeSH keywords were used to search for references published between 2018 and mid-2024 in Google, PubMed and clinical guidelines databases. Permutations of 344 keywords related to population (e.g., upper limb end-users), intervention (e.g., fitting of attachment; passive, body-powered, external powered, hybrid, activity-specific components), comparator (e.g., sound limb, able-bodied participants) and outcomes (e.g., pain, satisfaction, handedness, functions) were found. References focusing on interventions and outcomes were paired using occurrences of keywords in titles and abstracts. The scores combining the number of publications and level of evidence of study design calculated for each association were ranked (e.g., heatmap).

RESULTS

Out of 610 (100%) references considered, 364 (60%) involved human participants including 196 (32%) case series, 18 (3%) case controls, 148 (24%) cohort studies, and 2 (0.33%) randomized trials. Out of the 15 topics mentioned in more than 20% of the literature, 5 topics related to outcomes and 10 to intervention. The 5 most frequent topics were mentioned by 484 (79%) focused on functional ability, 469 (77%) on performance using prosthetic device, 446 (73%) on prosthetic control, 385 (63%) on prosthetic device and 383 (63%) on feedback. The heatmap of scores for 520 associations between interventions and outcomes showed an over-representation of references associating prosthetic device (318, 52%), control (446, 73%), and other aspects (385, 63%) with functional outcomes (484, 79%)(Figure 1).

		Neuromusculoskeletal pain					Fitting satisfaction					Ambidexterity level					Functional ability				
		All aspects of neuromusculoskeletal pain (S-R1.0)	Reddunn (S-R1.1)	Contralateral (S-R1.2)	Back (S-R1.3)	Pain (S-R1.4)	All aspects of fitting satisfaction (S-R2.0)	Attachment (S-R2.1)	Components (S-R2.2)	Terminal device (S-R2.3)	Quality of prosthetic fit (S-R2.4)	All aspects of ambidexterity level (S-R3.0)	Use of prosthetic hand (S-R3.1)	Use of contralateral hand (S-R3.2)	Use of both hands (S-R3.3)	Handedness (S-R3.4)	All aspects of functional ability (S-R4.0)	Dexterity (S-R4.1)	Gross motor skills (S-R4.2)	Daily activities (S-R4.3)	Performance (S-R4.4)
		116 (19%)	19 (3%)	3 (0%)	4 (1%)	115 (19%)	140 (23%)	3 (0%)	5 (1%)	48 (8%)	129 (21%)	33 (5%)	5 (1%)	8 (1%)	14 (2%)	10 (2%)	484 (79%)	76 (12%)	359 (59%)	86 (14%)	469 (77%)
Intervention																					
All aspects of prosthetic device (S-I1.0)	318 (52%)	130	28	0	0	196	196	28	0	56	168	84	0	56	28	28	1064	224	756	196	1008
Attachment (S-I1.1)	44 (7%)	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	28	28	28
Passive (S-I1.2)	22 (4%)	10	0	0	0	0	28	28	0	28	28	0	0	0	0	0	84	0	28	0	84
Body powered (S-I1.3)	27 (4%)	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	28	28	28
Externally powered (S-I1.4)	169 (28%)	63	28	0	0	168	140	28	0	28	112	56	0	56	0	0	784	140	560	140	756
Hybrid (S-I1.5)	15 (2%)	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	84	56	56	28	84
Activity specific (S-I1.6)	11 (2%)	4	0	0	0	28	28	0	0	0	28	0	0	0	0	0	28	28	28	28	28
Terminal device (S-I1.7)	162 (27%)	60	0	0	0	56	56	0	0	0	56	84	0	56	28	28	504	112	336	84	476
All aspects of prosthetic control (S-I2.0)	446 (73%)	175	28	0	0	336	308	28	0	140	224	56	0	56	0	0	1400	280	980	168	1372
Device (S-I2.1)	295 (48%)	90	0	0	0	168	280	28	0	140	196	56	0	56	0	0	952	252	644	112	924
Feedback (S-I2.2)	383 (63%)	152	0	0	0	280	280	28	0	140	196	56	0	56	0	0	1232	280	868	112	1204
Algorithms (S-I2.3)	283 (46%)	85	28	0	0	224	168	28	0	0	140	56	0	56	0	0	1064	280	756	168	1036
Simulator (S-I2.4)	7 (1%)	14	0	0	0	28	28	0	0	0	28	0	0	0	0	0	56	0	56	28	56
All other aspects of prosthetic device (S-I3.0)	385 (63%)	224	28	0	0	308	336	28	56	112	252	28	0	28	0	0	1232	224	1064	196	1204
Training (S-I3.1)	125 (20%)	63	0	0	0	84	140	28	0	28	84	28	0	28	0	0	392	56	252	84	364
Outcome measures (S-I3.2)	325 (53%)	187	28	0	0	280	280	28	56	84	224	0	0	0	0	0	1036	168	1008	196	1036
All aspects of surgical treatments (S-E1.0)	76 (12%)	45	0	0	0	140	112	0	0	84	112	0	0	0	0	0	252	28	224	56	252
Reattachment (S-E1.1)	11 (2%)	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ossointegration (S-E1.2)	22 (4%)	11	0	0	0	56	0	0	0	0	0	0	0	0	0	0	84	0	84	28	84
Targeted muscle reinnervation (S-E1.3)	26 (4%)	19	0	0	0	28	28	0	0	0	28	0	0	0	0	0	28	0	28	28	28
Regenerative peripheral nerve interfaces (S-E1.4)	43 (7%)	18	0	0	0	56	84	0	0	84	84	0	0	0	0	0	140	28	112	0	140
Agonist-antagonist myoneural interface (S-E1.5)	1 (0%)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All aspects of other solutions (S-E2.0)	99 (16%)	26	0	0	0	56	56	0	0	28	28	0	0	0	0	0	112	0	28	0	112
3D printing (S-E2.1)	49 (8%)	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	28	0	28
User-computer Interface (S-E2.2)	46 (8%)	18	0	0	0	56	56	0	0	28	28	0	0	0	0	0	84	0	0	0	84
Gamification (S-E2.3)	11 (2%)	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 1: Heatmap of the scores



DISCUSSION AND CONCLUSION

One of the stronger trends is that the literature is characterized by 492 (81%) of references with levels of evidence up to 4. Another trend is that functional abilities were the primary outcomes to evaluate prosthetic care interventions while pain, fitting satisfaction and handedness seemed to be overlooked. Altogether, there are opportunities to develop more holistic and standardized outcome measures and rehabilitation guidelines for populations living with upper limb loss.

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5.164 Development of a Thumb Prosthesis with Vibrotactile Sensory Feedback

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BACKGROUND

Current partial hand (PH) prostheses provide adequate grip and cosmesis but are often abandoned due to lack of sensory feedback.¹ Our previous work has identified touch sensation as a design priority for thumb prostheses.² Vibrotactile (VT) feedback has been shown to improve grip strength³ and reduce cognitive workload⁴ in trans-radial prostheses but has not been incorporated in thumb prostheses.

AIM

To assess the end-user acceptability of a sensate thumb prototype in terms of perceived ease-of-use (i.e., with minimal burden) and perceived usefulness (i.e., with a new level of ease) when performing activities of daily living (ADLs).

METHOD

A 35-year-old male with a non-dominant left PH amputation (D1-D5) from a traumatic work-related injury seven years ago tested the sensate thumb prosthesis prototype. It comprises a 3D-printed wristband connected to a force-sensing resistor (FSR) positioned on the volar pad of the thumb that detects pressure and a linear resonating actuator (LRA) unit in the prosthetic socket that provides haptic sensory feedback. After training, the participant completed the Jebson-Taylor Hand Function Test (JTHFT) with their dominant healthy hand (control) and with their PH prosthesis, both with and without sensation. The Prosthetic Socket Fit Comfort Score (PSFCS) questionnaire and an interview were completed.

RESULTS

On average, the participant performed dexterous thumb-dependent ADLs (e.g., turning over cards, picking up small common objects) 3.4 seconds faster with sensation activated (Figure 1). He had abandoned cosmetic thumb prostheses due to ineffective gripping. Sensory feedback provided an unprecedented ease of function. In simulated feeding, it enabled him to securely hold the spoon between his index finger and thumb – an action previously unachievable ([video](#)). Contrarily, the FSR's smooth surface caused large, heavy objects (e.g., checkers) to slip, suggesting the need for a slip-resistant surface in future designs. The device was rated 9/10 on the PSFCS, reporting no pain with use. The participant found the prototype "very useful" for "eating, self-care, and holding sensitive documents," and requested it for personal use.

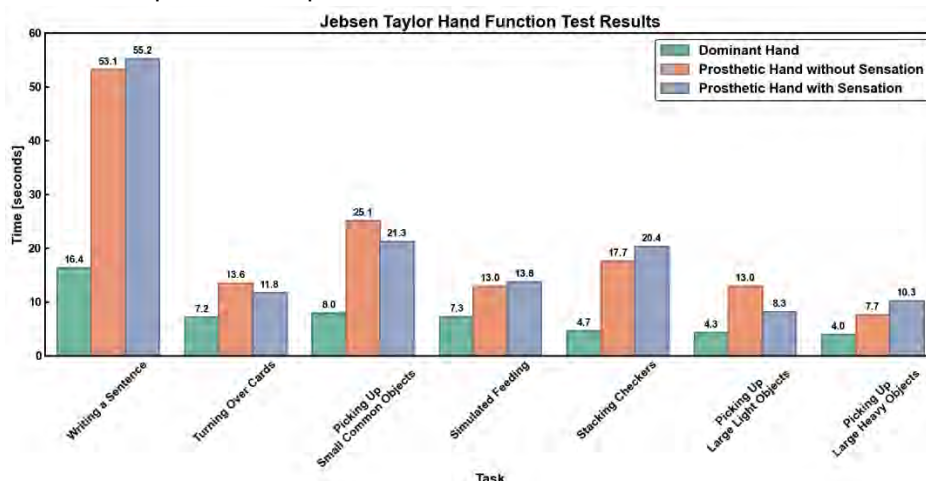


Figure 1: Jebson-Taylor Hand Function Test results evaluating thumb prosthesis sensate capacity



DISCUSSION AND CONCLUSION

This case report presents novel findings on PH prostheses with VT-thumb integration, confirming their suitability in upper limb prostheses.^{3,4} Limitations include a small sample size and the JTHFT's dependence on time, which does not fully capture functionality. To address this, ethics approval was obtained from the University Health Network REB (21-5500.6) for a multi-centre study with robust functional tests. The sensate thumb prosthesis improved ADL ease and was highly valued.

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5.165 Can We Better Describe and Minimize Operation Frustration for Myoelectric Pattern Recognition Users?

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BACKGROUND

Classification accuracies greater than 95% for classifying hand motions ^[1] are not uncommon. However, many users elect not to use pattern recognition hands due to retraining time burdens when accuracies inevitably decline from sweat or fatigue ^[1, 2]. Since there is an incongruity in literature accuracies and acceptance rates, are we missing metrics that can better describe how accurately algorithms respond to changes in real-time?

AIM

We seek to accurately classify the user's intent via electromyogram (EMG) signals while contracting to postures ('ON') and then back to neutral ('OFF') so that the user has more accurate real-time control.

METHOD

EMG Data from 12 subjects was collected under the COMIRB No: 14-0838 protocol where two DAQ systems (Noraxon & Delsys) were used to record 11 postures (Open/Close, Flex/Extend, Radial/Ulnar Deviation, Pronation/Supination, Thumb Adduction/Abduction, Off) sampled at ~3kHz and ~2kHz with 6 contractions for each training and validation dataset.

Linear Discriminant Analysis (LDA) & Fuzzy C-Means (FCM) algorithms were developed to filter, bin, extract features, and classify hand postures in real-time ^[3,4]. As variables and features were methodically adjusted, both 'ON' and 'OFF' accuracies were collected using cluster computing for tuning hyperparameters by minimizing misclassification errors.

RESULTS

One traditional way to improve accuracy is to include more features; however, the cost is increased computational time and response delays. We tested 15 different combinations of time domain features: Root Mean Square (RMS), Zero Crossings (ZC), Slope Sign Change (SSC), and Wavelength (WL). The addition of more features increased the 'ON' data accuracy means 7-11%.

There was no significant difference in 'ON' accuracy means for just 1 feature (RMS) between LDA & FCM and there was a significant difference of FCM performing better in 'OFF' accuracies (p-value = .001), we infer that FCM's ability to preserve accuracies yet use less features could lead to faster responsive control.

For better visualization, an example of misclassifications users would experience in real-time is displayed in Figure 1.

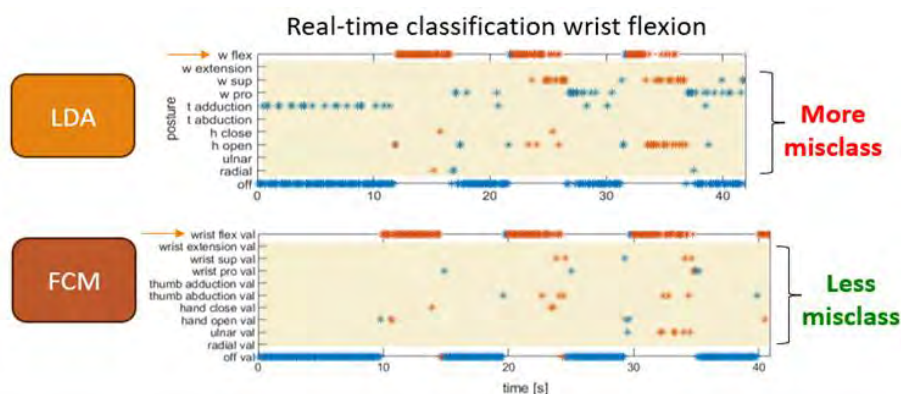


Figure 1: An example of comparing WristFlexion classification in both LDA and FCM algorithms showing all misclassifications for both 'ON' and 'OFF' sections in real-time.



DISCUSSION AND CONCLUSION

Adding more features can improve 'ON' accuracies; however, Fuzzy Logic seems to overall handle decoding rest states better than LDA, even with only 1 feature.

We suggest that reporting on a combination of ('ON') and ('OFF') misclassifications is important for better quantification of users' real-time control. In the future, these new metrics may be used to quantify total accuracy, responsiveness to intent, and indicate frustration experienced by users.

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5.166 Development of Novel Promoters for Gene-Specific Targeting of Somatosensory Neurons

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BACKGROUND

Optogenetics provides a methodology to map and stimulate the nervous system with single axon resolution¹. The peripheral nervous system (PNS) is composed of various neuronal subsets, motor and sensory, with different subsets expressing different genes. ATAC-seq data detects open chromatin within a gene, identifying likely promoter and enhancer regions². These regions can be used to develop promoters to target adeno-associated viral vectors (AAVs) to specific neuronal subsets, delivering optogenetic proteins.

AIM

Utilizing ATAC-seq genome data, likely promoter regions will be identified in genes specific to sensory neuronal subsets and inserted into AAVs to deliver optical proteins to specific sensory nerves.

METHOD

Two genes, NPY2R and NTRK3, were identified as unique to different sensory neuron subsets³. Whole genome ATAC-seq data⁴ from murine dorsal root ganglia (DRGs) was acquired from the Gene Expression Omnibus. Open chromatin regions were identified around the transcription start site (TSS) and the first intron of each gene. Approximately 1000-1500 nucleotides were included for each promoter, from both upstream and downstream regions of the TSS. These promoter constructs were inserted into AAV9-[*promoter*]-ChR2-mScarlet-WPRE viruses and injected into the L3 and L4 DRGs following a previously established methodology⁵. Transduction was evaluated using immunohistochemical labelling with appropriate antibodies in optically cleared DRGs.

RESULTS

Injecting the novel AAV9-NPY2R-ChR2-mScarlet-WPRE virus construct into L3 and L4 DRGs resulted in viral transduction of ipsilateral DRG cell bodies without viral expression in contralateral DRGs (Figure 1).

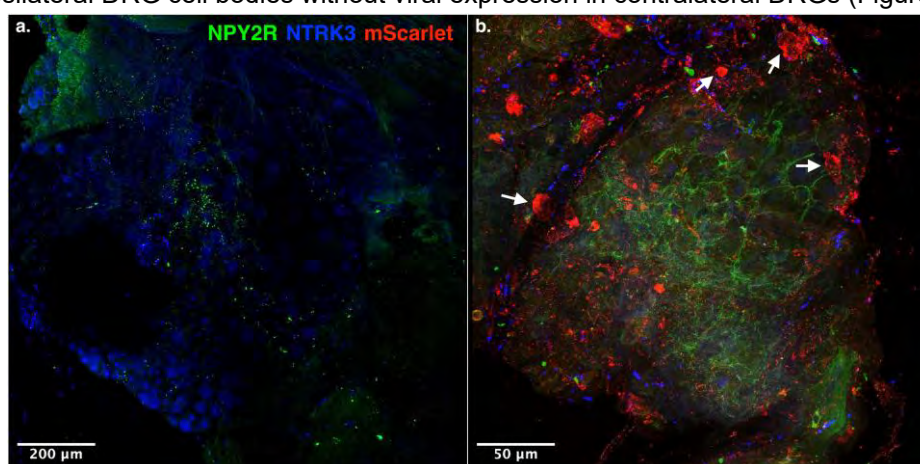


Figure 1. Immunohistochemical analysis confirms presence of NTRK3 in multiple cell bodies of the DRG as well as NPY2R in multiple axons of the L4 DRG (a) contralateral to the injection. Viral expression in cell bodies (white arrows) of the ipsilateral L1 DRG (b) is not present in the contralateral DRG.

Lack of strong immunohistochemical NPY2R antibody labelling in DRG cell bodies precludes confirming that viral expression transduced NPY2R-expressing cells or calculating transduction efficiency of the virus. However, lack of coexpression with NTRK3 signal in cell bodies implies that the virus successfully transduced a subset of neurons that do not express NTRK3.



DISCUSSION AND CONCLUSION

Immunohistochemical labelling issues preclude determining successful transduction efficiency of NPY2R neurons. Previous literature identified NPY2R and NTRK3 as genes unique to rapid-adapting and slow-adapting low-threshold mechanoreceptors (LTMRs), respectfully. Successfully delivering optogenetic proteins specifically to these neuronal subsets provides a methodology to map the peripheral nervous system in response to touch stimuli; the first step towards replicating a natural sense of touch in prosthetic systems using an optogenetic nerve interface.

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5.167 Modeling Regenerative Peripheral Nerve Interfaces (RPNIs) to Determine Ideal Surface Electrode Parameters for Prosthesis Control

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BACKGROUND

Regenerative Peripheral Nerve Interfaces (RPNIs) have shown promise for treating Phantom Limb Pain (PLP) while also increasing the available sites for myoelectric control of prostheses.¹ However, detecting RPNI signals from the surface is challenging due to the small signal size (100 μ V-2mV).² To improve effective myoelectric prosthesis control, surface electrodes should be redeveloped for enhanced focus.

AIM

This research will model RPNI EMG signals for use with surface electrodes, optimizing spatial filtering parameters like interelectrode spacing and circuit architecture to create more focal electrodes for prosthesis control.

METHOD

Using the ACDC Module in COMSOL, we modeled an RPNI placed within an idealized forearm. We plan to simulate action potentials within the RPNI. The muscle signals will be recorded from surface electrodes on the model and the signals will be analyzed through varied electrode spacing and circuit architectures. Key analyses will include signal-to-noise ratio, signal amplitude (RMS), and frequency analyses. The optimal electrode parameters for a redesigned surface electrode will be selected based on statistical analysis of these results.

RESULTS

Initially, the model was developed two-dimensionally to ensure the model parameters were functioning as expected and to verify the outcomes with previous volume conduction work. Now that the 2-D model is verified, we are finalizing the adapted 3-D model. This 3-D model will initially be verified through EMG modeling work completed by Dr. Lowery³⁻⁵ and then, it will be further adapted to meet the aims of this research. While we are still conducting simulations at this time, we expect the results to show that spatial parameters that improve the focus of an electrode will allow for better detection of RPNI signals within the model.

DISCUSSION AND CONCLUSION

Simulating an RPNI within a forearm will give an enhanced understanding of how to target these small muscle grafts in real-life applications. The improvement of surface electrode design has the potential to benefit any area where sEMG is used, not just prosthesis control. Ultimately, this research could pave the way for more precise and effective applications of surface electromyography across various medical and technological fields.

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Free paper session | Orthotics: spinal – Methods

5.171 Psychometric properties of the Staffordshire Questionnaire for Adolescent Idiopathic Scoliosis (SQ-AIS): convergent validity, internal consistency and test-retest reliability

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BACKGROUND

Adolescent Idiopathic Scoliosis (AIS) is a structural spinal deformity impacting health-related quality of life (HR-QoL). The Scoliosis Research Society-22 revised questionnaire is standard for HR-QoL assessment, though it has limitations in validity, reliability, and language appropriateness. To address these, the Staffordshire Questionnaire for Adolescent Idiopathic Scoliosis (SQ-AIS) was developed and validated, covering six domains: general health, pain, function/activity, self-image/appearance, mental health, and intervention. The psychometric properties of SQ-AIS remain unexplored.

AIM

To evaluate the SQ-AIS's psychometric properties, specifically convergent validity, internal consistency, and test-retest reliability.

METHOD

After necessary ethical approval, a cross-sectional study was conducted with AIS patients at two ISST camps (November 2023–January 2024). Convergent validity was assessed through correlations between SQ-AIS and SRS-22r scores at total and domain levels (Pearson's/Spearman's). Correlation categories were: very weak (<0.19), weak (0.2–0.39), moderate (0.4–0.59), strong (0.6–0.79), and very strong (≥ 0.8). Internal consistency (Cronbach's $\alpha \geq 0.7$) and test-retest reliability (ICC, classified from poor <0.50 to excellent >0.90) were evaluated. Pre- and post-camp SQ-AIS scores were compared. Analyses were performed in SPSS 27.0.

RESULTS

The cohort included 29 patients (79.3% female), mean age 18.2 years (SD=3.35). Thoracic curves ranged from 15° to 59° (median 40.14, IQR 21) and lumbar curves from 18° to 63° (mean 39.50, SD=13.96). SQ-AIS showed statistically significant correlations with SRS-22r across domains (0.325–0.779), with weaker correlations in function/activity ($p=0.325$), moderate in mental health ($r=0.572$), and strong in pain, self-image, and total scores (0.645–0.779). Internal consistency was high ($\alpha=0.772$ –0.919), and test-retest reliability was good to excellent (ICC=0.833–0.957), though moderate for the total score (0.557, CI -0.225 to 0.829).

Table 1. SQ-AIS test-retest reliability

SQ-AIS	T0	T1	ICC (95% CI)
SQ-AIS – general health	3.82 $\pm$ 0.44	3.60 (0.73)	0.833 (0.676, 0.913)
SQ-AIS – pain	4.69 (0.42)	4.69 (0.55)	0.955 (0.915, 0.976)
SQ-AIS – function/activity	5.00 (0.09)	5.00 (0.08)	0.957 (0.918, 0.977)
SQ-AIS – self-image/appearance	3.85 (1.02)	3.74 $\pm$ 0.59	0.896 (0.805, 0.945)
SQ-AIS – mental health	4.01 $\pm$ 0.60	4.22 (0.86)	0.919 (0.842, 0.958)
SQ-AIS – total score	4.44 (0.40)	3.94 $\pm$ 0.39	0.557 (-0.225, 0.829)

Normally distributed data is presented as mean $\pm$ standard deviation (SD), while non-normally distributed data is presented as median (interquartile range, IQR).

DISCUSSION AND CONCLUSION



SQ-AIS demonstrates strong reliability and validity, aligning with SRS-22r in pain and self-image domains. Weaker correlations in the function/activity domain may be due to SRS-22r's inclusion of broader impacts like financial strain and family effects, while SQ-AIS focuses on daily activities. Moderate test-retest reliability for the total SQ-AIS score may reflect lower post-camp scores due to patients reassessing HR-QoL after intensive treatment. SQ-AIS is a valuable alternative to SRS-22r, capturing both stable and evolving aspects of AIS impact on HR-QoL.

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5.172 Idiopathic scoliosis bracing techniques using digital workflow: The Ottawa Hospital experience

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BACKGROUND

The Ottawa Hospital Rehabilitation Centre recently adopted digital shape capture and model rectification techniques to produce scoliosis orthoses. To successfully integrate digital tools into the clinical workflow, revised methods were required clinically and technically. Our technicians developed new fabrication techniques in response to the new technology. Cobb angles and curve progression were measured, with the intent to investigate the effectiveness of these new methods.

AIM

The goal was to demonstrate that changes in clinical techniques (digital shape capture, model rectification, model preparation) and technical procedures prove beneficial to scoliosis patients and our team.

METHOD

Idiopathic scoliosis patients were followed to demonstrate our digital process from assessment, scanning, curve classification according to Rigo, model rectification using rectification software, model preparation, brace fabrication and fitting. Data pre and post the transition to a digital workflow was collected, including: the number of braces provided; the average in-brace correction percentage; curve angle outcome (improved, similar, worsened) upon follow-up.

RESULTS

Table 1: Treatment method comparison, clinical outcomes measured 12 months post-treatment

FOLLOW-UP OUT OF BRACE, TREATMENT METHOD COMPARISON			
METHOD	COUNT	AVG CORRECTION	SD
Before Rigo	36	24%	0.250602184
Transition	42	54%	0.365946543
Rigo with Traditional Casting	42*	37%	0.239770444
Rigo with Scanning and Foam	25*	32%	0.229832719

*These sample numbers reflect patients who have been measured at follow-up

Results show that average scoliosis correction obtained after the implementation of digital shape capture is similar to that obtained from traditional casting and modification methods (see Table 1). Data also shows similarities in patient scoliosis outcomes between these methods, including improvement on case-by-case basis. More follow-up data is expected, with our current data pool covering only 58% and 36% of patients assessed traditionally and digitally respectively.

DISCUSSION AND CONCLUSION

Digital technology for scoliosis orthoses has resulted in similar effectiveness compared to previous methods. However, the changes in clinical and technical methodology have anecdotally improved patient experience as well as technical load (literally, with the use of foam versus plaster models). In future, we hope to mitigate the environmental impact of using foam positives to fabricate scoliosis orthoses with the adoption of 3-D printing techniques.

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5.173 Patient and Parent expectations to Scoliosis Treatment

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BACKGROUND

Adolescent idiopathic scoliosis (AIS) is a coronal deformity of the spine, which develops in the final growth phase. Different treatments are available, physiotherapy, brace treatment and surgery. Evidence exists that bracing can reduce the curve progression and need for surgery. Compliance with bracing is reported low, due to psychological stress during treatment. Night-time braces might reduce the stress on the patients, but several studies has shown lower SRS22 Satisfaction with Treatment scores in braced patients even with good clinical results, compared to patients treated with Surgery. The last 10 years, patient and parent focus on different types of treatment has increased, and they seem more aware about their options, when seeking medical treatment.

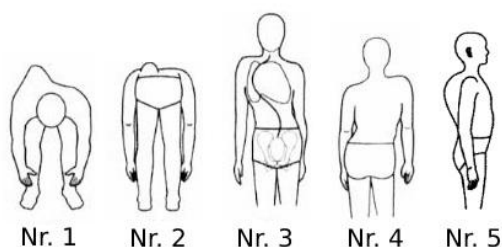
AIM

To examine patient and parent expectation to Scoliosis Treatment

METHOD

A questionnaire was created in Survey Exact, and distributed to AIS patients and their peers. The questionnaire was designed to allow the patients and their parents to rate, which deformity was their biggest concern, and which they believed different kinds of treatment could correct. The questionnaire included pictures from the Spinal Appearance Questionnaire, allowing them independently to rate the importance and expectations of correction on shoulder imbalance, rib hump and hunchback. Patient demographics and family history of scoliosis was recorded.

RESULTS



28 AIS patients and 22 parents was included in the study. Mean age 15 years (12-19), 4 observed, 20 brace treated and 4 had brace before surgery. 6 of the 22 parents also had scoliosis and 4 was previously treated. The biggest complaint from the patients was shoulder imbalance (81%) and haunch back (63%). The parents focused on the lumbar rib hump (76%) and the haunch back (64%). The majority of patients and parents expected the shoulder imbalance to be corrected by both brace (78%), surgery (68%) but only 40 % expected the haunch back to be reduced by bracing or surgery.

DISCUSSION AND CONCLUSION

Compliance and satisfaction, is better if patients are informed about the purpose of a treatment, and included in the decision. No previous studies has focused on the expectations with different treatments, toward achieving a correction of shoulder, waist and hunchback.

Conclusion. This study shows discrepancy of the cosmetic concern between the patients and their parents and a high expectation to all treatment modalities to reduce the shoulder imbalance. There is less expectation toward reduction of the hunchback and a lack of understanding of the mechanism of the different treatments.



5.174 Intra-rater and inter-rater reliability of Cobb angle measurement using a digital radiographic method in assessors of various experience

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BACKGROUND

Radiographic examination is crucial for assessing scoliosis, identified by a Cobb angle over 10° with vertebral rotation [1], aiding in evaluating curve pattern, magnitude, diagnosis, and treatment outcomes [2]. The Cobb method is the gold standard for measuring curve magnitude [3]. However, limited data exist on the reliability of digital Cobb measurements, and assessors' experience and judgment significantly impacting accuracy [4]. Reliability studies across assessor experience levels are limited.

AIM

To evaluate the intra- and inter-rater reliability of digital Cobb angle measurement and identification of upper-end, lower-end, and apical vertebrae in the groups of novice and experienced orthotist assessors.

METHOD

Six participants (three experienced and three novice assessors) digitally examined 52 scoliosis radiographs using SiPACS. Cobb angle measurement and identification of the upper-end, lower-end, and apical vertebrae were performed. Both measurements and details were repeated two weeks apart. In the first inter-rater reliability session, all assessors used the SiPAC technology for digital measurement. The second intra-rater reliability session was scheduled two weeks following the first and used the same methodology. Everyone was blinded to their past measurements and peers. ICC and Cohen's Kappa were used to assess Cobb angle measurement and other vertebral parameter identification intra- and inter-rater reliability.

RESULTS

The inter-rater reliability of Cobb angle measurement between experienced and novice orthotist assessors was considered excellent in the full sample (ICC = 0.975 and 0.978). For other spinal parameters, inter-rater reliability for identifying upper-end and lower-end vertebrae, moderate-to-almost perfect intra-rater reliability were found in both the experienced assessor group and novice assessor group (Cohen's Kappa = 0.588 to 0.799 and 0.615 to 0.888, respectively). Intra-rater reliability in identifying the apical vertebra in all assessors ranged from substantial to almost perfect (Cohen's Kappa = 0.666 to 0.842) in the entire sample analysis, while moderate-to-almost perfect intra-rater reliability was found in the experienced and novice orthotist assessors (Cohen's Kappa = 0.689 to 0.842 and 0.666 to 0.798, respectively). Subset analyses of thoracic and lumbar segment were conducted.

DISCUSSION AND CONCLUSION

Accuracy and reproducibility of measuring spinal parameters are crucial due to its clinical application in AIS. Overall, the findings indicated Cobb angle measurement's excellent intra-rater and inter-rater reliability in both groups, consistent with other studies [5]. While intra-rater and inter-rater reliability in identifying other spinal parameters was more complex, it showed similar results to previous studies [6]. Future studies should include more sample sizes and determine reproducibility of these findings.

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5.175 Understanding stakeholder perceptions of CAD/CAM and traditional methods of fabricating scoliosis braces: A questionnaire-based survey

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BACKGROUND

Adolescent idiopathic scoliosis (AIS) affects 2–3% of the general population ^[1]. Bracing is a common non-surgical intervention to prevent curve progression, typically using either traditional (plaster moulding) or CAD/CAM (3D scanning and digital rectification) fabrication methods ^[2]. Currently, no defined framework exists for choosing between these methods. Investigating the perception of stakeholders, including patients, orthotists, and surgeons may provide information to inform future clinical decision-making processes.

AIM

The aim of this study was to explore and compare AIS patient, orthotist, and surgeon perceptions of traditional and CAD/CAM brace fabrication methods regarding preferences, satisfaction, and associated challenges.

METHOD

Ethical approval was obtained from the Science, Engineering and Technology Research Ethics Committee at Imperial College London (SETREC: 7124148), and consent was obtained from all participants. Structured online questionnaires for each stakeholder group were developed in Qualtrics, including open-ended, multiple-choice, and Likert-scale questions. Participants were recruited globally through professional networks, societies, and social media, with snowball sampling encouraged to expand reach. Follow-up interviews were conducted online via Microsoft Teams for deeper insights. Quantitative data were analysed using SPSS, while qualitative responses underwent thematic analysis using NVivo software, following Braun and Clarke's methodology ^[3].

RESULTS

Thirty-one participants completed the questionnaire, with twelve attending a follow-up interview, representing seventeen countries and diverse clinical settings. Five main themes emerged: perceptions of fabrication methods, satisfaction and adaptation, decision-making, collaboration, and future technological trends. Stakeholders generally agreed that both traditional and CAD/CAM methods result in good clinical outcomes, though CAD/CAM was preferred, especially by patients. CAD/CAM offered faster fabrication, reduced material waste, and long-term cost benefits, though initial costs, training, and a depersonalised process posed challenges. The traditional method was valued for its personalised care, lower initial costs, and enhanced correction control but it was labour-intensive and lacked digital mould storage. Stakeholders anticipated a 77% increase in CAD/CAM adoption over the next decade, reflecting confidence in digital advancements.

DISCUSSION AND CONCLUSION

Stakeholders had similar perceptions in most aspects, with patients prioritising comfort, while orthotists and surgeons focussed more on Cobb angle correction. These differences in priorities highlight the importance of well-coordinated and patient-centred relationships among stakeholders in brace treatment. The identified themes can be used to inform the focus of future research and clinical practice decisions and enhance treatment strategies.

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5.176 Compliance Monitoring of Orthotic Treatment to Adolescent Idiopathic Scoliosis: A Comparative Analysis of Wear Time between Verbal Report and Thermosensor

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BACKGROUND

Orthosis wear compliance plays an important role in the treatment outcomes of adolescent idiopathic scoliosis. Nevertheless, treatment outcome depends upon multifaceted determinants, wherein compliance is pivotal. Compliance assessment mainly relies on patients' verbal reports; nowadays, thermal sensors are observed for real-time compliance monitoring with orthotic wear. This approach can enhance compliance monitoring, provide valuable insights about the patient's behavior, and ultimately improve treatment outcomes.

AIM

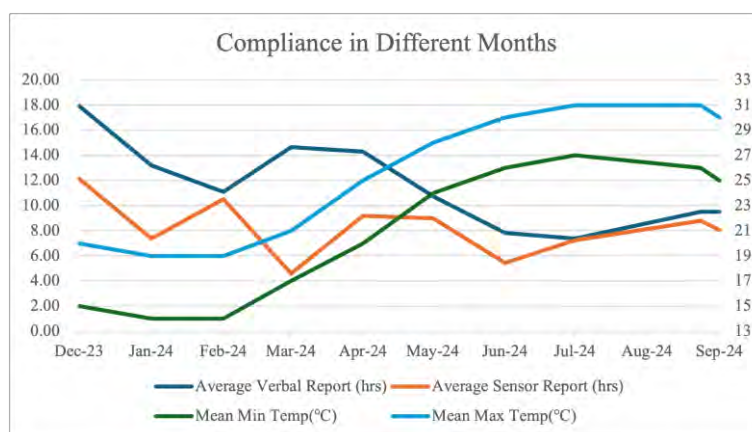
This study aims to address this gap by analyzing sensor data and verbal reports to assess the reliability of thermal sensors in predicting the patient's wear time.

METHOD

A total of 24 patients with adolescent idiopathic scoliosis were recruited to receive orthotic treatment and compliance monitoring using thermal sensors. The recruited patients had an average age of 12.08 ± 1.53 years, with a male-to-female ratio of 0.33. Patient data were collected verbally and through sensor reports during fitting, follow-up, and consultation sessions. Three data sets were collected per patient to compare the accuracy and reliability differences between single temperature sensor and multi-factor combined sensor detection.

RESULTS

After orthotic fitting, patients reported 13.52 ± 6.11 hours/day, surpassing sensor predictions of 10.04 ± 7.26 hours/day. Post-notification, sensor estimates rose slightly to 10.27 ± 7.15 hours/day as patient reports fell to 13.13 ± 5.89 hours/day. By the third data collection, patient reports averaged 11.15 ± 6.12 hours/day, aligning with sensor predictions of 9.59 ± 5.99 hours/day, indicating a decreasing trend. Patients informed about sensor monitoring displayed increased sensor-predicted wear time, suggesting sensors can enhance compliance. However, gender and severity did not significantly differ in wear time in the small sample.



Patients predominantly demonstrated low compliance, which was below 12 hours/day on average, with only a few patients able to wear the orthosis for over 18 hours/day consistently. Data collected from December 2023 to September 2024 show a negative correlation between the wear time and ambient temperature. The study underscores the potential of combining other factors to predict compliance accurately.

DISCUSSION AND CONCLUSION

While traditional assessment relies on verbal reports, advancements like thermal sensors offer real-time monitoring of orthotic wear compliance. We are also validating the impact of combining temperature with other factors such as force and IMU sensors on the prediction accuracy and reliability. Additionally, we continuously recruit adolescents with moderate idiopathic scoliosis to study changes in wear compliance and treatment outcomes during the treatment process.



5.177 Assessment of Rib Vertebral Angle Difference (RVAD) of Adolescent Idiopathic Scoliosis (AIS) for Prediction of Orthotic Treatment Outcomes

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BACKGROUND

Studies have shown that orthotic treatment offers promising effects on AIS. However, its treatment outcome could be influenced by various factors, such as patient compliance, skeletal maturity, and spinal flexibility. If scoliosis deformity worsens, it could lead to complications such as thoracic cage distortion, which may subsequently affect patient's cardiopulmonary function and quality of life.

AIM

We aim to gain a deeper understanding of the effectiveness of orthotic treatment for AIS and provide support for predicting orthotic treatment outcomes.

METHOD

This study has collected data from 50 patients with AIS. Each patient underwent four X-ray examinations: standing and supine position before orthotic treatment, first standing in-orthosis X-ray, and discharged standing out-orthosis X-ray. Based on the treatment outcomes, patients were divided into two groups, the change in Cobb angle between the standing position before orthotic treatment and the end of orthotic treatment was considered. A change within 5 degrees or reduction of Cobb angle over 5 degrees was defined as treatment success (Group 1), while an increase over 5 degrees was defined as treatment failure (Group 2).

RESULTS

RVAD represents the difference in angle between the rib and the corresponding vertebral body (Figure 1).^[1 & 2] The data from the standing position X-ray before treatment showed a significant difference between treatment success and failure, indicating that RVAD could be an important predictive indicator before treatment ($t=3.426$, $p<0.05$). By analyzing the data from the supine position before treatment and after fitting with spinal orthosis, it was observed that the data for Group 1 was higher than that of Group 2. The difference in values between the supine and standing positions before treatment showed an average of 8.87 ± 7.34 for Group 1 and 6.56 ± 5.16 for Group 2 ($t=1.200$, $p=0.236$). After fitting, the average difference for the two groups was 6.67 ± 5.52 and 4.85 ± 5.04 , respectively ($t=1.173$, $p=0.247$). While the differences between these two groups were not significant, possibly due to a small sample size, it can be observed that the change in the successful treatment group was greater than that of the failed treatment group.

DISCUSSION AND CONCLUSION

The study suggests that RVAD may have predictive potential in treating AIS apart from early-onset scoliosis. However, the study has limitations, including a relatively small sample size and focusing only on changes in curve apices. Future plans should include expanding the sample size and comprehensively measuring changes in all RVAD of the thoracic curve for a range of Cobb angles.

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Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Feet

5.181 Exploring the Potential of Composite 3D Printing for Dynamic Paediatric Prosthetic Feet: A Study on Stiffness and Hysteresis

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BACKGROUND

The dynamic response of paediatric prosthetic feet is crucial for enabling child the ability to partake in physical activity. This study explores the use of composite 3D printing with carbon fibre to create a dynamic response prosthetic foot. By replicating the geometry of an existing foot design, this research evaluates the feasibility and performance of 3D-printing as a manufacturing techniques for prosthetics. The mechanical properties evaluated are of stiffness and hysteresis.

AIM

To evaluate whether carbon fibre composite 3D printing can replicate and potentially improve the mechanical properties of a paediatric prosthetic foot, specifically its stiffness and hysteresis.

METHOD

An existing paediatric prosthetic foot was analysed to measure its stiffness and hysteresis. The geometry of this foot was then replicated using 3D modelling software. A 3D-printed prototype was created using carbon fibre and nylon base material reinforce with continuous carbon fibre filament, employing optimised printing parameters identified in a prior study. The printed prosthetic foot underwent mechanical testing, which measured its stiffness and hysteresis under controlled conditions. The results were compared to those of the original prosthetic foot to assess the differences in performance.

RESULTS

The results indicated that the 3D-printed carbon fibre prosthetic foot exhibited a lower stiffness and higher hysteresis compared to the original prosthetic foot. This suggests that the mechanical properties of the printed foot are not yet on par with those produced using traditional manufacturing methods. However, the study also found that the 3D-printed foot showed promising results in terms of replicating the general geometry and maintaining structural integrity. The differences in stiffness and hysteresis may be attributed to the limitations in the current design's optimisation for the 3D printing process. Despite the performance gap, the findings highlight the potential of composite 3D printing for developing more customisable prosthetic feet, with opportunities for further optimisation and improvements in future research.

DISCUSSION AND CONCLUSION

While the current study shows that carbon fibre 3D-printed prosthetic feet do not yet match the mechanical performance of conventionally manufactured prosthetics, they demonstrate significant potential for future development. Future research will focus on optimising the foot geometry and printing parameters to enhance the mechanical properties. By refining these aspects, composite 3D printing could become a viable and more accessible method for creating pediatric prosthetic feet with tailored dynamic responses.



5.182 Quality Development With a New Design of Affordable SACH Foot in Low and Middle-Income Countries: A Finite Element Analysis Approach

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BACKGROUND

WHO states that 80% of people with disabilities live in low and middle-income countries (LMICs) [1]. SACH foot demand in LMICs is still very high [2]. Affordable and better-quality SACH foot needs to be developed in LMICs, including accommodating prosthetic feet in tropical climates and affordable prices. Local materials are available at low prices, have good water resistance, are lightweight, and have good cosmetics [3].

AIM

Investigating new designs of SACH foot using a finite element analysis (FEA) approach and validation with an experimental mechanical test of a SACH foot prototype.

METHOD

Three new designs of SACH foot have been created, which were investigated using the finite element analysis (FEA) approach of the Ansys 2019 R3 program. The properties of the materials used are polymers and vulcanized rubber. The boundary conditions refer to the ISO 13028 standard and are rated a load of 1176,78 N. Based on the average value of total deformation, max-von mises stress, strain and safety factor obtained the best design to make it into the SACH foot prototype. The results of the FEA simulation were validated by conducting an experimental mechanical test on the SACH foot prototype.

RESULTS

The SACH foot prototype has better characteristics in load tolerance with a minor total deformation of 5,8% in the heel strike, 10,6% in the mid-stance, and 2,5% in the terminal stance compared to the local SACH foot in the market. Using polymer materials as reinforcement structures in the SACH foot combined with vulcanized rubber on the SACH foot body can improve the strength and water-resistance quality of the SACH foot, making it more suitable for use in activities in tropical climates in LMICs. Validation of FEA simulation results with experimental results can be said to be valid because it has a difference of less than 5% for the total deformation value in the heel strike, mid stance and terminal stance positions [4]

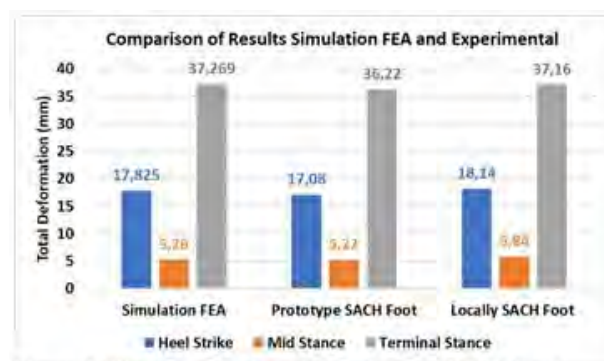


Figure 1. Simulation FEA and Experimental SACH Foot

DISCUSSION AND CONCLUSION

The new design of the SACH foot and polymer materials as the reinforcing structure on the SACH foot has better characteristics in accepting pressure loads and retaining water than the SACH foot with wood reinforcing materials available in the market. Therefore, the prototype of the SACH foot produced is also suitable for use in tropical climates; this follows the SACH foot development recommendations in LMICs [3]. In the future, it is necessary to conduct clinical trials involving lower limb prosthesis users.

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5.183 Analysis of a novel prosthetic foot design – a clinical and biomechanical evaluation

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BACKGROUND

The use of fibre-plastic composite was a milestone in prosthetic foot development 40 years ago. Energy storage and return (ESR) prosthetic feet have further developed since. Today, J- or C-shaped ESR foot designs are very common and have proven clear advantages^{1,2} over conventional feet and early ESR feet. The study foot incorporates a novel design: a hinge and a horizontally positioned carbon blade that is loaded centrally in a 3-point manner which results in a comparatively flexible and compact foot.

AIM

To clinically and biomechanically compare a novel foot design with state-of-the-art prosthetic feet.

METHOD

Twelve subjects were enrolled, 6 with unilateral transtibial amputation (TTA), 6 with unilateral transfemoral amputation (TFA). All were active ambulators (K3) and fitted with a state-of-the-art ESR foot in their everyday prosthesis. Baseline measurements were taken such as: a modified 6-minute walk test (6MWT), biomechanical gait analysis of walking on level ground and a 10° slope, questionnaire evaluating mobility (PLUS-M)³ and balance (ABC-Scale). After using the study foot in everyday life for at least 3 months, all measurements were repeated, and the preference was noted.

RESULTS

9 subjects preferred the study foot, 2 had no preference, 1 preferred the everyday foot. Plus-M showed a significant improvement, ABC-scale shows no differences. 6MWT indicates a significant improvement of 22m on average (Figure 1). Biomechanical analysis showed an 10% increased ankle range of motion, increased peak ankle power (+44% TFA, +14% TTA), propulsion ground reaction force (+21% TFA, +15% TTA, Figure 2), 52% higher axial compression at heel strike, 10% reduction of knee extension torque (TFA only) walking upslope.

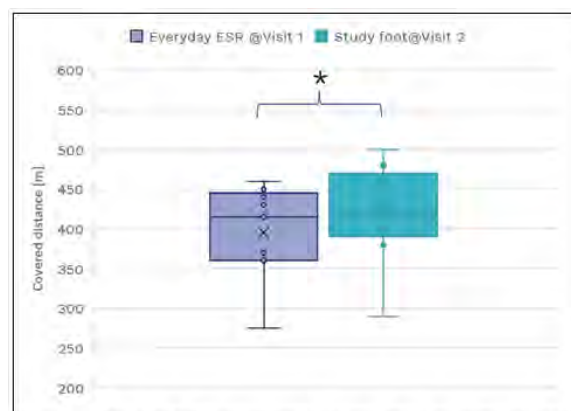


Figure 1. Six Minute Walk Test for all subjects; P-value: 0.013; Mean difference: 22.2m (MDC=45m)

DISCUSSION AND CONCLUSION

The increased propulsion ground reaction force may have positively impacted the distance reached in the 6MWT. Additionally, the setup should be considered since the 6MWT was carried out in a figure-eight form. The absolute expected walking distance is therefore lower⁴, but this arrangement could also promote a prosthetic foot with high ML-compliance like the study foot.

In summary, both biomechanical and clinical results support the overall user preference for the new foot concept.

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5.184 Fatigue analysis of low-cost, high-performance, mass-manufacturable prosthetic feet for low- and middle-income country markets

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BACKGROUND

Many amputees in low- and middle-income countries (LMICs) use prostheses with poor performance for their mobility needs. The Lower Leg Trajectory Error (LLTE) Framework predictively designs prosthetic feet to replicate able-bodied gait by optimizing the geometry and stiffness [1]. Early prototypes performed similarly to commercial carbon fiber ESR feet in gait lab testing [2] and proved durable through extended field trials [3]. These prototypes were redesigned to facilitate mass-manufacturing, address user feedback, and meet international standards.

AIM

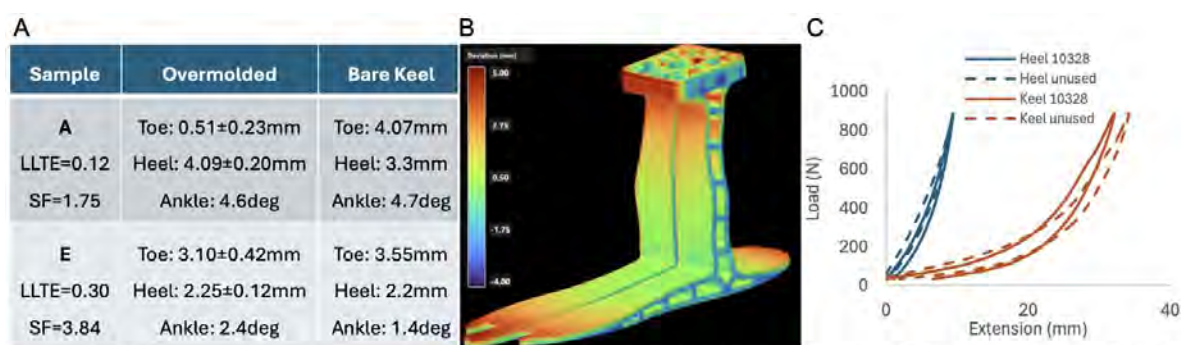
Analyse the trade-off between biomechanical walking performance and predicted fatigue life to select a final design that meets international standards and maximizes walking performance.

METHOD

Five prosthetic feet with varying endurance limit safety factors (SF) were optimized using the LLTE Framework. Each foot underwent ISO 10328 fatigue testing. Deformation was measured five times using a digital height gauge. Tested and unused feet were CT-scanned to assess internal deformation. Scans of the keel were aligned to the ground plane and displacement fields were generated using Voyager. A universal testing machine was used to measure the stiffness profile of unused and tested feet via the AOPA test.

RESULTS

Increasing SF results in a higher LLTE value (larger deviation from able-bodied gait). All five designs sustained the 2 million cycles of ISO 10328 but displayed minor plastic deformation (Fig. 1A, B). Stiffness of the heel increased by 3.6% on average. Stiffness of the keel increased by 2.37% for displacements up to 20 mm and 34.75% for larger displacements (Fig. 1C).



DISCUSSION AND CONCLUSION

Past sensitivity studies of LLTE feet that varied optimized foot stiffness by 60%, 80%, 120%, and 167% showed no significant difference in performance within 20% of optimum [4]. Sample A may be expected to perform similarly to the 120% and 167% stiffness feet since its LLTE falls between theirs. Sample E had the least plastic deformation in ISO 10328 but is expected to have reduced walking performance and user preference due to the high LLTE. Based on the fatigue results and performance trade-off, Sample A was selected for field trial testing. The plastic deformation observed was within the allowable range [5], and the increase in stiffness was below the stiffness perception threshold [6] for early and mid-stance. The effect of deformation on prosthesis alignment will be assessed



in future field trials. It is common for users in LMICs to use a prosthesis until failure, therefore fatigue testing to failure will be conducted to characterize performance past the rated lifetime.

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ACKNOWLEDGEMENTS

Willow Wood for assistance in running ISO 10328 fatigue testing. Lumafield for assistance in scanning the prototypes for deformation analysis.



5.185 The Relationship Between Plantar Pressure and Prosthetic Foot Wear in Northern Sri Lanka

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BACKGROUND

When prosthetic feet fail in low-middle income countries (LMICs) such as Sri Lanka, they often fail due to plantar wear. We hypothesise this is due to bending moments and plantar pressure, however, cultural variations such as barefoot walking, the local environment, available job types, and a cosmetic-focused design can also impact how prosthetic feet break. Additionally, as shoes alter the distribution of plantar pressure and position of bending moments, they may inform us about the failure mechanisms of prosthetic feet.

AIM

To understand what biocultural factors relate to prosthetic foot failure in northern Sri Lanka. To determine the relationship between plantar pressure and the plantar wear of prosthetic feet

METHOD

In February and March 2023, 19 participants (12M/7F) with lower limb amputations took part in the study. Photographs of the plantar surface of the participant's prosthetic foot/feet and their shoes worn into the centre were taken. Static and dynamic plantar pressure measurements were taken for each participant both shod and unshod using a Tekscan FootMat™ System. The plantar pressure data was then mapped to the plantar surfaces of the prosthetic feet and shoes and the corresponding wear scores were taken in accordance with methods described in (Ranson et al., 2024). Comparing the AIC and BIC of multiple linear mixed-effect models were used to determine which random and fixed parameters were significant when predicting wear from pressure.

RESULTS

For the majority of participants, for both unshod and shod tests, there was a positive correlation between wear and pressure. For the unshod static and dynamic tests models using mass, test type, and occasionally height was important for predicting wear from plantar pressure. For the shod static and dynamic tests models using the prosthetic foot area, the test type, and whether the shoe contained a prosthetic or regular foot were important for predicting wear from plantar pressure.

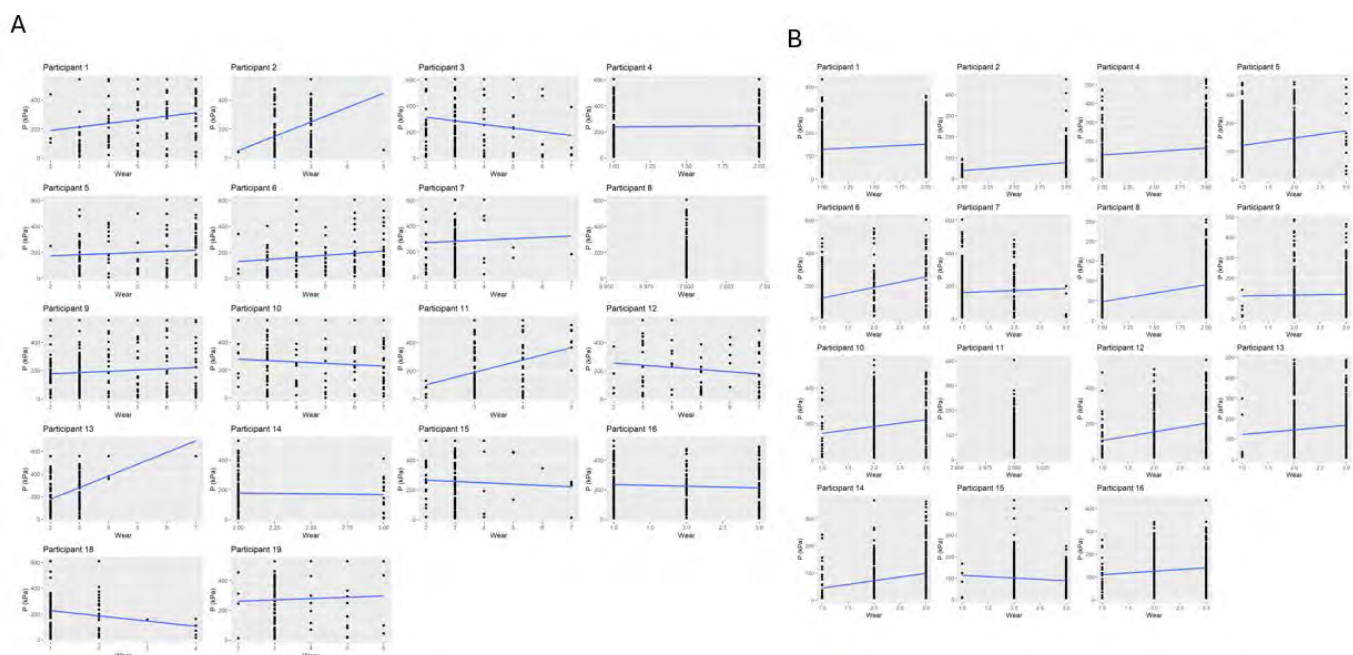


Figure 1a. Unshod plantar wear vs plantar pressure, 1b. Shod plantar wear vs plantar pressure



DISCUSSION AND CONCLUSION

The results confirm that there is a correlation between plantar pressure and plantar wear confirming our hypothesis that plantar pressure is a contributing factor in the failure of prosthetic feet. Mass, height, prosthetic foot area, and whether the shoe contained a prosthetic foot were all important biological factors in predicting the plantar wear of the prosthetic feet. These factors should all be considered when fitting persons with amputations with a prosthetic device to prevent the failure of the prosthetic device.

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5.186 Exploring methods to describe prosthetic foot adaptation to non-cyclic multiplanar movements – pilot case study

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BACKGROUND

Prosthetic feet sometimes referred to as crossover feet have design features that have been shown to enhance both subjective and objective outcomes, particularly accommodating diverse activity levels and functional demands (Morgan et al., 2018). Such demands may include multi-planar, non-cyclic movements, especially for various sporting activities. While typical clinical gait analysis methods focus on repetitive cyclic motions on flat surfaces, they may not fully reflect perceived functional aspects of prosthetic foot performance during atypical non-cyclic motions

AIM

The aim of this case study was to explore the effect of a movement task that challenges prosthetic foot performance in all three kinematic planes of joint rotation.

METHOD

This pilot case study was conducted with a participant who has a transtibial amputation. The activity tested simulates a movement which may occur in a sporting activity, or where quick speed and directional changes are needed. The individual was instructed to walk fast towards a specific point, then to jump and land on the forefoot of the prosthetic side with the intention to turn 180°, and lastly walk back to the starting position. This task was chosen in order to achieve a forced rotation between the shank and the foot, for exploration of this multi-planar joint motion. Motion analysis was performed with a Vicon system (Vicon Motion Systems Ltd., Oxford, UK), with the participant using a) a conventional ESAR prosthetic foot, and b) a novel ESAR crossover foot

RESULTS

Figure 1 displays the kinematics from the point of contact with the prosthetic forefoot and until the full cycle is completed with the consecutive heel strike. Both the sagittal and frontal planes of motion present higher amplitudes with the novel ESAR crossover foot, i.e. the foot performs more dorsiflexion and inversion than the conventional ESAR foot. Concurrently the conventional ESAR foot exhibits more rotation in the transverse plane than the novel ESAR crossover foot.

DISCUSSION AND CONCLUSION

These results demonstrated that the novel crossover foot provided more ankle joint movement in the sagittal and frontal planes and less transverse rotation, possibly indicating increased adaptability and stability. More user tests are needed for this type of exploration, to further enhance this method of prosthetic foot characterization. In conclusion, this exploration provided a way of challenging and objectively document multi-planar motions, needed to evaluate prosthetic feet designed to be of benefit during more dynamic movement tasks.

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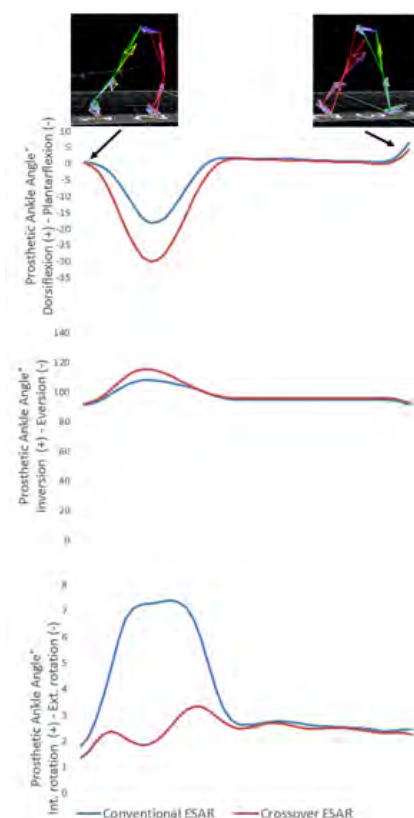


Figure 1: Ankle kinematics in three kinematic planes during a 180° jump task



5.187 A Data-Driven Shape Optimization Approach for Designing Prosthetic Feet According to Desired Keel Stiffness

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BACKGROUND

Passive-elastic prosthetic foot keel stiffness can have a profound effect on clinically relevant performance outcomes, including leg kinematics, gait symmetry, and metabolic cost [1], and is therefore an important variable for prescribing and designing a leg prosthesis. Keel stiffness is a function of the geometry and material properties of the prosthesis [2], and so optimizing shape according to a desired stiffness is one method to design prosthetic feet.

AIM

This study developed a numerical approach to optimizing prosthetic foot shape to achieve a desired keel stiffness as prescribed by a generalized equation that describes prosthesis keel load response.

METHOD

Previously we developed a data-driven equation that defines force-displacement (hysteresis) behavior of different prosthetic feet during terminal stance loading (i.e., keel stiffness) [3]. Building on that framework, our shape optimization process involves: 1) selecting a desired (target) hysteresis profile generated from the governing equation; and 2) executing an iterative Bayesian optimization routine [4] to identify the prosthetic foot shape that minimizes root mean square error (RMSE) between the solution and target hysteresis profiles. The optimization routine generates finite element analysis (FEA) data for an array of prosthesis designs using three variables that adjust the curvature and thickness of a base model.

RESULTS

Figure 1 displays an example prosthesis design solution from the optimization process and the hysteresis profiles for the target and solution based on a 3D-printable carbon composite (RMSE = 1.6 mm), difference in maximum displacement of 0.5%. Preliminary results on 5 hysteresis profiles suggest that our shape optimization approach using only three design variables is capable of converging on a solution that closely approximates the target hysteresis profiles and keel displacement for a given load (range of RMSE = 1.6 mm – 2.3 mm, range of maximum displacement error of 0.5-5.8%, and a mean of 1.9 mm).

DISCUSSION AND CONCLUSION

We demonstrated a method for combining data-driven modeling of prosthesis load response and shape optimization that incorporates design iteration and computerized structural analysis to generate foot designs according to a desired keel stiffness. While some error exists between the target and solution hysteresis profiles, our process was limited to three variables to simplify the approach. Future research may expand the variable set and refine the process to capture nonlinear dynamics.

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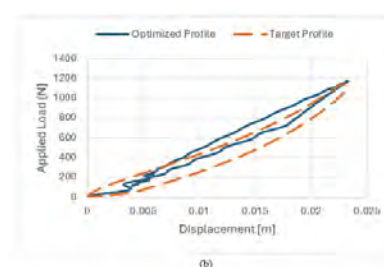
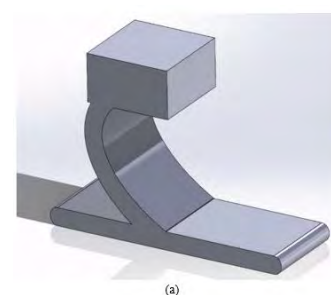


Figure 1: Optimized Prosthesis design (a), with generated hysteresis profile compared to the target (b)



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5.191 Descriptive Study for Mobility Aid Use and 2-Year Disability Occurrence in Community-Dwelling Older Adults

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BACKGROUND

Identifying high-risk populations is pivotal for preventing disability in an aging society (Platt, Keyes, & Galea, 2017). Users of mobility devices should be at high risk for disability, as using their devices reflects vulnerability in health-related backgrounds (Chau, Kim, Sison, & Shi, 2024).

AIM

This study aims to describe the prevalence of mobility device use among community-dwelling older adults and examine the two-year disability occurrence rate.

METHOD

This descriptive study enrolled Japanese community-dwelling older adults aged 60 and older from the National Center for Geriatrics and Gerontology Study of Geriatric Syndromes (NCGG–SGS) sub-cohort. Baseline assessments were held during on-site health checkups, and disability occurrence over 24 months was tracked using the national Long-Term Care Insurance System in Japan. Whether the participants currently use a mobility device was identified through a questionnaire with questions of “Do you use a cane or walker in your daily life?” administered by well-trained staff during the interview at baseline assessment. To present the changes between the non-users and users in the survival rate of disability occurrence over a 24-month follow-up period, Kaplan–Meier curves were plotted.

RESULTS

Of 19,787 participants (mean age $\pm$ SD: 73.2 $\pm$ 5.9 years; women: 10,542 [53%]), a total of 764 participants (3.9%) were users of mobility devices. Disability occurred in 912 (4.8%) non-users and 189 (25%) users (Figure 1). The prevalence of diseases such as stroke, dementia, Parkinson’s disease, and osteoarthritis was more than double that of non-users. Physical frailty was observed in 1,670 (8.8%) non-users and 281 (37%) users. Cognitive impairment was present in 4,788 (25%) non-users and 361 (47%) users.

DISCUSSION AND CONCLUSION

Results showed that mobility device users comprised a small proportion of participants in the community-based health checkup; however, they exhibited physical and cognitive declines and a high rate of disability occurrence. Our findings suggest that the status of using mobility devices is a visibly apparent indicator of high-risk approaches aimed at preventing disability, and mobility aid users require appropriate orthotic prescription and geriatric interventions to prevent disability.

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5.192 The responsiveness of the ground reaction force in relation to the knee joint center to ankle-foot-orthosis alignment changes

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BACKGROUND

Proper ankle-foot orthosis (AFO) alignment is typically assumed when the ground reaction force (GRF) aligns with the knee joint center (KJC) during midstance^[1]. Despite this widely held assumption, no studies have assessed the responsiveness of the GRF distance in relation to the KJC (GRF-KJC distance) to adjustments in AFO alignment. This gap in knowledge highlights the need for further investigation of the GRF-KJC distance.

AIM

This study aimed to evaluate the responsiveness of the GRF-KJC distance on AFO alignment changes in neurological patients wearing AFOs.

METHOD

Twenty-eight individuals wearing custom-made AFOs participated in a 3D motion analysis. Participants walked with five different AFO alignments: neutral AFO alignment (0 mm), a wedge of 5 and 10 mm underneath the heel (+5 and +10), and a wedge of 5 and 10 mm underneath the forefoot (-5 and -10). The GRF-KJC distance was determined in the sagittal plane during midstance. Differences between 0 mm and each wedge condition, and the 5 and 10 mm wedge conditions were tested with paired t-tests with Bonferroni correction. Responsiveness during midstance was evaluated with the effect size (Cohen's d).

RESULTS

Significant differences in GRF-KJC distance were found during midstance between all wedges and the neutral alignment, but not between the 5 and 10 mm wedge conditions. The effect size of the GRF-KJC distance during midstance on AFO alignment were medium to large (0.76 - 1.39) for all wedge condition compared to neutral alignment (Table 1). Between the 5 mm and 10 mm wedges, effect sizes were small to medium (0.47 – 0.67) (Table 1).

Table 1: Overview of the effect size and P-values (Bonferroni corrected) between different AFO alignments

Condition comparison	0 vs. -10	0 vs. -5	0 vs. +5	0 vs. +10	-10 vs. -5	+5 vs. +10
GRF-KJC distance difference [mm]	-13.91	-7.78	7.14	17.81	-6.13	10.67
Effect size	-0.98	-0.87	0.76	1.39	-0.47	0.67
P – value	0.00	0.01	0.00	0.00	0.31	0.10

DISCUSSION AND CONCLUSION

Medium to large effect sizes and significant differences were observed with 5 mm wedges, indicating that the GRF-KJC distance is responsive to AFO alignment changes at this increment. However, effect sizes seem to decrease with larger alignment changes. Despite this, the GRF-KJC distance is a useful parameter for tuning AFO alignment.

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5.193 Guideline-based prescription of ankle-foot orthoses in Charcot-Marie-Tooth disease improves walking ability

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BACKGROUND

Charcot-Marie-Tooth disease (CMT) is a slowly progressive neuromuscular disease that causes lower leg muscle weakness, foot deformities and sensory loss, resulting in gait abnormalities and reduced walking ability. Ankle-foot orthoses (AFOs) are prescribed to improve gait and therefore walking ability. However, clinical effectiveness regarding walking ability improvement and compliance is poor (Kim 2024, Vinci 2008). Prescribing AFOs according to the Dutch orthotic care guideline has the potential to improve treatment outcomes (van Duijnhoven 2023).

AIM

We performed a clinical evaluation of a first AFO prescription according to the Dutch orthotic care guideline (Brehm 2014) in CMT patients with and without an AFO at baseline.

METHOD

We analyzed data that were prospectively collected between 2012 and 2024 from CMT patients who were indicated for an AFO during routine clinical care. The effects of guideline-based AFOs were assessed for walking speed, energy cost of walking, gait biomechanics (ankle angle, angle moment, knee angle, knee moment) and perceived walking ability (rated on a 10-point scale, 10 representing the most satisfaction) by comparing baseline and 3-month follow-up measurements in the whole group and separately for patients with and without an AFO at baseline.

RESULTS

	All patients (n=24)		No AFO at baseline (n=13)		AFO at baseline (n=11)	
Age (years)	64.5 [57.0—73.75]		64.0 (54.0—72.0)		67.0 (57.0—74.0)	
Gender (M/F)	16/8		9/4		7/4	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Objective walking ability						
Walking speed (m/s)	0.99 [0.78—1.08]	1.07 [0.87—1.24]**	0.89 [0.79—1.03]	0.97 [0.86—1.20]*	1.04 [0.76—1.15]	1.16 [1.04—1.26]*
Net energy cost (J/kg/m)	3.27 [2.80—3.86]	3.14 [2.74—3.51]*	3.55 [3.20—4.76]	3.21 [2.61—3.53]*	2.81 [2.60—3.70]	2.91 [2.72—3.44]
Perceived walking ability						
Safety (0-10)	6.0 [5.0—7.0]	8.0 [7.0—9.0]*	5.0 [3.0—6.75]	8.5 [7.25—9.0]*	7.0 [5.0—8.0]	8.0 [6.0—8.0]
Stability (0-10)	4.0 [3.0—6.0]	8.0 [7.0—8.0]**	3.5 [2.0—4.75]	8.0 [8.0—9.0]*	5.0 [4.0—7.0]	7.0 [6.0—8.0]*
Walking intensity (0-10)	5.0 [3.0—7.0]	6.0 [5.0—8.0]*	3.5 [2.25—5.75]	6.0 [5.0—8.75]*	5.0 [3.0—8.0]	7.0 [4.0—7.0]
Safety while walking irregular surfaces (0-10)	3.0 [1.0—5.0]	6.0 [4.0—7.0]**	2.0 [1.0—4.5]	6.0 [4.0—8.0]*	5.0 [3.0—5.0]	6.0 [4.0—7.0]*
Fear of falling (0-10)	5.0 [4.0—8.0]	8.0 [5.0—9.0]*	4.5 [3.0—7.25]	8.0 [6.25—9.75]*	5.0 [5.0—8.0]	7.0 [4.0—8.0]
Gait biomechanics during stance						
Ankle angle min	-7.62 [-10.5—-4.23]	-2.14 [-5.70—0.65]**	-7.53 [-12.6—-3.13]	-0.19 [-4.02—1.46]*	-7.62 [-10.5—-4.79]	-2.74 [-6.99—0.65]*
Ankle angle max	22.5 [20.0—24.8]	16.5 [15.6—18.6]**	22.7 [20.4—24.9]	16.5 [15.2—19.3]*	21.7 [19.8—24.8]	16.1 [15.6—18.4]*
Ankle moment max	0.77 [0.61—0.96]	1.03 [0.92—1.11]**	0.88 [0.76—1.04]	1.03 [0.93—1.13]*	0.69 [0.49—0.79]	1.03 [0.92—1.11]*
Knee angle min	7.96 [-5.43—11.5]	1.13 [-5.31—4.67]*	10.4 [1.4—13.6]	2.16 [-5.18—5.98]*	0.99 [-7.07—9.18]	-3.76 [-7.00—3.20]
Knee moment min	0.03 [-0.09—0.23]	-0.09 [-0.33—0.00]**	0.12 [-0.17—0.28]	-0.11 [-0.40—0.02]*	-0.04 [-0.09—0.16]	-0.09 [-0.27—0.05]

AFO: ankle-foot orthosis. Data presented as median [interquartile range]. *: p-value <0.05, **: p-value ≤0.001.

Forty-eight CMT patients (23 without an AFO at baseline) were included. In 24 patients (10 without an AFO at baseline), the follow-up measurements were not performed due to loss to follow-up (n=8), use of a different (lighter) AFO than indicated (n=8), fitting problems (n=5) or poor compliance (n=3). Compared to baseline, guideline-based AFOs (n=24) improved walking speed, energy cost of walking, perceived walking ability and all biomechanical gait outcomes (see Table). Patients with a first AFO prescription (n=13), showed improvements in all variables, whereas patients with an AFO at baseline showed significant improvements in walking speed, 2 items of perceived walking ability and ankle biomechanics (see Table).

DISCUSSION AND CONCLUSION

Half of the CMT patients in our cohort completed the clinical evaluation and were provided with an effective AFO that improved both objective and perceived walking ability. Even though the effects were greater after a first AFO prescription, outcomes in patients already using an AFO improved as well. In order to provide more patients with an effective AFO that is worn satisfactorily and to improve quality of care, more research is needed to determine why and in which patients AFO prescription according to the Dutch orthotic care guideline is (un)successful.



5.194 Limitations in the Evidence for the Use of AFOs Following Stroke: A Systematic Review

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BACKGROUND

Best practice is dependent on high-quality evidence and effective translational research. The Best Practice Statement on the Use of AFOs Following Stroke ⁽¹⁾ set a standard for research quality. Since its publication 15 years ago, a comprehensive review of AFO research quality is required to assess progress and develop recommendations to advance research standards.

AIM

To identify common limitations in the literature and establish guidelines to improve future research design and reporting on the use of AFOs following stroke.

METHOD

An electronic search was carried out across key databases to identify relevant articles based on a pre-specified eligibility criterion. All studies investigating the use of AFOs following stroke were included, with a restriction to studies published after 2009 to ensure alignment with the Best Practice Statement on the Use of AFOs Following Stroke ⁽¹⁾. A customised checklist was developed to evaluate study design, participant characteristics and AFO specification allowing for a systematic and comprehensive evaluation of the quality and reporting standards within the selected studies.

RESULTS

A total of 54 studies met the inclusion criteria. The overall quality of the evidence was considered low, with only 8 studies (14.8%) designed as randomised controlled trials, 20 studies (37%) had small sample sizes (<10 participants) and 38 studies (70.4%) provided insufficient justification for the measurement systems (validity and reliability). Many studies lacked key information on participant characteristics, as 42 studies (77.8%) did not report lower limb muscle power or joint range of motion. Furthermore, AFO specification was limited with 45 studies (83.3%) not describing the material and thickness, 36 studies (66.7%) not specifying the AFO tuning procedure, and 6 studies (11.1%) not identifying the type of AFO used.

DISCUSSION AND CONCLUSION

The limitations in study designs and incomplete reporting of participant characteristics and AFO specifications, found in this review, impedes the translation of research into patient care and obstructs the development of evidence-based practice in the orthotic management of stroke rehabilitation. From both a research and clinical perspective, this may hinder progress, making it difficult for researchers to build on previous work and for clinicians to make informed evidence-based decisions. Adhering to proposed guidelines will promote more systematic and transparent reporting, enabling researchers and clinicians to better assess the quality of AFO interventions. This will ultimately enhance the evidence base, improve clinical decision making and patient outcomes.

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5.195 Cost-effectiveness of Specialized Orthotic Care to Improve Functioning in Adults with Neuromuscular Disorders: Results of a Randomised Controlled Trial

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BACKGROUND

People with leg muscle weakness due to neuromuscular disorders (NMD) are often provided with lower limb orthoses to improve walking. To enhance standardization of its provision, a multidisciplinary guideline in NMD has been published. Providing lower limb orthoses, including ankle-foot-orthoses and knee-ankle-foot-orthoses, according to this guideline in an expert setting may improve treatment outcomes and provide a more efficient use of healthcare resources compared to usual orthotic care.

AIM

To investigate effectiveness and cost-effectiveness of guideline-based provision of lower limb orthoses in an expert setting (i.e. specialized orthotic care) compared to usual orthotic care on functioning in adults with NMD.

METHOD

We performed a randomized controlled trial with measurements at baseline, 12 and 24 weeks follow-up. Sixty-one adults (mean age 62±12 years) with plantarflexor and/or quadriceps weakness due to NMD, who experienced walking problems and were indicated for an orthosis, were randomly assigned to specialized orthotic care (n=31), or usual orthotic care (n=30) at participants' regular care center. Primary endpoints were attainment of personal goals (at 24 weeks follow-up), and energy cost of walking (change from baseline to 24 weeks follow-up). Secondary endpoints included comfortable walking speed, spatiotemporal parameters, gait kinematics and kinetics, perceived stability, physical functioning, (fear of) falling, fatigue and satisfaction. Cost-effectiveness was calculated from a societal and healthcare perspective with Quality Adjusted Life Years (QALYs) as outcome measure based on the EuroQoL 5-Dimensions 5-Levels health states.

RESULTS

Personal goal attainment was significantly higher for specialized orthotic care compared to usual orthotic care ($p=0.011$). Reduction in energy cost of walking did not significantly differ between groups ($p=0.140$), although it decreased significantly with -0.55J/kg/m (-11.8%) [95%CI: -0.99 to -0.11] following specialized, but not following usual orthotic care. Secondly, we found significant effects on increasing walking speed, step length, perceived physical functioning, and orthosis satisfaction in favor of specialized orthotic care ($p\leq 0.042$). Specialized care was more effective for QALYs compared to usual care ($+0.13$) and, on average, less costly from a societal perspective ($-\text{€}6029$) but more costly from a healthcare perspective ($+\text{€}1224$), with a high and relatively high probability of cost-effectiveness respectively.

DISCUSSION AND CONCLUSION

Our RCT in adults with NMD showed that specialized orthotic care was beneficial in terms of attaining personal goals, walking speed, step length, physical functioning and orthosis satisfaction, and likely cost-effective. This suggests that guideline-based provision of lower limb orthoses in expert settings could benefit the daily functioning of adults with NMD, and could lead to cost savings.



5.196 Usage Patterns of Orthoses and Assistive Devices among Individuals Utilizing Lower Limb Orthoses: Findings of a Cross-Sectional Survey

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BACKGROUND

Individuals with lower limb impairments can use lower limb orthoses (LLOs) and/or other assistive devices (ADs) to enhance their balance and mobility.^{[1][2]} Those who are prescribed LLOs may choose to utilize orthoses only, ADs only, orthoses and ADs simultaneously, or no devices at all, depending on the situation. Identifying those situations in which patients use different devices can help clinicians and researchers better understand how patients choose to optimize their mobility.

AIM

This study aimed to determine how LLO users use different combinations of orthoses and ADs to perform various home- and community-based activities.

METHOD

A custom survey was developed to ask respondents about which device(s) they normally use while performing activities in and around the home (7 items), out in the community (9 items) and for exercise and recreation (4 items). This survey was pilot tested, then administered along with a demographic questionnaire to adults with at least 6 months of experience using LLOs that extended from the foot to a level above the ankle. Participants were recruited via flyers in clinics, social media postings, and emails or text messages to patients. Descriptive statistics were used to characterize device utilization. A XXXX IRB determined the study qualified for exempt status.

RESULTS

Data from 1036 participants were included in this analysis. Participants were 50% female and 60 years old on average (range of 20-93 years). 90% of the participants used a LLO at least four days/week and 79% reported 6 or more hours of daily use. Most participants (83-91%) used LLOs to perform community-based activities, but 24-35% of these individuals also used ADs to perform these activities. By comparison, activities that involved walking short distances in the home (e.g., getting up to go to the bathroom at night, moving from the bedroom to the kitchen) were more often performed without LLOs or ADs (Figure 1).

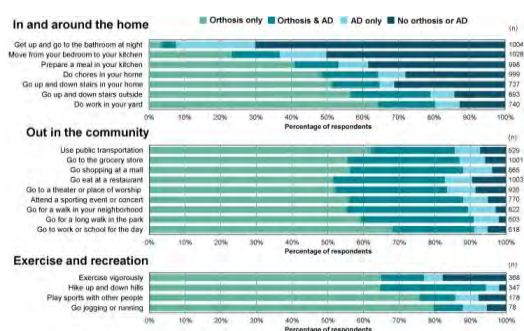


Figure 1. Percent of participants who usually use lower limb orthoses (LLOs) and/or assistive devices (ADs), or no devices, to perform each activity.

DISCUSSION AND CONCLUSION

LLOs were utilized extensively across a wide range of everyday activities. Simultaneous use of ADs and orthoses may be most beneficial for activities out in the community. Clinicians can apply this information by discussing LLO and AD use with patients to optimize their functional outcomes at home and in the community.

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5.197 Clinical practice of providing Ankle-Foot Orthoses to children with Cerebral Palsy in Norway

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BACKGROUND

Ankle-foot orthoses (AFO) are the most commonly used orthoses in children with cerebral palsy (CP), used to improve function by directly controlling the foot and ankle joints [Stockmann]. Numerous AFO-designs are available and recommendations for gait patterns such as Crouch gait and Equinus exist. However, information is scarce of how patients are assessed, how AFO-designs are selected, whether these choices align with recommendations and whether these AFO-designs are influenced by patient preferences.

AIM

The aim of this study is to document AFO provision practices among Norwegian orthotists, to assess their alignment with recommendations and to investigate the influence of patient-preferences on AFO-design.

METHOD

A cross-sectional, online survey was conducted in 2022 among Norwegian orthotists working with children with CP. The survey included questions on patient assessment for AFO-design, age-specific preferences for AFO-designs, fabrication, and fitting, and AFO delivery.

RESULTS

The response rate among all eligible orthotists was 54%. AFO goals are formulated by the referring physicians or by the orthotists. Initial gait assessment is done visually (74%) or with instrumented gait analysis (26%) using video, video vector or 3D gait analysis). A preference for flexible/articulated AFOs was observed for all gait patterns (Table1). Patient preferences were reported to change with age, focusing on flexible different design properties in kindergarten ("AFO must not prevent playing or transition"), primary school (promote independent use) and secondary school (AFO should be cosmetic and have the function the child wants). Fifty-one percent of participants use instrumented gait analysis to evaluate the function of AFOs at delivery.

Gait Pattern	Description	Proportion of participants who approved AFO-designs	
		flexible/articulated AFO	rigid AFO
Drop foot	Drop foot during swing but adequate DFL ROM	100%	2%
True equinus	Ankle in equinus during stance. Full knee- and hip EXT. Limited ankle ROM caused by contracture and/or spasticity	88%	53%
Genu Recurvatum	Full EXT or hyper EXT in knee. Impaired ankle motor control resulting in PF or reduced DFL, limiting forward motion of tibia.	81%	35%
Jump gait	Ankle in equinus. IC with hip and knee FL, followed by early extension movement in hip and knee.	70%	37%
Apparent equinus	Ankle with normal ROM, increased hip- and knee FL in stance.	74%	44%
Crouch	Flexion pattern in hip and knee. Increased DF in stance.	95%	79%

Table 1: Proportion of participants who approved articulated and/or rigid AFO for different gait patterns.

*flexible/articulated AFO= any one or several of the following: dynamic prefabricated without ankle joint; dynamic, custom made without ankle joint; articulated with open dorsi-flexion & plantar flexion stop; spring-loaded system joint; FES, functional electrical stimulation. DFL=dorsiflexion, ROM=range of motion, PF= plantarflexion, IC=initial contact, FL=flexion, EXT=Extension

DISCUSSION AND CONCLUSION

This study highlights the orthotists' role in individualizing AFO provision, balancing biomechanical optimization with the child's preferences and those of the clinical team. The study reveals a discrepancy between clinical practice of using flexible/articulated AFO-designs for children with Crouch gait and Equinus and prominent recommendations [Owen]. The findings suggest a need for more comprehensive recommendations that incorporate new technologies, patient age and environment to systematically improve AFO provision.

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Free paper session | Therapy, physical activity, sports – Physical activity

5.201 Development of a conceptual model to support participation of young people with limb difference in Australian sports and recreation

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BACKGROUND

Approximately 2500 young people in Australia are living with limb difference, a congenital or acquired physical disability. Children with disability generally participate in less physical activity compared to peers without disability. Few studies investigate the participation of children with limb difference in physical activity, even fewer exploring sports participation, and none in an Australian setting.

AIM

This study aimed to 1) investigate the participation experiences of young people with limb difference (and their parents) in Australia, and 2) develop a conceptual model to guide support of participation in sports and recreation.

METHOD

This qualitative study was designed by a team of multi-disciplinary researchers, clinicians and people with lived experience. Participation experiences were explored with nine Australian parent-child dyads. All parents were mothers, young people aged between 9-16 years with bilateral and unilateral limb difference. Data were collected via 18 semistructured interviews and analysed using interpretive description, including interpretation of themes, mapping of identified facilitators and barriers to participation to the socio-ecological model, and development of a conceptual model through synthesis of the findings, broader literature, member-checking feedback, and experiences of the research team.

RESULTS

Participation experiences were interpreted as: Theme 1) "Just treat me like everyone else": equitable participation in sports and recreation, Theme 2) "Provide them opportunities and let them take the lead": genuine choice within sports and recreation activities; and Theme 3) "I wish they were easier to get": the impact of sports-specific prostheses on participation. Within these three themes there were barriers and facilitators described, and when mapped to the social-ecological model allowed understanding of key influences, the levels at which they act, and the interplay between them. Family dyads experienced barriers and facilitators across all individual, interpersonal, community and societal levels of this model. These key findings and the experiences of the research team were integrated to develop a conceptual model, titled "Moving through childhood: Participation supports for young people with limb difference" to guide clinicians, coaches, families and policy makers in enhancing sports and recreation participation.

DISCUSSION AND CONCLUSION

Family dyads describe a need for equitable participation and choice in sports and recreation, and the conceptual model can now be implemented by clinicians, families and policymakers, with evaluation being recommended. This study also demonstrates that barriers and facilitators to participation exist at all levels of the socio-ecological model. Future work may look at developing specific strategies to support participation at the individual, interpersonal, community and social levels.



5.202 Predicting Physical Activity in Adults with Transtibial Amputation

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BACKGROUND

Physical activity (PA) offers numerous health benefits, yet individuals with lower-limb amputation often face mobility challenges that limit PA. Clinical-based outcome measures such as the Prosthetic Limb User's Survey of Mobility (PLUS-M) provide valuable insights into PA characteristics but incompletely capture real-world mobility. Machine learning techniques have demonstrated promising accuracy in predicting free-living PA and mobility.¹ When combined with accelerometry data, these approaches offer opportunities to enhance post-amputation rehabilitation monitoring and outcomes.

AIM

To develop and validate a machine learning model for estimating daily step count from PLUS-M responses and health factors and to examine the relationship between model-predicted and actual daily step counts.

METHOD

LASSO regression was used to construct the prediction equation. PLUS-M T-score and health state characteristics served as predictors within the model. Participants (n=106) wore an activPAL accelerometer for 7 days to objectively measure daily steps. Data were partitioned into training (80%) and holdout (20%) subsets to facilitate model development and validation, respectively. 3-fold cross-validation was employed to determine the optimal LASSO regularization parameter. The LASSO modelling technique was then applied to identify the optimal combination of predictors for estimating step count. Validity was examined by comparing equation-predicted steps with actual steps collected via the activPAL in the holdout data.

RESULTS

The predictor variables retained in the LASSO model included age, BMI, diabetes diagnosis, and PLUS-M T-score. The following equation was established to predict step count:

$SC = 3,089 - (27.6 \times \text{Age}) - (8.2 \times \text{BMI}) - (440 \times \text{T2D}) + (65 \times \text{PLUSM})$ where SC represents daily step count, T2D represents type 2 diabetes diagnosis (assigned a value of 1 if yes and 0 if no), and PLUSM represents PLUS-M T-score. An average of $4,119 \pm 1,865$ steps/day was measured by the activPAL in the holdout sample. The LASSO model predicted an average of $4,653 \pm 912$ steps/day in the same holdout data. A moderately high correlation ($r=0.77$) was noted between the actual vs. predicted steps/day.

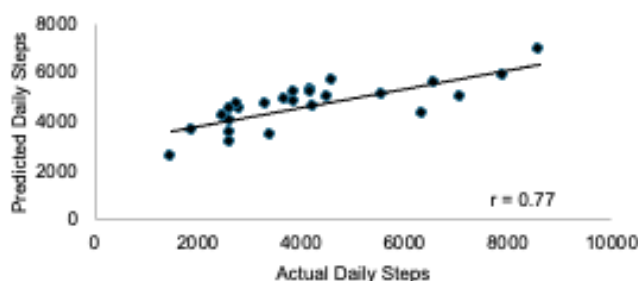


Figure 1: Relationship between predicted and actual step count values

DISCUSSION AND CONCLUSION

The current findings demonstrate the utility of leveraging machine learning techniques to estimate daily step count among individuals with transtibial amputation based on clinical assessments and health characteristics. This approach offers significant advantages over clinic-based mobility testing alone by providing a feasible method to continuously monitor real-world activity patterns and inform tailored rehabilitation strategies. In conclusion, the developed prediction model represents a promising tool to enhance free-living mobility monitoring and management for this population.

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ACKNOWLEDGEMENTS

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5.203 Home Exercise and Walking Adherence using a Mobile Device Outcomes Based Rehabilitation Program for People with Lower Limb Loss

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BACKGROUND

Mobile Device Outcomes-based Rehabilitation Program (MDORP) utilizes mobile technology, called Rehabilitative Lower Limb Orthopedic Assistive Device (RELOAD) to enhance the home rehabilitation of Services Members (SMs) and Veterans with lower limb loss (LLL). Home-based exercise programs (HEPs) are integral to rehabilitation of this population outside of the clinic. The ReLOAD system assesses walking quality, provides auditory feedback to correct gait deviations, and recommends patient-specific exercises that target their impaired functions and limitations

AIM

To examine the use of the RELOAD system in the clinic and at home to optimize assessment and care of SMs and Veterans with LLL.

METHOD

Eighteen physiotherapists (PTs) practicing across six Veterans Affairs Medical Centers (VA) and one Department of Defense (DoD) Facility partnered in this study. The PTs utilized ReLOAD as part of their standard of care: collecting in-person initial eval data; administering outcomes; conducting monthly in-person follow-up visits; tracking patient progress remotely; and prescribing targeted HEPs. The patients were deployed home exercise equipment, wearable sensors on knee sleeves and/or straps and mobile device to use at home when walking or performing HEP. Real-time verbal cues and music distortion was provided when walking to improve gait quality and symmetry. Descriptive statistical analysis was performed.

RESULTS

To date, 105 people with LLL (K4-level (24%), K3-level (52%), and K2/K1-level (24%)) have been enrolled. Over 500 exercises have been prescribed to 100 patients (95%) with 80% completing over 3,800 exercises. Typically, clinicians prescribed either three (60%) or four (33%) home exercises at a time. The five most prescribed exercises (systems addressed) were stool stepping (single limb balance and hip extensor/abductors strength and endurance), ball rolls with arm support (single limb postural stability and balance), partial squats (lower limb strength), chair squats (postural extensor strength), and braiding (balance and prosthetic gait control). Eighty-eight participants were prescribed sensors for home walks with 72% completed over 1,100 home walks (mean time=15 minutes). Patients reported that the real-time verbal cueing provided helpful hints to improve prosthetic use and music distortion helped maintain walking symmetry.

DISCUSSION AND CONCLUSION

RELOAD can be integrated into clinical practice at VA and DoD facilities. Physiotherapists in MDORP utilized different outcomes and the exercise library to prescribe targeted exercises for balance, strength, endurance, and agility. Exercise and walking adherence results were greater than standard of care expectations. The potential long-term cost savings for Veterans with LLL can be significant if ReLOAD is deployed as a telerehabilitation tool at VA and DoD facilities.

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5.204 Evidence-based physical activity guidelines for adults living with lower limb amputation

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BACKGROUND

People with lower limb amputation (LLA) often have sedentary behaviors. Evidence-based guidelines are essential to help these individuals engage in safe and effective physical activity. However, current physical activity guidelines for people with physical disabilities¹ do not include evidence for people with LLA

AIM

To systematically develop physical activity recommendations for people with LLA

METHOD

The Appraisal of Guideline, Research and Evaluation protocol (AGREE) II tool was used. A panel of clinicians and researchers with expertise in LLA and guideline development, people with LLA, and a nonprofit advocacy organization for people with limb loss was formed. Then, the expert panel met to refine the scope of the guidelines, review the evidence (based on a systematic review² of the relevant literature), and formulate the recommendations. End-user feedback was also sought.

RESULTS

For benefits in balance and mobility outcomes, adults with a major LLA should perform at least 60 minutes per week of moderate to vigorous aerobic exercise. This aerobic exercise prescription should be combined with strengthening or balance exercises. Strengthening exercises should include at least 3 sets of 10 repetitions of strengthening exercises for the major muscle groups of the lower limbs at least 2 times per week. Balance exercises should include at least 20 minutes of balance exercises 3 times per week. There was insufficient evidence to make recommendations for other fitness-related outcomes, such as cardiorespiratory function.

DISCUSSION AND CONCLUSION

The AGREE II process led to the development of the first physical activity recommendations for people living with LLA. This guideline will help to reduce the knowledge gap in the development of programs and policies to facilitate the participation of people with LLA in physical activity. Future research is needed to examine the impact and health benefits of adopting these recommendations for people with LLA.

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ACKNOWLEDGEMENTS

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5.205 A Clinician-Focused Dashboard to Enhance Myoelectric Prosthetic Training and Monitoring for Improved Rehabilitation Outcomes

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BACKGROUND

Upper limb loss significantly impacts daily life, and while prosthetics can help, training users to use them effectively remains a major clinical challenge. High-quality training is crucial for successful rehabilitation outcomes. Here, we review a clinician-friendly dashboard that provides detailed data visualizations and objective insights on myoelectric prosthesis control training compliance and performance. The tool aims to empower clinicians to provide more targeted therapy and monitoring, ultimately leading to improved outcomes for prosthesis users.

AIM

To describe how a web browser-based clinician dashboard can facilitate in-clinic or remote therapy and monitoring of individuals training myoelectric prosthesis control.

METHOD

Individuals with upper limb loss participated in an at-home myoelectric prosthesis control training program using a wearable myoelectric cuff system. ^[1] Training involved making muscular contraction patterns to calibrate the system and to control a virtual limb or play games in a mobile application. Clinicians had remote access to data collected from the system, including usage time, diagnostic information, calibration data, and game metrics, via a clinician dashboard. Clinicians monitored participant compliance, device performance, and game performance and provided remote support as needed.

RESULTS

Remote monitoring through the dashboard played a critical role in enabling clinicians to provide timely and proactive intervention and personalized therapy and support. Calibration data analysis allowed clinicians to assess calibration quality and monitor signal quality, identifying potential issues like contraction timing and electrode-skin lift-off. Game usage data helped determine user comprehension and system utilization, with lower performance indicating poor control and highlighting challenging motions. Another key advantage was the clinician's ability to facilitate pre-emptive outreach. When clinicians observed problematic myoelectric signals or potential control issues, they proactively contacted users to ensure proper electrode-skin contact while donning the cuff or schedule calls to provide functional control tips, enhancing system effectiveness.

DISCUSSION AND CONCLUSION

myoelectric control performance. By verifying usage and confirming user engagement through signal examination, clinicians could enable timely interventions. This dashboard-based approach opens new possibilities for accessible, personalized, and closely monitored at-home therapy, providing clinicians with the insights needed to support patients and improve outcomes – including pre-prosthetic training and real-world prosthesis use as well as phantom motor execution therapy for phantom limb pain management.^[2]

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5.206 Development of a network for scoring video-based exercises in the telerehabilitation system used for physiotherapy demands

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BACKGROUND

Some studies revealed that telerehabilitation practices have no apparent disadvantage over face-to-face physical therapy [1,2]. Health specialists can observe the patient practicing rehabilitation exercises over several distant communication modalities. For experts, increasing the current state of patient information at home by obtaining visual-based pose estimations certainly helps evaluate exercise quality and monitor the treatment progress [3]. Automatic evaluation of the exercise with an acceptable success level could improve the treatment without a therapist [4].

AIM

This research aims to develop a video-based motion detection module for our general-purpose telerehabilitation system utilizing “MediaPipe” pose estimation to evaluate chosen exercises automatically for Multiple Sclerosis (MS) patients.

METHOD

We integrate the “OptiTrack” motion capture system into our telerehabilitation system for MS, Duchenne Muscular Dystrophy (DMD), and posture problems. Three rehabilitation exercises for each problem and their motion templates chosen by physiotherapists provide signals for elbow and shoulder angles that can be compared with recorded video for patient exercises. A human pose inspection algorithm modified in Python libraries for “MediaPipe” is applied to real-time video recorded from an ordinary laptop webcam while the exercise takes place. Simultaneous recordings of chosen exercises are recorded and analyzed to assess the performance of the automatic scoring program.

RESULTS

The files are examined in the JavaScript platform, and variables are created in the HTML code to display the data and “MediaPipe” videos on the website. HTML and JavaScript work in an integrated way with the “Flask” framework. Code changes made in HTML are visible with Flask. After completing one exercise cycle, we transfer the data to the website via the telerehabilitation infrastructure server. A “MediaPipe” based application is developed that has a scoring function in which dynamic time warping is employed to normalize the signals in the time domain to compensate for exercise speed (time) differences. Figure 1.a shows the web illustrations of the exercise and pattern recognition results to find angles, while Figure 1.b presents an example of the comparison of signals with templates for assessment scores.

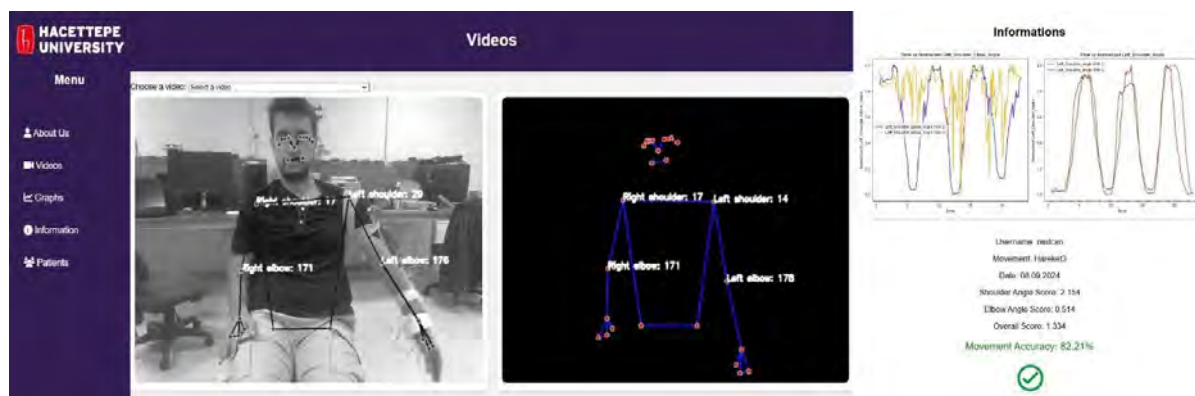


Figure 1.a. Website interface and Data Scoring



DISCUSSION AND CONCLUSION

The study's main goal is extracting kinematic data from the video-based motion tracking system, which is achieved and integrated into the more general telerehabilitation system as part of our telerehabilitation project. The general use of the "MediaPipe" environment is modified in this study, and exercise data recorded by the webcam and transferred to a remote server are utilized for the inspection of the experts remotely.

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5.207 Co-designing a Physical Activity Intervention for Individuals with Lower Limb Amputations

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BACKGROUND

People with lower limb amputation (LLA) have reduced physical function, balance, walking velocity, endurance, and limited community walking ability. Exercise has been shown to improve balance, walking speed and endurance and transfer ability in adults with LLA. However, the limited availability of rehabilitation services for LLA makes ongoing support for exercise challenging. To date, there is a dearth of research on community-based exercise interventions for the LLA population.

AIM

To co-design a community-based exercise LLA intervention using participatory research in collaboration with people with limb loss, caregivers and healthcare providers.

METHOD

This research is guided by an Experience-Based Co-Design (EBCD) approach. EBCD enables end-users (e.g., patients, families, and health professionals) to co-design health services and interventions. We conducted a phased sequential qualitative study. First, virtual focus groups with people with LLA, caregivers, and health professionals were conducted. Data were analyzed using inductive thematic analysis. Building on findings from the focus groups, co-design workshops were conducted with people with LLA and health professionals to co-design a prototype of a community-based exercise program. A diverse advisory committee of researchers, clinicians and people with LLA will finalize key features of the exercise program.

RESULTS

Ten focus groups were conducted (n=21 LLA; n=4 caregivers; and n=12 health professionals). Five workshops were completed (n=12 LLA; n=5 health professionals). Participants described preferences for exercise program structure and content, how a program should be delivered and some important operational considerations. Participants favoured a 3-pronged program structure consisting of exercise, education and social components. Exercise preferences were shared for 3 types of exercise: cardiovascular/aerobic (e.g., cycling, walking), strength (e.g., circuits with machines, free weights, body weight) and balance. Education needs (e.g., nutrition, mental health) and preference for a social component (e.g., brief and facilitated by a peer) were identified. A small group format with a hybrid (in-person and virtual) approach and some tailoring to meet individual needs were preferred. A final prototype and design considerations will be presented.

DISCUSSION AND CONCLUSION

Co-design processes facilitate a collaborative, patient-centered approach to development of interventions via partnerships between researchers and end users. Findings of this research include an intervention prototype. Future research is needed to examine the feasibility and effectiveness of the exercise program.

ACKNOWLEDGEMENTS

We'd like to thank the study participants. We acknowledge our funder: The War Amps.



Free paper session | Paediatrics – Paediatric management and service planning

5.211 Breaking Barriers: Inclusivity and Universal Design in Jönköping's Playgrounds

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BACKGROUND

Play is essential for children's physical, cognitive, and emotional development, contributing to their mental and social well-being. Despite this, playgrounds are often inaccessible and non-inclusive for children with disabilities, leading to exclusion from play. In Sweden, accessibility standards focus on physical access but do not fully ensure inclusive play experiences, affecting children with diverse abilities.

AIM

This study assesses the accessibility and inclusivity of playgrounds in Jönköping, Sweden, focusing on applying universal design principles, such as equitable and flexible use. Specifically, it investigates whether playgrounds provide equal play opportunities for children with different disabilities and identifies common barriers to accessibility.

METHOD

Through a case study, three playgrounds in Jönköping are evaluated for inclusivity features, such as pathways and sensory play elements. Observational analysis is conducted using criteria based on universal design principles, and a survey is carried out with parents of children with disabilities to gather their perspectives on current playground designs and preferences for future improvements.

RESULTS

The study revealed a stark lack of accessibility and inclusiveness across most playgrounds, with only one offering some features like ramps and a partially wheelchair-accessible play area. Additionally, just one playground encourages interaction and inclusion between children of differing abilities, using communication elements that connect different play areas. However, all playgrounds were found to be deficient in sensory play equipment, other than sandboxes, diverse inclusive play activities, and a variety of accessible play options, underscoring a major gap in inclusive design. While some playgrounds in Jönköping have basic accessibility features, such as ramps, these largely cater to wheelchair users and fall short of providing equal play opportunities for children with diverse needs.

DISCUSSION AND CONCLUSION

This study underscores the pressing need to enhance playground designs by adopting universal design principles that genuinely address the needs of children with diverse physical and cognitive disabilities. Current policies, though well-intentioned, often appear as token gestures rather than effective solutions, focusing narrowly on basic access without ensuring fully inclusive, engaging play for all children. Further research is necessary to address these gaps. Ongoing research will incorporate user feedback to understand the needs of children with disabilities better and inform more inclusive future designs. While not every playground feature needs to be accessible, every child has an equal right to meaningful, inclusive play.

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5.212 Motor Skills Improvement Evaluation of Cerebral Palsy Child With Lower Limbs Spasticity by Application of Variable Abduction Hip Orthosis

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BACKGROUND

VAHO is recommended for more than 25 years for motor skills improvement of children with spastic palsy of lower limbs of any etiology and prevention of hip displacement in CP children. There are not many published clinical studies that check this statement. Study objective is efficiency evaluation of orthotic fitting in CP children with lower limb spasticity by VAHO application, immediately after application and 6 months of VAHO usage.

AIM

Evaluation of efficiency of orthotic fitting using clinical assessment; objectively determining the difference in manifestation of motor disorder without VAHO, after application of VAHO and after 6 months of usage.

METHOD

Clinical examination and filling up questionnaire to evaluate motor skills using VAHO (the questionnaire is a part of instructions for VAHO application), obtained data analysis. In 10 children (6 boys and 4 girls, age of 4 to 12) we observed parameters: improvement of child's sitting, posture, walking, scissoring gait and walking distance in meters without orthosis, after VAHO application, and after 6 months of VAHO usage. Statistical analysis was made by Wilcoxon test of matched pairs.

RESULTS

In 80% of children studied, VAHO application led to motor skills improvement. We found statistically significant difference in motor skills improvement of children using VAHO comparing to their motor skills without VAHO, which was evident also after 6 months of application. Immediately after the application of VAHO, all children had improvement in posture while sitting, reduced scissoring gait and increase of walking distance in meters, all ($p = 0.005$)-statistically very significant differences. In all children there was an improvement of independent standing and walking - statistically moderately significant differences. Comparing the examined parameters immediately after fitting and after 6 months of usage, it was still present the same improvement, while in the walking distance in meters after 6 months there has been a further increase ($p = 0.018$).

DISCUSSION AND CONCLUSION

VAHO is intended for relatively small group of users with specific orthotic needs. The study confirmed the efficacy of VAHO application and improvement of motor skills in CP children with lower limbs spasticity. Experience of medical team is essential, as well as parent / guardian co-operation to avoid unsuccessful orthotic fitting. This study can help clinicians in deciding about orthotic solution in children with lower limbs spasticity.



5.213 Improving Transition in care for adolescents with congenital limb deficiencies: Implementing recommendation from a national guideline and the Just-Like-You project

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BACKGROUND

Transitioning to adulthood is a process with increasing autonomy for adolescents. For youngsters with a disability growing up brings extra challenges, especially during the transfer from pediatric services to adult (rehab)care. In the Just-Like-You project meaningful tools were developed in co-creation with adolescents and their parents, parallel to the publication of a national guideline for improving transition of care. However, creating a sustainable improvement of daily care remains challenging

AIM

Creating sustainable improvements in transition of care and transition to adulthood for adolescents with congenital limb deficiencies, spina bifida and cerebral palsy and their parents.

METHOD

In the Just-Like-You project adolescents participated in all phases of the project. The Design Thinking Method was used to reveal experiences with transition of care in our Rehabilitation Centre in The Netherlands. Focus group-sessions were held with 12 adolescents (ages 18-23) with cerebral palsy, spina bifida, (congenital) limb malformations and 4 parents. Thematic analysis was applied. A survey was conducted amongst health care professionals of the participating clinic (n=36). Subsequently tools were developed in co-creation sessions. In the implementation phase interviews are held with different team members to evaluate barriers and facilitators in creating a sustainable improvement.

RESULTS

Both focus groups and the survey with professionals revealed areas of improvement. To meet the needs of the adolescents and parents tools and information materials were developed to 1) facilitate transfer of care (e.g. road map, information about adult-centered teams), 2) share peer experiences (e.g. blogs and vlogs) and to 3) facilitate communication between parents-adolescents-professionals (workshopformat). Informationmaterials and tools were placed on an open source website www.netalsjij.nl which was adopted by the patient-union. The workshopformat was tested in several rehab centres and is now incorporated in a national program for the implementation of the national guideline for improving transition of care "Transtion Continued". Preliminary results on barriers and facilitators will be presented at the congress.

DISCUSSION AND CONCLUSION

Through participation of adolescents in all phases of the project meaningful improvements were developed. To create a sustainable change in rehabcare in the transition phase the communication between professionals of child and adult care is crucial. The workshopformat "transition road map" that was developed will be helpful in changing local policies under the leadership of the adolescents themselves.

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Special thanks to Cecilia Kalsbeek and Jan-Willem Gorter and all youngsters and their parents who participated in the Just-Like-You project.



5.214 Characteristics of Physical Behaviour in Children with Cerebral Palsy in Jordan

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BACKGROUND

Children with cerebral palsy (CP) demonstrate low levels of physical activity in everyday situations whether at home, at school or during leisure time ^[1]. This would potentially restrict their participation, impact their quality of life and increase the risk of developing secondary health conditions. Understanding the physical behaviour of children with CP is important to guide intervention planning.

AIM

The aim of this study was to longitudinally characterise the patterns of physical activities of children with CP in Jordan with different Gross Motor Function Classification System- E&R levels (GMFCS) using activity monitors.

METHOD

A convenient sample of 16 ambulatory children with CP (12 boys, 4 girls) aged between 2 and 14 years participated in the study. Children's GMFCS levels ranged between I and IV. ActivPAL 4 was used to monitor their physical activity for 7 consecutive days in their living environment. Duration and frequency of sitting, standing, walking, and sedentary events were identified, described, and compared across the GMFCS-E&R levels.

RESULTS

The number and duration of steps per day decreased with higher GMFCS-E&R levels with a median of 9947 steps/day and 142.1 minutes/day for level I and 195 steps/day and 3.5 minutes for level IV. About 50 steps in a row accounted for about 90% of all stepping bouts (steps in a row) for level I, 97% for level II, 98.5% for level III and more than 99% for level IV. The step bouts of about 50 steps in a row, however, accounted for about 46%, 81%, 85%, and 93% of all counted steps for levels I, II, III, and IV respectively. Only Level I showed several attempts to continuously walk for 2 minutes which accounted for 2.4% of all walking durations. Sedentary duration per day (which does not include sleeping duration) was very high for all participants with 18 hr/day for level I and more than 20 hr/day for level III and IV.

DISCUSSION AND CONCLUSION

Children with lower GMFCS-E&R levels showed more physical activity, however, the intensity of the physical activity obtained across all levels especially those with better ambulation ability was alarmingly low. Therefore, we recommend a more comprehensive examination of determinants of intensity of physical activities to further investigate the physical behaviour of children with CP in Jordan. Knowledge about patterns of physical activities and determinants of those patterns will optimally guide planning for comprehensive rehabilitation plans of care and improve physical activities.

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ACKNOWLEDGEMENTS

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5.215 Investigation of Lateralization and Mental Rotation in Adolescents with Idiopathic Scoliosis and Their Relationship with Postural Changes

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BACKGROUND

Asymmetrical spinal loading, linked to lateral preference, is often considered as a potential developmental theory for Idiopathic scoliosis (IS). There is a lack of comprehensive literature examining the associations between cognitive spatial abilities and IS.

AIM

The aim of this study was to investigate lateralization and mental rotation in adolescents with IS and their relationship with postural changes.

METHOD

We paired 27 adolescents diagnosed with IS and 27 healthy control participants (age range: 11-18 years). Both groups completed the Orientate Laterality Recognition Program to assess the lateralization and the Mental Rotation Test to measure motor imagery and spatial ability processes. In the IS group, deformity severity was assessed using the Cobb angle, while posture was evaluated with the posterior trunk asymmetry index (POTSI) and the anterior trunk asymmetry index (ATSI). The differences between groups were analyzed using Mann-Whitney U test, and the relationship between postural and cognitive spatial parameters in the IS group was assessed using the Spearman correlation test.

RESULTS

There was no difference in age between the groups (14.7 ± 2.3 years in the IS group and 15.2 ± 1.9 years in the control group). The mental rotation test score ($p=0.017$) and lateralization test score ($p=0.047$) were statistically lower in IS group than in the control group. In the IS group, there was no correlation between Cobb angle, POTSI, ATSI scores, and lateralization and mental rotation scores ($p>0.05$).

DISCUSSION AND CONCLUSION

These findings suggest that while IS may impact cognitive spatial abilities, such as lateralization and mental rotation, this impairment appears to be independent of the severity of spinal deformity or postural asymmetry. There is a need for comprehensive future studies on this topic.

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ACKNOWLEDGEMENTS

There was no conflict of interest.



Free paper session | Gait and balance – Techniques and measurements

5.221 Marker-less 3D computer gait analysis in lower limb amputees using mini HPC

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BACKGROUND

Application of human activity assessment systems in clinical settings and institutional hallways have increased in recent years. Understanding how people move in these settings can provide valuable insights into mechanisms of pathological gait, particularly during walking with lower limb prostheses.

AIM

The objective of the study was to determine whether gait parameter extraction remains feasible despite the influence of clothing worn during walking in clinical settings.

METHOD

A video-based deep learning approach has emerged as a promising method for analysing three-dimensional human movement within institutional hallways, culminating in the development of a "smart hallway". Four high-speed recording intelligent cameras (FLIR BlackFly S USB3) were mounted on the ceiling and calibrated to enable rapid and precise transformation ^[1] of video data into a kinematic coordinate system (NVIDIA Jetson AGX Orin). OpenPose, an open-source library, was employed to calculate body-segment lengths, step length, step time, and cadence following the detection of foot events ^[2].

The gait of 10 lower limb amputees (transtibial, aged from 45 - 74, providing informed consent National Medical Ethics Committee, Republic of Slovenia, 0120-22/2023/3) was analysed and features like segment length, stride, cadence, velocity, joint angles were extracted and statistically valued.

RESULTS

The spatio-temporal parameters aligned with the reference manual measurements. The difference between the Smart Hallway-based ground-truth segment length was, on average, less than 0.5 cm.

DISCUSSION AND CONCLUSION

The video-based deep learning approach for analysing three-dimensional human movement in institutional hallways demonstrates considerable potential for the development of smart hallways. The Smart Hallway provided information on limb joint angles and spatio-temporal parameters to support clinical decision-making. This marker-less system generates data without requiring additional extraction or analysis, thereby enhancing the possible application of gait analysis of lower limb amputees in clinical settings.

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5.222 Amputee Movement Analysis in a Smart Hallway

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BACKGROUND

The Smart Hallway concept brings 3D movement analysis to the point of patient contact by automatically capturing digital video when a person walks within a hallway, calculates 3D joint locations from 4 video cameras (using AI and our software), and then generates a report that quantifies gait outcome measures ^[1]. While initial validation tests were successful, further study with amputee gait is needed before use in regular clinical care.

AIM

Preliminary biomechanical evaluation of amputee gait within a Smart Hallway implementation at the University Rehabilitation Institute Republic of Slovenia.

METHOD

Five people with lower limb amputation, a functional prosthesis, and ability to walk at least 10 meters volunteered to walk through a Smart Hallway setup while video was collected at 60Hz. The OpenPose BODY25 model generated body keypoints for each frame. Following keypoint processing, 3D marker data were calculated for each frame. To assess distance measurements, limb length standard deviations were calculated from the marker data. Stride timing was evaluated by automatically calculating stride parameters from each trial and comparing these results with manually calculated values from the video.

RESULTS

Stride parameter results are displayed in Table 1. Average differences between manually measured parameters and Smart Hallway generated values were small, within 0.03 s. Limb length standard deviations (SD) averaged 2.9 ± 1.8 cm, with 12 of 19 segments under 3 cm SD. The largest SD was for the hip to knee segment (6.7 - 7.1 cm).

Table 1. Stride parameter average and standard deviation, and average difference between manual and calculated results

		Average	Average Difference
Left	Step Time (s)	0.62 ± 0.11	0.02 ± 0.00
	Stride time (s)	1.30 ± 0.34	0.03 ± 0.05
	Double Support Time (s)	0.13 ± 0.04	0.03 ± 0.05
Right	Step Time (s)	0.66 ± 0.22	-0.01 ± 0.02
	Stride time (s)	1.27 ± 0.35	0.00 ± 0.02
	Double Support Time (s)	0.24 ± 0.21	0.03 ± 0.02

DISCUSSION AND CONCLUSION

The results demonstrated the quality of data that can be obtained with the markerless Smart Hallway approach. The small differences in timing showed that usable stride parameter can be achieved. The relatively small SD for limb lengths indicates useful distance/location measurements, which leads to good body measurements. Use of a cane or forearm crutches did not affect the outcome measurements. This preliminary analysis demonstrated the viability of the Smart Hallway approach, with appropriate outcome measures that can be automatically produced as a person walks within an institutional hallway nearby the point of care.

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ACKNOWLEDGEMENTS

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5.223 Quantifying Movement Fluency in Prosthetic Patients in Key Functional Tasks: Sit-to-Stand and Sit-to-Walk

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BACKGROUND

Walking speed is a common outcome measure in rehabilitation after amputation. However, sit-to-stand (STS) and sit-to-walk (STW) movements are also key functional tasks to master following amputation [1]. They are core to many activities of daily living enabling patients to regain independence. Physiotherapists assess movement fluency (hesitation and smoothness) by observing STS and STW movements however, this relies on extensive experience and lacks objectivity. Quantitative instrumented movement analysis is not routinely used with amputees due to limited evidence of applying dynamic gait models to amputees and the timing and cost implications of data acquisition and processing. However, measures of movement fluency can be obtained from a single trunk marker and could overcome these issues.

AIM

This study aims to establish objective, accessible and scalable quantitative measurements of movement fluency in amputees.

METHOD

12 transfemoral amputees (6 limited community ambulators and 6 community ambulators) and 6 typical individuals completed walking, STS and STW tasks. Movement fluency was assessed using published algorithms [2,3] to obtain hesitation and smoothness in STS and STW. Comparisons were made between the groups.

RESULTS

In sit-to-walk, hesitation, and smoothness showed statistically significant differences among all three groups. Community ambulators were significantly less hesitant ($p = 0.009$) and smoother ($p = 0.007$) than the limited community ambulators, but significantly more hesitant ($p < 0.001$) and less smooth ($p < 0.001$) than typical individuals. In sit-to-stand, the community ambulators were significantly smoother than the limited community ambulators ($p < 0.001$), but not significantly different to typical individuals ($p = 0.77$). The STS hesitation algorithm was not suitable for use with the amputee groups due to patients using varying STS strategies. No strong relationships were found between movement fluidity and walking speed.

DISCUSSION AND CONCLUSION

Assessment of movement after amputation is not just about walking speed. Other important functional tasks can differentiate amputees and should be considered. These measurements can be obtained from a single marker and are therefore more accessible and scalable than traditional instrumented gait analysis. Quantifying movement fluency in functional tasks is important to understanding the restoration of function following limb loss and tracking rehabilitation. This could be used to classify amputees and aid prosthetic prescription.

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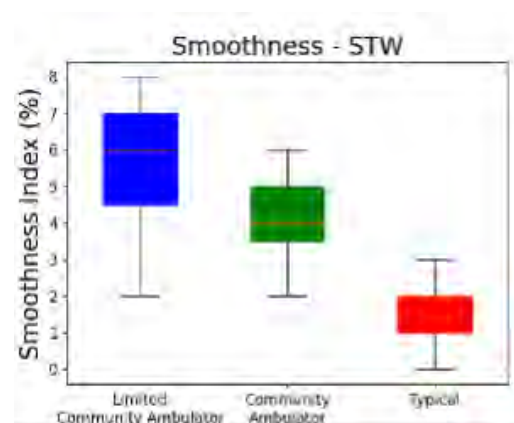


Figure 1: Comparison of STW smoothness between two transfemoral amputee groups and typical individuals.



5.224 Can predictive simulations accurately recreate treadmill gait of individuals with lower limb amputation?

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BACKGROUND

Musculoskeletal modeling and simulation allows analysis of variables difficult to determine *in vivo*, like joint contact forces.¹ Often, simulations are limited to recreating the data collected experimentally (prescribed simulations). However, predictive simulations can be conducted where goals or input parameters can be altered, allowing investigation of the resulting consequences in a consistent manner. Little research has been conducted to evaluate the feasibility of using these methods to simulate treadmill gait in those with amputation.

AIM

To determine the validity of a predictive simulation framework to accurately recreate treadmill gait biomechanics in those with amputation.

METHOD

3D motion capture data for an averaged treadmill gait cycle for each of 14 individuals with unilateral transtibial amputation (UTTA) were collected. An Inverse Kinematics (IK) solution was calculated using OpenSim and a common prescribed simulation workflow. A modified gait2392 model was used. This model was further altered for use with OpenSim Moco, contact elements were added, and a previously-validated representation of a treadmill was integrated.² An OpenSim MocoTracking problem was solved that tracked experimental kinematics/ground reaction forces (GRF) and minimized the sum of muscle activations squared. Pelvic and bilateral lower extremity kinematics (3 hip angles, 1 knee angle, 1 ankle angle per limb) across the gait cycle as well as GRF for the stance phase of the intact limb were extracted for each solution. The group means of each kinematic and kinetic variable for these solutions were compared to the experimental GRF and prescribed IK solutions using Pearson's correlations (r) and root mean square difference (RMSD).

RESULTS

Kinematics: r ranged from 0.88 (pelvis sagittal plane) to 0.99 (amputated side knee flexion), and RMSD ranged from 0.21 deg (pelvis frontal plane) to 1.76 deg (intact limb ankle flexion). *Kinetics*: greatest r value was vertical GRF (0.99) and the lowest was mediolateral (0.69). RMSD ranged between 0.01 body weight (BW) for mediolateral and 0.05 BW for vertical GRF.

DISCUSSION AND CONCLUSION

This workflow accurately predicted the kinematics and GRF generated by prescribed simulation approaches. All variables demonstrated low comparative errors and the RMSD for all fell below previously suggested thresholds.³ These results support that the current framework can create kinematically and kinetically accurate predictive simulations of treadmill gait in those with UTTA.

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Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Liner and socket design

5.231 Optimizing liner prescription to mitigate the effects of perspiration

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BACKGROUND

Individuals with lower limb amputation often report uncomfortably warm skin temperatures and residual limb perspiration during moderate to vigorous activities or exposure to hot and humid environments [e.g., 1, 2]. As perspiration accumulates between the residual limb and prosthesis, it can lubricate the interface, resulting in interfacial motion, or the movement of the residual limb relative to the prosthetic liner. Excessive interfacial motion can result in an insecure prosthetic suspension.

AIM

To identify a lower limb prosthetic suspension that remains stable, secure, and comfortable despite accumulating perspiration inside the prosthesis.

METHOD

Eligible individuals were randomized to receive either a liner perforated with many small holes (like the SoftSkin Air, Uniprox, GER), a liner perforated with fewer but larger holes (like the Silcare Breathe, Endolite, GBR), or a liner-liner (a thin, half-ply sock, Knit-Rite, USA). Subjects wore the study intervention in their home, community, and work environments. The Comprehensive Lower-Limb Amputee Socket Survey (CLASS) was used to assess the subject's as-prescribed liner (baseline) and again after the subject had worn the study intervention for at least two weeks [3].

RESULTS

Twenty individuals provided informed consent to participate in this on-going study (96±14 kg, 1.81±0.08 m, 53±12 years; 12 trauma, 7 diabetic/dysvascular, 1 cancer). The interim results (Figure) indicate large variability in the patient-reported outcomes. The stability and suspension of the study liner with fewer but larger holes (n=5) increased from the baseline as-prescribed liner. The stability of the study liner with many small holes (n=9) slightly decreased from the baseline as-prescribed liner, while the liner-liner (n=6) slightly increased. The suspension of the study liner with many small holes and the liner-liner decreased from the baseline as-prescribed liner. The comfort of all three study interventions slightly decreased from the baseline as-prescribed liner.

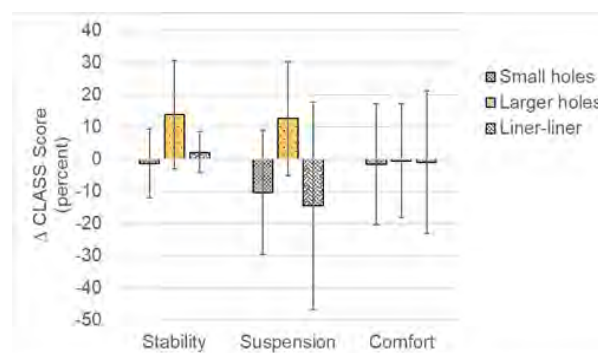


Figure 1. Change in CLASS scores (study intervention worn for two weeks minus as-prescribed baseline) for stability, suspension, comfort, and appearance outcomes. Error bars represent ± 1 standard deviation.

DISCUSSION AND CONCLUSION

Compared to the baseline as-prescribed liner, the results suggest increased stability and suspension of the perforated liner with larger holes. The stability of the perforated liner with small holes and the liner-liner remained unchanged, while their suspension decreased. Changes in comfort were negligible. These interim results suggest a perforated liner with fewer but larger holes would effectively mitigate the effects of perspiration.

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ACKNOWLEDGEMENTS

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5.232 Personal Experiences of Cosmeses for Lower Limb Prostheses – A phenomenographic analysis

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BACKGROUND

Satisfaction with the appearance of a prosthetic limb affects perceptions of body image^[1], self-acceptance^[2] and prosthesis embodiment^[3]. While cosmetic options for lower limb prostheses have increased dramatically over the past decade, little is understood of how different aesthetic designs are experienced by individual users^[4].

AIM

The objective of this qualitative study was to explore users' experiences of two different designs of cosmetic cover for lower limb prostheses.

METHOD

A phenomenographic approach was used to further understanding of prosthesis users' experience with different cosmetic covers. 10 prosthesis users tested two different designs of cosmetic cover; 1/a traditional foam cosmesis and 2/ a 3d printed cosmesis. After testing each cover for approximately 3 months, they participated in individual semi-structured interviews. Interviews were transcribed verbatim and analysed using methods outlined by Dahlgren and Fallsberg^[5].

RESULTS

A hierarchy of categories reflecting experiences of cosmetic covers was generated (figure 1). Visual appeal was highly prioritised by some participants, who appreciated aesthetic designs that reflected their personal identity. Other participants prioritised function of their device and were not concerned with aesthetic appearance. High levels of satisfaction with cosmesis were evident when participants felt comfortable revealing their prosthesis to others and when they perceived that they had been active in choices related to the aesthetic appearance of their device.

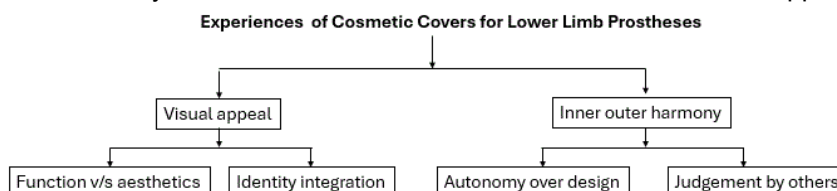


Figure 1. Hierarchy of categories

DISCUSSION AND CONCLUSION

Results from this study highlight the fact that preference for aesthetic design is highly personal and that user satisfaction with cosmetic covers can have a major impact on psychosocial health outcomes. Care should be taken to educate prosthesis users about the cosmetic options available to them and to allow them to choose an alternative that suits their aesthetic needs.

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5.233 Optimizing Distal Weight-Bearing in Transtibial Prosthesis Users

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BACKGROUND

Distal weight-bearing is an important socket fit issue for transtibial prosthesis users. An increase in residual limb volume may cause the limb to sit higher in the socket, eliminate distal weight-bearing, and create excessive distal limb motion that puts soft tissues at risk of injury. A volume decrease may cause the limb to sit lower in the socket and create excessive distal weight-bearing that also risks injury. Putty balls are currently used to assess distal weight-bearing in clinical practice, but they do not provide quantitative information during ambulation to the prosthetist.

AIM

Create a novel technology that both measures and adjusts distal weight-bearing in transtibial prosthesis users and develop a fitting protocol to optimize a prosthesis user's distal weight-bearing level.

METHOD

Participants were included in this study if they were at least 18 years of age, had a transtibial amputation at least 18 mo prior and were at an activity level of K2 or higher. Exclusion criteria were use of an assistive device or current skin breakdown. A custom mechanism, operated using thumb screws on the outside of the unit, was used to adjust socket length and the pre-stress in springs underneath. Distal weight bearing was measured using a custom sensor below this mechanism [1]. Participants conducted 2 min walking bouts while the research prosthetist assessed their gait and asked them to describe their socket comfort and satisfaction with the setting. For each participant, a preferred setting was determined. For each walking bout, the mean of the maximum distal weight-bearing for all steps, expressed as a percentage of body weight (%BW), was calculated.

RESULTS

Three participants were tested. For each participant, walking bouts were performed at nine mechanism settings (Fig. 1). A wide range of weight-bearing was achieved, expressed in %BW in black text underneath each bout. The maximum possible weight-bearing levels for the three participants tested were 7.4%, 12.2%, and 13.3%BW, respectively. The participants preferred setting were 2.7%, 9.2% to 12.2%, and 11.3%BW, respectively.

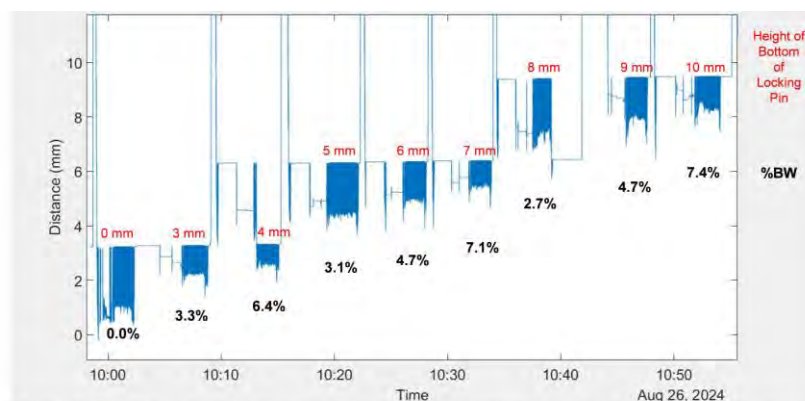


Fig. 1. Example test session results illustrating the different pin depths (blue line) and weight-bearing levels (black text) achieved. Preferred setting: 9-mm pin depth, 2.7%BW.

DISCUSSION AND CONCLUSION

The custom mechanism accomplished the intended objective of measuring and adjusting distal weight-bearing within a clinical fitting session. A preferred setting was identified for each participant. A next step will be to conduct take-home studies and compare clinical outcome at the preferred setting with that of the participant's traditional socket. Distal weight-bearing data will be collected to quantify changes from day-to-day and over the course of several weeks of use.

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ACKNOWLEDGEMENTS

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5.235 Carbon Fibre vs. 3D Printed - Trans Tibial Amputation and Socket Design: - An Evidence-Based Practice Review

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BACKGROUND

Multiple socket designs are available for trans tibial amputees, but selecting the most suitable one for long-term use remains challenging for Prosthetists. Key factors include the labor intensity of socket fabrication, and the impact of poor socket fit on patients' physical and mental well-being. A poor fitting socket can negatively affect patient gait and overall outcomes, making a comfortable and well-fitting socket crucial for optimal prosthetic function and overall patient satisfaction.

AIM

This study aims to assess and review the available evidence to identify the most effective socket design for trans tibial amputees, focusing on comfort and long-term effectiveness.

METHOD

An Evidence-Based Practice (EBP) approach was used to assess current literature on socket designs for trans tibial amputees. A comprehensive search of academic and professional databases, including CINAHL, ProQuest, Cochrane Library, and other full-text prosthetics and orthotics journals, was conducted. Key search terms included "trans tibial amputation," "transtibial amputee," "prosthesis fitting," "carbon fibre socket," "3D printed socket," "comfort of prosthetic socket," and "long-term effects of the use of prosthesis." Additional search terms, such as "compression between carbon fibre and 3D printed sockets," were used to refine results. To ensure accuracy, studies were included only if they reported socket strength outcomes (e.g., ultimate or failure force), were full-text articles, and were published in English. Non-full-text articles and review articles not meeting the criteria were excluded.

RESULTS

Six studies showed that carbon fibre sockets provide superior compression strength for long-term use compared to 3D printed sockets. However, 3D printed sockets are more suitable for complex stump shapes, offering a good long-term solution but lacking the adjustability of carbon fibre sockets after fitting. One study comparing carbon fibre, thermoplastic, and 3D printed sockets found that carbon fibre sockets had higher ultimate strength at failure than both thermoplastic and 3D printed PLA sockets. While thermoplastic sockets showed slightly higher average strength, 3D printed sockets offered a better strength-to-weight ratio. The study also identified four distinct failure mechanisms associated with each socket type.

DISCUSSION AND CONCLUSION

There is no consensus on the optimal socket design for below-knee amputees. While carbon fibre sockets are recognized for their strength and adjustability, 3D printed sockets offer advantages for more complex stump geometries. Further research, particularly randomized controlled trials, is needed to evaluate the long-term effectiveness of 3D printed sockets in larger populations and provide clearer guidance on the best socket design for clinical practice.

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Free paper session | Prosthetics: lower limb transfemoral – Policies and recommendations

5.241 Improving Quality of Life and functional outcomes for Above Knee Amputees over 65: An Observational Study

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BACKGROUND

This observational study examines the effects of Ottobock microprocessor knees (MPKs) on above-knee amputees aged 65 and older, who had been using basic mechanical knees for several years. The study focuses on the impact of a two-week trial following the definitive fitting of MPKs, assessing improvements in mobility, function, and quality of life (QoL).

AIM

Over 65 years old above-knee amputees often experience gait deviations and chronic pain issues, such as lower back pain, from the use of mechanical knees. Falls and near-misses are common, negatively affecting their function and mental well-being. To address these issues, a two-week trial of two different Ottobock MPKs (Kenevo and C-Leg 4) was conducted with 12 patients. Outcome measures were taken before and after the trial, and the results were submitted for local state funding approval. After receiving full approval, definitive fittings were completed, and follow-up assessments were conducted at 3 and 6 months to evaluate progress.

METHOD

12 subjects were included in the review. Outcome measures were taken before the two-week MPK trial, after the trial, and at 3 and 6 months following the final fitting. The measures included performance tests (6MWT, Patient-Specific Functional Scale, Activities-Specific Confidence Scale) and subjective self-reports, including a fall diary. Literature on the effects of microprocessor knees was reviewed by searching electronic and academic databases using key terms such as "above-knee amputation," "outcome measures," "prosthesis fitting," "microprocessor knee joints," "falls risk," and "amputation and gait."

RESULTS

The two-week MPK trial showed significant improvements. One subject who had 10 falls per month reported no falls during the trial. All participants showed progress in their functional goals, such as walking on slopes (improved from 0/10 to 9/10) and navigating rough terrain. The average Activities-Specific Balance Confidence score improved from 21.3% to 84.8%. Additionally, 6MWT results showed a significant increase in walking distance compared to mechanical knees. The Patient-Specific Functional Scale also showed significant improvement after the 2 weeks trial in comparison with mechanical knee.

DISCUSSION AND CONCLUSION

The review supports the use of MPKs for improving safety, mobility, and quality of life in above-knee amputees over 65. Trial results show that MPKs reduce fall risk, improve function, and enhance overall well-being. Recommendations for MPK use are based on both the literature and positive patient outcomes. MPKs are an effective option for older amputees, significantly improving mobility and reducing fall risk.

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5.242 Predictors of Functional Mobility in Adults with Lower Limb Amputation: A Prognostic Systematic Review

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BACKGROUND

Lower limb amputations (LLAs) substantially impact functional mobility, essential for daily activities and independence. With increasing diabetes-related cases and over 180,000 LLAs annually in the U.S., improving mobility outcomes is a major rehabilitation focus. However, limited comprehensive understanding exists on the factors affecting mobility. This systematic review evaluates prognostic factors influencing functional mobility in adults with LLAs, synthesizing evidence from varied research to inform clinical practice.

AIM

To identify and assess key prognostic factors that determine functional mobility outcomes in individuals with LLAs.

METHOD

A systematic review was conducted following PRISMA-P guidelines. Databases including PubMed, EMBASE, CINAHL, and Cochrane were searched for studies examining prognostic factors impacting mobility in adults with LLAs. The Quality in Prognosis Studies (QUIPS) tool was employed to assess study quality. Studies were categorized by sociodemographic, medical, physical, and psychological domains, with synthesis conducted through narrative integration.

RESULTS

Fourteen studies were included, comprising prospective, retrospective, and cross-sectional designs. Prognostic factors were categorized into four domains: sociodemographic, medical, physical function, and psychological. Key predictors of mobility included age, sex, comorbidities, and amputation level. Psychological factors, such as cognitive concerns and mental health, also had an important impact. Variability in methodological quality was noted, with most studies demonstrating moderate quality.

DISCUSSION AND CONCLUSION

This review identified strong predictors of mobility in individuals with LLA, including age, sex, comorbidities, amputation level, cognitive concerns, and mental health. Older age, comorbidities, and higher amputation levels were linked to reduced mobility, while mental health and male sex were associated with improved outcomes. Limited evidence for factors like race/ethnicity, balance, prosthetic use, income, etiology, working status, and activity level suggests the need for further high-quality research.

ACKNOWLEDGEMENTS

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5.243 Transfemoral: Challenges of one Leg's Policy of the ICRC Standard: A Case study in Rumbek Physical Rehabilitation Centre, South Sudan

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BACKGROUND

South Sudan as a youngest nation was affected by several civil wars during liberation period and after getting independence from Sudan in 2011 which increased the number of amputees. One leg's Policy means one device per unilateral amputee user and when the device needs a repair or a replacement, the service user should wait at least a week for transtibial amputee and more than that for transfemoral amputee to get a device ready for their mobility which reduce activities of their daily lives. Prosthetic and orthotic rehabilitation services provide complete care of rehabilitation services with promotion, prevention, and assistance to lost or weaken body parts (Eklund A & Sexton S, 2017).

AIM

This study aimed to understand the challenges of one prosthetic device per service user and how to improve a use of one leg's policy for prosthetic service users.

METHOD

This study was carried out in Rumbek PRC from 3rd - 30th October, 2024. The sources of data are primary data from 35 transfemoral amputees. And throughout the study, in-depth interviews and convenience sampling method was applied to collect the data from respondents one-on-one. During the interviews, note-taking was implemented, and each interview took from 25 to 30 minutes.

RESULTS

According to the indication of the data from 35 service users, age averages 40.5 (20) yrs with 15 females, the challenges such as complete damage of the foot, breaking of the device were raised by respondents which left user helpless in the house. However, 28 out of 35 service users suggested having one prosthetic device with a pair of elbow crutches to ease mobility when device is completely broken and find a way to the clinic while quarter of respondents suggested regular outreach to identify user with one device and became helpless. Therefore, the results showed the challenges of one leg's policy as damage and breaking down of device, distance from the Centre, weekend due to off working of the Centre.

DISCUSSION AND CONCLUSION

The challenges that the service users faced has been distinguished, deliberated and discussed.

Conclusion; for the service providers to continuously improve their living quality, they should implement 1) One device with a pair of the elbow crutches to ease their mobility 2) Community outreaches regularly. 3) If service user is green-light for a new device and old is safe after being repaired, it can be given back for emergency.

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5.244 An ENTREQ Meta-Synthesis of Prosthetic Limb Prescription Guidelines and Recommendations

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BACKGROUND

Prosthetists frequently rely on Clinical Practice Guidelines when deciding on the appropriate prosthetic components to optimize outcomes for their patients. However, given the vast array of prosthetic components available, and the even wider array of patient preferences and factors that can also affect prosthetic component selection, gaps in Clinical Practice Guidelines are likely to exist. Furthermore, for some cutting-edge prosthetic developments such as bone-anchored limbs, even general clinical recommendations may be sparse.

AIM

We performed a systematic review of the available literature concerning guidelines and recommendations for upper- and lower-limb prosthetic component prescription, with a particular focus on the role of prosthetists' decision-making in this process.

METHOD

Record identification and review adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses literature search extension (PRISMA-S) statement. Our meta-synthesis employed meta-study methodology to pool knowledge and summarize common areas of agreement and disagreement amongst the literature, adhering to the Enhancing Transparency in Reporting the synthesis of Qualitative research (ENTREQ) statement. We identified 758 records between database and manual search, from which 43 reports were included in systematic review and meta-synthesis.

RESULTS

An overwhelming majority of the included reports (37) focused on prosthetic componentry for lower-limb amputation, which supported the recommendation of microprocessor knees for community ambulators and the use of carbon fiber and fiberglass feet over solid-ankle cushion heel or energy storing and return feet. Substantially fewer reports (8) focused on prosthetic componentry for upper-limb amputation and typically only recommended the use of any prosthetic device, noting no general advantage of either body-powered or myoelectric prostheses over the other. Notable gaps in the literature included prosthetic recommendations for patients with partial-foot/hand or disarticulation-level amputations. Lower-limb prosthetic components including shock and torque absorbers and alignment adapters were rarely mentioned. Finally, all studies investigating componentry used in conjunction with non-suspended prostheses (e.g. bone-anchored limbs) based their recommendations on the assumption that patients used a socket prosthesis.

DISCUSSION AND CONCLUSION

Relevant literature on the topics of prosthetic prescription can be sparse. Several research gaps have been identified for future studies to establish consensus and recommendations, including joint disarticulation prostheses and prosthetic components for bone-anchored limbs. Addressing these knowledge gaps will contribute to ongoing efforts within the field to enhance quality of life for individuals with limb loss and limb difference.

ACKNOWLEDGEMENTS

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5.245 Preparation, Problem Solving & Personalization: How Health Care Providers Can Support Women with Lower Limb Absence Before, During & After Pregnancy

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BACKGROUND

There is little information available to women with physical disabilities, and lower limb absence (LLA) in particular, regarding what to expect during pregnancy and the postnatal period, leading to increased anxiety and uncertainty.¹⁻³ This lack of knowledge extends to health care providers who often do not have the knowledge or education required to answer many of the questions women with disabilities have regarding pregnancy, further exacerbating uncertainty.¹⁻²

AIM

This project seeks to understand how health care providers can best provide support to women with LLA during the perinatal period.

METHOD

To understand the experience of health care providers, we conducted semi-structured interviews with 11 individuals (5 physiatrists and 6 prosthetists) who had experience providing care to pregnant women with LLA. To complement their perspective, we also conducted semi-structured interviews with 19 women with LLA who had experienced at least one pregnancy. Reviews of the prosthetist's charts for 18 pregnancies from 11 of the women interviewed were completed to further supplement our knowledge regarding specific prosthetic adjustments made. Data from the interviews were analyzed using iterative thematic analysis including a codebook approach.⁴ Data from the chart reviews were analyzed using descriptive statistics and conventional content analysis.⁵

RESULTS

Three themes were developed from the interviews with health care providers: adopting a clinical approach of problem solving and preparation, managing the physical impacts of pregnancy and maintaining mobility, personalizing treatment to the individual's needs & context. These findings can be given more context when presented with examples from the interviews with women with LLA and the chart reviews. Six themes were developed from the interviews with women with LLA covering topics including the impact of the lack of resources, physical symptoms, prosthesis fit strategies, maintaining mobility, social influences and mental health. The chart reviews provide further insight on the prosthetic fit strategies including the high need for socket adjustments, low need for alignment adjustments and moderate need for new sockets.

DISCUSSION AND CONCLUSION

By integrating these results, we provide health care providers with key insights and practical recommendations on how to support women with LLA during the perinatal period. By doing this, there is potential to reduce the uncertainty and anxiety surrounding the pregnancy experience and provide practical tools for managing it well, ultimately improving the experience for women with LLA and their health care providers.

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5.246 Assessing Prosthetic Compatibility in Major Lower Limb Amputees: A Comparative Study of Pre- and Post-Amputation Prosthetic Suitability

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BACKGROUND

Major lower limb amputation are performed in patients suffering from arteriosclerosis, diabetes and infections. In Denmark approximately 1200 major lower limb amputations are performed annually¹. Amputations are a procedure making permanent change in a patients' physical capability and has an impact on mental wellbeing. A prosthesis can be a useful tool to regain mobility and increase quality of life², and the early rehabilitation starts right after surgery.

AIM

In this study we examined the change of prosthetic suitability assessment given at time of admission with the prosthetic suitability given at time of discharge comparing the findings with impactful risk factors.

METHOD

Data from amputees were extracted from the KOKO database from Orthopaedic Department Kolding, Hospital Lillebelt. Patient demographics and variables was analysed, according to assessment of prosthetic suitability. The patients was evaluated by admission, and just prior to discharge and divided into three groups, prosthesis suitable (PS), maybe suitable (MPS) and not suitable (NS). During the evaluation BAMS and New Mobility Score was also included. A regression analysis was performed on those, that changed prediction, during their hospital stay.

RESULTS

A total of 249 patients underwent a LEA in this study period, of which 107 did not meet the inclusion criteria; 107 patients was excluded due to age < 50 years, missing data, transferred to other hospitals and mortality. A total of 125 (51%) patients were eligible to further analysis, Mean age 72 y (60-79), 62 % males. 57 % was active or previous smokers, 43 % had diabetes and 62% arteriosclerosis. 28 was found suitable for prosthesis at the time of admission for surgery, 73 patients was considered maybe and 24 was not candidates for prosthesis. 37% of the patients changed prosthesis evaluation during the admission period of 5 days.

DISCUSSION AND CONCLUSION

Discussion: This study highlights the difference in prosthetic compatibility from time of admission to time of discharge. 61% of the patients assessed MPS at time of admission, are equally distributed between PS and NPS at time of discharge. 90% of PS and NPS remains unchanged from admission to discharge. NMS > 5 before surgery was the strongest predictor for prosthesis suitability, while age, living status and kidney disease didn't seem to correlate.

Conclusion: Patients undergoing lower limb amputations are vulnerable patients, and even though scoring systems to asses' prosthesis suitability preoperative exist, the clinical appearance of the patient can change post operatively and we recommend re-evaluation during their hospital stay.

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Free paper session | Orthotics: lower limb and footwear – Materials and design

5.251 Mechanical Characterization of a Stiffness-Adjustable Carbon Fiber Dynamic Ankle-Foot Orthosis Strut

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BACKGROUND

Dynamic ankle-foot orthoses (DAFOs) support the function of the ankle and foot in individuals with mobility challenges through providing stability, alignment and controlled range-of-motion during ambulation [1]. DAFOs also support recovery from trauma throughout rehabilitation [2], requiring changes to the allowable ankle joint range-of-motion. A novel DAFO was developed by Triton Systems, Inc. and features a stiffness-adjustable posterior strut permitting fine changes to the allowable range-of-motion without swapping components [3].

AIM

This study mechanically characterized the DAFO stiffness-adjustable strut component via bench testing and finite element analysis for establishing proof-of-concept prior to pre-clinical human subject trials.

METHOD

The DAFO adjustable mechanism modulates stiffness by varying the relative spacing of two parallel carbon fiber plates. Bench tests used a hydraulic-driven materials test system to measure the force-displacement response of the strut at different spacing. The strut was mounted as a cantilever to evaluate the relationship between estimated rotational stiffness and strut spacing. Testing involved five cycles of loading-unloading to an angular displacement of 8 degrees and repeated with minimum spacing (8.51 mm) and then gradually through a range of 8.51-21.8 mm. Finite Element Analysis (FEA) simulated the bench test results to map the strut's operational stress distribution.

RESULTS

Bench test results confirmed a positive relationship between rotational stiffness and relative spacing between the two carbon fiber plates. The rotational stiffness at the minimum and maximum spacing conditions was 5.675 N-m/rad and 6.106 N-m/rad, respectively. However, the adjustable mechanism only offered a small change in rotational stiffness relative to the range offered by different commercial struts. The strut was able to withstand cyclical cantilever loading to the displacements expected during use without signs of plastic deformation or failure. Estimated rotational stiffness from the FEA results aligned with the bench test results thereby validating the physical outcomes. FEA suggests stress concentrations at the mounting ends on both sides of the center adjustment mechanism as expected, but with internal stress below that of the yield strength of carbon fiber.

DISCUSSION AND CONCLUSION

The results demonstrated proof-of-concept of a stiffness-adjustable DAFO strut. This adjustability offers clinicians the flexibility to fine-tune stiffness for individual patients to modify available DAFO range-of-motion depending on patient need. Critically, this adjustable device can track patients along the rehabilitation journey and is more efficient as it eliminates the need for swapping multiple struts with varying stiffness levels and potentially minimizing changes to device alignment and fit.

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5.252 Mechanical testing methods for determining stiffness of ankle-foot orthoses: A scoping review

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BACKGROUND

Ankle-foot orthoses (AFOs) ankle stiffness represents the resistance against rotation around ankle joint, which determines the AFO functionality and effectiveness. Several methods have been developed for assessing AFO ankle stiffness, however, there is a lack of standardised testing including testing position and speed. Therefore, this scoping review sought to comprehensively collate the range of approaches and parameters used to assess AFO stiffness.

AIM

The aim of this scoping review was to provide a state-of-the-space review of the studies that investigate AFO ankle stiffness in the sagittal plane, then provide insight into the details of the developed devices and protocols.

METHOD

Six electronic databases (Medline via Ovid, SCOPUS, Web of Science, CINAHL via EBSCOhost, EMBASE via Ovid, IEEE Xplore) were searched for studies from when indexing began to April 2024. Articles of any design that developed or used testing devices and/or protocols to assess AFO ankle stiffness in sagittal plane were eligible for inclusion. There were no restrictions on population. Studies were excluded if the AFO stiffness in the sagittal plane was not implied or if stiffness was obtained through computational methods. The quality of each study was assessed using the modified LEGEND: Bench study appraisal checklist.

RESULTS

Seventy-three articles were included in this review, of which 51 that developed mechanical testing devices/protocols to quantify AFO stiffness (primary studies) while 22 articles referenced existing methods (secondary studies). The most common apparatuses used in the primary studies were the Universal Testing Machine (UTM) and customised manual machines. Other methods included specialty automated devices, manual devices in a gait analysis laboratory, hanging weights, UTM combined with motion capture, a muscle training machine and a six-axis robot arm. Ankle angle of the AFO was the most common controlled variable followed by loading force. Most secondary studies (85%) assessing the stiffness of novel AFOs. The included study qualities were rated as good (22%), lesser (69%) and not valid (9%).

DISCUSSION AND CONCLUSION

This scoping review has outlined the wide variety of devices and protocols used to assess AFO ankle stiffness in the sagittal plane. Many researchers chose methods that leveraged their available resources, demonstrating a variety of approaches to assessing AFO stiffness. Limitations included the potential for missed publications due to the definition of stiffness used in this study and the quality assessment tool chosen. For future studies, we recommend that parameters chosen are justified, reliability studies are undertaken, and AFO design is adequately reported.

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5.253 Development of a prediction algorithm and AFO stiffness database to prescribe the individual optimal AFO in people with neuromuscular disorders

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BACKGROUND

In people with plantarflexor weakness due to neuromuscular disorders, treatment outcomes of ankle-foot orthoses (AFOs) can be maximized by individually optimizing AFO stiffness¹. Individually optimizing AFO stiffness is time-consuming, limiting implementation. This can be overcome by an AFO stiffness prediction algorithm. In order to prescribe the individual optimal AFO stiffness after such a prediction, publicly available information on AFO stiffness properties is required.

AIM

1. Develop a prediction algorithm for determination of the optimal AFO stiffness in people with plantarflexor weakness
2. Measure AFO stiffness properties of commercially available AFOs.

METHOD

To develop a stiffness prediction algorithm, we created an in silico database using previously validated predictive neuromusculoskeletal simulations². For 37 neuromusculoskeletal models varying in severity of plantarflexor weakness, body mass and walking speed, the optimal AFO stiffness for minimizing energy cost was determined. These factors were used to create a predictive formula using linear regression. The predictive formula was validated in 22 people who walked without assistive devices and had their AFO stiffness individually optimized. The mean (absolute) difference and correlation between the predicted and measured optimal stiffness were calculated. In addition, the stiffness properties of 15 commercially available AFOs from 3 major manufactures in the sizes XS to XL were measured.

RESULTS

Based on the in silico data, the following regression formula was found: AFO stiffness (Nm/deg) = $-0.061 \times \text{severity of plantarflexor weakness (\% of reference)} + 0.045 \times \text{body mass (kg)} + 2.336 \times \text{walking speed (m/s)} - 0.657$. The predicted stiffness correlated significantly with the experimentally determined AFO stiffness ($r=0.426$, $p=0.048$). The prediction was on average 0.5 ± 1.2 Nm/deg too stiff, with an absolute error of 1.0 ± 0.8 Nm/deg. After correction for the offset, the absolute error was 0.6 ± 0.6 Nm/deg. The stiffness of the commercially available AFOs ranged from 0.4 to 4.5 Nm/deg, and increased with AFO size ($p=0.049$, XS: 1.8 ± 0.9 Nm/deg, XL: 2.8 ± 1.3 Nm/deg).

DISCUSSION AND CONCLUSION

Our algorithm predicted the individual optimal AFO stiffness in case of plantarflexor weakness with an absolute error of 0.6 Nm/deg, which is smaller than current manufacturer-based recommendations (1.2 Nm/deg difference).¹ This indicates the potential of the algorithm to improve individualization of AFO stiffness. In addition, the current stiffness range of commercially available AFOs seems inadequate in case of plantarflexor weakness, as no stiffness's above 4 Nm/deg were recorded. Further validation of the prediction framework and expansion of the AFO database are required for widespread implementation.

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ACKNOWLEDGEMENTS

We want to thank OIM Orthopedie and HyFyDY for their assistance during the study. The study was subsidized by ZonMw



5.254 Comparison of different materials and AFO plantar dorsiflexion moments in SHB-AFO made by 3D-Printer

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BACKGROUND

3D printers can produce prosthetic devices that would not be possible with conventional manufacturing methods. The strength and durability of 3D-Printer products depend on the method of modeling and the materials used. For SHB-type AFO, it is necessary to understand the characteristics of the material because the material determines the function of the orthotic device.

AIM

The purpose of this study was to compare AFO plantar dorsiflexion moments fabricated with different materials on a 3D printer to determine the mechanical properties of the materials and orthoses.

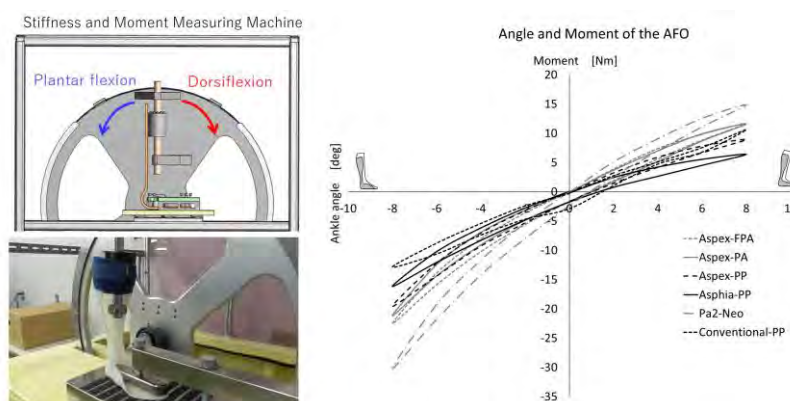
METHOD

The AFO under study is of the SHB type, in which the properties of the plastic material have a significant influence on the function of the orthosis. 3D modeling was done by SLS (Selective Laser Sintering). Five materials were used: Aspex-PP, Aspex-PA, Aspex-FPA, Asphia-PP, and Pa2-Neo. The orthosis was 3 mm thick; the ankle joint was trimmed to cover 1/3 of the anterior-posterior diameter. The mechanical properties of the orthoses were measured using a home-made AFO mechanical characterization tester. This tester can be moved repeatedly in the plantar dorsiflexion direction at any angle and speed. In this study, measurements were taken at 8 degrees of plantar dorsiflexion each time, taking into account the ankle joint movement during walking.

RESULTS

The relationship between the angle change of the AFO and the bottom dorsiflexion moment measured by the evaluation machine is shown in the figure. The vertical axis indicates the torque (N-m) acting on the AFO, and the horizontal axis indicates the bottom dorsiflexion angle (deg). Positive values indicate the dorsal flexion angle and negative values the bottom dorsal flexion angle. Table 2 shows the mean value and standard deviation of the bottom dorsiflexion moment for each angle, which is the result of the evaluation of each material.

The results show that the values of the bottom dorsiflexion moment for all five materials are larger than those of the dorsiflexion moment.



DISCUSSION AND CONCLUSION

Previous studies have reported that different materials have different strength properties for orthotics of the same shape. In this study, Asphia-pp showed similar properties to conventional PP. 3D printer manufacturing allows the use and design of a wide variety of materials. On the other hand, it is necessary to fully clarify and handle the properties of each material, the strength and durability of the manufactured product, and its functional characteristics.



5.255 Contribution of footwear sole shape and stiffness to maintaining effective leg rollover during gait in an Ankle Foot Orthosis-Footwear Combination

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BACKGROUND

An ankle foot orthosis-footwear combination (AFO-FC) is often used for motion control in treating gait disorders [1, 2]. Less common are studies which quantify the contribution of footwear to maintain rollover during gait in an AFO-FC. We did so by collecting ankle motion and force during continuous treadmill walking of subjects wearing an articulated carbon AFO-FC to control joint motion and facilitate rollover in the sagittal plane.

AIM

To test whether a flexible and curved footwear sole combined with an AFO which constrained ankle motion in an AFO STOP condition would maintain rollover similar to footwear combined with an AFO FREE and with no AFO (CONTROL) condition.

METHOD

Healthy subjects (8 females, 6 males) consented to participate in a three-condition protocol approved by the Georgia Tech Institutional Review Board. Ankle motion in the sagittal plane was controlled in an AFO. Conditions were: CONTROL (no AFO), FREE (AFO, no joint constraint) and STOP (AFO in maximal constraint). Each condition used the same curved flexible footwear sole. Subjects walked at their preferred speed, with continuous sampling of motion, force and center of pressure. All data were synchronized, filtered and time normalized to 100% of the gait cycle. Mean effective leg radius of curvature, ankle joint angles and moments for STOP, FREE and CONTROL were calculated [2]. [Vicon cameras (120 Hz), AMTI force plates (1080 Hz)].

RESULTS

Data were analyzed during minute 4 of treadmill walking when subjects achieved onset of steady state gait with minimal compensation. In ipsilateral leg, subjects exhibited significant ($p < 0.05$) yet modest ($<15\%$) differences in mean normalized leg radius of curvature (ROC) in STOP, compared to FREE and CONTROL conditions; and on contralateral leg no differences ($p > 0.05$) in ROC in STOP, FREE and CONTROL conditions (Figure 1). Subjects exhibited decreased ipsilateral ankle range of motion to within 3.7 (2.1)° in STOP, compared to 27.7 (4.2)° in CONTROL ($p = 0.000$) and 24.2 (3.6)° in FREE ($p = 0.091$) and no difference in ankle moments ($p > 0.05$). Cadence was similar in CONTROL, STOP and FREE conditions ($p > 0.05$).

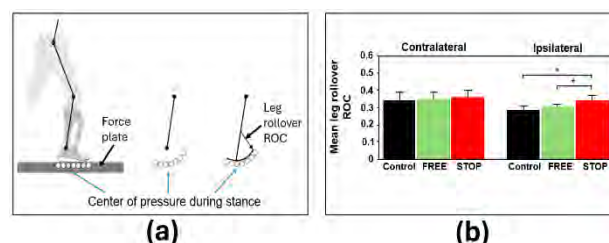


Figure 1. (a) Calculation of leg ROC. (b) Mean of leg ROC * $p < 0.05$

DISCUSSION AND CONCLUSION

These findings support that shape and flexibility of footwear sole contribute to rollover in stance phase during constraint of ankle motion by an AFO. This demonstrates the footwear sole can function as an ankle-foot surrogate when the natural ankle and foot rockers [3] are constrained by an AFO system.

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Free paper session | Robotics, soft robotics, exoskeletons – Various topics

5.261 An advanced soft lower back support: assessment of musculoskeletal stress relief of the lumbar region

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BACKGROUND

Pain and muscular disorders in the lower back are frequent consequences of physical work. Active and passive exoskeletons may reduce these negative effects as they can significantly reduce strain to the lumbar region by around 20% [1,2]. However, acceptance in work life is often low due to wearing discomfort. Comfort and acceptance are significantly increased with soft lower back supports (SLBS); however, their objectively measurable effect is controversially discussed [3].

AIM

In the present study, the effect of a soft lower back support, used during a typical repetitive lifting task of work life, was biomechanically evaluated.

METHOD

Twelve healthy individuals participated in the study (27 ± 3 y, 78 ± 8 kg, 180 ± 6 cm). They completed a repetitive asymmetric lifting task with a box weighing 10-15kg for 5 minutes with and without a SLBS (CX Soft Back, Ottobock, D, fig.1). Kinematic and kinetic parameters were measured using an optoelectronic camera system coupled with force plates (VICON, GB; KISTLER, CH). The EMG activity of the trunk muscles, knee extensors, and hamstrings (NORAXON, USA) was measured simultaneously. An isometric strength test, carried out in a specific standing posture immediately before and after the lifting task, was used to determine work-related fatigue of the back muscles based on the median frequency of the EMG spectrum [4].

RESULTS

Participants completed the lifting cycles with and without the SLBS using similar motion patterns. The average forward trunk lean remained comparable throughout. During the entire lifting cycle, both hip joints were $4-8^\circ$ more flexed with SLBS, combined with slightly more flexed knee joints ($2-3^\circ$). The integrated EMG of all analyzed muscle groups showed no significant differences with or without SLBS, but showed a tendency towards bilateral reduction with SLBS by 4-10% for the erector.spinae and rectus.abdominis muscles.

The fatigue of the back muscles was significantly lower with SLBS ($p < 0.01$), shown by decreased median frequencies for the erector spinae that by 9.4Hz/8.8Hz (left/right) after the lifting task without compared to only 3.1Hz/6.7Hz (left/right) with SLBS. This finding was also confirmed by the user-reported rating of muscular strain with the Borg-CR10 scale ($p < 0.01$).

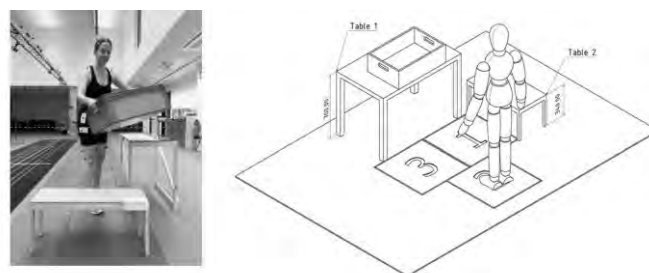


Fig. 1: Experimental setup to simulate the repetitive lifting process



DISCUSSION AND CONCLUSION

EMG-based biomechanical models showed a tendency towards reduction in trunk muscle activity during a lifting task with the SLBS that may suggest a reduction of joint compression forces in the lower back ^[5]. The reduction in muscular fatigue with SLBS confirmed by participants suggests that this effect may lead to positive preventive results. This should be validated in future studies.

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5.262 Design and development of a novel active orthosis for adaptive lumbar compression

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BACKGROUND

Low back pain is the leading cause of disability worldwide ^[1]. Current interventions include passive lumbar orthoses, which conventionally apply a constant, 'low' level of compression. Conversely, literature indicates that higher compression levels improve pain and disability outcomes ^[2]. This increased compression, however, comes at the costs of comfort and may not always be needed.

AIM

The aim of this study was to develop an active (mechatronic) lumbar orthosis that provides on-demand, short-time, and high-level lumbar compression, supporting and stabilizing the lumbar region only when necessary.

METHOD

We designed, built, and evaluated a fully functional prototype to demonstrate the technology's proof of principle. A custom test setup was developed to assess the performance of the actuation system, consisting of an aluminium frame, 6 extension springs, and a linear potentiometer to measure the displacement of the belt ends (Figure 1A). Additionally, a rigid cylinder test was performed with the complete prototype to simulate on-body compression (Figure 1B).

RESULTS

The result of the design process was a two-layer active orthotic device (Figure 1C): an elastic inner layer is used to fixate the orthosis and a flexible, but non-stretchable outer layer is used to apply compression via a motorized actuation system. Testing revealed that the actuation system achieves a force of approximately 265 N, within 3 s, over a distance of approximately 10 cm. It is quite closely matching the predictions from the model and meeting the set requirements. The rigid cylinder test showed a linear relationship between applied compression and applied motor current.

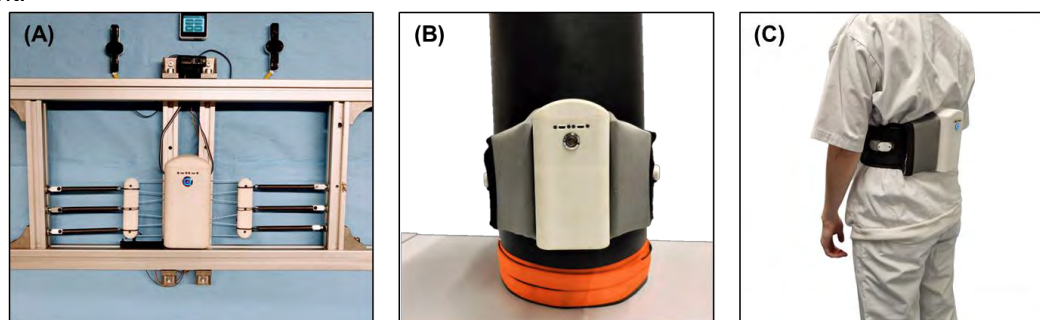


Figure 1: (A) Test setup; (B) Rigid cylinder; (C) Active orthosis worn by a user

DISCUSSION AND CONCLUSION

The integrated device allows switching between an inactive comfortable state and an active compressed state, as evidenced by the compression readings from the rigid cylinder test. The weight of the actuation system is 0.45 kg and the full prototype (including electronics) weighs only 1.3 kg. In comparison, it is only slightly heavier than commercially available simple support belts, but considerably lighter than exoskeletons for back support. To the best of our knowledge, this study presents the first active orthosis designed for supporting and stabilizing the lumbar region through short-term, high lumbar compression.

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5.263 Biplanar soft ankle assistive exoskeleton for dropfoot with a human-in-the-loop optimization approach

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BACKGROUND

Exoskeletons are frequently lauded for their potential efficacy in rehabilitation and assistance in people with motor disorders ^[1,2] yet relatively few have convincing evidence for use. Dropfoot, or inability to dorsiflex the foot during swing and position the foot for contact, is a common secondary gait disorder after e.g., stroke. It is often accompanied by excessive subtalar inversion ^[3] due to spasticity of the tibialis posterior, which can affect stability in stance and risk of falling.

AIM

Using our own developed soft powered cable-driven ankle exoskeleton aimed to improve dropfoot gait by simultaneously assisting dorsiflexion and eversion, the aims were to individualize exoskeleton support for 5 persons with chronic stroke and dropfoot gait, via a multi-objective human-in-the-loop approach that seeks improve gait symmetry and quality metrics.

METHOD

Our exoskeleton consists of motors worn on a backpack that control cables that span to the lateral and medial forefoot to dorsiflex and evert the foot. Five persons with chronic stroke donned the exoskeleton during 3D motion capture of overground walking. Three generations of exoskeleton control parameters were tested in a human-in-the-loop optimization that sought to minimize 2 objectives - step length asymmetry and foot kinematics deviation - using each participant's response to guide the next generation. Participants responded to a QUEST about their subjective experience with the exoskeleton and graded each solution.

RESULTS

Gait symmetry and quality improved with the exoskeleton. With each generation of optimization, the solutions progressively converged towards low asymmetry and kinematics deviation. A family of optimal solutions for motor control parameters were obtained in the final generation; these represent a balanced trade-off that improve both gait quality metrics (optimization criteria) to varying degrees.

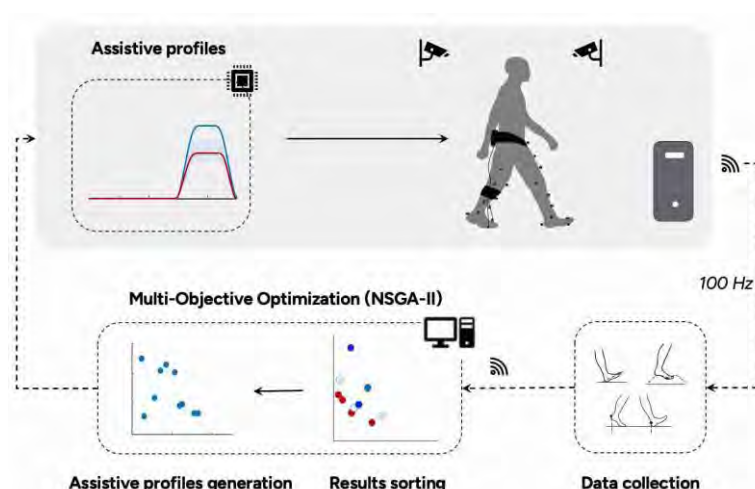


Fig 1. Experimental protocol of HIL optimization



DISCUSSION AND CONCLUSION

The exoskeleton successfully improved the specified gait quality metrics in this pilot group of persons with chronic stroke. To the best of our knowledge, this is the first device designed to provide assistance for dropfoot gait in two anatomical planes, using an individualized human-in-the-loop approach that seeks optimality of two objectives simultaneously. The generated family of optimal solutions can be considered as a group of “good” solutions and represent possible alternatives for individual goals and persons; one solution may be optimal when step symmetry is more important than foot orientation, and vice versa in another situation. Thanks to the human-in-the-loop approach, optimal solutions are identified for each person and the specified goals; solutions will be different if different goals are specified, for instance maximum speed or minimum muscular effort.

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ACKNOWLEDGEMENTS

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5.264 The use of Virtual Reality for training individuals with upper and lower limb prosthetics

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BACKGROUND

Virtual reality (VR) has become essential in prosthesis training, creating immersive, controlled environments that enhance patient control and skill. VR systems offer realistic simulations, real-time feedback, and customizable modules tailored to patients' needs. Augmented and mixed reality further extend these capabilities, improving rehabilitation outcomes for limb prosthesis users.

AIM

This research aims to review VR-based sensory feedback mechanisms for motor learning and control in prosthetic rehabilitation, evaluating their effectiveness and potential integration with game-based and myoelectric prosthesis control methods.

METHOD

In order to carry out this study, we searched Google Scholar, PubMed, Scopus, and ScienceDirect databases using the keywords Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (MR), Prosthetic Control, Upper Limb Amputee Rehabilitation, Lower Limb Amputee Rehabilitation, Sensory Feedback, Grasp Control, Embodiment and Prosthesis Training, Myoelectric Prosthesis, Hololens in the period from 2005 to 2024. Sixteen articles were selected and reviewed after the search.

RESULTS

The articles were categorized into three groups:

Training for Individuals with Upper Limb Prosthetics:

Eight studies focused on upper limb prosthetics, using AR-based feedback to improve motor control. Systems like HoloLens provided real-time color-coded grip feedback, enhancing handling of fragile objects. The ViPER system for myoelectric prostheses offered customizable mechanotactile feedback, improving motor skills over time.

Training for Individuals with Lower Limb Prosthetics:

Six studies examined lower limb prosthetics, where VR-based treadmill systems with auditory cues enhanced balance and gait. Auditory feedback improved stride length and symmetry, helping transfemoral amputees achieve a balanced gait. CAREN simulated real-life conditions, refining gait further.

General Feedback Mechanisms:

Two studies examined VR for both upper and lower limb prosthetics, emphasizing integrated feedback to improve motor control across tasks, showing VR's broad potential for rehabilitation.

DISCUSSION AND CONCLUSION

The study concludes that VR-based training systems with sensory feedback, including audio and AR, significantly improve rehabilitation outcomes for prosthetic users. While advances benefit upper limb prosthetics, challenges persist in adapting to daily tasks. VR with auditory cues notably enhances walking parameters for lower limb prosthetics, showing clinical promise. Future research should refine these systems and investigate multimodal feedback integration to further boost functional outcomes for users.

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5.265 Simulating optimal plantarflexion assistance with multiple objectives

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BACKGROUND

In simulation, devices can complement muscle forces based on various aims, i.e., to deliver assistance to minimize muscle effort or forces. Optimal assistance with different aims can be computed using bilevel optimization wherein motion, assisted by different moment profiles, can be simulated, and the one that best improves a given aim is identified. This approach has not yet been thoughtfully studied and holds the potential to explain human-device adaptation.

AIM

To investigate how optimal ankle plantarflexion assistive moment based on common criterion: minimal activations (min (a)), metabolic cost (min (E)), and muscle moments (min (M)) affect muscle dynamics and energetics.

METHOD

Bilevel optimization is a mathematical program that contains an inner loop nested in an outer loop. The outer loop searches for the parameters of a moment to minimize a given aim. The inner loop searches for the muscle excitations/controls to simulate walking, assisted by device moments, given an optimal criterion: minimal squared activations. Bayesian optimization and an inverse simulation direct-collocation optimization [1] were used as inner and outer loop algorithms, respectively. The assistive moment's profile was described based on four parameters, as in [2]. We used experimental data of twelve participants walking at preferred speed, and the metabolic cost was computed based on Bhargava model [3].

RESULTS

Optimal moments for a given assistive aim suboptimally reduced or even increased metrics that were not explicitly minimized. Assistance based on any aim decreased metabolic cost and muscle moments, yet suboptimally compared to explicitly minimizing the given aim. Assistive moment based on minimal moment increased activations. Assistive moments based on minimal activations and metabolic cost predicted similar peak timing, yet the latter had larger peak moment.

DISCUSSION AND CONCLUSION

Predicted muscle mechanics and energetics vary according to the assistive aim. Predicted optimal assistance based on min(E) resembles experimental observations using Human-In-The-Loop optimization [2].

Nonetheless, the metabolic reduction is lower, and the peak moment is larger than in experiments. Accounting for human-device adaptation might explain the disagreement. This simulation framework can predict optimal assistance upon various aims and be expanded to other tasks, e.g., sit-to-stand motion with minimal knee reaction forces. Our results encourage implicit formulation of the assistive aim when optimal performance is seek.

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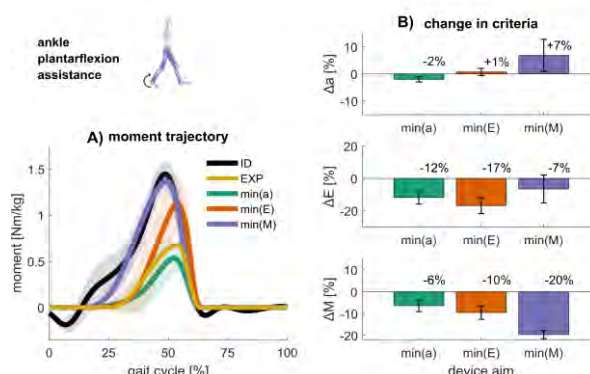


Figure 1. A) Inverse dynamic (ID), experimental moment based on min(E) (EXP) [2], and optimal moments based on device aims, and B) change in lower limbs' activations (Δa), metabolic cost (ΔE), and moments (ΔM), compared to unassisted conditions, among device aims.



5.266 Self-Touch Sensing and Discrimination System for Evaluation of Soft Artificial Limb for Enhancing the Usage of Hypoplasia Upper Limb

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BACKGROUND

Sensorimotor experiences during new born to infancy contribute to the development of body image and goal-directed behavior. Infants with upper limb hypoplasia misses the chance of the self-touch of the deficient limb especially for bilateral coordinate movements, and the lack of sensation and motion experience may be leading to the neglect, underuse and confusion when donning a upper limb prosthesis.

AIM

The goal of this research is to develop an artificial arm for encouraging self-touching of the facial-area with safety and cosmesis convincing to the parents. To functional test, a Self-Touch Sensing and Discrimination System, STSDS is developed.

METHOD

The STSDS consist of 12 optical sensors and white LEDs, 4 capacitive touch sensors, a microprocessor, a Li-Ion battery, and urethane porous hemisphere. The 12 optical sensors and LED were mounted on matrix frames separated with the porous layer and mounted underneath the glove to detect pressure deformation at contact. Capacitive touch sensors were assigned to 4 sections (dorsal, palmar, radial, and ulnar) of the thumb-up fist shape glove to enhance discrimination of self-touch and other bodies. Machine learning classification was conducted with k-nearest neighbors and SVM, and tested under filtered sensor data of 3 conditions: contact to the lip and surrounding, contact to linens and environment, and no-contact.

RESULTS

Discrimination accuracy verification experiment was conducted with male subject at 23 y.o.a., holding the glove in the hand and contacting at cue and maintaining till the next cue. Robustness was tested by setting 3-levels of applied moisturizing cream on the glove: 0, 0.3, and 0.6 g. The learning and test data was prepared offline from the recorded 16 sensor signal group by extracting data column from the settling state. The mean and standard deviation of the discrimination accuracies of all conditions and settings were 98.2 ± 2.1 % for k-nearest neighbors, and 89.5 ± 4.6 % for SVM.

DISCUSSION AND CONCLUSION

The discrimination accuracies were fare for practicing detection of self-touch to the face. The limitation of the experiment is the subject, device setup, and computation not conducted in practical condition and specifications. When Considering the report of Mueller¹⁾, the duration of the pre- and post-contact, contact duration are within 0.5 to 3 seconds for a contact to the face, and sensor response speed and sensitivity as well as glove softness are to be modified to meet this level.

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ACKNOWLEDGEMENTS

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Free Paper Session | Health care, policy, sustainability – Service capacity

5.271 Building Capacity in Prosthetic and Orthotic Care: A Walking Free Project Case Study in the Solomon Islands, South Pacific

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BACKGROUND

Diabetes-related complications, including amputation, have a high prevalence in Pacific Island countries [1]. Mission Gait Foundation's (MGF) Walking Free Project in the Solomon Islands demonstrates a sustainable approach to prosthetic care implementation. It includes strategies to introduce capacity for prosthetic fabrication and training in less resourced regions, aiming for true sustainability [2].

AIM

Describe the role of each stakeholder and the innovations employed to establish a permanent multidisciplinary prosthetic and orthotic production and rehabilitation program at the Kilu'ufi Hospital in Malaita, Solomon Islands.

METHOD

The portable prosthetic & orthotic container lab is a 12-meter shipping container, fully equipped with state-of-the-art equipment purchased by MGF. It was constructed in Richmond, Virginia, then shipped to Malaita. The Kilu'ufi Hospital supplied the foundation for the lab as well as utility hookups, and committed to ongoing administrative and professional oversight. The Solomon Islands Ministry of Health and Medical Services provided governmental support, including funding for two citizens to attend ISPO CAT II prosthetist training with Mobility India in Bangalore, India, as well as funding for supplies on a continuous basis.

RESULTS

The container lab provided immediate, fully equipped fabrication capacity. MGF has provided two follow up trips, one provided practical mentorship supporting initial prosthetic production, and a second focused on training and education of in-country physiotherapists, technicians, and prosthetist, including prosthetic assessments, residual limb care, pre-prosthetic physical therapy, device selection, casting, production, wear schedule, prosthetic gait training, and follow-up on fit. Local certified staff have completed lower limb prosthetic fabrication and comprehensive rehabilitation for a "start-up average" of seven patients per month since the initiation of the lab. This project required three years to complete from the memorandum of understanding to full functioning of the lab because of delays during the COVID19 pandemic, however in the absence of this complication, it could be completed within 18 months, allowing time for prosthetist certification.

DISCUSSION AND CONCLUSION

The use of portable container labs and strong local collaborations were shown to be effective strategies for capacity building in less resourced regions. This method contrasts with Walking Free's 20+ year history of developing in-country P&O labs, demonstrating increased efficiency and replicable production. The Walking Free Project in the Solomon Islands exemplifies how adaptability, cost-effectiveness, and community collaboration can foster long-term independence and productivity in prosthetic rehabilitation.

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5.272 Quality and Satisfaction Evaluation of an Intensive Prosthetic Limb Fitting Camp in Cambodia

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BACKGROUND

ISPO has expressed concern about short-term “missions” or “fitment camps” which provide a large number of prostheses during an intensive session [1], particularly the standard and quality of device design and fabrication and the clients’ training and aftercare [2]. Without these, harm may arise to the individual, and existing services may be undermined.

AIM

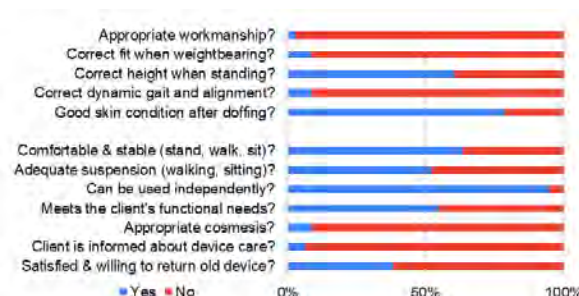
On the Cambodian Mine Action and Victim Assistance Authority’s request, we evaluated the device quality and experiences of ~600 clients attending an intensive prosthesis fitting mission in provincial Cambodia, from 14-31/03/2023.

METHOD

Prosthetists and clients completed standard device delivery quality and satisfaction assessments (Table), via a prosthetist assessment tool and structured client interview schedule. Clients were then invited to a further structured interview by telephone after three months. Independent from the data collection, interview content analysis and descriptive statistical analysis were conducted.

RESULTS

Device delivery assessments highlighted shortcomings in all criteria considered critical for safety. In conventional clinics, devices failing any of these delivery checks would be re-worked, as they would function poorly and potentially cause injury. Significantly, nearly 2/3 of clients who already had a functioning device requested to keep it.



533 clients were interviewed at delivery, 325 of whom were contacted by telephone between 25/05 and 12/06/2023. Round 1 structured interviews revealed satisfaction and dissatisfaction balanced approximately 2:1. However, frequent comments from clinician-assessors and clients noted gait deviations (n=139), wrong height (n=110), poor alignment (n=66), socket fit too loose (n=230) or too tight (n=67), and poor finishing (n=178) including pen marks, exposed rivets, poor trim lines and unadhered cosmeses.

Round 2 interviews showed 81% of respondents (n=263) reported using their new device for short periods, rarely or never. The other 19% (n=62) reported using their new device most or all day.

Clients were initially more positive about device delivery than prosthetists, but after three months, 189/275 clients (58%) who reported still having a previous device often or always used it instead of the new one. This calls into question their need for the new device, or if they are now living with a worn or inadequately-fitting prosthesis.

DISCUSSION AND CONCLUSION

This study raises concern about the patient selection for an intensive fitting mission, and the quality of devices delivered. Inadequate training and follow-up care may shift burden to local services if they exist, or leave a client without support. We propose a checklist of need and quality criteria to ensure safety and economic effectiveness of device provision services.

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5.273 Scaling up access to clubfoot treatment worldwide: progress, challenges and the role of the Foot Abduction Brace

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BACKGROUND

Approximately 200,000 children are born each year with clubfoot, the majority of whom live in low- and middle-income countries (LMICs). If untreated, clubfoot causes pain and reduced mobility, leading to activity limitations and overall disability. The Ponseti method is a highly effective and minimally invasive treatment.

AIM

This observational study aims to quantify the countries providing clubfoot services and the children receiving treatment in 2023, and compares progress since data were first collected in 2005.

METHOD

In 2024, data on clubfoot treatment in 2023 were collected from 70 countries. Informants completed a survey about new cases enrolled, treatment outcomes and health system integration. Data were analysed using descriptive statistics, with adjustments made for duplicates, and examined clinic locations, the number and ages of children starting treatment, types of support available and Ministry of Health involvement. We compared coverage trends over time, created a cartogram visualised clubfoot programme coverage across countries and considered trends in quality and sustainability of treatment provision.

RESULTS

Responding countries cover 83% of all expected cases in LMICs. There was an increase in enrollment numbers in 2023. Despite this progress, treatment coverage remains low at approximately 22% across respondent countries. While integration of clubfoot services into national healthcare systems varies widely, strong public-private partnerships in many countries suggest a foundation for sustainable, long-term treatment programmes. However, quality care remains a challenge, with only 67% of children receiving their first foot abduction brace, indicating gaps in ensuring comprehensive treatment necessary for successful clubfoot management. Lingering effects of COVID-19 restrictions include a higher percentage of cases enrolled after one year of age.

DISCUSSION AND CONCLUSION

This study demonstrates that scaling of Ponseti treatment in LMICs is feasible using a comprehensive clubfoot programme based on public health principles. Several countries now achieve over 50% coverage of babies born with clubfoot. Progress has been made through a coordinated approach to achieve maximum global coverage by Global Clubfoot Initiative members. However, there remains an urgent need to address approximately 80% of cases still without access to treatment, and to ensure the quality and sustainability of treatment including access to, and high quality provision of, Foot Abduction Braces.

Clubfoot care should be included in global and national health guidelines for assistive technology. Focusing on early diagnosis, timely referrals, and treatment, including surgery and assistive products, can strengthen health systems.

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5.274 ICRC Sudan Response Initiative - Exclusive Rehabilitation Services provision for Persons with Disabilities in South Sudan displaced due to Sudan Conflict

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BACKGROUND

Since the conflict erupted in neighboring Sudan in April 2023, 829,911 people were displaced to South Sudan. Amongst them, the most vulnerable population is people with disabilities (PwDs) having no access to physical rehabilitation services at their locations. ICRC in partnership with Ministry of Gender, Child, and Social Welfare, South Sudan and other INGOs is the sole P&O and mobility aid services provider to PwDs under its Sudan Response initiative.

AIM

To make prosthetic and orthotic services accessible to displaced people with disabilities in remote areas of northern South Sudan affected by the Sudan conflict.

METHOD

The PwDs were assessed at the outreach field trips in collaboration with the local host organisations, who organised the PwDs from the local communities, provided the place for clinical assessment and accommodation to the visiting professionals. The visiting rehabilitation team included Ortho-Prosthetist, Physiotherapist, Wheelchair Specialist and MHPSS Psychologist. Onsite assessments were carried out and mobility aids were provided. Later, the PwDs were air-lifted through ICRC Air-Operation team to the nearest PRC for fitment of prosthetic and orthotic devices along with gait training. Those with economical vulnerability were provided with multi-purpose cash grants and MHPSS counselling to those needing psychological support.

RESULTS

Under the initiative, 9 outreach missions were carried out during the period of 2 months' time at the locations bordering Sudan. Two more outreach missions are planned by the end of 2024. A total of 702 persons were screened/assessed in all the missions. Out of which 81 PwDs were referred to the PRCs for prosthetic and orthotic devices. 289 assistive devices were maintained, repaired, or delivered during the missions. 16 persons were provided with MHPSS counselling, and 89 persons were provided with multi-purpose cash grants (MPCG). 5 partner organisations collaborated with are; AHA (African Humanitarian Action), UNHCR, IRC, CARE and Directorate of Social Development. An impact/outcome indicator document is being developed in collaboration with the partner organizations to measure the impact of the outreach operations.



Fig - Referral network from field to the Physical Rehabilitation Centres

DISCUSSION AND CONCLUSION

ICRC in collaboration with partner organisations is aiming strongly to benefit more conflict affected PwDs with quality prosthetic and orthotic services by its Sudan Response initiative, which will continue through 2025. ICRC is also working on strengthening the referral pathway to improve access for the affected population to the physical rehabilitation centres by building capacity of the partner organisations where possible for future sustainability.

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- Ministry of Gender, Child, and Social Welfare, South Sudan



5.275 Racial Disparities in Prosthesis Prescription in United States Veterans with Lower Limb Amputation Due to Diabetes or Vascular Disease

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BACKGROUND

Mobility restoration through prosthesis fitting and rehabilitation is associated with improved quality of life (QoL) after dysvascular lower limb amputation (LLA).^[1] Increased prosthesis use is associated with higher levels of independence and function.^[2] The timing of prosthesis prescription can also impact health care outcomes. Multiple factors have been associated with prosthesis prescription rates after LLA,^[3] however there has been limited study of the potential effects of racial or ethnic disparities.

AIM

The aim of this study was to determine if there are racial or ethnic disparities in prosthesis prescription rates or time to prescription in Veterans who have undergone dysvascular LLA.

METHOD

Using data from national VA databases, we examined the association of race and ethnicity with prosthesis prescription in Veterans after their first transtibial or transfemoral amputation due to diabetes or vascular disease. Self-reported race and ethnicity were combined into the following categories: non-Hispanic White individuals (NHWI), non-Hispanic Black individuals (NHBI), and Hispanic individuals (HI). Outcomes were: 1) prescription of a qualifying prosthesis within 12 months after amputation; and 2) time to prescription. Survival analysis was performed using Cox proportional hazards models to compare the rate of prosthesis prescription by race/ethnicity, accounting for time and controlling for demographics, comorbidities, mental health, and health behaviors. Effect estimates were reported as adjusted hazard ratios (aHRs) with 95% confidence intervals (CI).

RESULTS

Of 2,862 eligible individuals, 1,690 (59%) were prescribed a prosthesis. NHWI were more likely to receive a prosthetic prescription than NHBI or HI (62%, 54%, and 53%, respectively; $p < .001$). NHWI had mean shorter times to prescription after amputation compared to NHBI and HI (108, 119 and 121 days, respectively, $p < .001$). In multivariable analyses, NHBI were significantly less likely to receive a prosthesis prescription than NHWI (aHR = .78; 95% CI=.69-.88). HI were also less likely than NHWI to receive a prosthesis prescription (aHR = .72; 95% CI=.58-.89). The differential effect was observed primarily in those who underwent a transtibial amputation.

DISCUSSION AND CONCLUSION

This national study of Veterans with LLA suggests that NHBI and HI are less likely to receive a prosthesis prescription than NHWI, and do so after a longer period from their LLA. Future research should determine the underlying factors and develop strategies to reduce these disparities, improving Veterans' mobility and quality of life after LLA.

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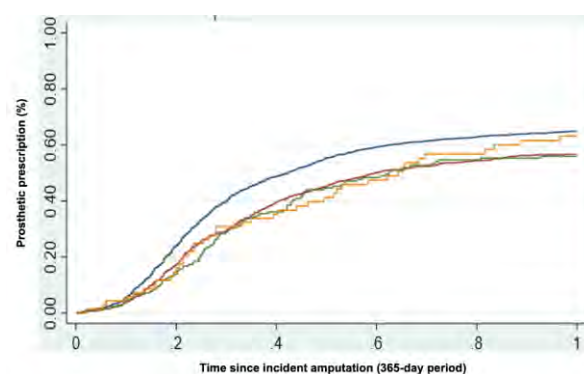


Figure 1: Prescription rates over the 365-day observation period after incident amputation comparing non-Hispanic White individuals (blue), non-Hispanic Black individuals (red), Hispanic individuals (green), and other racial/ethnic groups (yellow) demonstrating that non-Hispanic White individuals are more likely to receive a prosthesis prescription and receive it earlier than individuals in other racial/ethnic groups.



5.276 Work-Related Hazards, Work-related Musculoskeletal Disorders and Quality of Life in Prosthetic and Orthotic Professionals at SSPO Clinics

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BACKGROUND

Healthcare professionals face various risks, including work-related hazards and musculoskeletal disorders (WMSDs), which impact quality of life. WHO highlights hazards like biological, physical, chemical, and ergonomic dangers common in healthcare^{1,2}. WMSDs, often caused by unsafe work conditions, are prevalent among healthcare workers, including Thai professionals³. Specifically, prosthetic and orthotic (PO) professionals face risks from repetitive tasks and poor ergonomics⁴. This study will examine work-related hazards, WMSD prevalence, and quality of life for PO professionals at SSPO clinics in Bangkok, Thailand.

AIM

This study aims to explore the characteristics of work-related hazards, the prevalence of WMSDs, and quality of life in prosthetic and orthotic professionals at SSPO clinics.

METHOD

This cross-sectional survey study employs total population sampling to investigate work-related hazards, the prevalence of musculoskeletal disorders, and quality of life among 30 prosthetic and orthotic (PO) professionals at SSPO clinics. The research framework comprises three phases: (1) establishing a cross-sectional study design to investigate work-related hazards, musculoskeletal disorder prevalence, and quality of life among PO professionals; (2) selecting Thai-language questionnaires, including COSHEM's for hazards, the Standardized Nordic Questionnaire for WMSDs, and the WHOQOL-BREF-THAI for quality of life; and (3) data collection, anticipated to begin in October 2024. The study will provide insights into occupational health within this specialized field.

RESULTS

The expected outcomes will be analyzed using SPSS version 28.0. Demographic variables (e.g., sex, educational level, work position) will be summarized as frequencies and percentages, while continuous variables (e.g., age, years of experience) will be reported as mean $\pm$ standard deviation (SD) or median and interquartile range (IQR), depending on distribution. Data on work-related hazards and the prevalence of WMSDs will be analyzed as frequencies and percentages. Quality of life data, based on the WHOQOL-BREF-THAI, will be presented across four domains: physical health, psychological health, social relationships, and environmental health, along with overall quality of life and general health scores.

DISCUSSION AND CONCLUSION

This study will provide insights into the occupational health of prosthetic and orthotic professionals at SSPO clinics, highlighting work-related hazards, prevalence of musculoskeletal disorders, and quality of life factors. Findings underscore the need for targeted interventions to improve workplace safety and well-being in this specialized field. Future research should further explore these areas to enhance occupational health strategies.

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Free paper session | Gait and balance – Sensory and cognitive

5.281 Does full body neuromodulation enhance the quality of mobility? Biomechanical and clinical data

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BACKGROUND

The EXOPULSE Mollii Suit (EMS, Ottobock) is a non-invasive, full-body garment with embedded electrodes. It provides electrical muscle stimulation to reduce spasticity, active muscles and to relieve chronic pain. Literature reviews demonstrated the potential of the EMS, but they mainly focus on performance-based (PBO) and patient-reported outcomes (PRO) [1]. Biomechanical effects have barely been mentioned.

AIM

The aim was to assess the effectiveness of neuromodulation using the EMS on patients with neurological conditions based on clinical and biomechanical data.

METHOD

Five patients with various neurological disorders were assessed as part of standard care, all qualifying for EMS testing. The setup included PBO (Berg Balance Scale-BBS, Timed Up and Go-TUG, 10-Meter Walk Test-10MWT, L-Test, and Four-Square Step Test-FSST), PRO (EQ-5D-5L and a self-designed questionnaire), and biomechanical analysis of level walking. Measurements were taken at baseline (T0), immediately after the first stimulation (T1: same day as T0), after four weeks of daily 60-minute stimulation (T2), and four weeks after stopping stimulation (T3). Walking was captured with a Vicon 3D motion capture system and Kistler force plates. Mean and standard deviation of 5-10 valid trials were used to analyze movement strategies. Improvements or declines were quantified by median differences and percentage median differences between T0 and T2, and T2 and T3.

RESULTS

At T2, patients demonstrated significant improvements in the time distance parameter (TDP, Table 1). Four patients increased their walking speed (median change of +28%) and step length (up to +31%), while all reduced stance phase duration (up to 6%). They exhibited more natural and symmetrical movement patterns, with some experiencing less knee hyperextension and increased ankle power during terminal stance. Almost all, improved in all clinical outcomes (BBS: +21%, other PBO: 9%-32%, EQ5D5L: +75%). Two patients reduced their use of walking aids and those at nearly 100% fall risk at T0 meaningfully reduced their risk. After stopping stimulation (T3), most test results worsened except for the BBS. Movement strategies and TDP had mainly persisted or worsened at T3.

Table 1. Changes after stimulation phase (T2) and after discontinuing the stimulation (T3) compared to baseline (T0). Positive differences in walking speed and step length indicate improvements, negative values a decline. For stance phase, positive values express improvements

Changes		Walking Speed (m/s)	Step length (cm)		Stance phase duration (%)	
			left	right	left	right
T0 vs. T2	Min	-0.09	-2.7	-1.7	-6.2	-5.3
	Max	0.39	21.7	20.8	-1.1	-1.1
T2 vs. T3	Min	-0.10	-5.2	-8.3	-2.2	1.1
	Max	0.02	-0.7	-0.8	2.6	3.9

DISCUSSION AND CONCLUSION

In conclusion, the use of the EMS resulted in a more natural gait pattern and loads on the musculoskeletal system, which correlated with significant improvements in clinical outcomes. Stopping the stimulation can be associated with a decline. This data collection will offer valuable insights into the effectiveness of the suit as an intervention tool for enhancing movement, functionality, and quality of life in patients with neurological conditions.

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5.282 Impact of a Non-Invasive, Gait-Synchronized Vibrotactile Sensory Feedback on Gait in Lower Limb Amputees

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BACKGROUND

Lower limb high-tech prosthetic devices currently do not provide natural sensory information on movements or ground characteristics, leading to unphysiological walking patterns with the prosthetic leg. Studies have shown that sensory feedback can reduce risk of falling, cognitive efforts, metabolic cost and phantom limb pain. Even though sensory feedback is the subject of research of numerous research groups, no feedback system has yet become established in everyday use or availability.

AIM

We assessed the effect of a gait-synchronized, non-invasive, vibrotactile sensory feedback system on gait parameters of lower limb amputees such as risk of falling, coordination, walking speed and endurance.

METHOD

Eleven subjects with a lower limb amputation tested a non-invasive vibrotactile feedback system (VTFS) encoding real-time pressure applied to the prosthetic foot into vibrotactile stimulation of the residual limb's skin at home for a period of max. 120 days. Before and after the intervention all subjects performed four standardized gait tests: Timed "Up and Go" Test (TUG), Four Square Step Test (FSST), 10 Meter Walk Test (10MWT) and 2 Minute Walk Test (2MWT). Additionally, subjects participated in an interview, rating their experience with the VTFS on a 5-point Likert Scale and indicating whether they would like to continue using it.

RESULTS

The cohort included 9 unilateral and 2 bilateral lower limb amputees, with a mean time since amputation of 6.91 years: 46% below-knee amputees, 18% knee disarticulation, 36% above-knee amputation. After an average testing period of 8 weeks, the subjects showed a statistically significant improvement in gait stability (TUG, $p < 0.05^*$). On an individual level, 45% of the subjects demonstrated a clinically relevant improvement in gait speed (10MWT) and 36% an intervention-related improvement in coordination (FSST). No correlation was found between the individual performance of the subjects ($\Delta t_1 - t_0$) and both the duration of VTFS use and the time since amputation. 36% of the subjects reported a good experience with the system and 27% rated it as "best". 45% wanted to continue using the VTFS after the testing period.

DISCUSSION AND CONCLUSION

The results indicate improvement across all gait parameters throughout the cohort after a short intervention period, considering their time since amputation. Remarkably, the participant who had previously undergone Targeted Sensory Reinnervation (TSR) demonstrated the most meaningful clinical improvements, suggesting a possible synergistic effect between TSR and the VTFS. These findings warrant further research into this combined approach as an optimized rehabilitation strategy for individuals with sensory deficits.



5.283 Self-reported mobility of persons with bilateral lower limb amputation

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BACKGROUND

Walking is the main factor that influence quality of life (QoL) in the population of persons with lower limb amputation [1]. Providing good services, gait re-education and prosthetic devices that enable users to achieve their optimal mobility, can thus positively influence QoL and independent living. However, compared to persons with unilateral lower limb amputation (LLA), less is known about the mobility of persons with bilateral LLA.

AIM

Investigate self-reported prosthetic mobility among Norwegian persons with bilateral lower limb amputation

METHOD

Invitations to participate in a survey on prosthetic mobility was sent by mail from 14 orthopedic clinics in Norway to registered lower limb prosthetic users. Of a total of 1279 invitations, 504 persons responded (39% response rate). Of these, 455 people with unilateral LLA were excluded from the present analysis. Included persons with bilateral lower limb LLA (n=49, 37 men), answered the 12-item Prosthetic Limb Users Survey of Mobility (PLUS-M) short-form which include movements that range from basic (household) ambulation to more challenging indoor and outdoor activities. Norwegian data will be compared with the US bilateral reference sample (n=206).

RESULTS

Mean (SD) age were 63.8 (14.0) years. Mean age at first and second amputation were similar with 51.2 (21.6) and 51.8 (22.7) years, respectively. All were prosthetic users and mean (SD) prosthetic use was 10.3 (5.0) h day⁻¹. Descriptive statistics of the PLUS-M scores are presented below.

Table 1. PLUS-M scores for Norwegian persons with bilateral amputation.

Leg 1 Leg 2	Dysvascular cause			Non-vascular cause			Total sample		US sample
	TTA TTA	TTA TFA	TFA TFA	TTA TTA	TTA TFA	TFA TFA	Norway		
Mean	43.9	29.1	26.8	47.3	52.7		43.9		48.0
SD	3.2	4.7	3.2	3.3	5.4		2.1		10.1
Median	44.9	25.2	25.3	50.6	55.4		46.3		47.6
Min	21.8	21.8	21.8	21.8	21.8		21.8		17.5
Max	71.4	40.2	34.9	61.0	67.1		71.4		76.6
N	22	3	4	12	8	0	49		206

SD = standard deviation; TTA = transtibial level of amputation; TFA= transfemoral level of amputation. N= number of persons. US sample data from <https://plus-m.org/>.

DISCUSSION AND CONCLUSION

Person with distal amputations report better mobility compared to proximal amputations. Also, dysvascular TTA report better mobility compared to dysvascular TFA, but the sub-populations are small. Furthermore, the Norwegian sample report lower mobility than the US reference sample. In conclusion, a better understanding of mobility and factors influencing mobility in this fragile population is important for prosthetists to offer the best possible clinical help.

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5.284 Does Walking to a Beat Improve Prosthetic Gait? Investigating Immediate Effects of Rhythmic Auditory Stimulation-Based Biofeedback

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BACKGROUND

Gait training is essential for lower-limb prosthesis users (LLPUs) to regain mobility and participate fully in their communities. However, traditional gait training methods often face barriers relating to time, cost, and accessibility, which can limit their reach and effectiveness. To address these challenges, our team has been exploring wearable technology for out-of-clinic gait training, focusing on rhythmic auditory stimulation (RAS) to provide real-time biofeedback. Prior studies on RAS-based gait training have primarily relied on open-loop systems that do not adjust based on the user's gait performance. Effective gait training, however, requires progressive, personalized feedback to accommodate individual needs. Closed-loop RAS systems may better support these goals by dynamically adapting feedback to enhance temporal symmetry and functional mobility.

AIM

This study builds on previous work in developing a real-time gait event detection algorithm for LLPUs, now combined with adaptive, closed-loop RAS feedback strategies.

METHOD

Fourteen LLPUs (n = 14) were recruited to determine (1) whether RAS improves temporal symmetry and key parameters (e.g., speed, cadence) in LLPUs, (2) how open- and closed-loop RAS systems compare in efficacy, and (3) the usability and workload associated with symmetry training.

RESULTS

The findings demonstrated that RAS significantly improved temporal symmetry, with closed-loop systems outperforming open-loop systems ($5.5 \pm 2.4\%$ vs $3.3 \pm 2.2\%$, respectively). This suggests that adaptive feedback can meaningfully support mobility outcomes for LLPUs. Both RAS strategies allowed participants to maintain target cadence and speed with high usability ratings and similar workload levels.

DISCUSSION AND CONCLUSION

Future research will focus on developing adaptable, closed-loop systems to support sustainable, personalized training over longer-term assessments. Expanding these adaptable RAS systems could broaden access to effective gait training, offering a scalable solution that offers sustainable rehabilitation through innovative technology and collaborative practice.



5.285 Cognitive-Motor Dual-Task Interference during Recovery from Unexpected Balance Loss in Lower Limb Prostheses Users: Pilot study

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BACKGROUND

Many lower limb prosthesis users (LLPUs) have significant balance deficits, with around 50% of users experiencing falls annually, 40% of which result in injury¹. LLPUs' balance may be adversely affected by the cognitive effort required to use a prosthesis while standing and walking. However, data on the reactive balance strategies and kinematics of LLPUs experiencing balance loss while performing a concurrent cognitive task is limited².

AIM

To assess the effects of cognitive-motor dual-task interference on LLPUs' reactive balance and cognitive performance during unexpected balance perturbations.

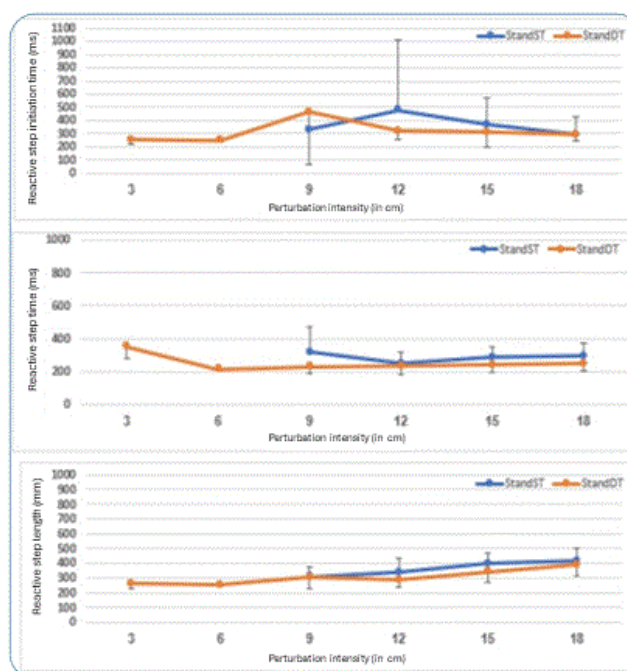
METHOD

Nine traumatic LLPUs (6 transtibial and 3 transfemoral, average age 49 years) were studied under two conditions: sitting with a cognitive task (counting backward by seven) and standing with a cognitive task. Perturbations were applied in four different directions: forward, backward, towards the prosthetic leg, and towards the intact leg, with six increasing intensity levels. They were instructed to prioritize both tasks, i.e., to avoid falling and to count backward by seven to the best of their ability. The single-step threshold, kinematics of the first reactive step, and cognitive task performance were compared between single- and dual-task conditions.

RESULTS

The single step threshold was lower in the dual-task condition compared to the single-task condition during backward perturbations (i.e., loss of balance in the forward direction), while no significant differences were observed for anterior or either of the lateral perturbations. LLPUs predominantly performed reactive steps with the intact leg. Interestingly, when reactive steps were triggered, the kinematics of the first reactive step in the single-task condition were similar to those in the dual-task condition (Figure 1A-C). There was no significant difference in cognitive task performance, with a comparable percentage of correct answers between conditions (86.2% in single-task vs 84.9% in dual-task, $p=0.564$). An additional observation was that during the dual-task condition, LLPUs often stopped counting backward following a perturbation, a behavior not observed in the single-task condition.

Figure 1: Kinematics of the first reactive step performance in standing among individuals using lower limb prostheses in standing Single task condition (StandST, blue) and standing Dual task condition (StandDT, orange). **Note:** 1) the data here was generated from backward perturbation trials, i.e., forward balance loss; and 2) no reactive steps were performed in ST condition in low intensities (intensity levels 3 and 6). **Abbreviations:** ms, milliseconds; cm, centimeters.





DISCUSSION AND CONCLUSION

LLPUs prioritize balance, as evidenced by both a lower step threshold and pausing the cognitive task, showing hesitation to step, supporting the “posture first” strategy. A simultaneous motor-cognitive task, however, does not significantly affect the kinematics of the first reactive step response following a sudden loss of balance, suggesting that the initial reactive step is likely an automatic reflex-like response. Findings suggest overlapping neural resources for reactive balance and cognitive tasks.

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5.286 Cognitive Task Interference Increases the Estimated Metabolic Costs of Walking in Lower Limb Prosthesis Users

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BACKGROUND

Lower-limb prosthesis users (LLPUs) have reduced sensory feedback and impaired motor control, resulting in postural instabilities, gait asymmetries, and increased metabolic costs. LLPUs also report needing to "concentrate on every step"¹, highlighting the cognitive resources required to compensate for these deficits. Although research indicates that medial-lateral center-of-mass and step width are predictors of metabolic costs in LLPUs,² the effects of dual-task interference on metabolic costs in LLPUs remain understudied.

AIM

To explore the effects of cognitive task interference on gait kinematics associated with the estimated metabolic cost of walking in LLPUs.

METHOD

Nine traumatic LLPUs (6 transtibial and 3 transfemoral, average age 49 years) walked on a treadmill who had no handrails at their comfortable gait speed for 60 seconds. They were secured in a safety harness. The study included three conditions: (1) sitting with a cognitive task, i.e., counting backward by seven; (2) walking, and (3) walking with a cognitive task. They were instructed to prioritize both tasks (to avoid falling and to count backward by seven to the best of their ability). We compared gait kinematics, i.e., center-of-mass displacement, step width, and cognitive performance between single- and dual-task conditions.

RESULTS

Table 1 shows that participants demonstrated significantly greater medial-lateral center-of-mass (ML-CoM) displacement during dual-task walking compared to single-task walking ($p=0.048$). Additionally, there was an increase in vertical center-of-mass (V-CoM) displacement when stepping with the prosthetic leg ($p=0.001$). However, no significant difference was observed when stepping with the intact leg ($p=0.449$). The step width in both the prosthetic and intact legs was greater under dual-task conditions, but these differences were not significantly different ($p=0.072$ and $p=0.094$, respectively).

Table 1: The effect of a concurrent cognitive task on kinematic parameters of gait that are associated with metabolic costs in lower limb prosthesis users (LLPUs).

	Single-task condition	Dual-task condition	P-value
ML-CoM displacement (cm)	6.59±1.90	6.93±2.10	0.048
V-CoM displacement, prosthetic limb (cm)	2.61±1.15	2.78±1.12	0.001
V-CoM displacement, intact limb (cm)	1.88±0.99	1.87±1.07	0.449
Step width, prosthetic limb (cm)	17.11±5.1	17.88±5.36	0.072
Step width, intact limb (cm)	17.30±5.37	18.08±5.73	0.094

Note: Data presented are means ± standard deviations. **Abbreviations:** ML-CoM, medial-lateral center-of-mass; V-CoM, vertical center-of-mass; cm, centimeters.

Interestingly, no significant effects were found in cognitive task performance under single- and dual-task conditions, i.e., cognitive performance in sitting=86.2%, cognitive performance in walking=85.2% ($p=0.564$).

DISCUSSION AND CONCLUSION

The kinematic data suggests that LLPUs may experience a higher metabolic cost when walking while performing a cognitive task compared to walking alone. This indicates that LLPUs may adopt an inefficient gait because they lack sufficient motor-cognitive resources to handle both tasks simultaneously, implying that walking among LLPUs is not automatic. Future research is needed to confirm these findings and evaluate further the effects of cognitive task interference in LLPUs.

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Free paper session | Prosthetics: bone anchored limbs – Mechanical loading in standard and bone anchored prostheses

5.291 Use of a Fully Powered Robotic Knee and Ankle Prosthesis with Bone-Anchored Interface

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BACKGROUND

Bone-anchored interfaces for lower limb prostheses are becoming more common, offering a simple and secure attachment option. Powered prosthetic components like powered knees and ankles are typically not recommended for use with bone-anchored interfaces, despite potential benefits. However, individuals who undergo osseointegration often have very short residual limbs and could significantly benefit from powered assistance, enhancing both stability and mobility.

AIM

To assess the feasibility of using a fully powered robotic knee and ankle prosthesis with an individual who has undergone osseointegration.

METHOD

This study evaluated a robotic prosthesis that included a Hybrid Knee and Polycentric Ankle, both microprocessor-controlled to deliver propulsive mechanical power, attached to an Integrum Axor II. The Hybrid Knee ^[1] actively extends for vertical mobility activities such as standing up and stair climbing, and actively flexes during the swing phase of gait. The Polycentric Ankle ^[2] provides active plantarflexion for push-off during level and incline ambulation and dorsiflexion for toe clearance. EMG and mechanical data were collected for one participant with a very short residual limb and bone-anchored interface (Integrum abutment) who trialed the robotic prosthesis.

RESULTS

The participant was trained to use the device in a short time-period, approximately 1 hour for all activities. She took advantage of the robotic prosthesis's power in activities such as standing up from a chair and ascending stairs in a reciprocal step pattern and appreciated the added plantarflexion push-off during walking. Although the increased weight compared to her own prosthesis (5.2 kg vs. 3.6 kg) was notable, it did not cause discomfort, and she found the functionality and support to be promising.

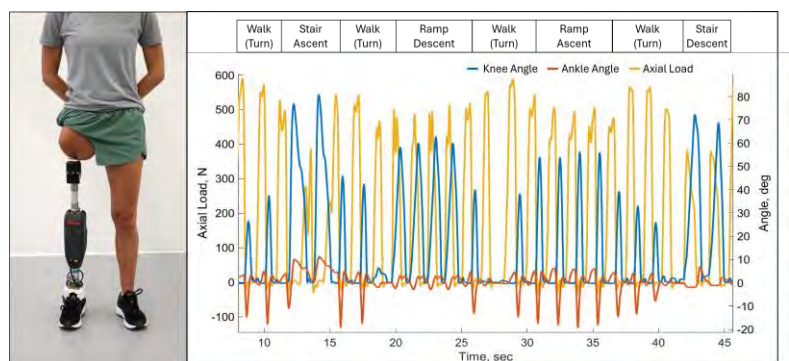


Figure 1. Example of one ambulation circuit including stairs, ramps, and level ground walking

DISCUSSION AND CONCLUSION

While the robotic prosthesis's weight posed a challenge, its functional advantages underscore its potential in advancing prosthetic technology for individuals who have undergone osseointegration. This trial demonstrated that a fully powered robotic knee and ankle prosthesis can be effectively used by an individual with a very short residual limb and bone-anchored prosthetic interface. Future work will evaluate cases with additional individuals.

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ACKNOWLEDGEMENTS

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5.292 Implant load during running on a transtibial bone anchored prosthesis: a multibody modelling case study

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BACKGROUND

Bone anchored prostheses (BAPs) using an osseointegration implant are a promising approach for persons with a transtibial amputation to solve socket-related problems. An additional advantage is the direct load transfer. However, it is unknown if high load/ dynamic activities, such as running, are safe. Mechanical failure of the implant, bone or their connection could result in dangerous situations for the BAP user. In the recent years, osseointegration implants for BAPs performed well in daily living activities such as walking, but limits of mechanical loads are unknown.

AIM

The aim of this study was to determine and compare the loads acting on the implant during running and walking performed on a running specific prosthesis (RSP) and a daily use prosthesis (DUP).

METHOD

A single unilateral transtibial BAP user using a press-fit osseointegration implant performed walking and running trials with a DUP and a RSP at varying speeds on an instrumented split belt treadmill. Two multi-body models of the participant with the RSP and DUP each were constructed. Kinematics reconstructed from marker data and ground reaction forces were used to compute forces and moments with inverse dynamics. Forces and moments were expressed in a reference frame located at the distal end of the dual cone adapter. The stance phase of individual strides was normalised and averaged.

RESULTS

It was found that the forces on the implant in the transverse plane and bending moments about anteroposterior and mediolateral axes were actually smaller during running compared to walking, but axial forces were higher for running. Temporal load distribution was different between DUP and RSP, but magnitudes were similar. The effect of increasing running speed did not increase implant loads substantially, it did substantially increase ground reaction force for the intact limb.

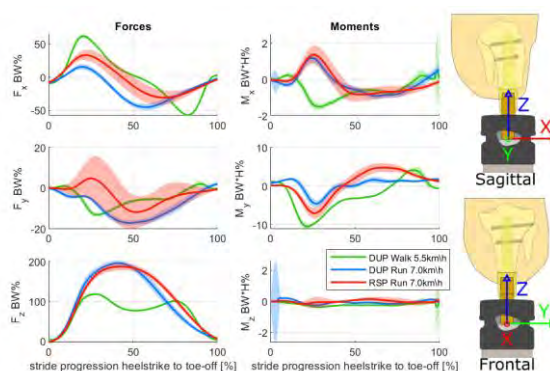


Figure 1: Local mean forces and moments during walking and running conditions from heel strike to toe-off at the dual cone adapter. Shaded area represents a single standard deviation determined from individual strides.

DISCUSSION AND CONCLUSION

Bending moments were smaller, but the compressive force was larger during running versus walking. This may indicate an acceptable load case, as bending is generally more harmful, but further analysis of the mechanical consequences on the bone-implant interface is needed. A cautious running strategy was observed, offloading the BAP at higher speeds. Running strategy variations should be considered in future studies. Results were inconclusive regarding safety, but findings suggest that running might be less dangerous as earlier perceived.



5.293 Exploring the opportunities of sensory feedback in improving usability and functionality of lower limb prostheses

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BACKGROUND

Advancements for prosthetic limbs in recent decades focused on the improvement of a device's functionality and control. The aim was to compensate the mechanical deficits that occur after amputation. Closing the sensory motor loop between the artificial limb and the human body was not established through this approach, despite other achievements in the field. Research has shown that users seek sensory feedback from their devices and its functionality could be improved by providing it [3]. The application of non-invasive vibrotactile feedback to lower limb prostheses has shown to improve prostheses' functionality and users' acceptance [1,2].

AIM

The aim of this study was to show the benefits in gait stability and safety of leg prosthesis users when using vibrotactile feedback.

METHOD

98 users of leg prostheses (all unilateral, both transfemoral and transtibial amputation level) used vibrotactile feedback for at least 30 days. At the beginning and the end of the trial, three different functional gait tests were performed (Four Square Step Test (FSST), Timed Up and Go Test (TUG), and the Ten Meter Walk Test (TMWT)). Vibrotactile stimulation was applied either to the thigh of the amputated leg or the contralateral thigh. Stimulations corresponded to the foot-to-ground contact of the prosthetic foot. The statistical effect size was calculated using a Bayesian general linear mixed model.

RESULTS

81% of the users (79 people) improved in the FSST, 86% (84 people) in the TUG test and 74% (72 people) in the TMWT. Of these, 39%, 15% and 18% were statistical significant improvements. Taking individual fluctuations into account, 41% of users (40 people) benefited from the use, while only 1% of users (1 person) experienced disadvantages. Overall, 72% of users (71 people) improved across all three gait tests.

DISCUSSION AND CONCLUSION

The improved test times with and after using the sensory feedback system show that gait stability, safety and speed of movement increased significantly within just one month and correspond with results of previous studies [1,2]. For people with a lower limb amputation, these improvements are directly associated with an improved quality of life and increased participation in public and social life.

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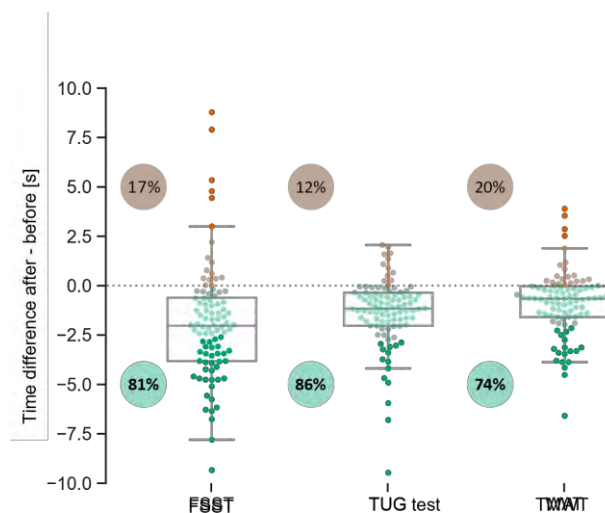


Figure 1: Change in individual best times for various tests of functional gait performance. The dark green dots represent definite improvements and the dark red dots definite deteriorations. The light green and light red dots indicate medium to small improvements or deteriorations.



5.294 Simulated Movement Symmetry Improves Joint Loading Symmetry in Unilateral Transfemoral Bone-Anchored Limb Users

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BACKGROUND

Bone-anchored limbs (BALs) are alternatives to socket prostheses that directly attach to residual bone. People with unilateral transfemoral amputations exhibit asymmetric gait patterns which increase the risk of musculoskeletal overuse injuries due to aberrant joint loading [1,2]. Thus, movement pattern training targeting biomechanical symmetry is a common intervention in amputation rehabilitation for socket users. However, as rehabilitation targets specific to BALs currently do not exist, the effects of targeted movement training in transfemoral BAL users are not well understood. Computational modeling provides a predictive platform that can represent clinical interventions to efficiently develop and test hypotheses without requiring actual patient intervention [3,4].

AIM

Determine changes in bilateral hip/knee joint loading and between-limb loading symmetry resulting from simulated gait retraining that targets symmetrical gait kinematics.

METHOD

Motion capture data from six individuals with transfemoral BALs (5F/1M, 48±7 y/o, 25.4±4.1 kg/m²) were used to develop subject-specific musculoskeletal models to determine baseline movement patterns and joint loading [5]. Simulated gait retraining was then performed by driving each model with the ideal movement patterns of predicted able-bodied gait that were personalized to each patient. Joint loading impulse (area under time series joint reaction force (JRF) curve) and hip joint loading symmetry (using the symmetry index between bilateral JRF impulses) from simulated retraining were compared to baseline solutions using Cohen's d effect size (medium: 0.5≤d<0.8, large: d≥0.8).

RESULTS

Following simulated gait retraining, all patients increased amputated limb hip JRF impulse (d=1.40) while the intact limb hip (d=0.03) and knee (d=0.36) JRF impulses were unchanged (Figure 1). Hip joint loading symmetry was moderately improved following simulated gait retraining (d=0.62).

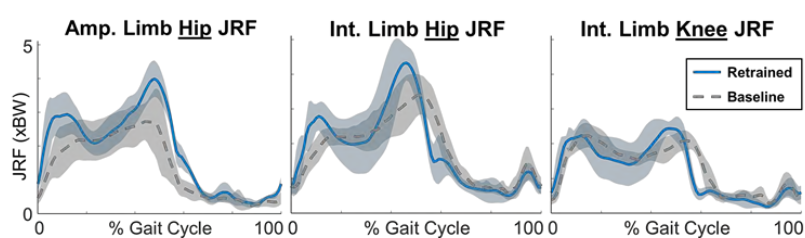


Figure 1. Ensemble average JRF curves observed from motion capture data (gray-dashed) and following simulated retraining (blue) for the amputated (left) and intact (center) limb hips and the intact limb knee (right) over the gait cycle.

DISCUSSION AND CONCLUSION

Patients with transfemoral BALs increased amputated limb hip joint loading following simulated gait retraining, with little change observed in the intact limb; resulting in improved hip joint loading symmetry. Additionally, following simulated gait retraining, bilateral hip JRF curves demonstrated increased peak loading during the loading response and terminal stance push-off, while unloading during mid-stance [6]. This cyclic loading and unloading pattern may indicate an improved mechanical environment for joint cartilage compared to the aberrant, sustained loading conditions at baseline. Coupled with the improved loading symmetry, these joint loading changes may indicate that enforcing movement symmetry restores a more natural joint loading condition which could indicate a decreased risk of musculoskeletal overuse injury development [7]. Computational methods like these could potentially aid the development of personalized movement pattern intervention planning.



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5.295 Primary stability of osseointegrating implant system for transfemoral amputations: a biomechanical in vitro study

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BACKGROUND

Transfemoral Osseointegrated Prosthetic Systems (TOPS) are successfully employed worldwide in amputees. According to literature, they enhance mobility and quality of life. However, rehabilitation to full mobilization can take up to a year due to concerns about implant-associated mechanical failures. Evidence of sufficient primary stability would be necessary to shorten the rehabilitation protocol.

AIM

The aim of this study was to assess the primary stability of the OPRA implant system without the osseointegration process.

METHOD

For this purpose, 19 anatomical femoral specimens were collected, QCT-scanned, and embedded proximally to avoid neck fractures. The specimens were further osteotomized in the midshaft and instrumented with OPRA implants following the surgical manual and CT-based implant size assessment. An experimental setup was designed to test the specimens under cyclic loading with increasing amplitude from 100N to 2000N at 0.6Hz. The load was applied mimicking heel strike during level walking. Relative displacements of bone and the implant system were measured utilizing a digital image correlation system.

RESULTS

None of the 19 specimens showed damage or permanent deformation after being loaded up to 2000 N. The obtained data showed the motion of the femoral shaft to be in the range of 0.01 mm to 0.02 mm in the distal. No mechanical play was observed in all femoral specimens after testing.

DISCUSSION AND CONCLUSION

The OPRA implant system proved to provide sufficient primary stability in axial loading even prior to osseointegration and despite the high age of the donors' specimens and corresponding low bone quality. Thus, the recommended rehabilitation protocol might be shortened for the benefit of the patient.



Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Rehabilitation

5.301 A low-cost pin-lock suspension system for ICRC polypropylene-based prostheses: A preliminary trial

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BACKGROUND

Prosthetic suspension systems provide a strong, reliable connection between a residual limb and the prosthesis during the swing phase of the gait cycle, affecting comfort, control, proprioception, and function. ^[1] Conventional suspension systems are incompatible with polypropylene-based prostheses and are inappropriate for the environmental and resource-constrained settings of low- and middle-income countries (LMICs) where polypropylene is the dominant system, instead using suspension with poor durability, limiting range of motion, and with low levels of satisfaction. ^[2]

AIM

This study investigates the effect of a novel pin-lock system on the walking capacity and functional ability of unilateral transtibial (UTT) amputees, and their satisfaction of the new suspension system.

METHOD

6 UTT participants were recruited in Cambodia to trial a novel pin-lock suspension system over half a day within the local prosthetic clinic. All participants had ICRC polypropylene-based prostheses with supracondylar or cuff suspension, which were trialled alongside and compared against the new pin-lock system. Participants underwent gait analysis (Timed Up and Go Test, TUGT and 3-Minute Walk Test, 3MWT), performed functional assessments (FAs) and activities of daily living (ADLs), and carried out a semi-structured interview to capture opinions of the new system. Direct measurements of pistoning and limb rotation were also captured, along with donning and doffing performance.

RESULTS

The new system showed a significant reduction in pistoning of 13.7mm (87% decrease) ($p=.034$). Regarding limb rotation, a reduction of 7.0° (68% decrease) ($p=.082$) was observed. Investigating gait, no change was observed between TUGT duration or 3MWT distance. On average, the new system showed a longer ($\sim 2x$) time to don and doff. A thematic analysis was performed on the comments captured from the participants and prosthetists during the FAs, ADLs, and structured interviews.

Overall, they reported more confident foot placement, increased range of motion, and reduced overall pain and improved comfort.

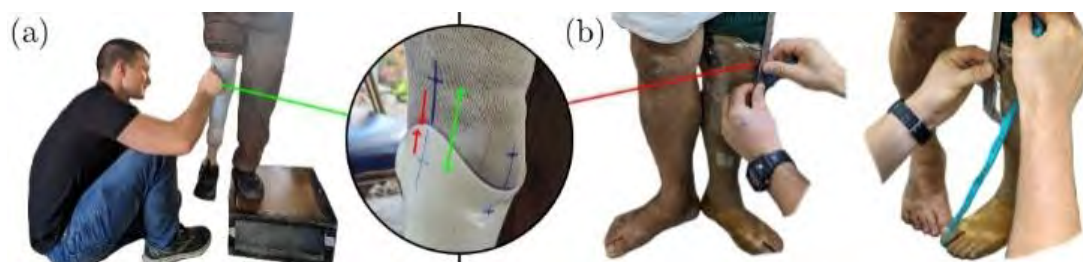


Figure 1. Direct measuring techniques: (a) pistoning using floating leg, and (b) rotation using heels/toes.

DISCUSSION AND CONCLUSION



The new pin-lock suspension system reduced the prosthesis free-motion relative to the user, improving the prosthesis attachment for polypropylene prosthesis systems that was previously incompatible. The improved functionality was also supported by the participants' and prosthetists' comments. Observations of increased donning/doffing duration and insignificant gait changes were expected due to the short trial length, and will be explored in a future, longer, at-home trial.

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ACKNOWLEDGEMENTS

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5.302 A Cross-Sectional Study: Life Satisfaction of Trans-Tibial Amputees who are Using CRP Fabricated ICRC Polypropylene Prosthesis in Bangladesh

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BACKGROUND

The level of patient's satisfaction is crucial for managing the healthcare budget and assessing the effectiveness of healthcare services. Once the patient experience with lower limb amputation, their life of satisfaction goes down and quality of life depended as physical psychological and social relationship (Al Imam et al., 2023). In this study shows the impact of using low-cost device (ICRC PP technology) how they are satisfied of experiencing this appliance.

AIM

The primary goal of the study was to understand how Trans-Tibial amputees experienced greater life satisfaction using ICRC polypropylene prosthesis made by CRP.

METHOD

A cross-sectional study was conducted, where 30 participants were involved in this study. The sample was selected by purposive sampling method. OPUS and QUEST 2.0 were used a data collection tools and for analysing the data SPSS 26 was used.

RESULTS

Among all; around 40% (n=12) were having a fair amount of pain while they doing their daily activities. In terms of age categories OPUS score for LEFM Score were measured for age group 25-34; mean 42.83 with SD ± 8.321 which is indicating better satisfactory result than others. However, in QUEST rest shows bit healthier score below 25 ages mean 47, SD ± 8.124 , in between 25-34 ages mean 52.33, SD ± 9.365 ; in between 35-44 ages mean 52, SD ± 10.943 ; in between 45-55 ages mean 49.67, SD ± 2.517 and above 55 age 58.5, SD ± 4.95 that is bit higher satisfaction score but only one participant.

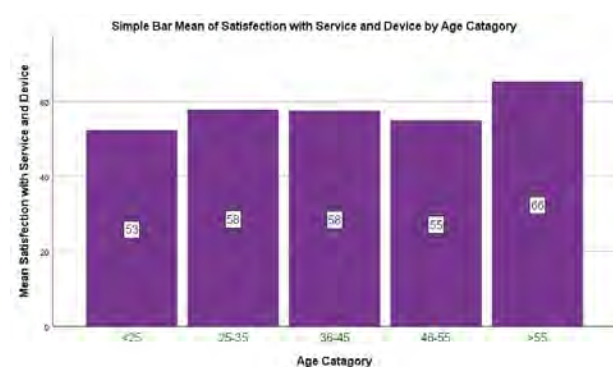


Figure 8. Satisfaction with Service and Device by Age

DISCUSSION AND CONCLUSION

The overall findings of the study found that Psychotically, Social and Environmentally, life satisfaction of Trans-Tibial Amputees are using ICRC PP technology were less satisfied at young age then orderly in context of Bangladesh. However, future research in this topic is recommended for more accurate data.

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5.303 Evaluating the strength and reproducibility of 3D-printed prosthetic sockets using standardized shapes and materials

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BACKGROUND

3D printing is gaining attention for prosthetic socket manufacturing. However, testing 3D-printed products relies on ISO 10328, resulting in inconsistent outcomes due to undefined residual limb shapes and materials [1]. Standardizing these aspects and sharing 3D printing parameters is crucial for achieving reproducible results across studies.

AIM

This study aims to evaluate and compare the strength of various limb shapes and materials using ISO 10328. We also plan to share standardized limb shapes to promote reproducibility across future studies. This comparison will help clarify differences in results across various studies, aiding in the understanding of variations reported in the literature.

METHOD

We will utilize scan data from 100 transtibial prosthetic users to generate an average residual limb shape for testing under ISO 10328 protocols. This average shape will be derived through Principal Component Analysis (PCA) to capture the key variations in the dataset. Additionally, a worst-case scenario shape will be created based on the average shape to simulate extreme conditions. Both the average and worst-case shapes will be subjected to ISO 10328. For the residual limb material, plaster and a TPU+PLA blend will be used to evaluate performance across different testing conditions.

RESULTS

Principal Component Analysis (PCA) identified the average shape of the residual limb, revealing principal components that correlate with limb length and circumference. The first principal component showed a strong correlation with stump length (correlation coefficient: 0.89) and no correlation with average circumference (correlation coefficient: -0.23). The second principal component had a moderate correlation with stump length (0.44) and no correlation with average circumference (0.27). Different residual limb shapes resulted in varying breaking force, with the worst-case shape exhibiting earlier breakage.

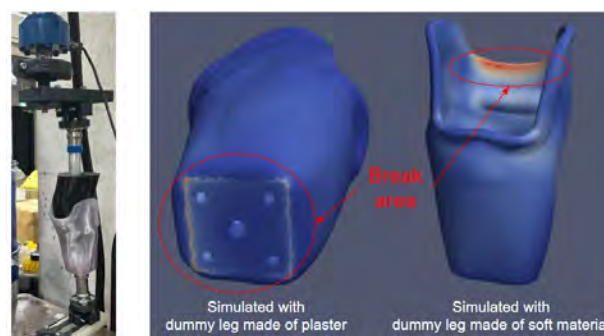


Figure 1. Stress evaluation based on different limb materials (Left: Physical and simulation test condition, Center, Right: Simulation results)

In the material comparison, plaster-based limbs showed breakage around the contact area with the pyramid adapter, whereas TPU+PLA limbs experienced breakage near the socket trimming line. These results were consistent with simulation outcomes, confirming that the observed breakage patterns aligned with the anticipated material behavior.

DISCUSSION AND CONCLUSION

While ISO 10328 lacks explicit definitions for residual limb shapes and materials, these factors significantly impact test results. Standardizing at least limb shape and material, and ideally adopting an industry-wide common residual limb shape, would enhance test reproducibility. The variation in failure locations based on limb material also suggests the importance of selecting appropriate materials to simulate realistic failure modes, improving the accuracy of prosthetic socket strength evaluations.

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5.304 The Skew Flap surgical technique might be the next step forward for patients undergoing a trans tibial amputation

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BACKGROUND

Approximately 1250 TTAs are performed yearly in the Netherlands. ⁽²⁾ Currently no consensus exists regarding which technique should be used for TTAs, however findings from a recent study show that the skew flap (SF) or fish mouth incision (FMI) technique may lead to better results than the golden standard long posterior flap (LPF). ⁽¹⁾ This study compares the outcomes for SF/FMI and the LPF technique for TTA.

AIM

To compare the LPF and SF in terms of revision rates, re-amputation rates and time to prosthesis in the Radboud university medical centre in the Netherlands.

METHOD

This retrospective cohort study assessed the medical records of all patients who underwent a TTA between January 2014 and June 2024. Patients were divided in groups based on surgical technique used for TTA, but also based on underlying pathology (vascular and trauma).

RESULTS

A total of 220 patients was included in the analysis. (LPF=190 vs SF/FMI=30) The SF/FMI lead to fewer revisions compared to the LPF within our study population (0% vs 12.9%).(p=0.05) The LPF was chosen more often for vascular pathologies than trauma (80.5% vs 50%). (p=<0.01) No significant differences in terms of re-amputation rates and time to prosthesis were found between the surgical techniques. Trauma patients showed a faster time to prosthesis <=6 weeks than vascular patients (40% vs 19.1%).(p=0.03) Vascular patients underwent more re-amputations within 6 months than trauma patients (19.1% vs 0%).(p=0.01)

DISCUSSION AND CONCLUSION

We found a significant difference in the revision rates between the SF/FMI compared to the LPF in favour of the SF/FMI. Our study could not confirm the findings of the SwedeAMP study ⁽¹⁾, possibly (partially) due to the small SF group. Findings regarding re-amputation rates do resemble findings by other smaller studies. More research should be performed on larger study populations to investigate the (other) possible benefits of the SF/FMI over the LPF for TTA.

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5.305 Development of a Pilot Study Protocol for Evaluating Wound Healing and Early Prosthetic Rehabilitation in Primary Unilateral Transtibial Amputees

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BACKGROUND

Timely prosthetic fitting after amputation is crucial for lower limb amputees' mobility and quality of life, yet readiness assessments lack standardization and objectivity ^[1]. Clinical judgment is inconsistent, relying on superficial evaluations of residuum healing. Disagreements persist over optimal post-amputation practices, such as rigid vs. soft dressings ^[2] and casting techniques for prosthetic sockets ^[3]. To address these challenges, objective measures like biomarkers are needed to improve healing assessments and prosthetic readiness evaluations.

AIM

This project aimed to develop outcome measurement techniques for a pilot study protocol to assess the acceptability of various measures, including biomarkers, for monitoring surgical site wound healing and early prosthetic rehabilitation. The study will follow a cohort of primary unilateral vascular transtibial amputees undergoing six standard care pathways, including rigid versus soft dressings and hands-on versus hands-off casting techniques.

METHOD

Over 20 outcome measures were identified, including residuum volume and shape, oxygen saturation, wound temperature and colour, and healing biomarkers. MATLAB 2024a scripts (MathWorks Inc., California, USA, 1984) were validated against CloudCompare (CloudCompare 2.13.2, 2024) using cylinder, sphere, and residual limb 3D stereolithography (STL) files, analysing shape (mesh-to-mesh Euclidean distance) and volume differences between STLs. A commercially available sleep monitoring ring's efficacy as a continuous oxygen saturation monitor was evaluated against three medically certified devices through Bland-Altman and Spearman's Rank correlation analyses. MATLAB scripts were used to realign thermal infrared and normal camera images of limbs over time, visualizing temperature and colour changes. Initial testing of ELISA (Enzyme-Linked Immunosorbent Assay) and wound blotting techniques ^[4] for assessing systemic and local levels of healing biomarkers was performed.

RESULTS

MATLAB and CloudCompare produced similar root mean square errors when comparing shape and volume differences between spheres and cylinders. The Go2Sleep ring showed poor correlation with medical devices, failing to meet the required strong Spearman's Rank correlation coefficient (0.90–1.00, $p \leq 0.05$) and a maximum 3% Bland-Altman mean bias. The MATLAB scripts effectively visualized temperature changes, and initial testing of a sandwich ELISA test for localized fluorescence detection of the inflammation biomarker C-Reactive Protein (CRP) was conducted.

DISCUSSION AND CONCLUSION

The development of this pilot study explores advanced technologies for assessing residual limbs post-amputation and during early prosthetic rehabilitation. Techniques like laser limb scanning, pulse oximetry, infrared thermal imaging, and ELISA assays show potential to improve wound healing assessment accuracy. Challenges like biomarker variability and assay optimization are addressed, laying the groundwork for refining outcome measure methodologies to enhance patient care post-limb loss.



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ACKNOWLEDGEMENTS

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5.306 Wound Healing, Management, and Early Prosthetic Rehabilitation: A Scoping Review of Healing and Non-Healing Definitions, Physical Biomarkers, and Chemical Biomarkers

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BACKGROUND

Post-amputation healing is a complex, multi-phase process (haemostasis, inflammation, proliferation, and remodelling) requiring precise cellular coordination. This process is hindered by complications such as infection and tissue necrosis ^[1,2], especially in individuals with comorbidities like diabetes ^[3], delaying prosthetic rehabilitation and impacting quality of life ^[4,5]. Current residuum healing assessments focus solely on surface examination ^[6]; identifying objective biomarkers may improve evaluations, guide rehabilitation timelines, and reduce complications in clinical practice.

AIM

The project aimed to identify predictive, diagnostic, and/or indicative biomarkers (physical, chemical, or other) of healing or non-healing of the tissues and structures found in the residual limbs of adults with amputation.

METHOD

A scoping review was conducted according to Joanna Briggs Institute (JBI) and PRISMA-ScR guidelines. On May 6, 2023, searches with terms “biomarkers”, “wound healing”, and “amputation” were carried out across Web of Science, Ovid MEDLINE, Ovid Embase, Scopus, Cochrane, PubMed, and CINAHL. Inclusion criteria included: (1) references to biomarkers and healing, (2) residuum tissue healing, (3) clear methodology with ethical approval, and (4) publication date from 2017 onwards. Articles were assessed for quality (QualSyst tool) and evidence level (JBI system). Data extraction categorized studies by type, wound, and model; biomarkers recurrent across categories were reported.

RESULTS

Of the 3,306 articles screened, 219 met inclusion criteria, with 77% rated as strong quality. However, 43% did not define healing, and 84% lacked non-healing definitions, highlighting a lack of standardized criteria regardless of study type. Healing definitions included criteria like epithelialization (14% of 219 sources) and wound size reduction (28%), while non-healing was most commonly defined by complications (4%) or need for surgery (4%). Of 156 sources using physical biomarkers, histology appeared most frequently (64 sources) offering crucial diagnostic insights into cellular healing. Other physical biomarkers included oxygenation and haemodynamic measures like ankle-brachial index (25 sources). 203 sources used chemical biomarkers. 38 chemical biomarkers were identified. Interleukins (indicative) and HbA1c (predictive) were the most common, each cited in 50 sources. Additional markers included routine blood markers, growth factors, and proteins like matrix metalloproteinases.

DISCUSSION AND CONCLUSION

This review advocates for biomarkers to provide quantitative insights into residuum health post-amputation, capturing infection risk, tissue adaptation, and responses to prosthetic use. Incorporating psychosocial factors, which affect recovery ^[7], is also essential. A comprehensive grading system is proposed, assessing both surface-level and deep tissue healing by integrating biomarkers, psychosocial metrics, and functional recovery outcomes for a more accurate assessment of post-amputation healing and prosthetic readiness.

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Free paper session | Outcome measurements – Clinimetric properties

5.311 Swedish translation, cultural adaptation and testing of the Prosthetic Upper Extremity Functional Index-2

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BACKGROUND

The Prosthetic Upper Extremity Functional Index (PUFI)¹ is a Canadian self-report questionnaire for children (3–18 years) with an upper limb prosthesis. The questionnaire asks about performance of various two-handed activities. Children under 10 years answer with a parent. The answers provide a comprehensive picture of the child's real-world prosthesis use. Children's daily activities change with time, and therefore an updated Canadian version, PUFI-2, has been developed.

AIM

We aimed to translate and culturally adapt PUFI-2 for use in a Swedish context.

METHOD

The translation and cultural adaptation of the Prosthetic Upper Extremity Functional Index-2 was conducted according to the International Society for Pharmacoeconomics and Outcomes Research Principles of Good Practice for cross-cultural adaptation of patient-reported outcome measures.² The recommendation comprises ten steps, including forward and backward translation. The forward translation was made individually by three professional experts from prosthetic rehabilitation. The backward translation was performed by a bilingual expert to ensure both conceptual and semantic equivalence. The Swedish version was tested on the target group and evaluated using cognitive debriefing.

RESULTS

Ten children of varying age, sex, and self-reported experience of prosthesis use tested the new Swedish version and found it easy to understand, as did their parents. The results showed good content validity for the items in the Prosthetic Upper Extremity Functional Index-2, and the index could discriminate between children with different habits of prosthesis use. The individual result was presented in pie charts which was appreciated and perceived as easy to understand for children and parents, providing a simple overview of how useful the prosthesis was, or how many activities were difficult to perform. Both children and parents appreciated the photos for the response options that provided valuable tips on how to perform an activity in different ways and what children and parents could practice at home.

DISCUSSION AND CONCLUSION

According to the UN Convention on the Rights of the Child³, every child has the right to express their opinion. By using PUFI-2 before the children visit the rehabilitation clinic, they have increased opportunities to take part in goal setting and planning of their own treatment. In conclusion, the Swedish version of PUFI-2 was user-friendly and meaningful for both Swedish children and parents to complete. For the therapist and the team, PUFI-2 is helpful for evaluation of function and fit of the prosthesis, as well as the child's performance of daily activities.

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5.312 Validity Testing of the Children's Amputee Mobility Predictor

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BACKGROUND

Children with leg length discrepancies (LLD) face unique functional challenges that existing assessment tools fail to address. The Amputee Mobility Predictor effectively evaluates adult functional capacity but overlooks pediatric-specific activities and developmental differences.¹ This led to the development of the Children Amputee Mobility Predictor (CAMP), designed for children and adolescents with LLD.² While the CAMP appears well suited for clinical use and addresses gaps present in existing tools, validation in an independent sample is required.

AIM

To determine the convergent and known-group validity of the CAMP, a performance-based functional capacity measure for children with LLD.

METHOD

A convenience sample of children and adolescents aged 2-18 years with unilateral LLD who use prostheses or Extension-prostheses was recruited. Convergent validity was examined using correlations between participants' CAMP scores and measures of balance and mobility, including the Timed Up and Go (TUG) test, the Pediatric Balance Scale (PBS) test, the 10-meter calculated walking speed, and the 2-Minute walk test. Known-group validity was evaluated by comparing differences in CAMP scores among participants grouped by Medicare Functional Classification Level (MFCLs).

RESULTS

Thirty participants with LLD were enrolled in the study, classified as MFCL 2 (n=5), MFCL 3 (n=13), and MFCL 4 (n=12). The CAMP demonstrated a good negative correlation with the TUG test ($r = -.88$, $p < .001$) (Fig. 1a) and a moderate positive correlation with the PBS test ($r = .66$, $p < .01$) (Fig. 1b). Both the 10-meter calculated walking speed and the 2-Minute Walk test scores demonstrated fair positive correlations with the CAMP ($r = .45$, $p < .05$; $r = .49$, $p < .01$, respectively). CAMP scores significantly differed between MFCLs ($H(2)=12.230$, $p=.002$), with level 4 scoring higher than level 2 ($p = .003$). While no significant differences were found between levels 2 and 3 ($p = .399$), the difference between levels 3 and 4 showed a tendency towards significance ($p = .05$).

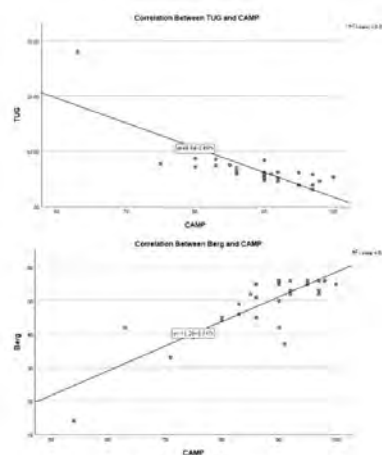


Fig. 1a (top) and 1b (bottom)

DISCUSSION AND CONCLUSION

The study's results support the validity of the CAMP as a measure of functional capacity. Correlations between the CAMP and balance measures indicate convergent construct validity. Fair correlations with mobility may be due to developmental variability and compensatory strategies in children with LLD. Significant differences in CAMP scores between MFCLs Levels 2 and 4 provide evidence of known-group construct validity. The near-significant difference between Levels 3 and 4, suggests that a larger sample size may be needed to demonstrate difference between these levels, as well as between Levels 2 and 3.

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5.313 Test-retest reliability of the Assisting Hand Assessment for individuals with Upper limb difference with or without using a Prosthesis – AHA-UP

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BACKGROUND

Currently, there is no tool for assessment of performance that can be administered to people with unilateral hand difference independent of whether they use a prosthesis or not. A version of the Assisting Hand Assessment, a performance-based outcome measure that describes use of the affected hand in semi-structured bimanual activities, the Assisting Hand Assessment for individuals with Upper limb difference with or without using a Prosthesis (AHA-UP), was developed (2).

AIM

The aim was to examine the test-retest reliability of the Assisting Hand Assessment for individuals with Upper limb difference with or without using a Prosthesis.

METHOD

Participants were recruited consecutively at a limb difference clinic and, after providing written consent, filmed twice with 1-3 weeks apart and no intervention between (3). The AHA-UP has 19 items scored on a three-point Likert-scale designed to capture the efficiency in grasping, releasing and using the affected limb in bimanual activity. A certified assessor scored the performances. Data were analyzed using ICC 2-way mixed-effects model with 95% confidence interval and absolute agreement on each item (SPSS v26). Standard deviation and Standard Error of Measurement were calculated to estimate the data distribution around the exact test value.

RESULTS

Sixteen children and adults with acquired (n=8) or congenital (n=8) differences of the upper limb using passive (n=5), active (n= 5) or no prosthetic device (n=6), were filmed and scored. Results showed good to excellent test-retest reliability (ICC between 0.786 to 1.000) for the majority of items. The item "Reaches" with ICC 0.400 and the item "Chooses" with ICC 0.727 demonstrated poor and moderate reliability respectively. Participants sum score ranged from 19 to 54 with a difference of 1–4 points between assessments. Six participants obtained the same score, ranging from 19 to 46, in the repeated assessment. Standard Error of Measurement was 0.229, which is considered appropriate for performance-based outcome measures.

DISCUSSION AND CONCLUSION

The AHA-UP demonstrated good to excellent test-retest reliability. The ICC-scores suggest that the AHA-UP provides reliable measures and reflects actual change within patient's activity performance during the assessment. The definition of the items "Reaches" and "Chooses" needs to be clarified to obtain a higher reliability. There is a reduced generalizability of the results due to the small sample, but the positive result encourages further development of the instrument.

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5.314 Can the Amputee Mobility Predictor Assessment Tool Predict Functioning at Discharge from Primary Rehabilitation?

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BACKGROUND

Most people with lower limb loss would like to get a prosthesis and be able to walk again, but fitting a prosthesis is not safe for all. Before amputation, we can predict the ability to walk with prosthesis using the BLARt score (Bowrey, 2019); after amputation, the Amputee Mobility Predictor without Prosthesis (AMPnoPRO) assessment tool (Gailey, 2002) or exercise stress testing (Erjavec, 2008) can be used. Predicting the walking potential is also important for selection of appropriate prosthetic components.

AIM

The aim of our study was to find out whether the Amputee Mobility Predictor without Prosthesis (AMPnoPRO) can predict functioning of patients admitted to primary rehabilitation and first prosthetic fitting at discharge.

METHOD

We included patients with unilateral trans-tibial or trans-femoral amputation who were admitted to inpatient rehabilitation in 2021 and 2022, were fitted with a lower limb prosthesis for the first time, and were able to walk with the prosthesis either with or without a walking aid. At admission, we administered the AMPnoPRO; before discharge, Amputee Mobility Predictor (AMP), 6 Minute Walk Test, 10 Metre Walk Test and L-test were used for assessment. Because of Gailey's criteria, each patient was also classified into K-levels of activity based on AMPnoPRO and AMP. The study was approved by the Medical Ethics Committee of our Institute (No 035-1/2021-27/3.5).

RESULTS

We included 200 patients, 151 men, 126 amputated due to diabetes, 143 after trans-tibial amputation, 68 years old on average (SD 10 years). The K-level assigned at admission and discharge differed for 125 patients, with 17 falling into a lower K-level and 108 into a higher one at discharge. There were statistically significant differences between the K-levels determined at admission in the results of the 6 Minute Walk Test, the L-test and walking speed, but the difference between two adjacent levels exceeded the minimum detectable change only between K-level 1 and 2.

DISCUSSION AND CONCLUSION

In half of the included patients, the AMPnoPRO predicted a lower activity level than the one that they actually achieved at discharge. We suggest that the boundaries of each K-level should be re-examined and set so that the differences on other tests (6 Minute Walk Test, walking speed, L-test) between levels are greater than the minimum detectable change or even the minimal clinical important difference for people with lower limb loss.

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5.315 Developing candidate items for a survey of prosthetic attention in upper limb prosthesis users

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BACKGROUND

Upper limb prostheses (ULP) can help restore functional independence for those with limb loss, yet they often lack the intuitive control and sensations of a biological limb. This can increase the need to pay attention to the prosthesis, potentially resulting in dissatisfaction and disuse.¹ Measuring constructs like prosthetic attention can enhance clinicians' and researchers' ability to evaluate patient outcomes, yet no tool exists to assess this construct.² Surveys offer an ideal means to assess prosthetic attention as they can solicit information about how respondents use their prosthesis for everyday tasks.^{3,4}

AIM

The aim of this study was to develop and refine candidate items for a new survey to measure prosthetic attention in ULP users.

METHOD

Situations and activities that may require attention during use of an ULP were identified through a comprehensive process that included a review of existing surveys, focus group discussions with ULP users, and input from experienced clinicians and researchers. Candidate items were pooled into a library, selected through a process of binning and windowing, and rigorously evaluated via cognitive interviews with target respondents. Candidate items, instructions, and response options were examined for clarity, relevance, and comprehensiveness. Items were carefully revised or removed based on feedback provided by a diverse group of ULP users.

RESULTS

Eight hundred forty-four survey items were created and categorized into bins reflecting different situational modifiers (e.g., type of task). The research team narrowed the list to 109 items through a multi-stage winnowing process. Feedback from a first round of cognitive interviews with 28 ULP users prompted major revisions to 13 items and creation of 3 new items. These items were subsequently tested in a second round of interviews with 5 ULP users. Instructions and response options were also refined based on participant input. A total of 77 items were ultimately deemed by the study team to be clear, understandable, and relevant to measuring prosthetic attention based on feedback provided in the cognitive interviews.

DISCUSSION AND CONCLUSION

This study resulted in the development of candidate items for a novel survey of prosthetic attention. Items describe real-world scenarios most relevant to ULP users. Feedback from cognitive interviews informed critical revisions to instructions, response options, and item content. A candidate item pool of 77 clinically-relevant items was created. These items are now ready for large-scale testing calibration, and psychometric evaluation with ULP users.

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5.316 Prosthetic Mobility Curves: Lifetime Mobility Values Following Lower Limb Amputation

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BACKGROUND

Mobility is a dynamic factor that changes throughout an individual's life. Similar to pediatric growth charts, that have been an established staple of pediatric medicine for decades, mobility curves can facilitate ready comparison of an individual's prosthetic mobility relative to their peers according to age, gender, amputation level, and amputation etiology. The present study builds upon previous work [1] to further stratify mobility into single years of patient age allowing clinicians to assess mobility changes over time against normative data in this population.

AIM

The purpose of this study was to generate prosthetic mobility curves specific to an individual's age, amputation level, and etiology.

METHOD

A retrospective, cross-sectional analysis was performed on mobility outcomes (PLUS-M T-scores) [2] collected in private prosthetic clinics across the United States between April 2016 and December 2021. Individuals were included if they were >18 years old, had a unilateral AKA or BKA, and either traumatic or dysvascular/diabetic (DV) etiology. Data were analyzed across 61 years of age (25-85). Individuals <25 and >85 were grouped accordingly due to limited sampling at the extremes. Averages for each age group were excluded if the age group had less than 15 individuals. The mean PLUS-M score was calculated for each age group and a cubic fit was applied to the mean data across age ranges. A 95% confidence interval was also calculated around the fitted line. A secondary analysis on knee type (microprocessor vs. non-microprocessor) was also conducted for individuals in the AKA group.

RESULTS

A total of 29,522 individuals (6,437 AKA & 23,085 BKA) met inclusion criteria and were included in the final sample. Trend models were built for AKA-Trauma ($y = -1.45 \times 10^{-4} x^3 + 0.020x^2 - 0.955x + 65.76$ $R = 0.79$ $p < 0.001$), AKA-DV ($y = -6.16 \times 10^{-5} x^3 + 0.0058x^2 - 0.117x + 40.39$ $R = 0.86$ $p < 0.001$), BKA-Trauma ($y = -1.71 \times 10^{-4} x^3 + 0.0265x^2 - 1.38x + 78.48$ $R = 0.90$ $p < 0.001$), BKA-DV ($y = -2.36 \times 10^{-4} x^3 + 0.0402x^2 - 2.36x + 95.08$ $R = 0.96$ $p < 0.001$). Patients with MPK had on average, higher PLUS-M scores compared to nMPKs (Figure 1).

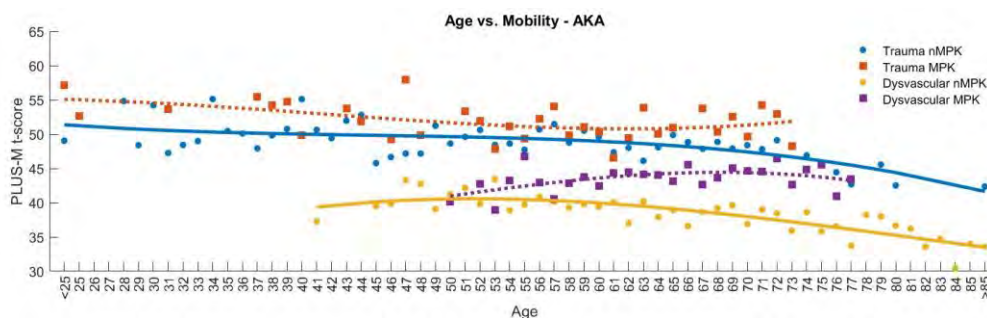


Figure 1. Those with an MPK (square markers and dotted line) have higher PLUS-M T-scores compared to those with a nMPK (circle markers and solid line)

DISCUSSION AND CONCLUSION

In general, mobility decreases with respect to age across amputation levels and etiologies. MPKs had increased mobility across all AKA age groups. These findings begin to demonstrate potential for modified goal setting based on prosthesis type integrated into the patient's care. The results of this study provide clinicians and patients tools for improved goal setting based on matched peers in terms of age, amputation level, and etiology.

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5.317 Validity, Reliability, and Efficiency of the PROsthetic Mobility Performance Test (PROMPT)

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BACKGROUND

The PROsthetic Mobility Performance Test (PROMPT) is a novel performance test developed using modern measurement theory.¹ PROMPT was created to accommodate the spaces and times most prosthetists² and physical therapists³ are willing to allocate to performance testing. Shortened, targeted versions of PROMPT were designed for rapid administration. While PROMPT appears to be a promising tool for evaluating prosthetic mobility, additional psychometric testing is needed to confirm this assumption.

AIM

The goal of this study was to evaluate PROMPT's psychometric quality and administrative burden.

METHOD

A repeated-measures study was conducted to evaluate PROMPT's criterion validity, construct validity, inter-rater reliability, test-retest reliability, and administrative burden. Participants with lower limb amputation were recruited from a participant pool, local clinics, and medical records. At session 1, participants were administered three performance tests (PROMPT, Amputee Mobility Predictor [AMP], and Timed Up and Go [TUG]) and three self-report surveys (Prosthetic Limb Users Survey of Mobility [PLUS-M], Prosthesis Mobility Questionnaire [PMQ], and Activities-specific Balance Confidence Scale [ABC]). At session 2 (3-7 days later), participants were re-administered PROMPT and TUG. Spearman's correlations, ANOVAs, and post-hoc tests were used to evaluate validity indices. Intraclass correlation coefficients were used to assess reliability indices. Wilcoxon tests were used to assess administrative burden.

RESULTS

A total of 106 participants (mean age 57.7±15.2 years, 74% male, 75% transtibial amputation, 49% traumatic etiology, 73% unlimited community ambulators or active adults) completed the study; 5 were dropped from reliability analyses due to changes in health. PROMPT general and targeted task sets correlated strongly with AMP ($r>0.88$) and TUG ($r<-0.91$). PROMPT general and targeted task sets correlated moderately or better with PLUS-M ($r>0.59$), PMQ 2.0 ($r>0.65$), and ABC ($r>0.70$). PROMPT scores increased with participants' K-level (all significantly different, $p<0.001$). Inter-rater reliability ICC(1,1) and test-retest reliability ICC(2,1) exceeded 0.99 and 0.95, respectively, for all task sets. PROMPT targeted sets required significantly less time to administer (median 9.8 minutes) than the PROMPT general set (14.0 minutes) or the AMP (16.0 minutes). The PROMPT general set also required significantly less time than AMP.

DISCUSSION AND CONCLUSION

This study demonstrated that PROMPT has excellent psychometric qualities, including robust evidence of concurrent criterion validity, convergent and known groups construct validity, inter-rater reliability, and test-retest reliability. Further, PROMPT's low administrative burden makes it ideal for administration in situations where time is limited. Based on these findings, PROMPT can be recommended for use in clinical practice and research studies involving lower limb prosthesis users.

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ACKNOWLEDGEMENTS

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Free paper session | Prosthetics: lower limb transfemoral – Knees

5.321 Participation in work life of individuals using a microprocessor-controlled prosthetic knee joint: Results of a digital Patient Survey

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BACKGROUND

One important aspect of the burden of disease (BoD) is participation in work-life (PW) and return-to-work (RtW), which affects patients, their families, health care, and society. Patients in Germany are legally entitled to PW^[1] and essential rehabilitation measures^[2] are provided. Current PW/RtW-research considered etiology, age, basic componentry, amputation level, time since amputation/definitive fitting, mobility, Reintegration-to-Normal-Living-Index (RNL), Quality of Life (QoL), and occupational rehabilitation^[3,4,5].

AIM

The purpose of this observational study was to gain a deeper understanding of PW/RtW in a cohort of individuals utilizing a microprocessor controlled knee (MPK) and their potential benefits.

METHOD

Individuals using a MPK (C-Leg/Genium, Otto Bock) >3 months (mo), age >18 years (y), with/without prior prosthesis in Germany were invited to participate in a digital survey^[6]. The latter included Likert scales, self-designed items, RNL, Amputee Body Image Scale (ABIS), and EQ-5D-5L. Data analysis: Minitab/Matlab; Chi2-/Fisher-Exact Test; Bonferroni-correction; Kruskal-Wallis/Mann-Whitney-U Test. The study was conducted in accordance with all ethical/legal requirements.

RESULTS

520 participants responding to the productivity chapter of the survey were analyzed. 55.96% were employed (Full/part time distribution almost comparable to the national cohort). 11.54% were not employed and 32.5 % retired. 21.3% of those who worked were retrained, 44.3% reported that their job changed: 60% changed type of professional activity, 73% spend most of their work time sitting. Higher probability of RtW was demonstrated for: traumatic amputation (1.85 times vs. other etiologies), higher mobility grade (MG4:4.06/MG3:2.85), time to definitive fitting (3-12 mo: 4.53 times vs.<3 mo (.001), Genium: 2.88 times higher vs. C-Leg (.007)), ABIS (10-point decrease increased OR by 28%), satisfaction with the MPK (3.21 times), participating in all-day activities (RNL with each 7-point increase 1.42), QoL (0.1 utility increase=1.38 times) The likelihood of maintaining PW increased by 1.31 for every additional 5 y after amputation. Negative RtW factors identified were age at amputation (by 10% for every 5-y increase), definitive fitting >12 mo (decreased 4.47 times (.003)), and the use of assistive devices (OR: 0.26). Overall, the impairment in PW was rated low.

PW Limitation of professional duties		mean	SD
Professional duty	Mastering a regular working day	2.35	2.3
	Work without additional breaks	2.84	2.3
	Change location at any time	2.43	2.4
	Carrying, picking up or moving objects	3.30	2.5
	Same posture over a longer period	3.62	2.6
	All necessary movements for work	2.90	2.5
	Concentrate on work throughout	2.83	2.6
	Take part at social activities at work	2.57	2.5
Total limitation		2.78	2.5

Table 1. PW limitations (n=289) 9-point Likert scale (1=no limitation, 9=full impairment).



DISCUSSION AND CONCLUSION

This is the first time an MPK cohort that has effectively RtW/PW has been analyzed cross-sectional. Important factors related to RtW/PW were identified in this specific amputee population with an employment status that is comparable to the normal population in Germany.

Integration of MPK in occupational rehabilitation should be considered for patients with PW/RtW potential.

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ACKNOWLEDGEMENTS

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5.322 Comparison of microprocessor controlled and non-microprocessor controlled prosthetic knees in all domains of the ICF-model: a pragmatic clinical trial

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BACKGROUND

Persons with a transfemoral amputation or knee-disarticulation can use a prosthesis with a prosthetic knee unit to regain mobility. Prosthetic knees can generally be divided into two categories: microprocessor controlled knees (MPKs) and non-microprocessor controlled knees (NMPKs). Prosthesis use can influence all aspects of daily functioning, health, activities and participation. Multiple studies have compared MPKs to NMPKs based on different aspects and outcome measures, but results vary between studies and raise the question which type of knee is most effective.

AIM

Since prosthesis use can influence all aspects of daily life, we aimed to compare the MPK to the NMPK in all ICF-domains in adult prosthesis users following the standard healthcare procedures in the Netherlands.

METHOD

For this multicenter pragmatic clinical trial, adults using a lower limb prosthesis with socket (> 1 year experience) due to various aetiologies were included. A baseline measurement (T0) was performed while participants used the NMPK. One week later, they received the MPK and started a four-to-six week trial period, during which they received physical therapy twice a week. In the last week of the trial period, measurements were repeated with the MPK (T1). A combination of functional tests and questionnaires was used. For statistical analyses, paired t-tests and Wilcoxon signed rank tests were applied. The Benjamini-Hochberg procedure was applied to correct for multiple testing.

RESULTS

Twenty-five participants (median age: 57 (range 19-75)) were included. For body functions and structures, participants showed significant improvements in safety and walking- and balance confidence, as well as a significant decrease in numbers of stumbles and falls at with the MPK compared to the NMPK. In terms of activities, we found significant improvements in walking distance and self-reported walking abilities with the MPK compared to the NMPK. Additionally, participants were significantly more satisfied with their participation and experienced fewer restrictions while using the MPK compared to the NMPK. Lastly, regarding environmental factors, participants reported significantly greater satisfaction with the appearance and utility of their prosthesis, experienced less social burden and reported better well-being with the MPK compared to the NMPK.

DISCUSSION AND CONCLUSION

Participants demonstrated significant improvements in all ICF-domains with the use of a MPK compared to an NMPK. Using an MPK can reduce fall-risk and improve a person's walking ability, daily activities, participation, satisfaction and confidence. Therefore, it is important to consider all ICF-domains when selecting or evaluating a new knee, rather than focusing solely on walking ability.



5.323 Metabolic cost in level ground walking with high activity transfemoral prosthetic users on passive vs. powered microprocessor-controlled knees

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BACKGROUND

Individuals with lower limb amputation using passive prostheses experience higher metabolic demands and reduced self-selected walking speeds¹ and up to 65% more exertion to generate half the ambulation speed of able-bodied individuals². With 0.5 kg added mass below the ankle of a non-amputee, greater EMG of muscles to initiate leg swing were seen and greater swing-phase muscle moments indicating a 6% metabolic rate³. Can powered prosthetic knees reduce the amount of exertion?

AIM

This study aims to assess the effectiveness of an actively motorized powered knee (AMPK) compared to passive microprocessor-controlled knees (PMPKs) in reducing the metabolic cost for high-activity transfemoral prosthetic users.

METHOD

The study measured the metabolic cost of level ground walking using the heart rate index (HRI) to estimate the Metabolic Equivalent of Task (MET)⁴. The subjects were measured on their prescribed PMPK at baseline, then used the AMPK for one week and were measured again on the AMPK. Factors affecting heart rates were controlled, e.g. caffeine and food consumption and exercises before both testing sessions. The activity level was measured using the PLUS-M. The Bayesian analysis included pilot data from five subjects.

RESULTS

The study included 13 subjects (2 women and 11 men) with a mean age of 51.7 years (range: 32-76 years). The average Plus-M T-score was 61, with a range from 50.5 to 71.4. The PMPKs included five Rheo Knees, three Genium, three C leg, and one Plié. The most probable value for the difference in MET is 0.32, with a 95% Highest Density Interval (HDI) of 0.01 – 0.63 (light blue area, Fig. 2). There is a 98% probability that MET is lower for the AMPK compared to PMPKs.

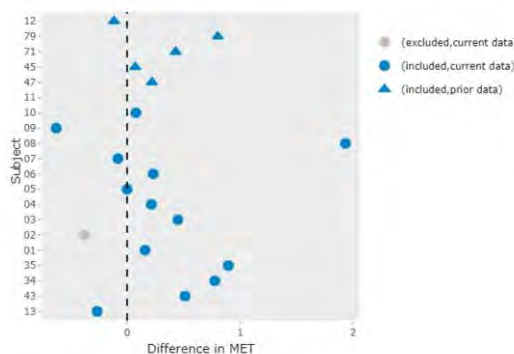


Fig. 1 Difference in MET (PMPK-AMPK)

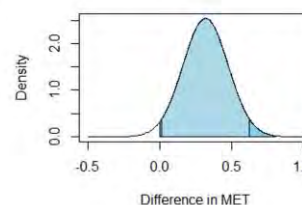


Fig. 2 Posterior distribution of difference in MET

DISCUSSION AND CONCLUSION

The results of the investigation indicate lower metabolic cost in level ground walking using the AMPK compared to PMPK, despite the additional average weight of 1.05kg. The limited number of female subjects in the sample and the geographical locations of the study limit the generalizability of the results. Using the HRI as a measure for metabolic cost has its limitations. Although the study design aimed to minimize these limitations, certain uncontrollable factors persist. The results indicate that the AMPK might reduce the anticipated increase in exertion during walking for Individuals with a transfemoral amputation.

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5.324 Powering Forward: Investigation of a Powered Microprocessor Knee, A Single Case Study

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BACKGROUND

Prosthetic knee technologies have been continuously developing to address issues of increased energy expenditure and compromised mobility of prosthesis users. It is well documented that the progression to microprocessor knees (MPKs) has been successful in improving mobility and quality of life^[1]. Advancement in technology to powered MPKs proposes many benefits when compared with non-powered MPKs^[2], however little investigation has been done into this within a real-life clinical setting.

AIM

The aim of this study was to investigate if a powered MPK provides improved functional outcomes when compared with a non-powered MPK, for a single above knee prosthesis user.

METHOD

A single case study was conducted with a non-powered MPK user - a unilateral K3 amputee. A 6-month trial of a powered MPK was undertaken by this user. The user had access to both MPKs during the trial as each was on a separate prosthesis (with copy of socket and similar foot type). At the end of the trial, data to compare the MPKs was collected using three methods: user feedback (self-scoring system and daily activity diary), clinic-based outcome measures (Timed Up and Go (TUG) Test and 6 Minute Walk Test) and gait lab analysis (spatiotemporal and force vector data).

RESULTS

User feedback of powered MPK:

Easier to walk longer distances; less tired when walking; easier to ascend stairs; increased socket comfort; reduced back pain; not suitable for working conditions or swimming hobby due to the IP rating (the non-powered MPK was suitable due to the higher IP rating).

Clinic-based outcome measures:

	Powered MPK	Non-powered MPK
TUG Test (s)	10.2	8.1
6 Min Walk Test (m)	580	520

Gait lab analysis:

With the non-powered MPK, the user had a higher cadence and walking speed, and the step length was longer and more equal to the contralateral side. Force vectors during sit to stand through each side were also more symmetrical. The Limp Index was the same for both MPKs.

DISCUSSION AND CONCLUSION

User feedback illustrated that the powered MPK significantly improved quality of life, specifically relating to endurance. Outcome measures demonstrated the user walking longer distances at a slower pace, which supports feedback of increased endurance. Positive user feedback was not reflected in gait lab analysis.

To conclude, the powered MPK improved perceived functional outcomes for this user when compared to the non-powered MPK, however this was not corroborated with gait analysis.

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5.325 Short-term Results of an observational study: Active Microprocessor-Controlled Knee Prostheses Compared to Passive Microprocessor-Controlled Knee Prostheses after Transfemoral Amputation

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BACKGROUND

Active electronic microprocessor-controlled prostheses (aMPKs), like the Intuy knee introduced by Rebococon Bionics, are designed to improve gait symmetry and reduce muscle strain, making activities like stair climbing easier, and studies indicate a 24% reduction in oxygen consumption during this activity compared to passive MPKs (pMPKs) ⁽¹⁾. However, current research lacks exploration of walking distances, subjective experiences of users or individual preferences of the user.

AIM

The aim of this study is to compare the Intuy Knee with pMPKs regarding functional outcomes and patient-reported outcomes (PROMs), such as locomotor capabilities and quality of life.

METHOD

This observational study compares measurement outcomes in transfemoral amputees using a pMPK and after 4 weeks of using the aMPK Intuy Knee. The main outcome measurements are the 6 Minute-Walk-Test (6MWT), the Stair Assessment Index (SAI), and the Hill Assessment Index (HAI). Secondary outcome measurements include functional tests and PROMs like the Locomotor Capability Index (LCI 5).

RESULTS

So far, we have included 8 participants in the study (87.5 % male; 63 ± 8 years; time since amputation 57 ± 117 months; 75 % using the Kenevo, 12.5 % using the Quattro, 12.5 % using the Plie).

With the Intuy Knee, results for the 6MWT show an improved distance of 11 ± 35 meters (8 %). The SAI improved by 0.5 points (4 %), and the HAI score improved by 1 point (9 %) both with the Intuy Knee. Advanced activities from the LCI 5 questionnaire improved by 4 ± 9 points (14 %).

Additionally, 62.5 % of the participants prefer the Intuy Knee over their former pMPK. 37.5 % did not prefer the Intuy Knee because of higher weight or no profits compared to their pMPK.

DISCUSSION AND CONCLUSION

The study indicates that the Intuy Knee (aMPK) improves functional outcomes, overall locomotor capability, suggesting that aMPKs can enhance mobility and quality of life.

Up to now, most participants prefer the Intuy Knee, but especially participants with lower mobility grades are bothered by the heavy weight of the pMPK. In the further course of this study we will evaluate the benefits for higher mobility levels and bilateral amputees.

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5.326 The effect of prosthetic foot and knee sophistication on patient-reported mobility outcomes after vascular lower limb amputation

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BACKGROUND

Clinical practice guidelines report insufficient evidence to guide patient-specific prosthetic prescription, with inadequate data to link component type to mobility and satisfaction. While there is increasing consensus regarding the benefits of greater prosthesis sophistication in persons with traumatic amputation, this agreement is lacking in those who have undergone amputation from vascular causes.

AIM

To determine if lower limb prosthesis (LLP) sophistication is associated with patient-reported mobility and/or mobility satisfaction, and if these differ by amputation level.

METHOD

This cohort study identified eligible participants through large U.S. Veteran's Affairs datasets, then prospectively collected patient reported mobility. Veterans who underwent an incident transtibial (TT) or transfemoral (TF) amputation due to diabetes and/or peripheral arterial disease and received a qualifying LLP were enrolled. The *PROClass* LLP sophistication system was used to assign each prosthetic foot/knee to one of three functional sophistication categories: basic, intermediate, or advanced.¹ Self-reported mobility was measured using the Locomotor Capabilities Index-5 *advanced mobility* subscale. Mobility satisfaction was based on a 0–10 point Likert scale. Multivariable regression estimated adjusted odds ratios (aORs), adjusted β ($a\beta$) coefficients and 95% confidence intervals (CI).

RESULTS

347 participants agreed to participate. On average, lower limb amputees who received *intermediate* and *advanced* prostheses were more likely to achieve *advanced* mobility and more likely to be satisfied with their mobility, Table. When controlling for potential confounding factors, those who received *advanced/intermediate* prostheses were more likely to achieve *advanced* mobility than those who received *basic* prostheses, with the association strongest and only significant in TF amputees, with over 10 times the odds (aOR = 10.2, 95% CI, 1.1 – 96.8). *Advanced/intermediate* prostheses were associated with greater mobility satisfaction compared to a *basic* prosthesis but was only significant in those who underwent a TT amputation ($a\beta$ = .79, 95% CI, .09 – 1.5).

Table. Outcomes by prosthesis sophistication category for satisfaction and advanced mobility (N=347). Results demonstrate that on average, lower limb amputees who are prescribed an intermediate or advanced prosthesis are more likely to achieve advanced levels of mobility and to be satisfied with their mobility 12 months after prosthesis prescription.

Variable	Basic (N=112)	Intermediate (N=177)	Advanced (N=58)	p-value
Advanced mobility, n (%) [*]	27 (24)	70 (40)	24 (41)	.02
Mobility satisfaction, mean ($\pm$ SD) ^{**}	5.4 (3.0)	6.3 (2.7)	6.1 (2.6)	.04

^{*}percentages based on column totals.

^{**}0-10 point Likert scale.

DISCUSSION AND CONCLUSION

Greater prosthesis sophistication is associated with better patient-reported mobility outcomes in both TT and TF amputees; however, the results are paradoxical. In TT amputees, greater sophistication is associated with higher levels of mobility satisfaction but not higher levels of mobility. In TF amputees, greater sophistication is associated with achieving higher levels of mobility but not higher levels of mobility satisfaction. Further research is needed to better understand the paradoxical relationship between mobility level and satisfaction with mobility in TT and TF amputees.

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5.327 Evaluating Short and Long-Term Effects of an Active Microprocessor-Controlled Knee on Mobility in Transfemoral Amputees: A Randomized Cross-Over Investigation

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BACKGROUND

Passive microprocessor-controlled prosthetic knees (MPKs) enhance mobility and safety for transfemoral amputees by using real-time sensor data to make instantaneous adjustments to optimize functionality, stability, and movements [1]. Active MPKs incorporate advanced robotics and sensors to offer powered assistance for walking, climbing stairs, standing up, reducing muscle effort, and improving symmetry [2]. This study is essential for understanding the short and long-term effectiveness, user satisfaction, and improvement areas of an active knee.

AIM

The objective was to evaluate the efficacy of an active MPK (A-MPK) compared to prescribed devices during daily activities, both short and long-term.

METHOD

The study was conducted in two clinics in the USA and involved three planned study visits, at two-week intervals, with an optional fourth visit for those wishing to retain the A-MPK longer. At the first visit, subjects completed baseline functional tests (6MWT, L-test, AMP-Pro) and questionnaires (PMQ, PLUS-M, Borg Scale, selected PEQ items) about their current prosthesis. During the second and third visits, subjects repeated the tests and questionnaires with either the A-MPK or their prescribed device, based on randomization. At the fourth visit, subjects completed the same tests and questionnaires with the A-MPK. Data were analyzed using mixed models (lmer) in R.

RESULTS

We assessed the performance of eleven users with MPKs and the A-MPK over a baseline period and after two weeks, with six users opting for an extended follow-up. In the short-term, the A-MPK demonstrated comparable or slightly improved outcomes over prescribed MPKs, with stable Borg scores and non-significant improvements in walking distance. The significant increase in L-test completion time indicated controlled descent and stability, and higher PLUS-M T-scores suggested better perceived mobility. In the long-term, as seen in the subset of six subjects, the A-MPK continued to show stable Borg Scale scores and 6MWT distance and consistent AMP-Pro scores, with non-significant improvements in PLUS-M and PMQ scores, reflecting increased mobility and satisfaction.

Table 1: Short and Long-Term Comparison of Functional Outcomes with the active MPK compared to prescribed MPK

	Short-term use (n=11)			Long-term use (n=6)	
	Baseline	After 2 weeks		Baseline	After 5-6 months
	Prescribed MPK mean (sd)	Prescribed MPK mean (sd)	Active MPK mean (sd)	Prescribed MPK mean (sd)	Active MPK mean (sd)
6MWT (meters)	369,2 (113,4)	377,2 (108,6)	381,7 (137,1)	381,5 (140,3)	393,1 (112,1)
Borg CR-10 (score 0)	3,4 (1,6)	3,1 (1,5)	3,4 (2,5)	3,3 (1,4)	3,2 (0,7)
L-test (seconds)	23,7 (8,2)	24,2 (9,4)	26,3* (11,9)	23,0 (10,0)	24,1 (10,8)
PLUS-M T-score	53,1 (9,1)	51,7 (10,2)	57,2* (7,9)	54,1 (8,3)	56,3 ^v (6,3)

*: Indicates a significant difference between the results with the active MPK compared to the prescribed knee after 2 weeks of use for the whole cohort (p-value < 0,05); ^v: Only 5 out of 6 users completed the PLUS-M questionnaire at the fourth visit

DISCUSSION AND CONCLUSION

One of the largest investigations on active prostheses showed potential benefits over prescribed MPKs, with improvements in satisfaction (PMQ) and significant self-reported mobility (PLUS-M), after two weeks. Sit to stand quality [3] compromised on L-test times initially, but returning to baseline by six months indicated successful adaptation. Despite the added weight, the 6MWT distances and Borg Scale scores were similar. Overall, the A-MPK demonstrated promising short and long-term benefits in mobility and user experience. Further research with a larger cohort over a longer follow-up is needed to validate these findings.



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ACKNOWLEDGEMENTS

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Free paper session | Device fabrication and design – Socket developments

5.331 A Comparison between Evidence-Generated Transtibial Sockets and Conventional CAD/CAM designs, from the Patient's Perspective

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BACKGROUND

There is considerable skill in personalised prosthetic socket design, which aims to balance a functional human-prosthesis coupling with comfortable and safe load transmission to soft tissues. Evidence-Generated (EG) sockets derived from past computer aided socket design (CAD/CAM) records, described previously [1], could provide a starting point for limb fitting, potentially reducing time spent on basic design and enabling prosthetists to focus on more highly-skilled customisation.

AIM

To compare evidence-generated sockets, derived from previous transtibial socket designs, to conventional clinician-led CAD/CAM (control) sockets.

METHOD

A crossover trial assessed non-inferiority of the EG technique for Socket Comfort Score (SCS) compared to clinician-CAD/CAM control sockets, and semi-structured interviews were conducted at fitting and one month later. The study was granted approval by Institutional (ERGO 76033.A3) and UK national review boards (IRAS 313408 / HRA REC 22/YH/0215). The protocol is published at clinicaltrials.gov/study/NCT06597266.

RESULTS

Seventeen people with 19 transtibial residual limbs were recruited, and socket designs were generated automatically using Bayesian inference to compare their residual limb shape and patient characteristics to a dataset of 163 previous transtibial socket designs [1]. Corresponding, clinician-designed control sockets took typically 10-30 minutes to rectify in TracerCAD software (Ohio Willowood Co., USA). All participants were successfully fit with both sockets. Evidence-generated sockets had no statistically-significant difference in SCS versus prosthetist control sockets ($p=0.38$, effect size=0.08), but a lower SCS variability across the 19 fitted sockets (95% C.I. 8.0-9.0 vs. 7.5-9.5, respectively).

Analysis of interviews revealed themes around fitting session experiences, similarities and differences between the EG and prosthetist control sockets, and residual limb factors impacting perceptions of socket comfort. These provided insights into the participants' experience of the study and the value of expert prosthetist input in socket design.

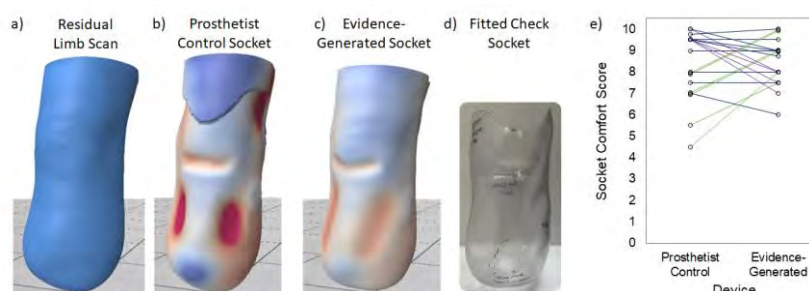


Figure 1. Sockets were designed based on a) residual limb scan by b) conventional CAD/CAM and c) analysis of retrospective expert clinician practice, and d) fabricated sockets were compared, in e) a crossover non-inferiority trial.



DISCUSSION AND CONCLUSION

Evidence-Generated sockets demonstrated noninferiority to conventional clinical computer aided design practice in terms of socket comfort. Both quantitative and qualitative results indicated how clinician input remains essential and is valued by prosthesis users. Work is underway to incorporate the evidence-generated sockets into computer aided design software such that they can act as a digital starting point for modification by expert clinicians at fitting, potentially reducing time spent on basic design, enabling prosthetists to focus on more highly-skilled customisation and co-design with their patients.

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5.332 Comparative Effectiveness of Casting Approaches for Individuals with Lower-Limb Amputation

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BACKGROUND

The conventional lower-limb prosthetic socket fabrication process consists of residual limb shape capture via a non-weightbearing negative wrap, plaster mold rectification, and check socket modifications. An alternative approach using a standing hydrostatic pressure cast is proposed to be simpler, relying less on manual cast manipulation, less rectification, and possibly less time to achieve a comfortable check socket.^[1] Hydrostatic pressure casting might also result in more consistent cast shape between prosthetists than hand casting.

AIM

To compare hand casting and standing hydrostatic pressure casting in persons with lower-limb amputation in terms of: 1) consistency in cast shape by different prosthetists; 2) time to cast, rectify, and modify a check socket; and 3) initial check socket comfort.

METHOD

With IRB approval, individuals with unilateral transtibial (TT) or transfemoral (TF) amputation were recruited across 3 sites. Participation required 3 visits: 1) enrollment, 2) casting, and 3) check socket fitting. Two prosthetists per site took 2 casts in random order: by hand (H) and using the Symphonie Aqua Casting System (Romedis, Germany) (S). One prosthetist per site rectified their casts and fabricated check sockets. Casting, rectification, and modification were timed using a stopwatch. The pre-rectified cast was digitized using the EINSscan (Shining3D, China).^[2] Check socket fit was assessed using the Socket Comfort Score before (initial) and after (final) prosthetist modification.^[3]

RESULTS

Results from 75 individuals (Table 1) illustrated that **initial** comfort was significantly better in the TF group for the hand cast socket. **Final** comfort was significantly better in the TT group for the hydrostatic cast socket. Total fabrication time for hydrostatic casting was significantly higher than hand casting. It took significantly **more time** to cast and significantly **less time** to rectify with hydrostatic casting. Time to modify the check socket was no different. Limits of agreement for cast volume and perimeters were wider for hydrostatic casting for both groups, suggesting hydrostatic casting was slightly less reproducible than hand casting.

		Group	Hand Cast	Symphonie Cast	p-value
Socket Comfort	Initial	TT (n=51)	6.3±2.5	7.0±1.7	0.050
		TF (n=24)	7.1±1.9	6.5±2.2	0.043
	Final	TT (n=51)	7.5±2.0	8.1±1.3	0.025
		TF (n=24)	7.8±1.7	7.4±1.7	0.154
Time (mins)	Total	All (n=75)	42.1±15.6	48.0±10.7	0.001
	Casting		10.6±5.5	23.7±6.1	<0.001
	Rectify		23.4±11.1	16.6±7.2	<0.001
	Modify		8.1±7.5	7.7±6.6	0.641

Table 1 Results for comfort and time (significance set at p=0.05).

DISCUSSION AND CONCLUSION

Hydrostatic casting took more time due to inclusion of a practice trial assessing participant's pressure tolerance. Overall, comfort differences were small. Adjusting the TT socket trimline improved final comfort of hydrostatic casting. Hydrostatic casting may have been less reproducible than hand casting due to variations in set-up of the Symphonie cylinder (e.g. choosing distal cup dimension or setting tower height differently). Furthermore, the speed



with which participants shifted their weight onto the residual limb during casting and the pressure maintained may alter cast shape.

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5.333 Workflow for a 3DPrinted Transtibial Socket Insert

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BACKGROUND

People with lower limb amputations often require multiple prosthetic sockets within the first year to accommodate changes in residual limb volume and shape. Digital manufacturing technologies offer promising solutions to streamline this process. This research developed and evaluated a novel transtibial prosthesis insert that provides an appropriate inner socket shape without the need to manufacture an entirely new socket.

Develop and evaluate a 3DPrinted transtibial prosthetic socket insert.

METHOD

The prosthetist uses CAD to create 2 files: current socket inner shape and desired new socket shape. 3DSlicer¹ opensource software is used to digitally align the 2 shapes, fill the shapes to create solid models, and subtract the shapes from each other to create a 3D insert model that conforms to the original socket's inner surface while matching the new limb shape internally. Slicer3D is also used to digitally trim excess material and create a hole at the bottom of the model for the attachment pin. Fusion360 software is used to smooth the model for 3D printing. Material tests, load testing², and a pilot user trial were completed.

RESULTS

Following testing, Ninjatek Cheetah TPU was selected as the most appropriate material. The printing parameters were cubic print pattern and 35% infill. The results from mechanical testing indicated that the insert is robust for use in daily activities. The insert was shown to withstand proof and ultimate loads without failing, as described in the ISO 10328 protocol, with a maximum compression of 20mm in the toe configuration. Furthermore, the insert also successfully withstood cyclic testing for 1,000,000 cycles, as described in the ISO 10328 protocol. The prosthesis user trial showed that the insert can accommodate residual limb volume change and does not compromise on comfort and fit.

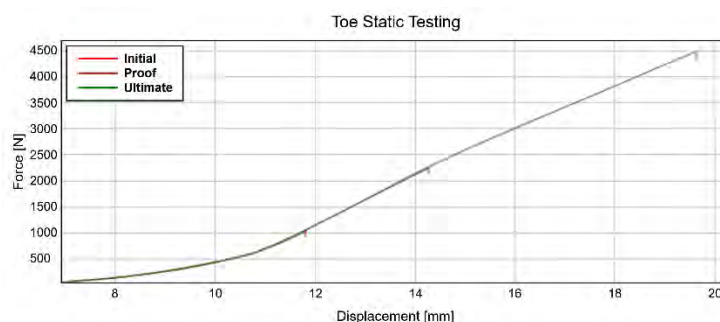


Figure 1. Toe Static Testing Results

DISCUSSION AND CONCLUSION

This new approach offers an alternative to manufacturing a new socket, which saves time and costs for the end-user, prosthetist, and the health care system.

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5.334 AOPA Socket Guidance Workgroup: the road to a set of mock limb shapes

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BACKGROUND

Despite the central role of prosthetic sockets in comfort and function, no standards or common guidelines exist to test their structural strength, either in ultimate failure load or in fatigue durability [1]. To address this issue, the American Orthotic and Prosthetic Association (AOPA) Socket Guidance Workgroup (SGW) identified knowledge gaps in 4 domains among which the shape and composition of a “mock residual limb”, required to generate in vivo representative loading within the socket [2].

AIM

The aim of this work was to design a set of socket-structure-critical transtibial mock limb shapes through expert consensus and Statistical Shape Model (SSM) analysis.

METHOD

A survey was submitted to prosthetists to gather their opinion on the critical shapes and dimensions of transtibial residual limbs from the socket mechanical strength standpoint. Responses were used as starting point of a Consensus Meeting of the AOPA SGW to determine the minimum set of critical shapes. The critical dimensions for circumferences and length were used as targets to generate digital meshes of the set of shapes applying SSM techniques [3] to a dataset of 202 transtibial residual limb scans. The resulting meshes were post-processed to remove distal bulbosities or undercuts. In a second survey, the shapes and dimensions were presented to the prosthetists and asked if they could be accepted as the expected critical shapes and dimensions.

RESULTS

Forty responses to the survey were collected describing 46 different shapes. During the Consensus Meeting, experts established that these could be reduced to three critical shapes, i.e. long, slender/conical; long, bulky/cylindrical and short bulky/cylindrical, with the critical dimensions reported as “target” in Figure 1. The resulting SSM-generated meshes are depicted in Figure 1 together with their corresponding dimensions. In the second survey, prosthetists were asked whether they agreed that each of the measurements obtained was critical. In the worst case (concerning the distal perimeter of the long, cylindrical/bulky shape), 32/36 prosthetists (89%) agreed that the measurement obtained could be considered critical for the mechanical strength of a prosthetic socket.

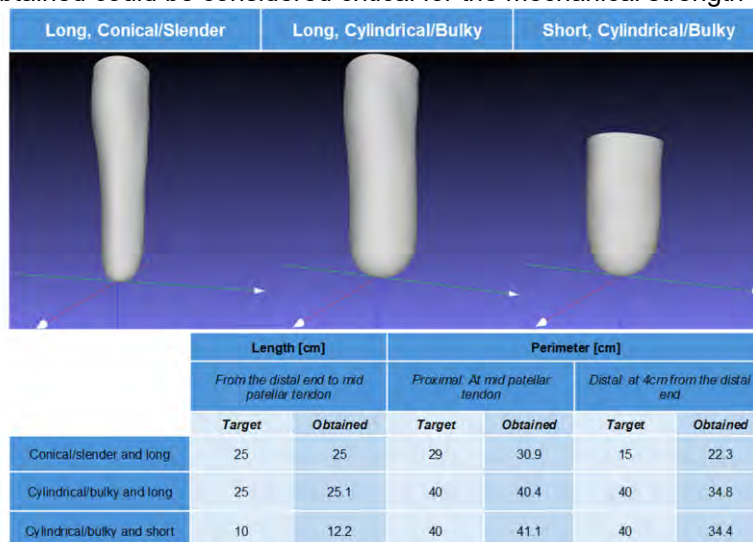


Figure 1. Results of SSM. Top: the 3 critical meshes obtained through SSM; bottom: the “target” and the “obtained” dimensions considering length from distal end to mid patellar tendon, and perimeter at mid patellar tendon and at 4cm from the distal end.



DISCUSSION AND CONCLUSION

By means of a four-step process consisting of two surveys, a Consensus Meeting, and the application of SSM on a large dataset of limbs with transtibial amputation, we were able to define three meshes with critical shapes and dimensions that will be used to fabricate mock limbs for socket testing. Structural analysis and bench tests will be carried out in the future to confirm the experts' opinions.

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5.335 Comparisons of (cost-)effectiveness of manual, hybrid, and digital shape capture and shape design techniques for lower-limb prosthetic sockets

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BACKGROUND

Advances in shape capture and socket design for prosthetic lower limbs have introduced digital and hybrid methods, yet limited data exist comparing their (cost-)effectiveness with traditional manual techniques.

AIM

This scoping review provides an overview of studies comparing the (cost-)effectiveness of shape capture and socket design techniques for transtibial and transfemoral prostheses, comparing manual, hybrid, and digital methods, and identifying the measurement tools used.

METHOD

Following PRISMA guidelines, five databases (PubMed, Embase, Web of Science, CINAHL, and Cochrane) were systematically searched. Eligibility criteria included studies involving humans with transtibial or transfemoral prosthetic sockets that compared at least two of the three techniques and measured (cost-)effectiveness. Quality was assessed using the Effective Public Health Practice Project Quality Assessment tool. Shape capture techniques were classified as not, semi-, or fully standardized. The International Classification of Functioning, Disability and Health (ICF) domains were utilized to categorize measurement tools.

RESULTS

A total of 556 studies yielded 20 eligible studies, involving 497 patients aged 5 to 81, predominantly using transtibial prostheses. Figure 1 gives a classified overview of the used hybrid and digital residual limb shape capture and socket shape design techniques. Manual and hybrid methods were compared in fourteen studies, and digital and manual methods in six. None compared hybrid and digital methods. Quality assessment rated eighteen studies as “low”, two as “moderate”, and none as “high”. Effectiveness constructs covered ICF domains “Body functions & Body structures” and “Activities and participation”, but most were not defined by the ICF. Cost-effectiveness was approximated using procedure time and socket attempts.

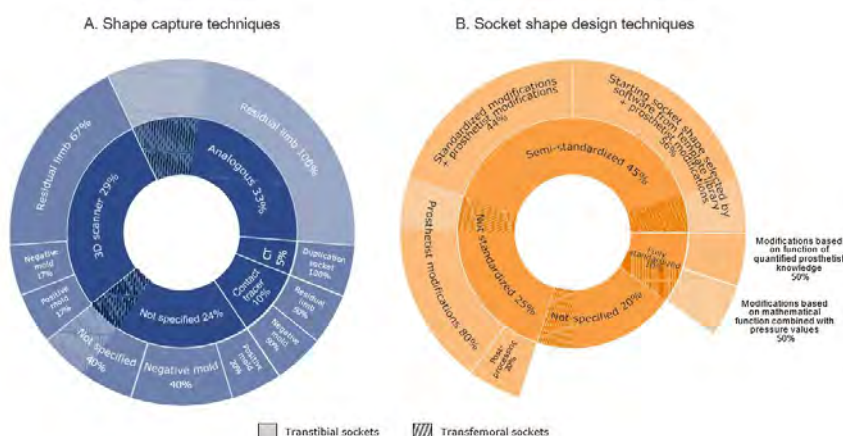


Figure 1. Overview of classification of hybrid and digital residual limb shape capture and socket shape design techniques. A) The inner ring represents major shape capture categories; the outer ring specifies the particular aspects or elements that are captured within each method.

B) The inner ring categorizes major socket shape design categories based on different levels of standardization, the outer ring specifies design techniques employed within each standardization level. Percentages reflect the distribution of studies across these categories.

DISCUSSION AND CONCLUSION

This review highlights a lack of comparative studies on (cost-)effectiveness, particularly between digital and hybrid methods. Standardized, robust evaluations across all ICF domains are needed to assess the value of emerging technologies in clinical practice.



5.336 Evaluating Artificial Intelligence Algorithms for the Standardization of Transtibial Prosthetic Socket Shape Design

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BACKGROUND

The increasing use of digital design of prosthetics comes with numerous benefits. However, the quality of the socket shape is still subject to the experience and expertise of a prosthetist. This study continues on a pilot that used artificial intelligence (AI) to standardize the transtibial socket shape design ^[1].

AIM

This study compares the outcomes of different AI algorithms that predict the shape of a prosthetic socket based on existing prosthetic socket shape designs.

METHOD

Data from 118 patients were collected by experienced Dutch prosthetists, consisting of a three-dimensional (3D) scan of the residual limb and a corresponding 3D model of the prosthetist-designed socket. Several pre-processing steps were applied to prepare and align the 3D data. Afterwards, three different algorithms (3D Neural Network, General Neural Network, Random Forest) were developed to either predict 1) the final socket shape or 2) the adaptations performed by a prosthetist to predict the socket shape based on the 3D scan of the residual limb. For all algorithms, 80% of the data was used for training and 20% for evaluation. Each algorithm's performance was evaluated by comparing the prosthetist-designed socket shape design with the AI-generated socket shape design using two metrics. First, we measured the Euclidean distance at a set of points to compare the AI-generated socket with the prosthetist-designed socket. Second, the surface-to-surface distance was used to assess the overall surface error between the AI-generated socket and the prosthetist-designed socket.

RESULTS

Table 1 shows the preliminary results for the three algorithms. For all algorithms, predicting the required adaptations yields better results than directly predicting the socket shape. The General Neural Network shows the most promising results with a median Euclidean distance of 1.59 mm and a surface-to-surface distance of 1.24 mm.

Algorithm	Euclidean distance (mm)				Surface-to-surface distance (mm)			
	Socket		Adaptations		Socket		Adaptations	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
3D Neural Network	10.05	4.25	1.81	0.60	7.43	3.26	1.25	0.57
General Neural Network	9.12	5.12	1.59	0.53	7.03	3.69	1.24	0.29
Random Forest	6.04	2.43	1.64	0.75	4.77	2.61	1.24	0.56

Figure 1: The median and interquartile range (IQR) for the Euclidean and surface-to-surface distances on the evaluation data.

DISCUSSION AND CONCLUSION

All algorithms predicting the adaptations outperformed earlier work ^[1]. Future research will focus on collecting more data, including measurement/socket/patient characteristics, performance feedback and additional shape modifications after initial provision.

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5.337 Towards Socket Testing Standardization: Advancing Mock Residual Limbs for 6DOF Gait Simulation

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BACKGROUND

The American Orthotic and Prosthetic Association Guidance (AOPAG) Workgroup identified a key knowledge gap in the structural testing methods for prosthetic sockets. Mock residual limb (MRL) shape and composition present specific challenges. As a result, a wide array of materials and processes for mechanical testing of new socket technologies have been proposed with little consensus ^[1]. Therein lies a need for standardized testing methods considering MRL fabrication simplicity and durability, while simulating cyclic gait kinetics to verify new socket technologies prior to clinical trials ^[1]. Previous work conducted by our lab on MRL fabrication laid the groundwork for the current project ^[2].

AIM

This research aims to develop a mechanical testing setup enabling efficient iterative design of socket technologies prior to user involvement, increasing the quality of products that reach end-user testing.

METHOD

We fabricated a transtibial MRL based on prior work ^[2], comprising of a 3D printed flexible polymer 'skin' (shore value 30), expansion foam mimicking soft tissue (50/50 hardener), and steel threaded rod as a proxy for bone. A commercially available six degree of freedom (6DOF) joint simulator (AMTI Vivo) capable of simulating gait movements and body weight loading was used for testing. The MRL was attached via threaded rod proximally, and a custom aluminium plate to mount the socket distally, allowing free movement of the MRL in the socket (Figure 1). Preliminary testing examined dynamic compression of the MRL to determine baseline loading tolerances and behaviour.

RESULTS

Displacement driven dynamic loading of the MRL in the socket generated ~1600N of compression occurring at ~37mm of vertical displacement. Previous static compressive loading through stacked weights only tested up to ~178N ^[2]. Designing the MRL for the Vivo setup enabled an ~800% increase in loading and introduced dynamic loading, dramatically expanding on the possible bench testing scenarios.

DISCUSSION AND CONCLUSION

The ~1600N dynamic loading exhibited by the proposed MRL demonstrated potential to withstand and react to maximum gait loading, particularly following heel strike at ~1.3 times bodyweight loading (~2kN) ^[3]. Further investigation into material compositions and behaviour of the MRL, followed by 6DOF gait movements, loading conditions, and integration of socket technologies are planned. With new socket innovations being released, the proposed bench testing method will contribute to advancing rigorous, standardized methods, reducing the need for user involvement in development stages.

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Figure 1. Vivo setup with movement axes



Free paper session | Outcome measurements – Patient reported outcomes

5.341 Cultural adaptation and validation of the Prosthesis Evaluation Questionnaire – Dutch Language Version in lower limb prosthesis users

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BACKGROUND

Using a lower limb prosthesis affects daily activities and quality of life.¹ Patient Reported Outcome Measures (PROMs) are measurement tools that can provide information about a patient's health status and daily functioning. They can be used to evaluate effects of interventions, increasing importance of these questionnaires in the current healthcare systems.² Currently there are no validated PROMs on prosthesis use available in Dutch.

AIM

To translate the Prosthesis Evaluation Questionnaire (PEQ), culturally adapt and validate the Dutch language version (DLV) in adult lower limb prosthesis users.

METHOD

Translation: the PEQ was translated from English into Dutch using a process of two independent forward translations, back-translations, cultural adaptation, consensus meetings and pilot testing on thirty adult lower limb prosthesis users.

Validation: at baseline (T0), adult lower limb prosthesis users filled out a digital version of the PEQ-DLV and RAND-36. After completion of baseline measurements, they received the PEQ-DLV again after two weeks (T1) and three months (T2). The analyses consisted of determining internal consistency, floor/ceiling effects, test-retest reliability using intraclass correlation and measuring construct validity by testing hypotheses using Spearman correlation test in case of non-normal distributed data.

RESULTS

Eighty-one (52M/29F) participants, with a mean age of 62 (SD=11,54) completed all questionnaires at T0. Cronbach's α for internal consistency was >0.7 in all subscales of the PEQ, except for subscale 'Appearance' (0,63). A ceiling effect was found in subscale 'Frustration' (16%). No floor effects were found. The intraclass correlation coefficients (ICCs) for test-retest reliability were considered good in subscales 'Ambulation', 'Appearance', 'Frustration', 'Residual limb health', 'Social burden', 'Sounds', 'Utility', 'Well-being' and 'Concentration' (range 0,72-0,86) and moderate in subscales 'Perceived response', 'Confidence' and 'Safety' (range 0,59-0,68). Spearman correlation coefficients of at least 0.4 were found between all compared subscales of the PEQ-DLV and RAND-36, except for 'Bodily pain' ($r=0,26$). Seven of the eight (87,5%) previously formulated hypotheses were therefore accepted, which means that the construct validity is considered good.

DISCUSSION AND CONCLUSION

The results show sufficient internal consistency, test-retest reliability and construct validity of the PEQ-DLV. Limitations of this study include less than anticipated number of participants and possibly fewer responses from less digitally skilled people by using digital questionnaires. There was an adequate variation in general characteristics within the study population, representing the amputation population. In conclusion the PEQ-DLV is validated and can be used among prosthesis users in the Netherlands.

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5.342 Validity and reliability of four patient-reported outcome measures for lower limb orthosis users

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BACKGROUND

Clinicians and researchers can use standardized outcome measures to evaluate the effects of rehabilitation interventions, including lower limb orthoses (LLOs). Patient-reported outcome measures (PROMs) are particularly useful for understanding how orthoses affect an individual's mobility at home and in their community. PROMs have been used in research studies to evaluate lower limb orthosis users,¹⁻⁴ but their validity and reliability in this clinical population have not been thoroughly studied.

AIM

The goal of this research was to assess the construct validity and test-retest reliability of four survey instruments used previously to evaluate the mobility of lower limb orthosis users.

METHOD

Adults with at least one month of experience using a lower limb orthosis were recruited from clinics across the U.S. PROMs included the Orthotic Patient-Reported Outcomes–Mobility (OPRO-M) 20-item Short Form,¹ PROMIS–Physical Function (PROMIS-PF) 20-item Short Form,² Orthotic and Prosthetic User's Survey–Lower Extremity Functional Status (OPUS-LEFS),³ and Lower Extremity Functional Scale (LEFS).⁴ Performance tests included the Timed Up and Go, 10 Meter Walk, and Two Minute Walk Tests. Participants were classified into four mobility groups, administered PROMs and performance tests at an initial visit, and then administered the PROMs 7 to 14 days later. Validity was assessed using Spearman correlations (r). Reliability was assessed by calculating intraclass correlation coefficients (ICCs). Smallest detectable change (SDC) values were calculated based on ICCs and z-scores.

RESULTS

The study was completed by 104 participants (mean age=53 years). Most participants used an ankle-foot orthosis ($n=94$), and the most frequently reported health conditions were stroke ($n=15$), spinal cord injury ($n=10$), and peripheral neuropathy ($n=9$). Correlations between the PROMs and performance tests were moderate-to-strong (Figure 1). ICCs exceeded 0.92 for all PROMs. SDC (90% confidence interval) values were 4.9 points for PROMIS-PF, 6.5 points for OPRO-M, 7.3 points for OPUS-LEFS, and 12.7 points for LEFS.

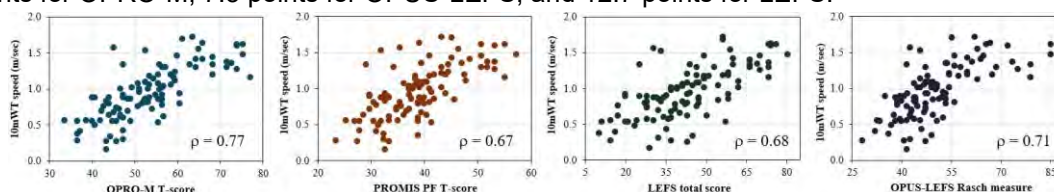


Figure 1. 10 Meter Walk Test (10mWT) speed was strongly correlated with scores from OPRO-M and OPUS-LEFS, and moderately correlated with scores from PROMIS-PF and LEFS.

DISCUSSION AND CONCLUSION

Correlations between the PROMs and performance tests provide evidence of convergent validity, confirming that all four PROMs measure aspects of mobility. ICCs above 0.9 indicate evidence of test-retest reliability, indicating these PROMs can be used for individual-level assessment. SDC values provide thresholds for evaluating changes in scores not attributed to error. Collectively, these results provide evidence of validity and reliability in lower limb orthosis users for all four PROMs included in this study.



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5.343 Validity and Reliability of the Arabic Version of the Locomotor Capabilities Index in Adults with Lower Limb Amputation: Cross-cultural study

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BACKGROUND

Amputations can have significant negative impacts on an individual's economic status, psychological health, and social life. The Locomotor Capabilities Index (LCI) measures how well people with lower-limb amputation can use prostheses to carry out activities. The validity and reliability of the Arabic version of the LCI were assessed in this article.

AIM

To evaluate the outcome of Locomoter capabilities index of the Arabic version of the patients with Lower limb amputation.

METHOD

The English Locomotor Capabilities Index had to be translated both forward and backward for cross-cultural adaptation to Arabic (LCI). The subsequent Arabic (SAUDI) LCI was then administered to 57 patients with amputation; 13 of them were women with a mean age of 53 years (ranging from 29 to 71) whilst 44 were men with a mean age of 55 years (ranging between 20 and 85 years). All patients were trained in the Al Nour Rehabilitation training center – in Mecca -KSA. The validity and reliability of the Arabic LCI were evaluated through several measures. In two different subgroups of 20 and 30 amputation patients, the Arabic LCI was compared to the Up-and-Go test (TUG) and the Index of EQ-5D Health Utility to assess its structural validity. Scores from various age groups were compared to determine the discrimination value. Thirty individuals with amputations underwent test-retest reliability (7–14 day) evaluations.

RESULTS

The Arabic LCI demonstrated good converging structure validity, exhibiting a strong correlation with TUG ($r=0.79$, 95%CI-0.9-0.60) and EQ-5D ($r=0.81$, 95%CI 0.61-0.92), as well as discriminatory effect, with mean scores for older amputees significantly lower than for younger amputees ($p < 0.05$) and high internal consistency (Cronbach alpha 0.93 (IC 95 % 0.91-0.94). Test-retest reliability for unilateral amputees had an intraclass correlation coefficient of 0.93. (95 percent CI 0.83-0.92). 17.5 percent of the cases involved the ceiling effect. The ceiling effect occurred in 17.5% of the cases.

DISCUSSION AND CONCLUSION

The Arabic version of the LCI has shown strong internal consistency and validity in adults with amputation. Test-retest reliability analysis in a smaller sample was appropriate. Further to the existing research, amputees with low to moderate functional abilities could benefit from future research considering Test-retest reliability seems to be acceptable in a small subsample.

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5.344 Swedish versions of the Prosthesis Evaluation Questionnaire's subscales: Residual Limb Health score and Utility score – translation and reliability analyses

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BACKGROUND

In lower limb prosthetic treatment ISPO has recommended outcome measures for routine clinical use, ⁽¹⁾ which include two sub-scores from the Prosthesis Evaluation Questionnaire (PEQ) – Residual Limb Health (RL) and Utility (UT) ⁽²⁾. In the original publication answers are given on a visual analogue scale (VAS) 0-10, but later versions have converted responses to Likert scale alternatives. No Swedish versions are available for these scores.

AIM

To translate the PEQ RL and UT scores to Swedish, to convert answers to a Likert scale and to test the versions on Swedish lower limb prosthetic users.

METHOD

The study involved forward-backward translation, transformation to Likert scale (0-10) responses, focus-group interviews and a large-scale test including test-retest assessment. The translation was performed by clinicians experienced in the target population. Two focus-groups, each with 4-6 prosthetic users, were performed before consensus on the Swedish versions were reached. Recruitment for the full-scale test was through prosthetic workshops and social media. Inclusion criteria for participation were to have a unilateral major amputation, be a prosthetic user for at least 6 months and to be ≥ 18 years. Descriptive statistics and reliability analysis were conducted. The study was ethical approved.

RESULTS

Test of the Swedish versions included 101 prosthetic users (43 women/58 men, mean age 64 years (SD 15); amputation cause: 40% trauma, 26% vascular/diabetes, 14% tumour, 20% other causes; amputation level 58% TTA, 42% KD/TFA). The majority (55%) had amputation since >5 years.

The mean results for the scores were RL 7.9 (SD 1.8) and UT 7.4 (SD 2.0). No floor or ceiling effects were detected. Internal consistency was for RL 0.755 and UT 0.911.

The test-retest analysis included 53 participants who answering the same questions a second time (approximately 4 weeks apart) and with no important change in prosthetic use between time-points. Results showed no statistically significant change of mean scores between test and retest. The intra-class correlation was RL 0.81 and UT 0.74, and the minimal detectable change was for RL 2.1 and for UT 2.2

DISCUSSION AND CONCLUSION

In the absence of an appropriate Swedish gold-standard measure for analyses of residual limb health and prosthetic utility, validation analyses were not possible. The descriptive results are in line with previous literature and the Swedish versions of RL and UT sub-scores show adequate statistical properties. The test-retest results showed that a change of > 2 score-points are needed to show a difference beyond measurement error when using these scales in Sweden.

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5.345 Prosthetic Limb Users Survey of Attention (PLUS-A): Calibration and Initial Validation for a measure of Lower Limb Prosthetic Attention

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BACKGROUND

Use of patient-report outcome measures (PROMs) is recognized as an important element in clinical practice and in research.¹ While a number of instruments exist for measuring a prosthesis user's ability to perform various activities, there are none available to measure the degree to which a user attends to (i.e., thinks about or pays attention to) their prosthesis while using it during activity.

AIM

The aim of this study was to calibrate and assess the construct validity of the Prosthetic Limb Users Survey of Attention (PLUS-A), an item bank developed to measure prosthetic attention.

METHOD

Candidate items designed to measure prosthetic attention, demographic questions, and several existing surveys measuring similar constructs (e.g., mobility) were administered online to a large, national sample of prosthesis users. Rigorous analytic methods were used in selecting items for the PLUS-A item bank that calibrated to an item response theory (IRT) model.² Scores for PLUS-A and existing measures were compared using Spearman rank correlation coefficients to assess convergent validity. Groups of participants believed to have different levels of the attention trait were compared using 1-way ANOVAs with Tukey post-hoc pairwise comparisons to assess known groups validity.

RESULTS

Data from 1094 survey respondents were used for analysis. All items were unidimensional, indicating they measured a single construct. Sixteen items were locally dependent and were subsequently removed. Three items exhibited differential item functioning, but it had a negligible effect on scoring. Ultimately, 42 of the 58 candidate items were successfully calibrated and retained in the final PLUS-A item bank. Comparisons between PLUS-A and existing surveys showed expected correlations (Table 1). PLUS-A scores also differed significantly between groups expected to have different levels of attention (e.g., those with vs. those without a history of injurious falls, those with <2 vs. those >5 years since amputation, those with below-knee vs. those with above-knee amputation, and those <50 and those >65 years old).

Table 1. Spearman correlations (all $p < .05$) between PLUS-A and existing surveys

Survey instrument	ρ	Interpretation
Prosthetic Limb Users Survey of Mobility (PLUS-M)	-.86*	Strong
Activities-specific Balance Confidence Scale (ABC)	-.79*	Strong
PROMIS Ability to Participate in Social Roles and Activities (APSRA)	-.56*	Moderate
PROMIS Pain Interference (PI)	.42*	Moderate
Expanded Socket Comfort Score (ESCS) Average	-.26*	Low
Multidimensional Assessment of Interoceptive Awareness (MAIA)	-.24*	Low

DISCUSSION AND CONCLUSION

This study presents a newly developed PROM for measuring prosthetic attention. Results provide convincing evidence of convergent construct validity and known groups construct validity. PLUS-A is a promising instrument for measuring prosthetic attention, but additional studies are needed to test other psychometric properties (e.g., test-retest reliability).

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ACKNOWLEDGEMENTS

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5.346 PLUS-M T-score Maps: Response Probabilities of PLUS-M Scores for Individuals with Lower Limb Amputation

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BACKGROUND

For individuals with lower limb amputation, improving mobility is a primary goal of rehabilitation. Increased mobility is associated with many aspects of well-being, including quality of life and satisfaction [1]. However, it is currently unclear how to change a patient's mobility after amputation. Where should care be focused to produce a meaningful improvement?

The Prosthetic Limb Users Survey – Mobility (PLUS-M) is a self-report survey created to measure prosthetic mobility [2]. A T-score map, similar to those made for various PROMIS measures [3] can help clinicians to guide clinical decision-making. Therefore, creating T-score maps for the PLUS-M can further help clinicians and patients target the next steps in rehabilitation care.

AIM

The aim of this study is to determine response probabilities of PLUS-M to generate PLUS-M T-score maps.

METHOD

The PLUS-M T-score maps were built using a training dataset (N=28,719) of patient outcomes collected in private prosthetic clinics across the United States. A Frequency Response Method (FRM) was used to calculate the most likely response. These responses were then “mapped” to a T-score. PLUS-M T-score maps were generated for two amputation levels (above and below-knee) and two etiologies (dysvascular and non-dysvascular), in addition to one for all patients. The maps were then tested using a separate test dataset (N=26,535). Accuracy was evaluated by comparing differences and Spearman correlation coefficients (SCC) between predicted and actual scores.

RESULTS

To use the T-score maps (Figure 1), the clinician draws a vertical line up from the individual's T-score located on the horizontal axis. The vertical line intersects the most probable response to each item in the PLUS-M 12-item short form. Specific answers are coded according to the colors noted in the figure legend.

On average, accuracy of the T-score map predictions was high (>91.5%) meaning a vast majority of the predicted responses were within ± 1 response option of the test dataset patients' true responses. There was also a strong correlation between the predicted and actual responses (SCC >0.801).

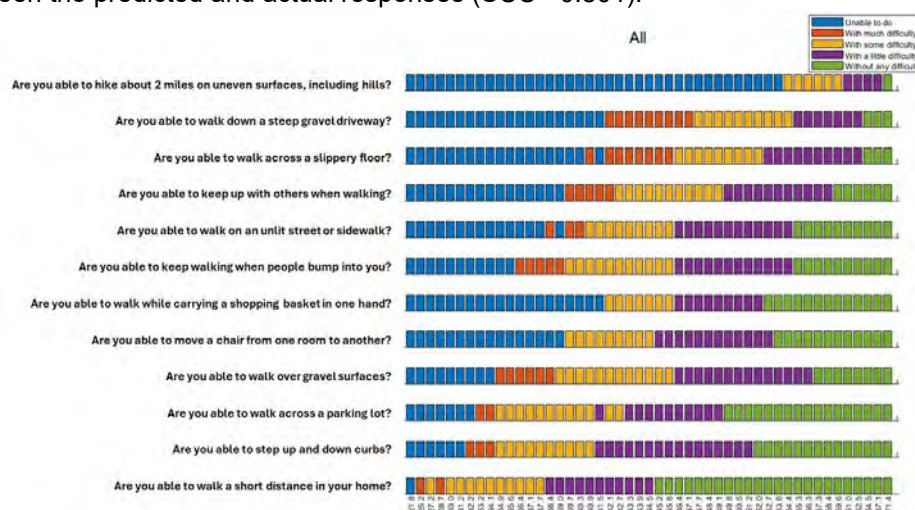


Figure 1: PLUS-M T-score map for all amputation levels and etiologies.

DISCUSSION AND CONCLUSION



This study provided multiple population-specific T-score maps based on patient characteristics such as amputation level and etiology. The resulting T-score maps have high accuracy and demonstrate promise as a new clinical tool. Clinicians can use these T-score maps to contextualize PLUS-M T-scores, understand changes in PLUS-M T-scores, and guide selection of interventions designed to improve patient outcomes.

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5.347 Expanding the Prosthetic Limb Users Survey (PLUS) system to measure fall-related health outcomes

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BACKGROUND

Falls are common, injurious, costly, and socially-isolating events, particularly among people with lower limb amputation.¹ Falls can also lead to adverse affective, behavioral, and cognitive outcomes. Although patient-reported outcome measures (PROMs) exist to measure some fall-related outcomes, they have methodological, conceptual, and psychometric limitations that make them less suitable for this population. Expanding the Prosthetic Limb Users Survey (PLUS) with new item banks could address these issues and improve our ability to measure fall-related health outcomes in this at-risk group.

AIM

The goal of this study was to develop new PLUS item banks to measure fall-related health outcomes in people with lower limb amputation.

METHOD

Rigorous methods, used previously to develop patient-reported outcome measures,^{2,3} were employed to create item banks for measuring fall-related health outcomes. Domains (constructs) and items (questions) were inspired by focus groups with 37 prosthesis users.⁴ Items were also sourced from literature review and content experts. Items, instructions, and response options were tested in cognitive interviews with 51 target respondents. Candidate items were administered in a cross-sectional study of more than 1000 lower limb prosthesis users. Item response theory (IRT) was used to calibrate the item banks. Results were compared to existing PROMs using Spearman correlations to assess evidence of convergent validity. ANOVAs and post-hoc tests were used to evaluate known groups validity.

RESULTS

A total of 1270 candidate items were created to measure four distinct fall-related health domains: self-efficacy, anxiety, avoidance behaviors, and interference. 335 items were selected and tested via cognitive interviews, and 292 items were deemed suitable for large-scale administration. Unidimensional and locally-independent items that functioned without bias due to age, gender, race, etiology, level of amputation, and fall history were identified for each domain (n=31, 24, 40, and 31, respectively) and calibrated to an IRT model. Three fixed-length short forms and a computerized adaptive test were developed for each domain. Domain scores correlated expectedly ($r>0.7$) and significantly ($p<.0001$) with existing PROMs. Scores also differed expectedly across known groups (Figure 1).

Table 1. Results of known groups testing show all four of the new PROMs differentiate respondents based on their reported fear of falling.

Fall-related health domain (reference sample size)	Fear of falling groups					Significant differences between groups ($p<.0001$)
	group 1 (not at all)	group 2 (a little bit)	group 3 (somewhat)	group 4 (quite a bit)	group 5 (very much)	
Anxiety (n=1001)	39.2 (7.4)	46.4 (6.3)	51.2 (6.6)	56.7 (7.3)	60.7 (7.7)	1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5
Avoidance Behaviors (n=1029)	38.9 (9.2)	46.7 (7.0)	52.1 (7.1)	55.5 (6.8)	59.6 (7.3)	1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5
Interference (n=1028)	38.2 (7.8)	45.8 (6.9)	51.4 (6.9)	55.5 (6.7)	59.5 (7.4)	1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5, 4-5
Self-efficacy (n=1002)	60.8 (8.2)	52.9 (7.6)	47.5 (6.7)	43.7 (7.1)	41.3 (7.5)	1-2, 1-3, 1-4, 1-5, 2-3, 2-4, 2-5, 3-4, 3-5



DISCUSSION AND CONCLUSION

This study produced four new PROMs for assessing fall-related health. They are brief, reliable, and exhibit evidence of construct validity. They were each developed based on experiences of lower limb prosthesis users, address issues present in existing instruments, and are referenced to a large population of people with lower limb amputation. Additional psychometric testing is ongoing, but these instruments can now be used in research and clinical practice to measure fall-related health outcomes.

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ACKNOWLEDGEMENTS

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Free paper session | Education – Service and clinical education

5.351 Grading, Assessment, and Competency: Transitioning from School to Practice

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BACKGROUND

Assessment methods in educational settings often do not align with those in clinical practice. Emphasis on grades during the academic portion of training can create barriers to learning and readiness for clinical practice. Alternative assessment methods can reduce the psychological and emotional burden on students while supporting the development of competency. Assessing competency more effectively prepares trainees for higher performance in clinical settings following completion of an academic training program.

AIM

To review the history of grading, discuss the impact of grading on student emotions and motivation, describe alternative assessment methods, and suggest practical solutions for designing learning activities to support the development of competency.

METHOD

This presentation will include:

- An overview of research related to the history of grading and the impact of grading on student performance and motivation
- Descriptions of alternative assessment methods, including contract grading, specifications grading, and ungrading
- Specific examples of learning activities and assessment methods that have been implemented in NUPOC's MPO program

RESULTS

Assessment methods impact student performance and can reduce or increase student motivation and engagement. Research related to these effects demonstrates the negative impacts of high-stakes assessment. Student feedback on the impact of alternative assessment methods in the NUPOC MPO program will be presented. The effect of alternative grading on faculty time will be described.

DISCUSSION AND CONCLUSION

Educators in academic clinical programs strive to effectively prepare students to transition to clinical practice roles. The performance of trainees and novice clinicians is assessed differently in clinical practice than in most educational settings. Understanding the impact of different assessment methods allows clinical educators to more effectively support the development of competency and better prepare students for independent clinical practice.

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5.352 Teaching and Assessment Methods to Increase Student Engagement and Performance in an Online Course

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BACKGROUND

Online education can be reduced to a 'plug and play' experience in which students watch a recorded lecture, comment on a discussion board, and complete online assessments. However, research shows that student/faculty and student/student interaction, combined with low stakes formative assessments, improves learning and retention. The more engaged a student is in the learning process, the greater their academic success.

AIM

Evaluate an online course at Northwestern University's MPO program. Universal Design for Learning principles, improved digital accessibility and new assignments were incorporated and evaluated. Quantitative data in the Course Management System (Canvas) and the video platform (Panopto) were compared to determine if student interaction and performance increased.

METHOD

A mixed methods research approach was used by collecting both quantitative and qualitative data. These results were compared between students to determine the level of student interaction, engagement, and performance in the course. In addition, student feedback and reflections were collected to determine how the new features of the course contributed to student perceptions of learning.

User analytics were downloaded and analyzed to evaluate differences in student interaction and engagement, including how much time students spent in Canvas, how many times they visited the Home Page, and how much time each student spent watching a lecture in Panopto (if at all). Data sets were compared to see if students who spent more time in Canvas also spent more time watching videos in Panopto. Engagement online in both Canvas and Panopto was compared to student performance in the class. Feedback provided in the learning diaries was evaluated.

RESULTS

Quantitative data proved to be inconclusive due to the many variables that need to be considered in the analytical data from Canvas and Panopto. Quantitative data is shown in Figure 1.

The qualitative feedback from students proved to be more useful. The Learning Diaries provided valuable student feedback on how they felt they best learned the material. For example, 100% of students felt quizzes embedded into Panopto were helpful in their learning. Most students found the weekly introduction videos kept them more engaged with the course. Students with accommodations found the improved accessibility features within Canvas improved their learning experience.

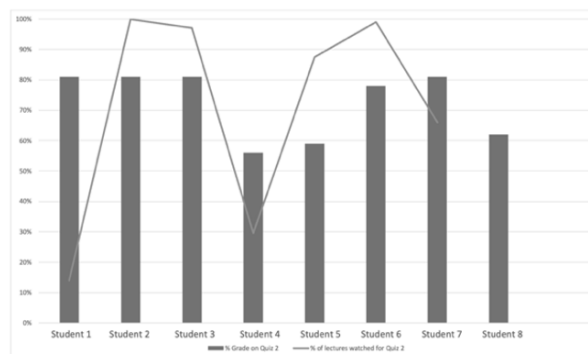


Figure 1. Percentage of time spent watching the lectures compared to the score on Quiz #2 for the 8 lowest performing students.

DISCUSSION AND CONCLUSION

Students stated they benefited from more engagement in the course and reflecting in the Learning Diaries. Incorporating UDL principles appeared to benefit all students by capturing their interest, connecting them to the material, and fostering collaboration.

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5.353 The Development of P&O Sustainable Rehabilitation in Northern Syria Through a Decade of Conflict- Human and Technical Resources Challenges

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BACKGROUND

The ongoing conflict for more than 10 years in Syria has resulted in a huge growing number of casualties and disabilities among population. The urgent need to deliver P&O sustainable rehabilitation services passed through critical situation. The two main challenges were the shortages of qualified technicians and technology.

AIM

In this abstract, I will highlight the progress of P&O in Northern Syria and discuss the challenges and the suggested solutions.

METHOD

More than 8 years of work, investigation and relations in different P&O rehabilitation centers and NGOs, which work in the field, I can say that the main challenge is the complete absence P&O education. With the result that the service providers were just young volunteers who have not any idea or background about Prosthetics. The pioneers started with some basic training delivered by Pakistani technicians and the prostheses they manufactured were low quality and cost. This Pakistani technique based on a type of plastic pipes. In late 2012, HI started providing temporary fiberglass sockets. Non- cosmetic and unfunctional were the features of prostheses at that time. They were just an additional burden for the user because of the materials and the unqualified technicians. In 2013, Human Study School for Rehabilitation Science and ISPO partner led the next period by admitting 13 students in CAT II program, 7 of them continued their education and got their CAT I certificates in 2019. It is worthy to mention at this point that those students and through their academic education introduced new concepts and materials to Northern Syria. I was really revolutionary in P&O sustainable rehabilitation. Still not enough, because of the sore need for technicians, they started informally training a new generation of about 10 technicians in 2016. The new generation got an optimum education and skills but without accreditation; which became a barrier to practice and deliver service to vulnerable population.

RESULTS

The conflict is progressing and the need for P&O rehabilitation is growing dramatically. Thus, I suggest that ISPO venerable board to organize a type of evaluation and exam to the new generation of technicians and grant them an accreditation to be able to elevate the suffering of the victims of war and reintegrate them in society again.

DISCUSSION AND CONCLUSION

Well- educated P&O technicians, specialists are essential for the recovery of vulnerable community in war zones, and they need to be guided and supported by ISPO and other partners.



5.354 A day in the life: a qualitative study of decision-making in prosthetic and orthotic clinical practice

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BACKGROUND

When providing prosthetic and orthotic services, clinicians are required to participate in a broad variety of activities including, collaborative client care, management of resources, justification of interventions and device manufacture^[1]. While activities performed by clinicians may be clear, there is a paucity of research documenting the decisions made by prosthetist/orthotists throughout a typical working day^[2]. A deeper understanding of the reality of decision-making in prosthetic and orthotic practice will help inform quality improvement initiatives, as well as development of educational guidelines.

AIM

The objective of this qualitative study was to explore clinician perceptions of the types of decisions that are made during the provision of prosthetic and orthotic services.

METHOD

24 prosthetist/orthotists (12 from Sweden and 12 from USA), each with a minimum of 10 years clinical experience, were recruited to participate in 6 focus groups. Participants were initially requested to independently list activities that they perform during a typical working day. Together, they then grouped activities into common thematic categories. For each category, participants were asked to discuss and list the types of decisions that they are commonly required to make. Focus groups were recorded and transcribed for analysis using inductive content analysis^[3].

RESULTS

Decisions required to be made by prosthetist/orthotists through a typical working day range from low complexity decisions of narrow scope and limited impact, to high complexity decisions requiring extensive information gathering and can have a major impact. High complexity decisions typically involve diagnosis or treatment of a client, or the motivation of actions toward a funding agency. While patient related decisions were relatively similar between Sweden and the USA, differences were observed in decisions related to communication with clients and the decision to consult colleagues.

DISCUSSION AND CONCLUSION

This study highlights the vast number of decisions that are required to be made during the provision of prosthetic and orthotic services. Most high complex decisions were perceived to be made during a consultation with a client but could be revisited at a later point in time. Differences in decisions taken by clinicians in Sweden and USA may be a reflection of the different healthcare systems and different approaches to prosthetic and orthotic education.

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ACKNOWLEDGEMENTS

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5.355 Motivations for Persuing a Career in Prosthetics and Orthotics: Insights from Bachelor P&O Students in Thailand

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BACKGROUND

Prosthetics and Orthotics (P&O) is a specialty within the medical and healthcare field, focused on the research and development, design, manufacture, and application of prostheses and orthoses, playing an essential role in rehabilitation ⁽¹⁾. Despite the high demand for P&O professionals, P&O program in Thailand can admit only 24 students per year, and statistics show that some students drop out each year for various reasons. Unlike other healthcare fields, where motivation for career choice is well-documented ⁽²⁾, little is known about the factors that drive students in Thailand to pursue a career in P&O. Understanding these motivations is critical to shaping recruitment strategies, curriculum, and support systems within the education program.

By identifying the reasons that influence students' career choices, educators, policymakers, and administrators in the field can better align educational strategies to attract, support, and retain talented individuals in this healthcare profession.

AIM

- To identify the factors influencing students' decisions to pursue a career in Prosthetics and Orthotics.
- To analyse the differences in motivational factors among students at various stages of their education.
- To provide insights into recruitment and support strategies that could enhance the appeal of P&O as a career in Thailand.

METHOD

This study will use a cross-sectional survey to collect both quantitative and qualitative data from Bachelor of Science in Prosthetics and Orthotics (B.Sc. in P&O) students across all four years in accredited P&O program in Thailand. The structured online survey will consist of two sections: the quantitative section, where participants will rate the influence of specific factors on their career choice using a 5-point Likert scale, and the qualitative section, where students will be asked to share any additional comments or reasons for choosing P&O as a career.

RESULTS

The results of this study are expected to:

1. Reveal the key factors influencing students' career choice in P&O and identify differences in these motivation across academic years.
2. Provide insights into the evolution of students from entry to graduation.
3. Offer recommendations for recruitment and retention strategies in P&O education and inform curriculum enhancement to better support students.

DISCUSSION AND CONCLUSION

This research will contribute valuable insight into factors that motivating students to choose a P&O career, addressing a gap in existing literature within the field. The findings may guide policy development, curriculum improvements, and targeted recruitment efforts that emphasize the factors most appealing to prospective students.

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Free paper session | Device fabrication and design – Novel design approaches

5.361 Tuning the mechanical response of 3D-printed Ankle Foot Orthoses: a numerical study

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BACKGROUND

Ankle-foot orthoses (AFOs) are commonly prescribed for people with neuromuscular skeletal conditions to correct specific features of pathological gait. Traditional AFO manufacturing using vacuum formed thermoplastics is a labor-intensive process that is difficult to accurately repeat and evaluate the finished device. The design of an AFO is largely dependent on subjective evaluation and the experience of the orthotist and remains largely empirical. Recent advances in three-dimensional (3D) printing allow the rapid prototyping of AFOs, but the expanded design options complicate clinical and technical decision-making.

AIM

This study aims to evaluate how the AFO design characteristics of four base materials, the material thickness and the trimline location affects the mechanical responses of 3D-printed AFOs.

METHOD

A 3D surface scan of the lower limb was used to establish the lower limb geometry and a prototypical solid AFO was designed, 3D printed, and tested in the sagittal plane, under dorsi and plantarflexion loading. Additionally Fine Element Modelling was employed to investigate the mechanical responses of the AFOs under the dorsi and plantarflexion loading. A parametric study on the effect of base materials, thickness, and trimline location is conducted based on a validated numerical model.

RESULTS

The results reveal that AFOs exhibit distinct behaviors under plantarflexion and dorsiflexion motions, with AFO stiffness correlating to thickness through a power function. AFO stiffness is more sensitive to posterior trim depth than inferior, while both trim depths significantly influence stress concentration around the ankle region. AFOs constructed with PA12-CF exhibited the highest stiffness for both DF and PF, while PA12 and PLA AFOs exhibited similar properties.

DISCUSSION AND CONCLUSION

This investigation demonstrates the potential of combining 3D printing and computational modeling to improve the design and fabrication process of AFOs, providing insights into the development, customisation and optimisation of 3D-printed AFOs.

ACKNOWLEDGEMENTS

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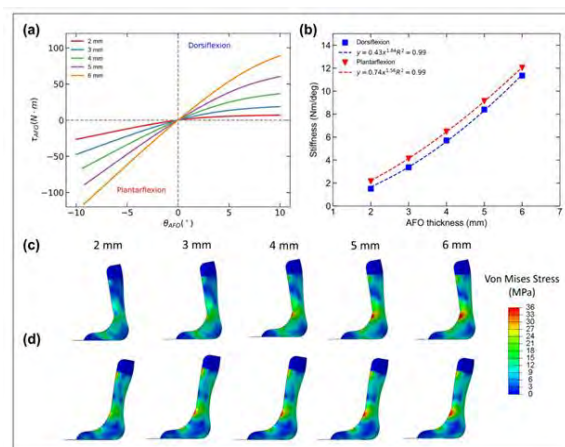


Figure 1: Effect of AFO Thickness. (a) AFO moment-ankle relationships of baseline AFO with various thickness under plantarflexion and dorsiflexion. (b) The stiffness of baseline AFO with various thicknesses. Deformation and stress contours of the baseline with various thicknesses at 10° rotation; (c) dorsiflexion and (d) plantarflexion.



5.362 Development of an AI enabled Mass Customisation pipeline for patient specific orthotic devices

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BACKGROUND

Diabetic foot ulcers (DFUs) are a common and serious complication with an annual incidence of 2.2% among persons with diabetes [1]. Treatment using custom-made orthotics can prevent the development of these ulcers through early identification of pre-ulcerative signs [2]. However, current procurement processes are often slow and expensive due to manual consultations and fabrication methods [3,4]. Mass customisation is a manufacturing approach enabling individualised products at mass production efficiency [5]. Furthermore, recent developments in advanced manufacturing technologies are making high-level mass-customised systems commercially viable [6].

AIM

The study aims to develop a proof-of-concept for a fully automated design-to-manufacture pipeline for the mass customisation of orthotic devices for early-stage diabetic foot ulcers, leveraging advancements in smart and digital manufacturing technologies.

METHOD

The pipeline follows standardised individualisation steps by Spallek et al. [7]: Data acquisition; Data manipulation; Design synthesis; and Fabrication. For data acquisition, synthetically generated 2D RGB images of the plantar surface from 3D scans of participants' feet are used. These images then undergo data manipulation via computer vision and deep learning techniques, extracting foot dimensions and locating "ulcers" on the foot. This drives an automated CAD program that generates user-specific insoles with an offloading region around the ulcer site, then fabricated via additive manufacturing. The pipeline's accuracy and robustness were tested using multiple synthetic 2D images with known ulcer locations. The resulting CAD insoles were compared to their 3D scans and some fabricated to verify manufacturability.

RESULTS

All stages of the mass customisation pipeline have been developed, with final integration underway. Initial testing on a sample population demonstrates the pipeline can robustly generate user-specific orthotic devices designed for early-stage DFU treatment. Key functions for the foot dimensioning and the identification and location of marked "ulcers" have shown high accuracy when directly compared to the captured 3D scan data. Test fabrications of the generated CAD files were successfully completed using an appropriate insole material, confirming production feasibility across multiple users.

DISCUSSION AND CONCLUSION

The initial results indicate that the pipeline performs consistently across a varied sample population, suggesting broad user applicability. This aligns with the study's aim of developing a reliable, fully automated design-to-manufacture solution. While preliminary testing confirms the feasibility of producing customised orthotics for DFU treatment, further studies are needed to evaluate the pipeline's sensitivity and to test an even broader population sample for comprehensive reliability validation. If proven effective, this automated approach could streamline orthotic production and reduce associated costs for diabetic foot care.

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ACKNOWLEDGEMENTS

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5.363 Rethinking the Design of Night Orthoses for Children with Duchenne's Muscular Dystrophy: An In-House Innovation Challenge

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BACKGROUND

In Norway, night braces are commonly prescribed for children with Duchenne's Muscular Dystrophy (DMD) to prevent contractures in the plantarflexors. Traditionally, these braces are made from rigid polypropylene or copolymer with foam padding and straps. However, patient feedback has highlighted dissatisfaction, with issues such as discomfort, overheating, and poor adherence. These concerns have prompted the need for a redesign to better meet patient needs.

AIM

The aim of this initiative was to improve the orthotic design of night braces for children with DMD to address the main patient-reported concerns and enhance comfort and compliance.

METHOD

Patient and family feedback was collected through a questionnaire, revealing key issues including overheating, weight, discomfort, and nocturnal perspiration. To address these concerns, an in-house innovation challenge was launched. Six teams, each consisting of at least one prosthetist-orthotist and one technician, were tasked with designing new night braces. A youth with DMD acted as the test subject and was part of the judging panel. Teams had five weeks to create prototypes using available materials and fabrication techniques. The designs were evaluated based on comfort, weight, function, and appearance by a panel of experts and the test subject.

RESULTS

Six different night orthoses were evaluated in the innovation challenge, scored on weight, function/biomechanical design, comfort, and appearance. The designs were assessed by a blind judging panel, including the test subject, who rated the prototypes based on comfort and overall performance. The winning design was a 3D-printed orthosis, which stood out due to its light weight, improved comfort, and positive feedback from the test subject. The results highlight that a 3D-printed design can effectively address common patient concerns, such as overheating and discomfort, while maintaining the necessary support and function. This suggests that innovative fabrication techniques, such as 3D printing, may offer valuable solutions for improving the design of night orthoses for children with Duchenne's Muscular Dystrophy (DMD).

DISCUSSION AND CONCLUSION

The results highlight the value of starting with a clear goal when redesigning orthoses, as evidenced by the success of the 3D-printed night orthosis in addressing key challenges like weight and comfort. While 3D printing proved to be an effective solution in this case, it's important to recognize that conventional methods may still be the most appropriate for some needs. A thoughtful approach, guided by the patient's requirements, ensures optimal orthotic outcomes. Further refinement and implementation of such designs could significantly improve patient compliance and quality of life.



5.364 3D-Print of Standing-Shell for Patients with Neurological Disorders, an Innovation Journey evaluating 3D-Printed Biomaterial versus Traditional Material

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BACKGROUND

This study investigates the use of 3D printing technology for manufacturing standing shells (SS) for patients with neurological disorders, focusing on comparing bio-based materials with traditional materials and initiating a life cycle analysis (LCA). Traditional SS are typically made using polypropylene (HDPE) through a process involving casting a positive mold and vacuum forming. 3D-printing has the potential to simplify the manufacturing process and reduce environmental impact by using bio-based materials.

AIM

- To compare the properties of biobased material versus traditional material
- Initiate a life cycle analysis (LCA)
- Test print a standing shell

METHOD

3D printing of SS and test samples is performed using an ABB robot with a KFM extruder head. Three materials were used in the experiments: traditional HDPE, PLA (polylactic acid), and a commercial wood-plastic composite (WPC) mixed with sawdust from walnut and pine. To evaluate the mechanical properties, tensile testing according to ISO 527 was conducted, along with compression tests to assess anisotropy in the 3D printed samples. A life cycle analysis was performed using SimaPro software to assess the environmental impact.

RESULTS

Mechanical tests showed that the elastic modulus of PLA and WPC (with added sawdust) was comparable to traditional PP (600–1400 MPa), while elongation-at-break decreased from 17% for PP to around 4–6% for PLA/WPC blends. This follows the theory of fiber-reinforced composites, where the addition of reinforcement fibers increases strength but reduces toughness. Compression testing revealed different behaviors for PLA and WPC depending on the printing direction, attributed to the layering process and variability in bonding during 3D printing.

DISCUSSION AND CONCLUSION

Material properties need to be tailored for specific applications like SS, where some flexibility is important. The blending of polymers and reinforcement fibers shows potential for reducing the amount of polymer in favor of bio-based material. Compatibility between fibers and polymers is crucial, and future research may include the use of bio-based compatibilizers, such as lignin. The life cycle analysis indicated potential environmental benefits, such as reduced carbon footprint and less transportation, along with societal advantages in terms of reducing patient discomfort.

The study suggests that 3D printing with bio-based materials like PLA and WPC could replace traditional methods for producing SS. However, material properties need to be tailored to meet the specific requirements of SS, such as flexibility. Further research is needed to optimize material choices, printing design, and to conduct more detailed life cycle analyses.



Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Manufacture and design

5.371 Development of an Affordable and Breathable Trans-tibial Socket and Liner for Hot and Humid Climates

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BACKGROUND

Prosthetic sockets and liners are critical human-machine interfaces that significantly impact the satisfaction and quality of life for amputees. Proper fit and comfort are essential, as friction and moisture can lead to skin breakdown, particularly in hot, humid climates like India. Current solutions inadequately address perspiration, leading to slippage and skin issues (Ghoseiri & Safari, 2014; Klute et al, 2010).

AIM

To develop a cost-effective, modular, breathable, and lightweight transtibial prosthetic socket and liner that maintains strength and provides effective load bearing and ambulation.

METHOD

This study incorporates honeycomb structures into the prosthetic socket and liner to enhance mechanical properties and promote breathability. We employed polyethylene terephthalate glycol (PET-G) for lightweight socket designs, utilizing additive manufacturing (3D printing with fused deposit modeling). The liner is constructed from flexible polyurethane rubber, layered with cotton and antibacterial silver ion fiber, featuring honeycomb perforations to dissipate heat and moisture from the residual limb.

RESULTS

The socket was tested with one transtibial amputee. Initial testing shows that the honeycomb structure significantly improves the strength-to-weight ratio and energy absorption. The breathable design reduced perspiration-related issues, enhancing overall comfort for users.

DISCUSSION AND CONCLUSION

The results of the study confirm that the incorporation of honeycomb structures effectively addresses both mechanical stability and perspiration issues in prosthetic sockets and liners. While further studies with a larger number of subjects are needed to evaluate the long-term effects, these findings suggest that our innovative design can improve the quality of life for amputees in humid climates.

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5.372 An Indicative survey of computer aided design (CAD) use in transtibial shape capture

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BACKGROUND

The use of computer aided design (CAD) in the field of external limb prosthetics has been under development for over 40 years. With technology making CAD systems more user friendly and accessible it is reasonable to assume that the use of CAD would be widespread. There is a dearth of current evidence, from literature, on the prevalence of CAD use and the factors which may influence this.

AIM

This research aims to provide an insight into the use of CAD as a shape capture tool in clinical practice, at transtibial level, and consider clinicians perceptions of the achieved results and the factors which may influence this.

METHOD

A cross-sectional survey was developed to capture the current CAD usage, and perceptions of the achieved outcomes, in a selection of English-speaking, High-Income Countries (as defined by the World Bank). Ethical approval was granted. The 25-question online survey was distributed via profession affiliated organisations.

The survey questions captured demographic data, volume of use, access, training and perceived socket outcomes.

RESULTS

92 complete results meeting the inclusion criteria were received. Of this 69.5 % were currently using CAD in clinical practice. The greatest perceived benefits were time saving, storage of residuum dimensions for comparison, and repeatability. 80% of respondents using CAD believed the socket produced was the same or superior to a POP cast socket. Post-training confidence and years of CAD use correlated to positively reported socket outcomes.

28 respondents did not use CAD but had access. The reported barriers for CAD use in this group were CAD systems not being 'user friendly', lack of training and casting being quicker.

For the participants that did not have access to CAD, set-up costs and the lack of support prohibited CAD instigation.

DISCUSSION AND CONCLUSION

The location, despite differing healthcare funding, did not affect the results. There is a positive correlation between increasing level of CAD experience and increase CAD use. CAD usage was reported at 100% for some participants with 37 of 64 using CAD 60% of the time or more at transtibial level.

The evidence base for CAD is poor with a dearth of research. From the survey CAD is commonly used as an option for shape capture in HIC's. All clinicians benefitted from training and training increased confidence and perceived socket outcomes with longer training producing more favourable results.

ACKNOWLEDGEMENTS

Thank you to all the organisations who circulated the recruitment advert and to the clinicians who completed this.



5.373 Influence of Operator and Environment on Repeatability of Remote Scanning of Residual Limbs

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BACKGROUND

Current clinical techniques used to measure residual limbs, such as plaster casting and water submersion, are limited in their accuracy and can only be performed by clinicians at dedicated centres. The potential of creating accurate residuum scans using smartphone technology, from which measurements could be extracted was previously investigated [1]. A commercially available application, Polycam, produced clinically acceptable results when employed by an experienced operator. This study investigates whether similarly accurate results could be achieved by a layman across a range of scanning environments.

AIM

To evaluate the efficacy of the Polycam mobile scanning application across multiple environments and operators, to determine its suitability outside the clinical conditions for remote measurements of residual limbs.

METHOD

To establish a baseline performance, operator 1 (an experienced scan operator) performed scans on a plaster cast of a transtibial residuum across multiple environments. Control scans were captured using an Artec EVA scanner against which the Polycam scans would be compared. Operator 2 (an inexperienced scan operator) travelled between different Sri Lankan clinics, showing resident clinicians how to perform the scans. Operator 2 and six novice operators performed scans on three residuum plaster-cast models using the same Samsung Galaxy S21 5G. Operator 2's scans, which were scaled according to anthropomorphic data [2], were used as the control scans against which the novice operator scans were compared.

RESULTS

Operator 1 achieved consistent Root Mean Squared Error (RMSE) values, between 0.2 mm – 0.4 mm from the Artec EVA criterion scans, with the expected exemption of the point-light environment, producing significant shadow and mesh deformation. Generally, the standard deviation (SD) between repeated measurements is small with an average SD of 0.06 mm, suggesting high repeatability. The novice operators at the Sri Lankan clinics produced scans with a greater RMSE than operator 1, nevertheless all RMSE results remained below 1.0 mm, on par with RMSE values of in-vivo residual limb scans captured by the Artec EVA scanner [1].

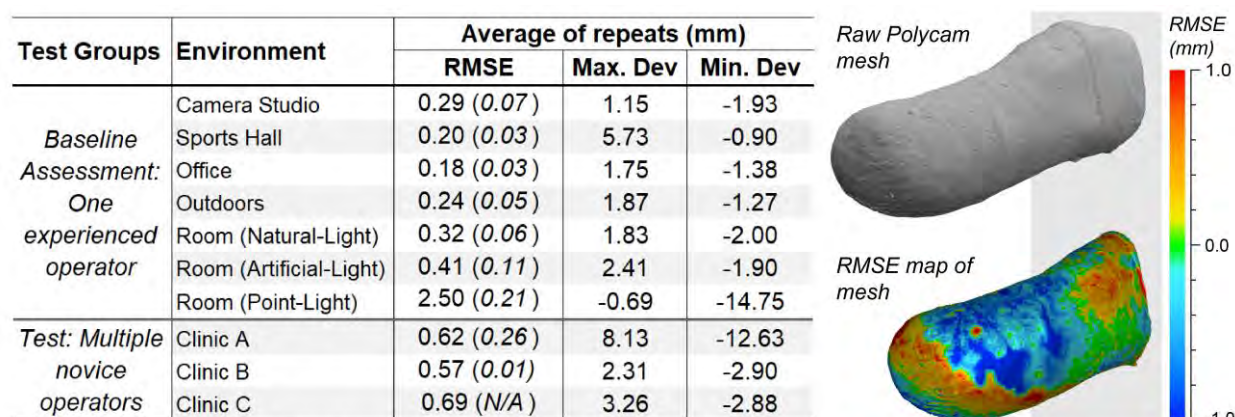


Figure 1. Left: Table of values for each study, where the numbers in brackets indicate the standard deviation between the repeated measures. Right: Raw mesh of a control scan from Clinic A, and corresponding RMSE map showing the difference between the control scan and another novice operator's scan.

DISCUSSION AND CONCLUSION



Current results suggest reliable measurement of residual limb plaster cast models from untrained operators is easily achievable, and that mobile scanning may be a suitably accessible technique for measuring and assessing residual limbs in localities with limited access to clinical facilities. The question of whether these results may be applied to in vivo scanning however still requires investigation, but prior work on in-vivo scanning ^[1] suggests these results may be transferrable.

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ACKNOWLEDGEMENTS

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5.374 Evaluating the Effectiveness of Transtibial Prosthetic Socket Shape Design Using AI: A Clinical Comparison with Traditional Plaster Cast Socket Designs

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BACKGROUND

The increasing trend toward digitization in patient-specific socket design brings many potential benefits. However, the digital design process still relies on the prosthetist's skills and expertise. Artificial Intelligence (AI) offers the potential to streamline the design process, increasing speed and consistency.

AIM

This study investigates the feasibility of creating an AI algorithm to enhance prosthetic socket shapes for transtibial prostheses, aiming for a less operator-dependent, standardized approach.

METHOD

The study comprised two phases. In phase one, a cross-sectional study developed an AI algorithm for prosthetic socket shape design using retrospective data from residual limb 3D scans and corresponding prosthetic socket shapes of 116 patients provided by OIM Orthopedie. MeshMonk was used to standardize the mesh structures, and the dataset was divided into training and test sets for algorithm optimization and evaluation. In phase two, the algorithm was tested on ten randomly selected participants from Papenburg Orthopedie. In a two-week within-subject study, AI-designed prosthetic sockets were compared with manually crafted plaster prosthetic sockets. Participants rated socket comfort (SCS), and an independent physiotherapist and prosthetist evaluated the fit.

RESULTS

The prosthetic socket shapes predicted by the AI algorithm deviated by an average of 2.51 mm from the actual designs in the test set. In participant testing, eight of ten AI-designed prosthetic sockets and all ten manually crafted plaster sockets were deemed satisfactory for further home testing. Participants rated the prosthetic sockets designed by AI at 7.1 ± 2.2 (n=8) and the manually designed prosthetic sockets with plaster at 6.6 ± 1.2 (n=10) on average.

DISCUSSION AND CONCLUSION

The study demonstrates promising results for using an AI algorithm in prosthetic socket design. Still, long-term effectiveness and refinement are necessary for improved comfort and fit in more deviant cases.

ACKNOWLEDGEMENTS

Thanks to OIM Orthopedie for the data and to all participants. This study was funded by ZonMw (project 10310012110003).



5.375 Developing a hybrid prosthetic manufacturing method: Combining 3D-printed sockets with HDPE pipe reinforcement for cost-Effective and reliable solutions

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BACKGROUND

Especially in developing countries, limited manufacturing capacity hinders adequate prosthetic provision. Digital methods, especially cost-effective FDM printing, are under consideration but face challenges with strength. Traditional analog methods, however, have proven reliability. To address this gap, a hybrid approach that combines the strengths of both analog and digital methods is needed, maximizing the advantages while minimizing limitations.

AIM

This study aims to develop an optimal prosthetic manufacturing solution by clarifying the pros and cons of digital and traditional methods, proposing 3D-printed sockets reinforced with HDPE pipes for enhanced strength and reliability.

METHOD

This study evaluates traditional, digital, and hybrid prosthetic manufacturing methods based on three key criteria: patient satisfaction and scalability. Strength is assessed through comparative testing of HDPE, 3D-printed sockets, and hybrid sockets combining both materials. Patient satisfaction was measured through feedback from a survey of over 200 participants, assessing comfort and usability. Scalability is evaluated by analyzing operation time, including each method's process steps and actual work time, to assess efficiency and practicality. This approach aims to identify the most durable, scalable, and patient-preferred method for prosthetic socket production, suitable for applications in resource-limited settings.

RESULTS

Strength testing revealed that the hybrid sockets demonstrated sufficient strength, indicating enhanced durability by combining materials. Patient satisfaction ratings, scored on a scale of 1 to 10, averaged 9.7 for the hybrid design in terms of comfort and usability. Scalability analysis showed total operation times of 305 minutes for HDPE-based production (with 305 minutes of manual work), 470 minutes for 3D printing (110 minutes of manual work), and 435 minutes for the hybrid method (235 minutes of manual work). These findings demonstrate that the hybrid method leverages the benefits of digital reproducibility and reduced manual work time by 3D printing the socket at a minimum required thickness, while reinforcement with additional materials enhances strength through analog techniques.

Table 1. Comparison of each method

	HDPE based	3D printed	Hybrid (Proposed method)
			
Manual work time [min]	305	110	235
Printing time [min]	0	360	200
Total manufacturing time (without fittings) [min]	305	470	435
Reproducibility	△	⊙	○
Cost	⊙	△	○

DISCUSSION AND CONCLUSION

This study presents the feasibility and practicality of combining 3D-printed sockets with HDPE pipe reinforcement in prosthesis manufacturing, emphasizing an approach that is both cost-effective and structurally reliable. The cost-effectiveness of this method is notable, as HDPE pipe is significantly cheaper than 3D printing materials, reducing overall material expenses. Additionally, the use of digital technology enables rapid training, making this approach accessible even with limited prior experience. By combining these technologies, this method offers a scalable, cost-effective solution, especially advantageous for developing countries where resource limitations demand efficient and affordable solutions.

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Free paper session | Prosthetics: bone anchored limbs – Outcomes

5.381 Safety and performance of contemporary press-fit titanium osseointegration implants in lower extremity amputation: A 5-year follow-up study

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BACKGROUND

Bone-anchored prosthesis (BAP) treatment using press-fit femoral osseointegration implant's (OI) has been used for more than 2 decades. Development of contemporary titanium OI's has enabled treatment in individuals with a transtibial (TTA) or short transfemoral amputation (TFA). Despite the fact that BAP-treatment has established itself as an effective and safe treatment for individuals with mid-diaphyseal TFA, there is still a hiatus regarding its outcomes in individuals with a TTA or short TFA.

AIM

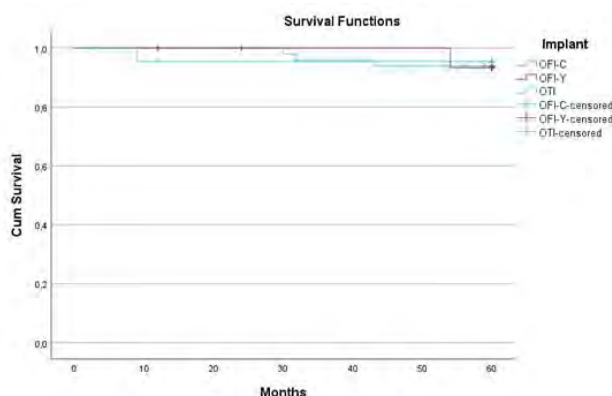
This study reports on 5-year follow-up safety, prosthesis wearing time, and health-related quality of life (HRQoL) of lower-extremity BAP-treatment.

METHOD

All consecutive individuals undergoing BAP-treatment between 2015 and 2018 using 3 different OI's were eligible. The curved- or gamma-osseointegration femur implant (OFI-C, OFI-Y) was used in case of a mid-diaphyseal- or short-TFA, respectively. The osseointegration tibia implant (OTI) was used in TTA. Adverse events evaluated included: infection (soft tissue, bone, implant), stoma-related complications, aseptic loosening, implant breakage, periprosthetic fracture, and complications between surgical stages. Functional outcomes assessed were the Questionnaire for TFA (Q-TFA) Prosthetic Use Score (PUS) and Global Score (GS), for prosthesis wearing time and HRQoL, respectively.

RESULTS

Ninety individuals were included, with 14 lost to follow-up. A 94.2% implant survival was achieved at 5-years (OFI-C=93.8%, OFI-Y=93.3%, OTI=95.5%), as 5 implants were explanted (see Fig below). Twenty-seven (36%) individuals experienced 56 infections, 95% of soft tissues. Septic implant loosening occurred 3 times (OFI-C=2, OTI=1), resulting in explantation twice. Infection/implant-year-ratio was 0.09, 0.16, and 0.24 for OFI-C, OFI-Y, and OTI, respectively. Periprosthetic fracture occurred 5 times (OFI-C=5), all surgically treated (n=4 fixation, n=1 explantation). Partial aseptic loosening occurred once, conservatively treated. Stoma problems occurred frequently requiring surgery 26 times, mostly in OFI-Y. Two individuals required explantation due to unexplained pain. Complications between surgical stages were mostly surgical site infections, requiring stage 2 expedition 7 times. Baseline Q-TFA-PUS and -GS increased significantly over time for the total cohort and stratified per implant type.



DISCUSSION AND CONCLUSION

Lower-extremity BAP using contemporary press-fit titanium OI's results in acceptable rates of survival and safety, with substantial improvements to functional outcomes.



5.382 A Prospective Study on Direct Skeletal Fixation: Beneficial Outcomes are Sustained at 2 Years

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BACKGROUND

During the 2003 – 2014 Afghanistan conflict, there were 265 UK Armed Forces Service Personnel who suffered major joint amputations ⁽¹⁾. Although these severely disabling injuries have been successfully treated with advanced rehabilitation and modern prostheses, traditional prosthetic sockets were not the solution for all persons with limb loss. Direct skeletal fixation (DSF) involves the attachment of the intra medullary portion of a prosthesis directly to the skeletal residuum, providing an alternative for those who face challenges mobilising with socket-based prosthesis.

AIM

This prospective study aims to assess the effects of DSF surgery on physical and mental health outcomes in the second cohort of UK military personnel with transfemoral amputations who reported socket related issues resulting in their selection for DSF.

METHOD

Eight male participants (three with unilateral transfemoral amputations, four with bilateral transfemoral amputations, and one with transfemoral/trans tibial amputation) who underwent implantation with the Osseointegration Group of Australia-Osseointegration Prosthetic Limb (OGAP-OPL) prosthesis consented to participate in the study. Patient-reported outcomes were evaluated pre-operatively and at one and two years post-operatively using the Short Form Health Survey (SF-36). Physical functional performance was measured through the 6-minute walk test (6MWT).

RESULTS

Figure 1 presents the SF-36 physical and mental health component scores. The 6MWT distances improved from pre-operative levels at the 1-year follow-up (increasing from 279m to 367m) and continued to improve by the 2-year follow-up (from 367m to 397m). Notably, one participant who was wheelchair-bound before surgery successfully mobilised with prostheses at both follow-ups.

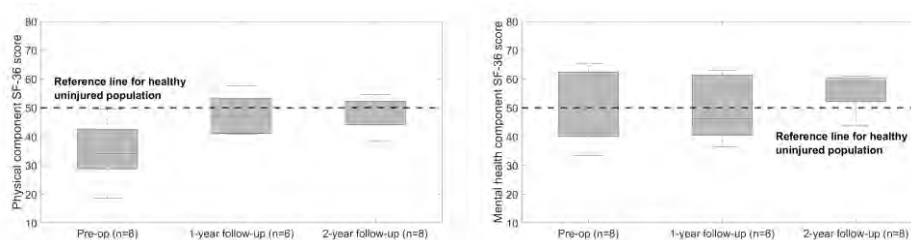


Figure 1. Physical and mental health component scores of the SF-36 questionnaire for transfemoral amputees with DSF.

DISCUSSION AND CONCLUSION

DSF offers a promising solution for persons with limb loss who cannot tolerate prosthetic sockets. Compared to pre-operative scores, patient-reported outcomes and functional abilities improved at the 1-year mark, approaching those of uninjured individuals. These improvements were sustained at 2 years. DSF has the potential to provide physical and mental health benefits and allow veterans to be fully integrated in society. Long-term follow-up of all who undergo DSF is essential to further understand the effect of this procedure on quality of life beyond 2 years. A specific registry would help facilitate this.

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ACKNOWLEDGEMENTS

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5.383 Lower Back Pain Decreases 1-year after OI Surgery for Lower Extremity Amputation Patients measured with the ODI questionnaire: preliminary results

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BACKGROUND

Lower back pain (LBP) is one of the leading comorbidities following amputation of the lower extremity. Alterations in movement mechanics result in asymmetrical compensatory strategies, leading to LBP and increased disability. Bone-anchored prosthesis using an osseointegration implant (OI) are used to solve socket-related problems. The use of a bone-anchored prosthesis also changes the lumbopelvic coordination, which may have a positive influence on LBP¹.

AIM

The aim of this two-centre retrospective cohort study is to determine whether LBP changed 1-year after OI surgery compared to baseline (while using a socket-suspended prosthesis).

METHOD

All patients who had OI surgery between November 2011 and March 2023 were eligible for inclusion. Before surgery (baseline) and 1-year after OI surgery the ODI (0-100 score) was used to quantify the functional disability caused by LBP. A higher score illustrates a higher disability. The data has been collected in two centres: 1. Radboud university medical centre (Nijmegen, the Netherlands) and 2. University of Colorado Hospital (Denver, United States of America). The data collected is part of usual care data and has been analysed retrospectively. The data was not normally distributed, therefore the Wilcoxon Signed Ranks test was used to analyse the ODI change after 1 year for the whole group. The Mann-Whitney U test was used to compare the difference in ODI change between the Nijmegen and Denver group after 1 year.

RESULTS

We included 200 patients, 163 (81.5%) from Nijmegen and 37 (18.5%) from Denver, of which 111 (55.5%) had a transfemoral amputation and 80 (40%) a transtibial amputation, 9 (4.5%) had a bilateral amputation. The median (25th and 75th percentile) ODI score at baseline was 16 (0 – 30) and at 1-year follow-up 0 (0 – 14) and the change was statistically significant with the Wilcoxon Signed Ranks test ($Z=-6.53$, $p<0.001$). Subgroup analysis at centre level using the Mann-Whitney U test illustrated a median (25th and 75th percentile) ODI change after 1 year for the Denver group of -14 (-31 - -1) and for the Nijmegen group 0 (-18 – 0), $Z=-2.70$, $p=0.007$.

DISCUSSION AND CONCLUSION

Functional disability due to LBP decreased significantly 1-year after osseointegration surgery for the entire study population. Subgroup analysis showed a larger decrease in ODI for the USA group. Further research is being done on creating a prediction model to predict ODI response after OI-surgery.

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5.384 Single Stage Titanium Press Fit Osseointegration of the Femur: Safety, Mobility Improvement, Patient-reported Outcomes

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BACKGROUND

Single stage titanium press-fit transfemoral osseointegration provides a direct transcutaneous skeletal connection between a prosthetic leg and the residual femur, eliminating socket-based problems and conferring enhanced mobility, balance, and proprioception to amputees. To date, very few centers have published outcomes.

AIM

To describe the safety profile (primary), mobility outcomes (secondary), and patient-reported outcomes (tertiary).

METHOD

Retrospective review of all patients who underwent single stage titanium press-fit femoral osseointegration between April 2016 and June 2022 with minimum 1 year follow-up. The primary aim was assessed by evaluating for systemic complications, antibiotic administration, or surgery such as to address infection, loosening, or fracture. The secondary aim was assessed by evaluating changes in mobility Timed up and go (TUG), 2 minute walk test (2MWT), 6 minute walk test (6MWT). The tertiary aim was assessed by evaluating changes in patient surveys: Limb Deformity-modified Scoliosis Research Society (LD-SRS), Questionnaire for Persons with a Transfemoral Amputation (QTFA), and Patient-Reported Outcomes Measurement Information System (PROMIS).

RESULTS

Sixty-seven integration procedures in 65 patients were evaluated. Index amputations etiologies were: trauma (52), infection (8), vascular (1), oncologic (2), deformity (1), and chronic pain (3). 60 patients were existing amputees, seven had simultaneous amputation with osseointegration. Follow-up duration was an average of 1.9 ± 1.3 years. No patients experienced systemic complications such as pulmonary embolism. Fourteen patients (21%) had infection concern which resolved with antibiotics. Nine patients (13%) had debridement; 5 (7%) had periprosthetic fracture surgery, and 2 (3%) had implant removal. Implant survival was 100% at 1 year, 100% at 2 years, and 98% at 5 years. At one year, patients reported increased prosthetic use (9.3 vs. 13.7 hours/day, $P < 0.001$), improved mobility on the TUG (11.9 vs. 9.8 s, $P = 0.050$), 2MWT (88 ± 57 vs 127 ± 26 m, $P < 0.001$), 6MWT (232 ± 153 vs 374 ± 89 m, $P < 0.001$). Survey outcomes improved: LD-SRS total (domain) score (3.1 vs. 3.7, $P = 0.003$); QTFA prosthetic use (53.8 vs. 80.8, $P = 0.002$), mobility (54.5 vs. 75.4, $P < 0.001$), and global (37.7 vs. 62.9, $P < 0.001$) scores; PROMIS physical function (35.7 vs. 43.6, $P < 0.001$), global physical health (41.0 vs. 46.3, $P = 0.012$), and global mental health (44.3 vs. 49.6, $P = 0.012$).

DISCUSSION AND CONCLUSION

Press-fit transfemoral osseointegration is safe and reliably improves function and quality of life.



Figure 1 | Pre- vs. Post-operative x-ray
A, preoperative standing AP hip-to-ankle x-ray demonstrating malalignment of the right residual femur with the socket prosthesis. B, postoperative standing AP hip-to-ankle x-ray with significantly improved alignment with prosthesis after insertion of osseointegration implant.



5.385 Rehabilitation and Mobility Outcomes of Transfemoral Osseointegration: a Case Series with 18-Month follow-up

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BACKGROUND

Transfemoral osseointegration (OI) is a surgical procedure that uses a percutaneous titanium implant to anchor a prosthetic limb directly to the femur to create a bone-anchored prosthesis (BAP).^{1,2} Osseointegration aims to improve mobility, stability, and comfort by creating a more secure attachment compared to a traditional socket-based prosthesis. Studies indicate that functional outcomes, such as walking ability, efficiency, and self-perceived mobility, generally improve,^{1,2} though long-term assessments are essential to confirm sustained benefits and adjust rehabilitation goals.

AIM

The aim of this study is to track rehabilitation progress and functional mobility outcomes of individuals with unilateral transfemoral amputation undergoing the OI procedure before the surgery and up to 18-months post-surgery.

METHOD

Participants were consecutively enrolled. Outcomes were collected before the surgery with a socket prosthesis and repeated at 6-, 12-, and 18-months post-surgery with a BAP. At each timepoint the physiological cost index (PCI), Timed Up and Go Test (TUG), Amputee Mobility Predictor (AMP), 2-Minute Walking Test (2-MWT), and the L-Test of Functional Mobility (L-Test) were collected. The participants completed the Prosthetic Limb Users Survey of Mobility (PLUS-M) and the Questionnaire for Persons with Transfemoral Amputation (Q-TFA).

RESULTS

5 individuals (3 males, 2 females; mean age 48.8 (34–59 y); mean time since amputation 139 (38–450 mo)) underwent transfemoral OI surgery with a press-fit implant. Participants starting loading day 4–5 post-op and progressed to no gait aids depending on the loading protocol (standard loading 4 mo; slow loading 4.5–5 mo; very slow 5–6 mo). At 6 months, self-report measures (PLUS-M and Q-TFA) improved and were maintained in follow up. Distance and timed walking measures initially worsened at 6 months and then improved to baseline (2MWT) or better than baseline (L-test). TUG did not change. AMP scores improved by 1–2 points in 3 participants. PCI was reduced at 12 and 18-months post-surgery compared to baseline.

DISCUSSION AND CONCLUSION

Self-report measures improved immediately with the BAP, but functional walking tests initially declined at 6 months. This is expected as some participants had just transitioned to no gait aids and required additional time to improve gait pattern and walking speed. The L-test, requiring turns, showed more improvement than standard TUG test which has a ceiling effect. The improved PCI at 18 months reflected improved efficiency in walking. Although the small sample size limits inferential analysis, transfemoral OI appears to improve functional mobility over a longer time frame than the initial self-reported mobility improvements.

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5.386 Examining Complication and Re-operation Rates After Osseointegration Reconstruction

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BACKGROUND

Osseointegration has emerged as a promising alternative to rehabilitating with a traditional socket mounted prosthesis. Advantages have been reported to include improved functional mobility, better osseoperception, improved comfort, reduced pain, better biomechanical alignment, and better gait, which all lead to a less restricted lifestyle and significantly improved quality of life. A major concern of the Osseointegrated approach lies in the risk of infections occurring from the permanent transcutaneous opening often referred to as the stoma. Several systematic reviews have indicated that the occurrence of minor infections can be quite common, serious complications are reported to be rare. In addition to commonly anticipated complications including fractures, surgical debridement or revisions, we have identified several significant events in which a patient may require to be readmitted and go through additional surgery.

AIM

To examine the complication and re-operation rates after osseointegration procedure

METHOD

A retrospective review using osseointegration registry for all surgeries performed by the Osseointegration Group of Australia between November 2010 and November 2020. The surgeries were all performed by a single surgeon. All events leading to a readmission and subsequent re-operation have been identified through hospital operation records and pooled together for meta-analysis. Events identified include: revision of implants, periprosthetic fracture fixation, surgical debridement due to infections, neurectomies and soft- tissue refashioning.

RESULTS

A total of 569 surgeries have been identified with a minimum 12-month follow-up time (mean follow-up time 6.5 ± 2.0 years) and included in this study. These included tibial, femoral and upper limb Osseointegration patients. 91 of these were performed using a 2-stage protocol while the remaining 478 were performed in a single stage. Among all cases, there were a total of 428 re-operation events recorded which occurred among 179 patients, indicating a high recurrence rate among the same patients. Interestingly, the rate of debridement's and soft-tissue refashions were found to be reduced for patients who were operated using a single stage surgery.

DISCUSSION AND CONCLUSION

Many events leading to readmission after the primary surgery may not necessarily be graded as a complication of the osseointegration technique but will still amount to a significant inconvenience for the patient and financial burden of the healthcare system. In this study, we have identified several addition possible reasons in which an osseointegration patient may need to be re-admitted into hospital for additional surgery.



Free paper session | Therapy, physical activity, sports – Sports and movement

5.391 Leisure sports running of individuals with transfemoral amputation: The user benefit of specific prosthetic sports components

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BACKGROUND

Running training for recreational sports has extremely positive effects on cardiopulmonary parameters [1]. Making this possible for individuals with transfemoral amputation is challenging. Prostheses with specific sports components (knee and foot) or standard prostheses with microprocessor-controlled prosthetic knees with integrated "sports modes" can be used for this purpose [2]. Experience shows that specific sports prostheses are clearly preferred by interested users. To date, no objective data exists to validate this experience.

AIM

The present study aimed at the biomechanical evaluation of user benefits of sports prostheses for recreational running compared to a standard prosthesis with a prosthetic knee with implemented "sports mode".

METHOD

Six unilateral individuals with transfemoral amputation participated (5m,1f, 44±12y, 184±8cm, 84±9kg). All participants were regular runners with sports prostheses (knee: 3S80, foot: 1E90/91, Ottobock) and a prosthesis with sports mode in everyday life (Genium X3 combined with various ESR feet, Ottobock). After warm-up, jogging with the sports prosthesis (SP) and everyday prosthesis (EP) was analyzed in randomized order on a 25m running track. Kinematic parameters were measured with an optoelectronic system and the ground reaction forces with 4 force plates (VICON, GB; KISTLER, CH). Biomechanical evaluation parameters were calculated from this data. Perceived exertion was captured using the Borg scale.

RESULTS

The mean running speeds were similar (EP:2.7±0.3m/s, SP:2.8±0.2m/s) but SP resulted in significantly longer step lengths with higher symmetry ($p<0.01$, SP:1.06/1.11m, EP:1.01/0.83m [prosthetic/contralateral]). Ground reaction forces were considerably different, especially the accelerating horizontal force in the second part of the support phase. With SP, the mean maximum value was significantly higher with 24.1% of body weight (BW) compared to EP (10.7% BW, $p<0.01$). All force components were significantly more symmetrical with SP (figure 1). Maximum prosthetic knee flexion angles during flight at running speed were similar (EP:90.3°, SP:88.1°, $p>0.05$). However, this parameter was significantly smaller with EP on the contralateral side indicating necessary compensations (EP 75.2°, SP:87.7°, $p<0.05$). The mean Borg Scale for perceived exertion was significantly lower for SP (SP 1.5, EP 8.2, $p<0.01$).

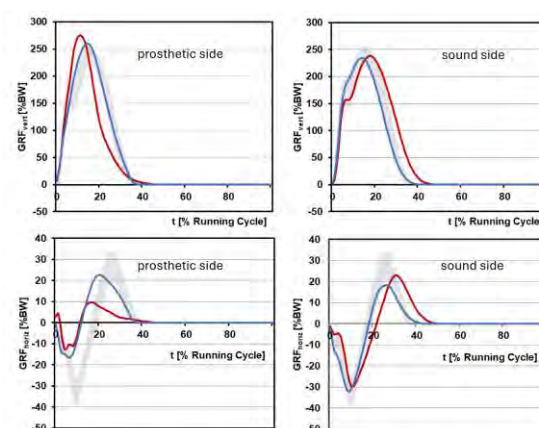


Fig. 1: Mean Ground Reaction Forces (above: vertical component, below: horizontal component; blue: sports prosthesis, red: everyday prosthesis, shaded area: reference group (mean velocity 3.3 m/s))

DISCUSSION AND CONCLUSION

The results show that specific sports prostheses are superior for ambitious running in recreational sports. Both the higher dynamics and the lower weight of SP suggest that significantly longer distances and, thus, a greater training effect may be achieved with these prostheses. Everyday prostheses with "sports mode" are only recommended for running on uneven terrain as no available prosthetic sports knee allow for knee flexion during weight bearing.

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5.392 Compensatory trunk movements of transfemoral amputees when walking with different gait velocities

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BACKGROUND

After transfemoral amputation, asymmetric motion patterns of the pelvis and upper body can be observed in the frontal plane. During the prosthetic side stance phase, an increased lateral trunk lean toward the prosthetic side has been shown [1-4]. Different calculation methods are used to determine the trunk movement. In prosthetics, the 7th cervical vertebra (C7) is usually taken as an orientation for the trunk overhang.

AIM

The aim of this study was to analyse whether the lateral trunk lean, analysed with a newly defined trunk segment, show a relevant compensatory mechanism of transfemoral amputees (TFs)

METHOD

Based on the experience in prosthetics, a marker model for motion analysis of TFs was developed, which determines, among other things, lateral trunk lean using the axis from C7 to the sacrum and the center of the pelvis as a new trunk segment (Figure 1, left). Measurements took place in three gait laboratories. In total, level walking of 33 TFs with different velocities (slow, mid, fast) was biomechanically analysed. Optoelectronic cameras (VICON, GB or Qualisys, S) and force plates (KISTLER AG, CH or AMTI, US or Bertec, US) were used for gait analysis. For comparison, the same analysis was performed with 30 able-bodied subjects (NAs).

RESULTS

The lateral trunk lean of the TFs is extremely different from the result of the NAs. A different motion pattern with a larger range of motion was observed (see Figure 1, right). During prosthetic side stance, the trunk leans to the ipsilateral side and is rapidly moved to the contralateral side at the end of stance. The maximum range of motion of this segment is increased for the TFs with 7.4deg(slow), 7.1deg(mid), 7.8deg (fast) compared with 3.1deg (slow), 3.0deg (mid), 3.4deg (fast) for the NAs.

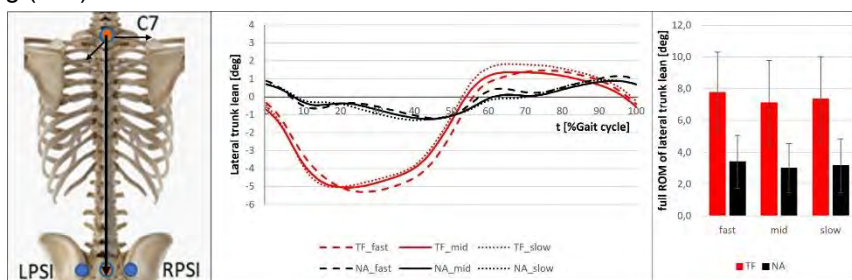


Figure 1. Lateral trunk lean of TFs (red) and NAs (black) during level walking.

DISCUSSION AND CONCLUSION

The pattern of lateral trunk lean determined with the new segment shows comparable results as described in the literature for TFs [1-4] and for patients with cerebral palsy [5,6], calculated with different standard marker models. Clear differences of this motion between NAs and TFs could be shown. The ROM is increased in the TFs and the motion is not as symmetric as in the NAs. These are typical compensatory mechanisms of TFs.

With a similar use of a marker on C7 and the sacrum, Köhler et al. showed that this trunk lean could be useful

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5.393 Investigation of Limb Symmetry in the Use of Running-Specific Prosthesis in Unilateral Transtibial Amputees

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BACKGROUND

Physical exercise is recommended for amputees for rehabilitation and lifelong health maintenance. Running improves many aspects of health, including physical, mental and social well-being, and participation is increasing among amputees with the use of Running-Specific Prostheses (RSP). On the other hand, people with transtibial amputation often complain of symptoms associated with musculoskeletal deformities due to asymmetric movement patterns. Therefore, biomechanical studies including sports activities in this population are needed.

AIM

The aim of this study was to evaluate the symmetry of the amputee and intact knee in the use of RSP, which is increasing in popularity and use among amputees.

METHOD

Participants were video recorded in the sagittal plane during slow running with RSP to convert knee flexion motion into angles for the amputated and intact knee and to make measurements using the software's virtual goniometer. The peak flexion of knee (PFK) during the swing phase and the initial flexion (IFK) of knee during the initial contact of the stance phase were both recorded as angles for both extremities. The Symmetry Index was used to assess the symmetry of the kinematics between the amputated and intact extremities.

RESULTS

20 participants were recruited to the study (aged 34.11 ± 5.13 years; BMI 25.35 ± 2.42 kg/m²). PFK was 70.38 ± 8.05 degrees for the amputated side and 74.74 ± 7.86 degrees for the intact side; IFK was 17.62 ± 4.96 degrees for the amputated side and 19.77 ± 5.06 degrees for the intact side. PFK and IFK values were significantly different between amputated and intact extremities (PFK, $p=0.003$; IFK, $p=0.047$). The amount of PFK symmetry was determined as $6.06 \pm 7.8\%$, and IFK symmetry was determined as $12.34 \pm 25.5\%$.

DISCUSSION AND CONCLUSION

Two important kinematic parameters of the knee in the sagittal plane including stance and swing phase were analysed and it was concluded that PFK demonstrated moderate symmetry and IFK demonstrated asymmetry pattern in the amputated and intact extremities. It is critical to quantify and stimulate symmetrical movement patterns to benefit from physical activity without causing secondary injuries in individuals with amputation. Although many benefits of running at recreational level alone have been defined, we suggest that individuals using RSP should be assessed in terms of movement patterns and be included in a rehabilitation programme to encourage symmetrical movement patterns before encouraging further participation in sport.



5.394 Case Study: Effects of a stiffened cycling specific foot with varying forefoot lengths on a transtibial cyclists' performance

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BACKGROUND

For PWDs, participation in cycling has not only provided alternative mode of transportation but also benefits in terms of recreation and health.

Current cycling prosthesis can be classified in two designs, through the pedal and off-center. Energy efficiency and balance are important measures in endurance sports such as cycling, however there are limited studies that explore the effects of the different forefoot positions on these measures in transtibial amputees.

AIM

The study aims to determine the effects of different forefoot lengths on a transtibial cyclist energy efficiency and pedal symmetry.

METHOD

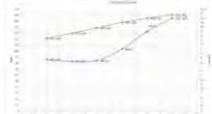
A 54-year-old K3/K4 transtibial amputee was recruited to cycle with three different conditions- With his dynamic foot, a 4.5cm offset and no offset. An initial ramp session a month prior to trial was conducted in a performance laboratory to measure his Aerobic Range (Z2) while using his current prosthesis without pedal attachment and mountain bike's preferred position. Only the foot was changed in the second session while maintaining power at Z2 and 5-10 minutes of rest was provided during the change of foot condition. The patient's lactate, VO₂, HR, Cadence, Power and L/R Balance were measured for all conditions.

RESULTS

Zone two where the conditions were determined between 137-145 bpm, and 134-155W. The benchmark and trial sessions differed with the attached/clipped condition of the foot and the pedal. There were no observed differences in Lactate and VO₂ between sessions and cycling foot offset. The 4.5cm offset provided the most symmetry with a 4% L-R average difference, followed by the 0cm offset at 14% with the patient's 27 cm foot at 23.7% (1st session) and 18.5% (trial).

The patient preferred the 4.5cm offset the most, followed by the 0 offset. The preference was also due to the feeling of the same alignment in the socket as with the normal foot while pushing on the pedal.

Table 1: Session Data between trials and foot

	Initial Session and Test Setup	0 Offset	4.5 cm Offset	27 cm Foot 9cm offset
Picture				
Ave Z2 Power	135-155W	145	145	145
L-R Bal.	23.7% L>R	14% L>R	4% L>R	18.5% L>R (2 nd)
Z2 HR	133-155	150		
Max HR				

DISCUSSION AND CONCLUSION

While there was no difference observed in physiological effect while maintaining the aerobic power zone, it could not be said for anaerobic zones. The patient's subjective preference was with the 4.5cm, socket alignment with the zero offset could be adjusted but was not considered. Improved L/R balance may be attributed to (1) clipped condition of the foot, preventing slippage of the foot and (2) 0-4.5cm (1/6 foot) offset which allowed a more direct transfer of force to the pedal than rotation or flexing of the foot

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ACKNOWLEDGEMENTS

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5.395 Enjoying a Floorless Rollercoaster with your Prosthetic Leg on: An Innovative Design Enhancing Amusement Park Accessibility

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BACKGROUND

People with lower extremity prostheses are prohibited from riding (floorless) rollercoasters with their prosthesis on. Current roller coasters, particularly floorless roller coasters, pose the risk of prosthetic leg detachment and ejection out of the rollercoaster, due to the high G-forces exerted during the ride. Prostheses ejection might lead to accidents and injuries to rollercoaster riders and bystanders

AIM

This research aims to develop a product that ensures the secure attachment of prosthetic legs that can withstand the dynamic forces of rollercoasters, while ensuring user comfort, ease of use, and adherence to safety standards.

METHOD

A double diamond approach was used involving G-force measurements in a rollercoaster, interviews with stakeholders, a questionnaire with prosthesis users and a risk assessment. The research led a list of requirements and subsequently to the concept generation and development of two primary concepts: the SafeStrap and the MeshSafe. These designs were prototyped and evaluated under real-life conditions in the rollercoaster 'De Baron' in the Efteling amusement park, with four prosthesis users and with a test dummy. Feedback from the participants with prosthetic leg and rollercoaster operators and videos from the test with the dummy were collected.

RESULTS

The measurements, the input of stakeholders from rehabilitation centers, prosthetic manufacturers, amusement parks and regulatory bodies informed concept generation and product development. In addition, the user survey showed the priorities of prosthetic users, with most of them willing to use a practical safety product. Based on the list of requirements two solutions were developed, the SafeStrap and the MeshSafe (Figure 1). Testing of the prototypes showed both systems effectively prevent prosthetic detachment. The SafeStrap showed advantages in simplicity, compactness, and adaptability for diverse rollercoasters, while the MeshSafe showed a slightly better performance with transfemoral prostheses. There was no significant difference in the feedback from the participants regarding the MeshSafe and the SafeStrap.

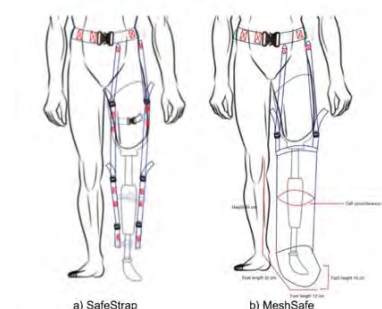


Figure 1. Final design iteration of the SafeStrap (left) and MeshSafe (right)

DISCUSSION AND CONCLUSION

This study developed and evaluated two innovative safety solutions for securing prosthetic legs on rollercoasters. While both systems prevented prosthetic detachment, SafeStrap, emerged as the most promising solution, because of its compact design and adaptable components. The SafeStrap offers a practical and user-friendly mechanism to secure prosthetic legs during roller coaster rides, opening up the access and inclusion for individuals with lower extremity prostheses in amusement park rides.

ACKNOWLEDGEMENTS

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Free paper session | Rehabilitation medicine and surgery – Population analysis

5.401 Experiences with Rehabilitation Outcome and Prosthetic Fitting after Hemipelvectomy and Hip Disarticulation

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BACKGROUND

Aktiv Ortopedteknik Rehabilitation, Sweden, serves Stockholm County Council, as a Specialist Centre for people with amputations or limb deficiency. Hemipelvectomy and hip disarticulation are rare. The evidence and experience on outcomes such as prosthetic use is limited ⁽¹⁾. Further knowledge is needed to support health care professionals and enable correct information about realistic expectations. We wanted to gain experiences of fitting patients with prosthetics after amputations on these levels.

AIM

The aim was to describe our experiences with rehabilitation and outcomes of patients with hemipelvectomy or hip disarticulation and improve knowledge about expectations.

METHOD

This is a retrospective data register report combined with interviews.

Patients with a hemipelvectomy or hip disarticulation that underwent rehabilitation at our clinic during 2019 to October 2024 were included, n=8. Characteristics such as age, gender, reasons for amputation and number of physiotherapy assessments were recorded. Quality of life was assessed with the Swedish EuroQol Group EQ5D. A question guide for the interviews was conducted, based on the follow ups described in the Swedish National Quality Register for Lower Limb Amputees (Swedeamp) and consensus from 4 experienced physiotherapists working at Aktiv Ortopedteknik. Exclusion Criteria: Not being a Swedish Citizen (1).

RESULTS

All patients were fitted with prosthetics, 4 women, 4 men, mean age 42. The causes of amputations were Trauma (1), Aortic Dissection (1), Sarcoma (5) and Critical Limb Ischemia (1).

When interviewed (October 2024), 4 patients were prosthetic users, and 4 patients had seized using the prosthesis. Occasions when patients found the prosthesis beneficial were; during exercise, walking the dog, traveling, visiting restaurants, walking stairs. Reasons not using the prosthesis were: high energy consumption, bad suspension, too heavy. Several patients indicated that their expectations were not met but they were still satisfied with the prosthetic rehabilitation. When estimating health on EQ5D from 0 (the worst health you can imagine) to 100 (the best) the mean answer was 73.

Mean assessments with physiotherapist was 13 (with and without prosthetics).

DISCUSSION AND CONCLUSION

These findings indicate that prosthetic fitting seldom stands as a single locomotion solution for patients with hemipelvectomy or hip disarticulation. Even though the expectations with the prosthetics weren't met there were occasions when the patients found their prosthesis beneficial. The patients were satisfied to have the option of choosing to use a prosthesis. To be discussed further is if these patients need more time for rehabilitation to maximize the outcome.

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5.402 Past, Present and Future of Injury Prevalence in High-Income Countries: insights and projections to 2030 from the Global-Burden-of-Disease-Study

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BACKGROUND

Injury prevalence is a metric which can be used to understand health care utilization and prioritize injuries based on the magnitude of the injury rate. Given the aging population in high-income countries (HICs) and subsequently ageing of the injured population, the probability of long term or permanent consequences of injuries is also likely to increase. Understanding past trends and exploiting patterns of prevalence injury rates (PIRs), future PIRs can be predicted.

AIM

To determine temporal changes in the past of different injuries, i.e., *Amputations, Burns, Fractures, Head Injuries and Spinal Injuries*, in HICs and to project future trends.

METHOD

Data on PIRs from the Global-Burden-of-Disease-Study 2019 (GBD2019) was collected. To understand past trends of GBD2019, joinpoint regression analysis was used to find trends expressed as annual percent changes (APCs), averaged APCs and to compare trends across injuries. To project future PIRs up to 2030, ARIMA time series analysis was utilized on the GBD2019 data.

RESULTS

All injuries showed negative averaged APCs during 1990 – 2019. However, an increased PIR is found for the last APC period of the same time interval, greatest being in *amputations* with 2.3 (2.1 – 2.4). All PIR trends were statistically neither parallel nor identical across the injuries. Forecasts showed an absolute and relative increase in PIR projection (Figure 1). With amputations having in relative and absolute terms highest increase of all injuries.

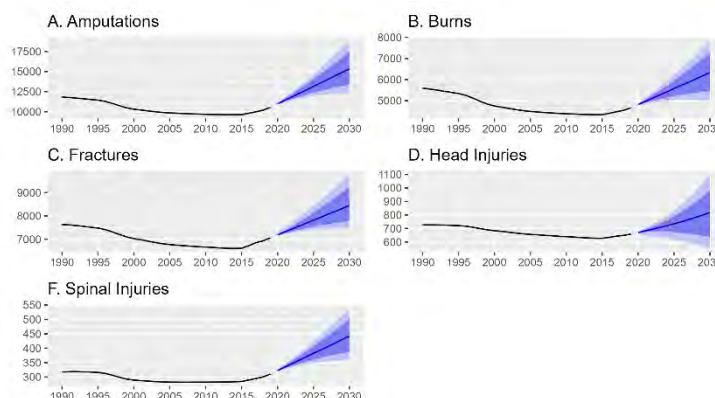


Figure 1. Projected injury rates per 100,000 persons.

DISCUSSION AND CONCLUSION

The trends of PIRs positively declined in the past. However, the last trend showed an increase. This increase is continued in the projected forecast up to 2030. Reflection and advocating for strategies to mitigate the possible outcome of increased PIRs are given. This proactive approach will form the foundation for future resource allocation and planning. Additionally, there may be a need to adjust current treatment strategies and standards to address the expected increase in demand.



5.403 Lower Extremity Amputation and Shared Decision-making: Patient experiences & Perceived facilitators and barriers among surgeons - A national cross-sectional survey

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BACKGROUND

Major lower limb amputation (MLEA) profoundly impacts patients' lives and shared decision-making (SDM) can be crucial when making such sensitive decisions as determining the appropriate amputation level. Although clinicians aim to involve patients actively, barriers persist in implementing SDM effectively.

AIM

This study explores patients' and surgeons' experiences with SDM in pre-amputation communication, examining patient experiences and attitudes toward a decision-support tool and identifying facilitators and barriers to SDM among surgeons involved in amputation level decisions.

METHOD

Two electronic surveys were conducted. The first surveyed 49 individuals with MLEA recruited through social media, healthcare professionals, and patient organizations. The second survey received responses from 28 vascular and 24 orthopedic surgeons. Both were distributed between November 2023 and January 2024. The study-specific surveys included themes on pre-amputation communication, SDM preferences, discussion of amputation levels, and the potential use of a decision-support tool. Descriptive statistics and inter-specialty comparisons were applied to analyze responses.

RESULTS

Among patients, 43% felt unprepared for amputation, 54% reported that the decision about the amputation was made within a few hours, and 80% did not know the surgeon with whom they discussed the amputation. While 59% were satisfied with pre-amputation discussions, 22% expressed dissatisfaction; 73% wanted involvement in decisions about amputation level, and 68% saw a decision-support tool as beneficial.

Among surgeons, significantly more vascular surgeons than orthopedic surgeons believed that a decision-support tool would improve pre-amputation conversations (70% vs 42%), enhance patients' decision-making experiences (78% vs 46%), and benefit their work (63% vs 33%). Both groups agreed on the importance of asking about the patient's preference for SDM (67%), however, 39% of the surgeons thought patients found it difficult to understand the pros and cons of different amputation levels. Additionally, vascular surgeons felt excluded from final amputation level decisions, and 63% of orthopedic surgeons reported limited genuine choice of amputation level.

DISCUSSION AND CONCLUSION

Patients facing MLEA generally desire active involvement in SDM, while clinicians face barriers to effective implementation such as limited choice of amputation level. A decision-support tool could enhance SDM by supporting patient engagement and fostering interdisciplinary collaboration between orthopedic and vascular surgeons, potentially improving patient preparedness and satisfaction with treatment.

ACKNOWLEDGEMENTS

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5.404 Effect of postoperative ambulation level on the quality of life in a trans-tibial amputee

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BACKGROUND

Quality of life of a trans-tibial (TT) amputee is not only determined by his functional rehabilitation but also social, economical and psychological rehabilitation. A number of studies have analyzed the influence of lower limb amputation on these factors. This study analysed the effect of functional recovery on other parameters of quality of life in a TT amputee.

AIM

To assess the influence of level of ambulation postoperatively on the socioeconomic and psychological aspects in a transtibial amputee

METHOD

This was a 10 years retrospective and 2 years prospective study. A total of 160 patients of trans-tibial amputation were followed. Their postoperative ambulatory status was calculated using Pinzur's ambulatory level. Their quality of life was determined on the basis of answers to a five point questionnaire which included their social, economic and psychological aspects. These parameters were correlated to assess the influence of functional recovery on the quality of life.

RESULTS

All the amputees with Pinzur's 0-1 level of ambulation suffered loss of income consequent to loss of job. All of them felt increased level of depression and anxiety after amputation. 50% of the patients with postoperative 0-1 level of ambulation felt socially neglected. Comparatively much less percentage of amputees with 5-6 level of ambulation suffered economic, social and psychological crisis.

DISCUSSION AND CONCLUSION

Quality of life of a TT amputee is determined not only by his functional rehabilitation but also social, economical and psychological factors. From this study we concluded that post operative functional outcome significantly affects the quality of life of an amputee. An amputee with better ambulation level fares better economically, psychologically and socially in comparison to an amputee with poor ambulatory outcome

Questionnaire	Answer	Ambulation level			
		0-1 (n=8)	2-4 (n=56)	5-6 (n=96)	Total (N=160)
Occupation change/lost job	Yes	100% (8)	75% (42)	34.4% (33)	51.9% (83)
	No	0% (0)	25% (14)	65.6% (63)	48.1% (77)
Income decline	Yes	100% (8)	83.9% (47)	41.7% (40)	59.4% (95)
	No	0% (0)	16.1% (9)	58.3% (56)	40.6% (65)
Loss of social support	Yes	50% (4)	57.1% (32)	12.5% (12)	30% (48)
	No	50% (4)	42.9% (24)	87.5% (84)	70% (112)
Increase in depression	Yes	100% (8)	92.9% (52)	51% (49)	68.1% (109)
	No	0% (0)	7.1% (4)	49% (47)	31.9% (51)
Increase in anxiety	Yes	100% (8)	82.1% (46)	31.3% (30)	52.5% (84)
	No	0% (0)	17.9% (10)	68.7% (66)	47.5% (76)

Correlation of ambulatory scale and quality of life

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5.405 Outcomes in patients after major lower limb amputation: Early results and future perspectives of the Danish Amputation Database (DanAmp)

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BACKGROUND

Annually, around 1200 major lower extremity amputations (MLEAs) are performed in Denmark, at 21 different hospitals. There are large national differences in amputation rates, mortality, and rehabilitation. The patients are some of the most multi-morbid and vulnerable patients in the orthopedic wards, and there is a need to comprehend the impact of amputation on patients' life. The Danish amputation database (DanAmp) was established in 2023, and will describe and investigate the perioperative course of patients having MLEA in Denmark. DanAmp also registers patients' health-related quality of life and functioning up to 3 years after the operation.

AIM

To describe early in-hospital results and present future perspectives of DanAmp.

METHOD

DanAmp is a national research database under implementation. It was pilot-tested in 3 Orthopedic Departments in 2023, and implementation to other Orthopedic Departments began in December 2023. Inclusion is based on patient consent. Demographic, peri- and postoperative data is collected during hospital admission. Patient-reported follow-up data is collected via e-questionnaire at 3, 6, 12, 24, and 36 months. Data are entered in a REDCap database. Variables are based on available evidence and existing clinical guidelines.

RESULTS

By October 2024, nine of 21 orthopedic departments reported data in DanAmp, and 233 out of 326 (71.5%) screened patients were included. The primary reason for exclusion was cognitive impairment (52%).

Median age was 73 years (IQR 64-78) and 64 % were men. The most often reported comorbidities were arteriosclerosis and diabetes (64% and 46%). Self-reported health status (EQ5D-VAS, 0-100) 1 month before amputation was mean 51 (SD 27) and 26% could not walk before amputation. Amputation level was 1% hip disarticulation, 65% transfemoral, 1% knee disarticulation, and 33% transtibial amputation. 51% of patients were operated within 0-1 days from time of indication, and 36% within 2-7 days. A total of 33% of amputations were performed by a specialist surgeon and 51% were supervised by a specialist surgeon. 70% were mobilized within first postoperative day, and 92% were discharged with a rehabilitation plan. Post-operative length of stay was a median of 7 days (IQR 5-11).

DISCUSSION AND CONCLUSION

DanAmp seeks to address critical knowledge gaps concerning outcomes after MLEA, by systematically monitoring the entire treatment trajectory. Further, DanAmp wishes to increase focus on amputations by creating a national professional forum for research, learning, and quality improvement and thereby help to ensure the best possible and consistent treatment across Denmark. Implementation of the database is continuing.



5.406 Demographic and medical statistics from the Centre for Handicapped (CFH) database, 1987-2024: a Central Sri Lankan prosthetics and orthotics centre

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BACKGROUND

To provide effective rehabilitation care, it is paramount to understand the end-user population. Until 2009, Sri Lanka experienced a 26-year civil war affecting primarily northern and eastern districts, creating a large amputee population.

AIM

In this study, we use routinely collected data from prosthetic and orthotic (P&O) centres to investigate geographic variability in amputee demographics in Sri Lanka, and compare demographics between cities affected and not affected by civil war.

METHOD

The Centre for Handicapped (CFH) is a P&O centre in central Sri Lanka which provides patient care in Kundasale and via mobile clinics. An anonymized copy of patient records were obtained in May 2024 and included 14,357 unique patients (1987-2024). Here, we focused on patients who received prosthetics from CFH, investigating demographic and temporal trends. Chi-squared tests with a Yate's correction were used to compare results between the CFH and the Jaffna Jaipur Centre for Disability Rehabilitation (JJCDR) from the north [1].

RESULTS

6,017 unique patient IDs were provided prosthetics and had demographic and cause of amputation (5,337 male, 676 female, 4 NA). Key findings include: (i) 55.88% of patients had war-related amputations, (ii) the highest non-war-related causes of amputation were vascular (11.00%), and diabetes (10.71%). (iii) 31.43% of amputees were injured in a different district from the one they live in now, 81.81% of which were injured in a warzone, meaning differences in districts could be displacement due to war, and (iv) 97.67% of patients with amputation site recorded were lower-limb amputees. CFH had a larger proportion of males than the JJCDR ($p < e-4$), and the JJCDR had a larger proportion of war-related amputees ($p < e-4$).

DISCUSSION AND CONCLUSION

Low-and middle-income countries are often treated as homogeneous entities. However, differences in demographics, causes of amputation, etc. can indicate differences in end-user needs, and therefore affect rehabilitation care. Here, we show that variation exists within a post-civil war country depending on if the district being served was directly affected by war or not. Further investigations into demographic and temporal trends in the amputee populations throughout Sri Lanka should continue to be analysed and considered in relation to P&O services and end-user needs.

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ACKNOWLEDGEMENTS

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Prize nominee session | Best papers – Sustainability

5.411 Understanding repair and replacement of prosthetic limbs using routinely-collected data: a retrospective study over three decades in Cambodia

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BACKGROUND

Prosthetic limbs deliver major quality of life and socioeconomic benefits for people with amputation, particularly in low-resource settings. The value of administrative data analysis to enable sustainable health care improvement is established [1], but there has been limited research into the failure, repair, and replacement of prosthetic limbs. Survivorship data is sparse and highly variable, and rarely addresses differences between demographic groups.

AIM

Therefore, we investigated the distribution of time between device delivery, repair and replacement for a Cambodian cohort, considering the influence of a range of service delivery, user demographic and health characteristics [2].

METHOD

This study undertook an observational retrospective analysis of routinely-collected longitudinal data describing people accessing prosthetics services over multiple time points. Secondary data analysis was approved by Institutional (ERGO45577&51898) and Cambodian national review boards (230&311NECHR). All records were collected in the 'PMS-5' database (ICRC). Each line of data described a clinical contact such as an assessment, device provision, repair, or replacement. We conducted Kaplan-Meier survival analysis, and a Cox model to compare repair and replacement likelihood between groups.

RESULTS

The study analysed 14,822 device deliveries to 6,986 clients, with median 3 devices/person (interdecile range IDR 1–9), and 22,205 repairs, median 1 repair/device (IDR 0–4). The median device survival before repair was 237 days (IDR 38–854), and replacement was 727 days (IDR 208–2154). Devices used by people in more active occupations were repaired earlier, and devices were replaced earlier when used by children, replaced later for upper- than lower-limb devices, and replaced earlier for volume change than for wear and tear. Several less intuitive trends were revealed such as different preferences or capacities between clinics for device repair vs. replacement,

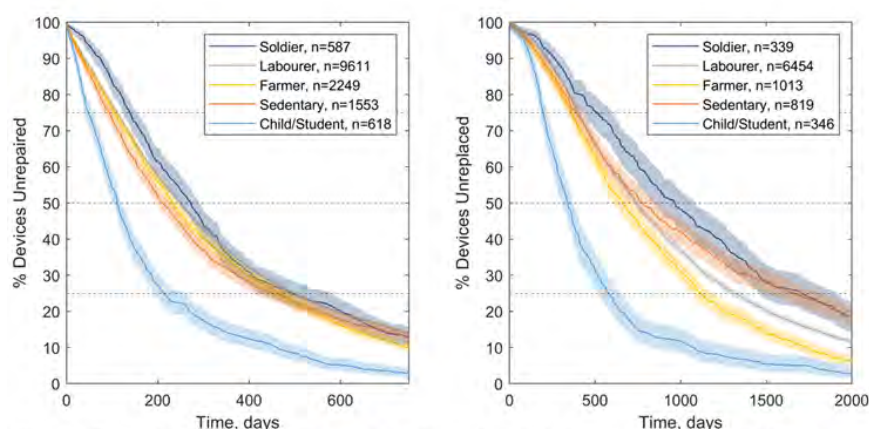


Figure 1: Example survivorship data of prosthetic devices before repair (left) and replacement (right), used by physical rehabilitation service clients with different roles. Shaded zones indicate 95% C.I. and dashed lines enable the 25th percentile, median and 75th percentile times to repair to be compared between groups.

and earlier device repair and replacement for women than men



DISCUSSION AND CONCLUSION

Prosthetic limb repair and replacement is influenced both by the device's durability and the user's access to well-resourced physical rehabilitation services. A worn-out device may indicate poor quality, or the opposite: that it fitted well and enabled great mobility. However, such analysis may enable us to identify a 'Goldilocks' timeframe for device repair or replacement, identify groups who are less well-served by current devices or rehabilitation models, and contribute to cost effectiveness analysis of current services. Furthermore, the findings represent benchmark data against which engineers could measure new technologies, to ensure that innovation justifies its inherent risk by offering a genuine improvement which balances functionality, cost, and durability.

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5.412 Empathy to Exhaustion: A Mixed-Methods Qualitative Study Exploring Burnout in Orthotic and Prosthetic Clinicians

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BACKGROUND

Burnout, first defined in the 1970s, affects healthcare professionals across disciplines. Despite this, burnout research in Orthotics and Prosthetics (O&P) is limited. O&P clinicians face unique stressors from clinical and technical responsibilities, impacting mental health and job satisfaction. This study aims to quantify burnout and explore contributing factors. With O&P growing rapidly in the United States, addressing burnout is vital for clinician well-being and profession sustainability.

AIM

This study aims to quantify burnout levels in O&P clinicians and qualitatively explore the factors contributing to this phenomenon, filling a current gap in research on the topic.

METHOD

This IRB approved study follows a constructivist and phenomenological approach using a mixed-methods design. An outcomes survey, including the Abbreviated Maslach Burnout Inventory (aMBI), was distributed to Baylor College of Medicine (BCM) alumni and preceptors, quantifying burnout across three dimensions: Emotional Exhaustion (EE), Depersonalization (DP), and Personal Accomplishment (PA). Follow-up interviews examined respondents stressors, burnout prevention methods, and personal experiences. Interviews were coded for themes using MAXQDA software and analyzed with SPSS. Statistical analyses (Mann-Whitney U, Pearson's Correlation, Kruskal-Wallis) assessed the data.

RESULTS

106 respondents met inclusion criteria and completed the aMBI. Of these, 36 opted in and completed follow-up interviews. Most respondents reported low burnout in PA and DP, but high burnout in EE (37.7%). It was discovered that 78.3% of total participants are experiencing burnout in at least one of these three categories, with men experiencing DP more than women ($p=0.043$). Interviewees frequently cited workload as a stressor and only half felt supported at work. Interviewees experiencing high burnout levels frequently described worsening mental health and relationships, and the financial stress of loans as a barrier to career change. High burnout levels also correlated with increased considerations of leaving the field due to unsustainable expectations and work hours.

DISCUSSION AND CONCLUSION

Burnout affects a large percentage of Orthotic and Prosthetic clinicians, with high rates of EE overall, and high DP, especially among men. Key contributors include workload, staffing shortages, and financial stress. Burnout impacts clinician well-being, patient care, and retention, highlighting a need for targeted interventions within this growing profession. Burnout in O&P clinicians mirrors that of physicians¹, highlighting the need for systemic changes to retain and attract qualified professionals.

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Burnout Category	Degree of Burnout	Survey Respondents (106)		Interview Respondents (36)	
		N	%	N	%
Personal Accomplishment (PA)	Low/None	78	73.6%	29	80.6%
	Mid	8	7.5%	1	2.7%
	High	20	18.9%	6	16.7%
Depersonalization (DP)	Low/None	64	60.4%	18	50%
	Mid	27	25.5%	14	38.9%
	High	15	14.2%	4	11.1%
Emotional Exhaustion (EE)	Low/None	29	27.4%	7	19.4%
	Mid	37	34.9%	14	38.9%
	High	40	37.7%	15	41.7%
# of Categories in which a respondent exhibited BO					
No Burnout		23	21.7%	5	13.9%
1 Category (mid/high)		37	34.9%	13	36.1%
2 Categories (mid/high)		28	26.4%	13	36.1%
3 Categories (mid/high)		18	17%	5	13.9%
Respondents Experiencing Burnout		83	78.3%	31	86.1%

Figure 1. Summary of burnout scores from aMBI for both interview participants and those who only responded to the survey.



5.413 Construction Reliability of a Locally Sourced Pressure-Reducing Wheelchair Cushion for Less-Resourced Settings

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BACKGROUND

In low-resource settings, up to 80% of individuals with spinal cord injuries develop life-threatening pressure ulcers within two years ⁽¹⁾. Appropriate wheelchair cushions effectively reduce ulcer incidence and severity but can cost upwards of US\$100. The Tuball cushion is a low-cost alternative made from readily available materials such as aluminum can tabs, rubber bands, bicycle tubes, a pillowcase, polyethylene plastic balls, and a plywood board ⁽²⁾.

AIM

This study aimed to assess whether individuals with limited knowledge of cushion fabrication could reliably construct the Tuball cushion.

METHOD

A convenience sample of occupational therapy students (n=11) were randomly allocated into two groups, constructors or sitters. Constructors (n=6) constructed the cushions. Sitters (n=5) then sat on each cushion in a standardized inflation state, while their pressure distributions were mapped. Intraclass correlation coefficients (ICCs) with 95% confidence intervals were calculated to evaluate the inter-rater reliability of cushion construction using various pressure indices: dispersion index (primary outcome), and peak pressure index, contact area, and seat pressure index (secondary outcomes) across all six cushions.

RESULTS

The dispersion index demonstrated 'good-moderate' inter-rater reliability (ICC=0.75, 95% CI: 0.10-0.97). For secondary outcomes, ICCs indicated 'excellent' reliability: peak pressure index (ICC=0.88, 95% CI: 0.57-0.99), contact area (ICC=0.95, 95% CI: 0.83-0.99), and seat pressure index (ICC=0.92, 95% CI: 0.71-0.99).

DISCUSSION AND CONCLUSION

Results indicate that the Tuball cushion can be reliably constructed by individuals without previous experience, when given equivalent materials and clear instructions. Its durability, with a lifespan of at least one year ⁽²⁾, enhances its sustainability compared to foam cushions, which often degrade faster. The Tuball's design offers a low-cost, practical solution for pressure relief in less-resourced settings, where commercial cushions are often financially inaccessible. However, variability in locally sourced materials may affect the cost, consistency, and functional lifespan of Tuball cushions across different regions, impacting their accessibility and performance.

While this study confirms construction reliability, clinical applicability in diverse settings remains to be assessed. Wheelchair cushions cannot compensate for a poor wheelchair fit, which may result in uneven pressure distribution and can even increase the risk of skin breakdown. Further research is required to assess clinical applicability in less-resourced settings. This study contributes to the field by demonstrating the construction reliability of the Tuball and highlighting the need for ongoing evaluation to enhance its clinical utility and ensure optimal outcomes for users.

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Free paper session | Seating and wheelchairs

5.414 Impact and Retention of a Peer-led eHealth Wheelchair Skills Training Program

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BACKGROUND

Despite skills training being an essential component of best practice in manual wheelchair (MWC) provision ^[1] it is typically inadequate or absent even in well-resourced countries ^[2]. Access to rehabilitation therapists is often restricted and they often lack the skills and experience to provide authentic training. To better address issues of access and impact, we developed and evaluated the TEAM Wheels eHealth tablet-based training program delivered by peer trainers ^[3].

AIM

To measure TEAM Wheels impact on MWC-related outcomes, retention of benefits, and outcome correlations with participant demographics and program engagement.

METHOD

Community-dwelling MWC users in Canada were recruited in a multi-site RCT with a wait-list control group. The 4-week TEAM Wheels intervention included 3 virtual sessions with a peer trainer and training with a tablet-based app with over 200 educational and practice videos. Outcomes were measured pre/post-intervention and after 6 months. Outcomes related to satisfaction with activity performance, MWC skill capacity, self-efficacy and health-related quality of life were compared using ANCOVA. Demographic and tablet engagement data were compared using independent t-tests and Pearson correlation.

RESULTS

Among participants retained (n=42), 19 were allocated to TEAM Wheels. Compared to controls, there were significant differences in satisfaction ($p = 0.026$), skill capacity ($p = 0.004$), self-efficacy ($p = 0.017$), and quality of life ($p = 0.029$). At 6-month follow-up, there were further improvements in participation ($p = 0.043$) and skills ($p = 0.025$), with retention in the other measures. Outcomes were comparable across sex, age, education, MWC experience, and living situation, although trending towards greater improvements among more novice participants and those with more education and living alone. Participants who met the goal of 300 training minutes had significantly larger improvements and more time spent on the training app was highly correlated with all outcomes except quality of life.

DISCUSSION AND CONCLUSION

The improvements TEAM Wheels provided across multiple outcomes were retained or enhanced six months after program delivery, and across a variety of participant demographics. Engaging authentic MWC users as peer trainers may be a key component in addition to participants investing time and effort with the training app. An eHealth approach may be more economical and accessible than the traditional out-patient format.

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5.415 What makes a peer-trainer and how to enjoy being one: lessons learned from the TEAMWheels program

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BACKGROUND

Wheelchair skills are essential for maximizing participation in meaningful activities for wheelchair users. However, provision of manual wheelchair (MWC) skills training is variable across Canadian rehabilitation centers. Delivery by therapists can be costly and lack authenticity of lived experiences for MWC users. A peer-led MWC skills training program integrating videoconferences and a tablet-based app (called TEAMWheels) was developed to increase community-based MWC skills training opportunities. Based on previous research, peer-led interventions may have benefits beyond MWC skills improvement, including increased self-efficacy, enhanced social participation and increased satisfaction with accessing services.

AIM

The aim of this study was to explore experiences and perceptions of peer-trainers (PTs) after delivering the TEAMWheels program in three Canadian cities.

METHOD

A descriptive qualitative design employed semi-structured interviews with PTs who delivered the TEAMWheels program to MWC users. Open-ended questions explored MWC experience and previous peer mentor involvement, preparation for the TEAMWheels PT role, and experiences specific to the study (i.e., participants and research team). Interview recordings were transcribed verbatim, content coded, and inductively constructed into themes.

RESULTS

All TEAMWheels PTs from three cities (n=7) participated. The first theme revealed how PTs merged their lived experiences and personal skillsets to fill the role. Three subthemes included “*wanting to answer an unmet need*,” “*speaking from lived experience*,” and “*skills and qualities as ingredients for diverse PT recipes*.” Overall, this theme enriched understanding of what participants perceived as important qualities and competencies to accomplish the PT role. The second theme exposed essential building blocks of quality experiences for trainers in peer-led initiatives. Three subthemes included “*individualizing the relationship*,” “*permitting flexibility in program delivery*,” and “*empowering PTs through enhanced competence*.” Overall, this theme provided a comprehensive appreciation of the influence of structural aspects of TEAMWheels on PTs experiences.

DISCUSSION AND CONCLUSION

Our findings revealed the importance of preparing PTs with tools to navigate the complexity of a peer-trainee relationship. Success of the intervention and relationship relied not only on the competencies of the PT, but also on the trainee and structural elements specific to the program and its delivery. This study provided meaningful insights that transcend MWC skills training on how to optimize the experience of PTs in peer-led interventions.



5.416 Physiologic Responses of Competitive Wheelchair Basketball Athletes During Early Season Fitness Assessments

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BACKGROUND

Wheelchair Basketball is a fast-paced Paralympic sport. Athletes are eligible to participate if they have a health condition that presents with a permanent physical impairment: impaired muscle power, impaired passive range of motion, limb deficiency, hypertonia, ataxia, or athetosis. The different underlying health conditions and comorbidities of these athletes may impact autonomic regulation. Fitness assessments, such as the six-minute push test (6MPT), are commonly performed in early season to establish baseline metrics and assist coaches in developing training sessions and competition strategy.

AIM

To describe the physiologic responses of a diverse group of competitive wheelchair basketball athletes to early season fitness assessments.

METHOD

A convenience sample of (n=16) wheelchair basketball athletes competing on a registered National Wheelchair Basketball Association (NWBA) Division II or Division III team in Arizona, USA were instructed to perform the six-minute push test (6MPT)¹ at their top speed. Physiologic vital signs and the rating of perceived exertion (RPE) were collected pre- and post-6MPT. RPE was measured using a modified version of Borg's CR-10 scale. The Karvonen formula was used to calculate the target heart rate for each athlete:

$$HR_{\text{target}} = HR_{\text{rest}} + (HR_{\text{max}} - HR_{\text{rest}}) \times K$$

The desired workout intensity coefficient (K) was set at 80% for this analysis. Athlete sport classification was used as a proxy to represent physical function.

RESULTS

The average basketball experience of the athletes was 11.3 years (range 1-32). Figure 1 summarizes individual athlete performance on the 6MPT. Over eighty percent of athletes (n=13) had an abnormal physiologic response to exercise and 25% (n=4) had multiple abnormal responses. Twenty-two abnormal responses were recorded (Table 1). Vital signs were not significantly correlated with RPE, pushing speed, or distance pushed. There was a moderate correlation between push distance and RPE ($r_s=.55$, $p=.03$). Abnormal responses did not correspond to sport classification.

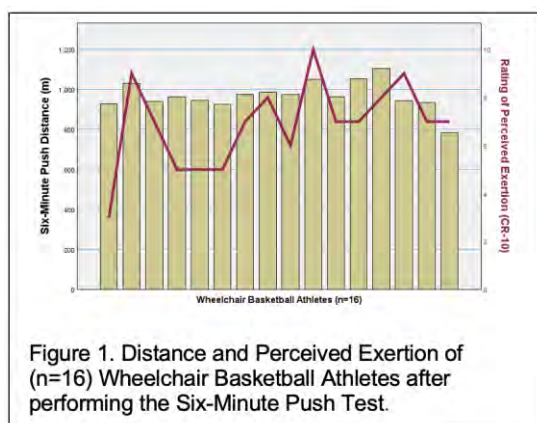


Table 1. Frequency of Abnormal Physiologic Responses of Athletes.

Physiologic Variable	Abnormal Athlete Responses	
Heart Rate (HR)	Significant drop	(n=3)
Systolic blood pressure (SBP)	Rise < 20 mmHg	(n=6)
	Decrease	(n=7)
Diastolic blood pressure (DBP)	Rise >10 mm	(n=2)
Oxygen Saturation (SpO ₂)	Decrease	(n=1)



DISCUSSION AND CONCLUSION

High rates of abnormal physiologic responses were found in this study. This is likely an indication of autonomic dysregulation, suggesting that vital signs alone are not sufficient to describe baseline fitness.² Additional assessment measures should be considered, such as Borg's CR-10 RPE Scale, which was correlated with performance on the 6MPT in this group of athletes.

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ACKNOWLEDGEMENTS

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5.417 Exploring Athlete Factors that Influence Agility in Wheelchair Basketball

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BACKGROUND

Wheelchair basketball (WCB) is a fast-paced team sport that requires constant changes in speed and direction. Athletes compete in specialized wheelchairs with negative camber to enhance stability and agility. Thus, agility in a WCB context is influenced by the athlete's physical capacity, wheelchair fit and configuration, and individual mastery of sport movements and skills. The Illinois Agility Test (IAT) requires athletes to quickly change speed and direction through a course (Figure 1) and is broadly used across sports to evaluate movement agility.

AIM

To describe wheelchair athlete agility, as measured by the IAT, and explore the relationships between agility, athlete sport experience, sport classification, and sport wheelchair customization.

METHOD

A deidentified dataset consisting of 72 athletes from several sport organizations in Southern California and Central Arizona were used in the analysis. Athletes performed the IAT using a standard course (Figure 1) and verbal instructions.¹ For those with multiple IAT assessments, the fastest time recorded was used. The dataset also included demographic information. Athlete sport classification was used as a proxy for physical capacity. This point system (1.0-4.5) describes how impairment impacts athletes for WCB. Wheelchair fit and configuration were categorized based on whether the sport chair had been personalized (custom) or was a program chair (loaned). Years of training in the sport represented sport experience.

RESULTS

The 72 athletes (70% male) had 9.7 ± 7.8 years of WCB experience. IAT times ranged from 24.4-79.7 seconds. Sixty-two percent (n=45) had a WCB classification, but there was no difference in IAT times based on classification (U=187.5, p=0.48). Significantly faster IAT times were achieved by those using custom sport wheelchairs and those with more years of WCB experience (Table 1).

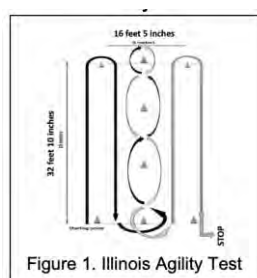


Table 1. Comparison of Illinois Agility Test times (seconds) between groups based on equipment and sport experience.

	ILLINOIS AGILITY TEST	Mann-Whitney U Analysis		
	Avg + SD (range)	U	z-score	p-value
SPORT WHEELCHAIR				
Custom (n=52)	32.6 ± 05.7 (24.4 - 56.0)	340	-2.26	.024*
Loaned (n=20)	39.6 ± 13.8 (28.2 - 79.7)			
SPORT EXPERIENCE				
0-5 Years (n=25)	36.9 ± 10.6 (28.2 - 79.7)	377.5	-2.48	.013*
> 5 Years (n=47)	33.3 ± 08.2 (24.4 - 67.6)			

*Statistically significant at p<.05

DISCUSSION AND CONCLUSION

The use of a standardized outcome measure (IAT) allowed for comparison of a diverse group of WCB athletes. Interestingly, IAT performance was correlated with differences in sport experience and wheelchair fit, but not physical capacity. These results are supported by the motor learning principle of task specificity, where athletes who have performed more repetitions of sport movements using customized equipment had better IAT times. On the other hand, the lack of correlation between IAT times and physical capacity may be attributed to the use of custom wheelchairs that are designed based on each athlete's ability. The high percentage of athletes using custom sport chairs (70%, n=52), despite not being covered by US medical insurance, also highlight wheelchair fit importance.

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ACKNOWLEDGEMENTS

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Free paper session | Prosthetics lower limb: transtibial, ankle, foot – Various topics

5.421 Assessing Sex Differences in the Perspectives and Priorities of People with Lower Limb Amputations – A Qualitative Study

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BACKGROUND

Despite accounting for 30% of people with lower limb amputations (pLLAs),¹ females with lower limb amputations (fLLAs) are underrepresented in research.² fLLAs also experience unique challenges when compared to males,³ including greater challenges with ambulation,⁴ higher rates of mental health problems,⁵ and lower success with prosthetic fit.⁴ Using qualitative methods to explore sex differences in pLLAs can expand our understanding of fLLAs' unique experiences and inform sex-specific rehabilitation and prosthetic design. As females have been historically underrepresented, it is imperative researchers meaningfully collaborate with fLLAs to ensure efforts reflect their needs and priorities.

AIM

This study sought to explore and better understand sex differences in pLLAs. We partnered with fLLAs to develop an interview guide to probe potentially sex-specific priorities.

METHOD

A committee of five fLLAs were engaged in developing an interview guide. The resultant guide included 10 questions targeting aspects of a user's prosthesis, as well as physical and psychosocial aspects of daily life. Interviews with male and female pLLAs were conducted online and recordings were transcribed verbatim. Data were analyzed collaboratively with the committee using Codebook Thematic Analysis.⁶ Themes were extracted and assessed for sex differences.

RESULTS

Interviews were conducted with 18-pLLAs (9-female, 9-male) with comparable demographics. Different themes arose between sexes in prosthetic, physical, and psychosocial experiences. *Prosthetic*: Females expressed desire for greater prosthesis ankle mobility and reported limb shape changes and muscle loss negatively impacting fit. *Physical*: When reporting on positive mobility experiences, females discussed basic activities of daily living (ADLs) whereas males discussed advanced ADLs. *Psychosocial*: Females emphasized negative experiences with healthcare professionals and concerns over child-rearing post-amputation.

DISCUSSION AND CONCLUSION

Prosthetic-related themes offer additional insight into fLLAs' challenges with prosthetic fit,⁴ while motivating future research considerations for sex-specific prostheses. Themes relating to physical mobility may link and expand understanding of fLLAs' ambulation challenges presented in literature.⁴ Also, sex-specific mobility challenges have implications for sex-specific rehabilitation. Finally, themes relating to psychosocial experiences present new research avenues and insight into sex-specific psychosocial challenges.⁵

This study explored sex differences focussing on pLLAs' perspectives. Extracted themes demonstrated an array of sex-specific experiences, presenting implications for future research to address sex-specific rehabilitation and prosthetic design.

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5.422 Biomechanical Outcomes of Prosthetic and Orthotic Utilisation in Individuals with a Minor Lower Extremity Amputation

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BACKGROUND

Restoring independent daily activity is crucial for patients with a lower extremity amputation (LEA), including minor LEAs at or distal to the ankle level. Minor LEAs result in various biomechanical deficits¹ that pose unique challenges to mobility and function and severely impact individuals similarly to major LEAs². A variety of prosthetic and orthotic devices are available³, but a tailored approach is necessary due to varying amputation levels. Identifying the optimal criteria for specialised interventions is crucial for patients to improve functionality and quality of life and prevent altered biomechanics, which could lead to further complications such as re-amputation.

AIM

This scoping review aimed to examine the kinematic, kinetic and electromyographic outcomes of various types of prosthetic and orthotic devices in adults with a minor LEA.

METHOD

A systematic search of MEDLINE, CINAHL, SPORTDiscus, APA PsycInfo and Scopus was conducted. Studies were eligible if they investigated the biomechanical outcomes of externally applied devices utilisation such as orthotic and prosthetic devices. The eligible population comprised adults with a minor LEA at various foot levels⁴, including midtarsal, tarso-metatarsal, transmetatarsal, metatarsal-phalangeal, rays, and toes.

RESULTS

Twenty-nine relevant studies primarily reporting biomechanical gait outcomes were included. Individuals with a minor LEA utilized five different types of devices: (I) Shoe filler or toe filler, (II) foot orthosis or therapeutic insole/footplate/insert, (III) ankle-foot orthosis, (IV) clamshell prosthesis, and (V) partial foot prosthesis. These devices were typically custom-made, and some included added modifications. Spatiotemporal parameters during locomotion were reported in 20 (69.0%) studies. Socket-interface pressure and plantar pressure distribution were reported in 13 (44.8%) studies. Joints moments and power were reported in 12 (41.4%) studies. Joints angles were reported in 11 (37.9%) studies. Ground reaction force behaviour was reported in 10 (34.5%) studies. Centre of pressure trajectory was reported in 7 (24.1%) studies. Muscle activity was not reported.

DISCUSSION AND CONCLUSION

Custom-made devices, extending to the shoe but not beyond the ankle, enhanced spatiotemporal parameters and plantar pressure distribution in more distal amputations. Above-ankle devices were more effective than foot orthoses in more proximal amputations. Well-fitted devices increased forefoot leverage during walking but lacked active plantarflexion support during more challenging tasks such as stair ascent. The findings underscore the essential role of prosthetic and orthotic prescriptions based on tailored patient-centered care. The review highlights the need for higher-quality research considering appropriate pooling of participants by amputation level, incorporating electromyographic measures, and considering novel technology in the development of advanced mechatronic devices.

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5.423 Effective use of external power may not be intuitive for many patients with lower-limb amputation – results of a literature review

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BACKGROUND

Adding external power to prosthetic components to compensate for lost muscle function appears to be a logical step in prosthetics. However, clinical research with commercially available powered prosthetic ankle-foot (PwrAF) and powered knee (PK) mechanisms has shown inconsistent and conflicting results (e.g., 1-4). Therefore, an analysis of individual results might help better understand why some patients may benefit from powered components while many others apparently do not.

AIM

To analyze individual responder rates to PwrAF and PK interventions and identify potential reasons for known challenges to the use of powered prosthetic lower limb components.

METHOD

A literature search with terms pertaining to PwrAF and PK was performed in four literature databases. Identified publications on commercially available PwrAF and PK were screened for reporting of individual or subgroup results. Findings of pertinent publications were extracted and collated and will be presented as a narrative literature review.

RESULTS

A total of 6 publications on commercially available PwrAF and three on PK reporting results of individual participants or defined participant subgroups were found. For both PwrAF and PK, individual responder rates varied by outcome assessed but usually ranged between 30% and 50% for walking speed, metabolic energy consumption, performance-based and patient-reported mobility and function, and musculoskeletal pain for PwrAF (e.g., 1,2) and gait symmetry, walking speed, and longer-term acceptance of PK (e.g. 3,4). Studies looking into the biomechanics of PwrAF use found only 20% of participants were able to generate net positive ankle power while walking (5), and most users were unable to stiffen the residual knee to ensure proper power transfer to proximal for propulsion (6). No comparable mechanistic studies were found for PK use but similar clinical problems with their effective use may be assumed as one study found only 4/10 participants being able to properly use the upstairs mode for reciprocal stair climbing (4).

DISCUSSION AND CONCLUSION

The integration of power delivered by prosthetic ankle and likely also knee components into the neuromuscular control of walking and the effective transfer and utilization of that power in the kinetic chain of the prosthetic leg for propulsion does not appear to be intuitive for many patients and require improvements in the fitting and rehab process. Optimization of patient selection, prosthetic device tuning, and patient training appears necessary to ensure powered prosthetic components deliver clinical benefits to a majority of patients.

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5.424 Symmetric Gait with Prosthetic and Orthotic Devices in Children with Congenital Lower Limb Deficiencies

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BACKGROUND

In congenital lower limb deficiencies (CLLD), bones of the skeleton may be partially or totally absent ^[1]. During childhood, amputation and/or extensive corrective surgeries are often required for fitting of devices ^[2]. An important clinical goal of the prosthetist and orthotist and the orthopedist is to work towards gait symmetry between the leg requiring a prosthetic or an orthotic device (Device-leg) and that without (Non-Device-leg).

AIM

To investigate gait symmetry in children with lower limb deficiency using their prosthetic or orthotic devices. A further purpose was to explore the child's physical endurance while walking.

METHOD

Twenty-six children with longitudinal CLLD, mean (SD) age 9.4 (2.9) years were enrolled, of which 12 children used prostheses (PROSTH) (5 ankle-disarticulation and 7 limb-lengthening prostheses), 6 used orthoses (ORTH) (2 ankle-foot, 3 supra-malleolar and one child a free articulated knee-ankle-foot orthosis), and 8 used shoes/insoles (FO) (7/8 with heel height). The longitudinal CLLD was classified as fibular hemimelia (FH), congenital femoral deficiency (CFD) or CFD/FH ^[2]. A three-dimensional gait analysis (3D) (Vicon) was performed to assess kinematic, time and distance parameters and to compute a gait deviation index (GDI) ^[3]. Physical exercise capacity was measured with the six-minute walk test (6MWT) ^[4].

RESULTS

There were no differences in age ($p=0.117$) between the groups. In PROSTH, 3/12 were classified as CFD, and 9/12 as FH/CFD; in ORTH 6/6 as CFD/FH; and in FO 4/8 as FH, 1/8 as CFD and 3/8 as CFD/FH ($p=0.013$). Foot amputation had been performed in 6/12 in the PROSTH group, and limb-lengthening surgery in 3/12 in the PROSTH and 5/6 in the ORTH group ($p=1.000$). There were no differences between the Device-leg and the Non-Device leg in neither the PROSTH, ORTH or FO groups in cadence, walking velocity, step length or step width. GDI differed in the PROSTH group (10/12 participants) between Device-leg and the Non-Device leg, median (min, max) 77 (56, 83) vs 85 (70, 92) ($p=0.005$). Walked distance at 6MWT did not differ between groups ($p=0.866$).

DISCUSSION AND CONCLUSION

The results indicate that the various types of devices in combination with performed surgery compensate for the longitudinal CLLD. The lower GDI score in the Device-leg in PROSTH is likely to have been influenced by the high number of CFD/FH involvement. Analyses of specific kinematic and kinetic parameters will provide further information about possible gait asymmetries in children with CLLD.

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5.425 Predicting Post-Amputation Residual Limb Volume Change With Realistic 3D Model Visualization: A Case Study

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BACKGROUND

For 12-18 months post-amputation, changes in amputee residual limb volume can create challenges with prosthetic fitting and discomfort¹. Measurement methods such as structured light or lidar scanning provide accurate information on the residual limb's volume and shape change^{2,3}, however monitoring and predicting these changes is challenging due to the dynamic nature of the limb and inter-individual differences. Tools which could predict these changes over time, would improve the transferability of this data to clinical prosthetic fitting and rehabilitation contexts.

AIM

To create a pipeline which predicts residual limb volume and shape change over time from input scans, with highly realistic 3D model-based visual representation.

METHOD

14 trans-tibial amputees, 6-10 weeks post-amputation were recruited (age 53.1 ± 11.3 years, height 1.7 ± 0.1 m, mass without prosthesis 89.1 ± 31.0 kg). Participants were involved in the study for 36-weeks during which their residual limb was scanned monthly using a validated structured light scanner². The month 1 (T1) and 9 (T9) scans for one participant (P01, 67 years old, height 1.61 m, mass without prosthesis 71.2 kg) were processed and aligned using Artec 18 Professional. The Python API in Blender⁴ was used to crop the scans at the patella attachment, analyse their shape and simulate temporal changes. Scans were divided into 100 equal segments along the z-axis to calculate the distance of perimeter vertices from the geometric centre. The input scan (T1) was then remodelled by indexing this data and translocating vertices accordingly. Finally, texture data were applied, emulating the shape change of the residual limb from T1 to T9. This predicted volume was compared to the T9 scan using distance deviation analysis in Artec 18 Professional.

RESULTS

The residual limb volume measured for P01 was 983.1 ml at T1 and 694.1 ml at T9. The predicted volume at T9 was 692.0 ml. Distance deviation analyses (Fig. 1) showed a root mean square error of 1.63 mm.

DISCUSSION AND CONCLUSION

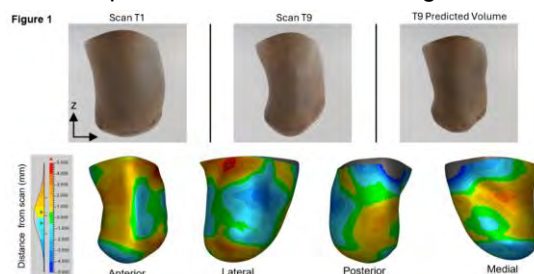
This pipeline demonstrated that residual limb shape and volume change can be successfully predicted in a single trans-tibial case study with a 0.3% difference between the measured and predicted volumes. If integrated into a monitoring system (possibly using phone-based lidar scans as the tool's input³) this could inform clinicians and amputees during rehabilitation or socket fitting stages. This work will be progressed by processing the data for the remaining 13 participants and for all timepoints, allowing the creation of prediction algorithms, which take into consideration different shapes and volumes.

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5.426 Effect of Diabetes on postoperative ambulation following below knee amputation

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BACKGROUND

Ambulation forms an important part of rehabilitation program after lower limb amputations. Diabetes Mellitus and its complications are commonly associated with below knee amputation. In spite of this, there is an absence of studies on the effect of diabetes on the post operative ambulation of an amputee. This study analysed the role of diabetes as an independent factor affecting post operative ambulation and compared it with non diabetics in below knee amputation

AIM

To analyze the effect of Diabetes mellitus on postoperative ambulation of below knee amputees as an independent factor and compare it with non diabetics

METHOD

In this study a total of 105 below knee amputation patients were followed. Out of them, 48 amputees were diabetics and 57 non diabetic. Their post operative ambulatory level was compared by using Pinzur et al ambulation scale. Both groups were age, sex and BMI matched.

RESULTS

There was a worsening of ambulatory level in 33.3% diabetics as compared to 10.7% in non diabetics postoperatively. Of the prosthetic users, 78.4% were in non diabetic group and 21.6% were in diabetic group. 17.6% of prosthetic users required additional support, of whom 66.7% were diabetics

DISCUSSION AND CONCLUSION

Diabetes Mellitus is an independent factor which has an adverse effect on the functional outcome of a patient after below knee amputation

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5.427 AOPA Socket Guidance Workgroup: the road to mock limbs' technical specifications

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BACKGROUND

To date, there are no generally accepted guidelines for assessing the structural strength of prosthetic sockets, either in terms of ultimate load or fatigue life [1]. Therefore, socket mechanical properties remain largely unknown. To address this issue, the American Orthotic and Prosthetic Association (AOPA) Socket Guidance Workgroup (SGW) identified knowledge gaps in four areas, including the design and composition of a "mock residual limb" required to simulate in vivo loading within the socket [2]. First, the SGW identified a set of 3 critical mock limb shapes [3], and the next challenge is to determine their composition.

AIM

The aim of this work was to establish a list of technical specifications for the mock residual limb that will support in defining its composition

METHOD

First, a list of technical specifications for mock limb fabrication was outlined during an ISO TC 168 WG3 meeting in 2023. The list was used as a starting point to gather experts' opinion on the requirement for the mock limbs via an on-line survey, asking them to agree or disagree with each item on the list, to add any additional technical specification, and to rank the items in order of importance. Finally, they were asked to suggest numerical values for some of the items on the list. The results of the survey were discussed during a consensus meeting of AOPA SGW experts with input from ISO TC 168 WG3, held in September 2024.

RESULTS

Eighteen testing experts answered the survey, providing prioritised technical specifications (Table 1). The fourth column shows the percentage of respondents who agreed that an item should be part of the list. During the AOPA SGW consensus meeting, experts agreed that none of the proposed additional items should be included in the list as they were not pertinent. The last three items were labelled as "user considerations", as requirements that should not be imposed on the end user but are important to ensure the safety and effectiveness of the mock limb.

DISCUSSION AND CONCLUSION

The three-stage agreement process was concluded with a list of agreed technical specification that will be used to evaluate manufacturing options, by starting from processes currently in use in testing laboratories and described in the literature. It is expected that a limited set of alternative compositions, e.g. mostly rigid vs mostly compliant solutions, will be identified and compared experimentally, through Finite Element Analysis and/or bench testing.

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The authors thanks AOPA for hosting the SGW, and ISO TC168 WG1-WG3 and SGW for their key contributions.

Ranking	Items	Notes	Agreed it should be included	Classification
1	Durable	Cyclic testing: Millions of cycles. Ultimate testing: Thousands of Newtons.	100%	Technical specification
2	Reproducibility of mechanical properties	It should be easy to fabricate a new mock limb with the same mechanical properties.	100%	Technical specification
3	Ease of fabrication	Does not require a complex and time-consuming procedure, to ensure it can be built in most testing centers, even for custom-made shapes.	72%	Technical specification
4	Biomimetic	When the socket (whatever design) is donned on the mock limb, the load distribution at the interface is consistent with clinical expectations.	72%	Technical specification
5	Presence of alignment marks	The mock limb should include all required landmarks to ensure that: 1) its own coordinate system is well aligned in the coordinate system of the testing machine, and 2) that the socket distal connector "neutral" alignment can be replicated reliably.	94%	Technical specification
6	Donning and doffing of the socket	Should ensure easy donning and doffing of the socket accommodating any pressure points created by the prosthesis during socket construction.	100%	Technical specification
7	Frequency operability	Should be able to sustain high frequency loading during cyclic testing, to minimize test duration.	94%	Technical specification
8	Handling (weight + oddness of shape)	Should be easy to handle during mounting on the testing machine and for storage. This implies that the weight of the mock limb should be within handling limits.	94%	User consideration
9	Shelf life	Does not change property when stored.	94%	User consideration
10	Cost	Affordable cost.	67%	User consideration

Identified by ISO TC 168 WG3 + AOPA SGW

User consideration: a hurdle which is not prescribed to the end user and is non-essential, but important to meet the goals of addressing safety and effectiveness of the socket but should be documented and shall be considered with the technical specifications.

Technical Specifications: driving factors which determine if socket testing can be achieved.

Table 1. Technical specifications are reported in order of importance based on the respondents' overall preferences. The 1st column reports the ranking order, the 2nd the item title, the 3rd the extended description of each item, the 4th the percentage of respondents that agreed the item should be included in the list and in the 5th the item label.



Free paper session | Education – Curriculum planning and professional competencies

5.431 Integration of a residual limb mannequin to augment lower limb prosthetic education

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BACKGROUND

COVID19 impacted the education of 89.4% of enrolled learners worldwide ⁽¹⁾. Models have been used in teaching of science and visual theories for many years. In Higher Education learning objectives vary by discipline with medical training involving a significant percentage of practical work. In response to the limitations of practical teaching mannequins were integrated into the prosthetic and orthotic teaching program to allow the practical elements of education to continue.

AIM

This research aims to gather student perceptions of mannequin use and its validity as a teaching tool in an undergraduate prosthetic and orthotic program.

METHOD

This research was conducted with BSc Prosthetic and Orthotics students attending 2nd and 3rd year classes. Students from these year groups were selected as they had received practical teaching with volunteer prosthetic users as well as with mannequins. This important insight allows them to compare the two experiences in their responses. Recruited participants complete an anonymised 24 question online survey to gather student opinions of mannequin use. The questionnaire contained Likert scales, multiple-choice questions and one open response question.

RESULTS

39 complete responses were received from a possible total of 71 (56%). Overall responses to changes in the education program were positive. From responses received all students agreed with the statement 'Mannequin learning allowed me to develop prosthetic practical skills in a less stressful environment' with a significance of $p=0.013$. This was confirmed with 71% of students feeling confident about their practical skills prior to patient sessions. 60% of students were positive about the effectiveness of mannequins as a method of study. 64% of student believed that mannequin use should be a permanent aspect of clinical teaching. Pertinent Likert responses can be seen in Figure 1.

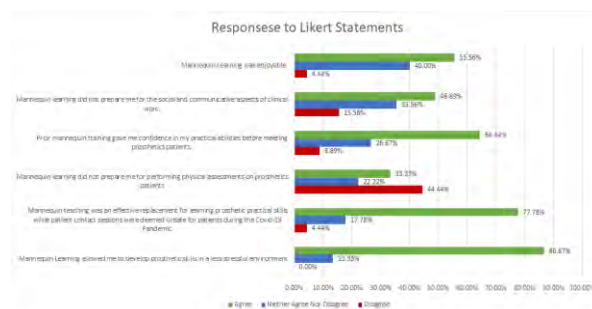


Figure 1. Responses to statements

Inversely, 68% of students felt anxious when entering patient contact sessions, 49% felt that mannequins did not prepare them to complete physical assessments on patients and 46% did not feel the mannequin provided an accurate representation of the anatomy of the residuum.

DISCUSSION AND CONCLUSION

Student responses to the use of mannequins in teaching was overwhelming positive. This allowed students to learn the technical process without the additional stress of patient care. Students felt they could better understand the process required for accurate shape capture. However, it is important to note that the mannequins are a training tool and do not replace the necessity to treat individuals with limb loss to complete a full assessment and enhance communication skills.

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5.432 Exploration of the Graduate Outcomes Survey for graduates of Australian orthotic/prosthetic courses

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BACKGROUND

A variety of stakeholders have an interest in the employment outcomes of orthotic and prosthetic (O&P) graduates including: governments, professional associations, universities, and prospective students.

The Graduate Outcomes Survey (GOS) is a national survey that collects demographic and employment outcome data of university graduates in Australia. Analysis of these data can provide insights into the short-term employment outcomes of O&P graduates.

AIM

This study aimed to explore the utility of the GOS in describing the demographic and short-term employment outcomes of O&P graduates from Australian courses between 2016-2023.

METHOD

Subjects: Graduates of Australian O&P courses at La Trobe University (LTU) and University of the Sunshine Coast (USC) from 2016-2023.

Apparatus: GOS is an electronic survey administered since 2016 by the Social Research Centre on behalf of the Australian Federal Government.

Procedure: The survey is administered to graduates 4-6 months after course completion. Deidentified data were provided by LTU and USC in a standard format that enabled synthesis into a national data set from 2016-2023.

Data Analysis: Descriptive statistics (n, %) characterised the demographic and employment outcomes. Regression analyses were used to explain the extent to which demographic variables influenced employment outcomes.

RESULTS

140 O&P graduates completed the GOS between 2016-2023 (41% response rate).

Respondents were typically young adults (median 23 years, IQR 4 years), female (69%), and Australian born (83%). No respondents identified as an Aboriginal or Torres Strait Islander. Most respondents were from high- and middle-socioeconomic postcodes. A small proportion of respondents (10%) indicated they had a disability, impairment, or long-term medical condition.

Based on data from 2023, 90% of respondents were employed in an O&P position at the time of the GOS. Most respondents moved interstate to find employment (61%). The median full-time salary of respondents working in Australian O&P positions was AUD\$70,000 (IQR \$3,513). Variation in median salary was not explained by the demographics reported in the GOS (i.e., sex, age, state of employment).

DISCUSSION AND CONCLUSION

While the demographics of O&P graduates were similar to other allied health professions in Australia, the rates of employment were much higher (Department of Health and Aged Care, 2023; QILT, 2023).

While the GOS provides high-level data of value to Government, it lacks detail that may be important to other stakeholders (e.g., the type of O&P role). That specificity may justify the need for a profession-specific survey, acknowledging the expertise and resourcing that will require.

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We thank the data & analytics teams at both LTU and USC for their collaboration on this project.



5.433 Challenging Experiences of Prosthetics and Orthotics Practice Education: the value of Debriefing Sessions

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BACKGROUND

The BSc (Hons) Prosthetics and Orthotics programme at the University of Strathclyde has two 17-week placements, one for each discipline. When students struggle on practice placements, or practice educators report challenges supporting student learning, a debriefing session with the practice educator is recommended (Hunt and Obard, 2016). Practice placements are vital for prosthetics and orthotics but there is limited understanding of the challenges faced in supporting students on placement, and learning which might be gained from these experiences.

AIM

The aim of this investigation was to critically review debriefing sessions conducted between 2022-2024, identify lessons learned, and report on changes implemented following the debriefings.

METHOD

The debriefing session offers an opportunity, after a challenging placement, to reflect on the experience. Practice educators and two members of the Higher Education Institution (HEI) were involved in the reflective conversations. A critical review of the debriefing documents was conducted. Two authors independently reviewed notes from each session. Challenges experienced by the practice educators were themed, and changes implemented by the HEI and the practice educator were recorded. A series of meetings were held to discuss and agree findings until consensus was achieved.

RESULTS

Eight debriefing sessions were offered relating to seven students, over a three-year period. All offers of a debriefing session were accepted. Debriefing sessions lasted between 30 minutes and 90 minutes. Meetings were offered in person or via zoom, with all practice educators preferring an online meeting. Two HEI staff were present and between one and four practice educators attended each meeting. Challenges encountered were split evenly between prosthetic and orthotic placements.

The four key themes which emerged were: supporting students with mental health challenges, managing students with physical mobility challenges, poor student attitude and poor performance with multiple factors. The following updates were made following debriefing sessions: changes to practice educator training, development of a resource to support 'reasonable adjustments', amendments to placement paperwork and prompts to open mental health conversations early in the placement.

DISCUSSION AND CONCLUSION

All practice educators reflected on the challenges faced and, on their decisions regarding student performance. All practice educators felt decisions made regarding progress were correct. A few noted in future they would highlight challenges faced at an earlier opportunity. All practice educators reported that they valued the opportunity to reflect on the experience and felt heard when discussing their experience. The HEI reflected on the process of documenting debriefing sessions and identified further improvements to this process.

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ACKNOWLEDGEMENTS

Many thanks to all practice educators who support our student learning, particularly those who took part in the debriefing conversations.



5.434 The Development and Evaluation of the Realism of an Alternative Prosthetic Model for Prosthetics and Physical Therapy Education

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BACKGROUND

PT and PO students have limited exposure to patient handling and lack self-practice in proper clinical techniques only possible during onsite classes when patients are available. Teaching tactile procedures such as palpation, bandaging, and casting presents a challenge, particularly when there are no available model subjects.

AIM

The researchers aimed to develop a prototype of a physical anatomical learning model that can capture the dimensions, shape, and specific anatomy of an above-knee (Transfemoral) amputee.

METHOD

To evaluate the effectiveness of the Learning Model, the researchers utilized an instructional sheet that contains an "Effectiveness-Survey Questionnaire" and a Measurement Chart. The former captured responses from PT-PO evaluators, while the latter collected measurements from PO evaluators. Every participant received an individual copy of the instructional sheet. The creation of the Learning Model was first designed using Blender 3D, a 3D modeling and rendering software. The structure of the anatomical structures was sourced online while the shape of the residual limb was created from the output of a 3D scan of an actual transfemoral amputee.

RESULTS

An overall score of 3.25 / 5.00 was achieved, indicating a passing score. Statistical analysis was conducted on two data sets (The Baseline and PO Evaluators' Mx). Through an Unpaired T-test, the two-tailed P-value was calculated as 0.9385. This difference is not statistically significant. This suggests that the measurements obtained from the PO evaluators and the Baseline Mx show consistency. In terms of measurements, the discrepancies were highest in the angles. The flexion angle had the highest discrepancy (+/-3.86 cm); while the adduction angle (+/- 0.25cm) got the least. Between the diameters, AP had +/- 1.14 cm discrepancy while ML had +/- 1.55 cm. Among circumferences, the distal end circumference showed the closest value to the baseline amounting to +/- 0.06 cm; while the 10 cm below the IT (whose value is +/- 0.56 cm) got the highest difference from the baseline. Most participants also found the model highly beneficial, observing that it closely resembles an actual patient

Type of Data	Baseline Mx	PO Evaluators Mx
Mean	21.1800	20.6670
SD	14.3922	14.9392
SEM	4.5512	4.7242
N	10	10
P-value (two-tailed)		0.9385

Figure 1. Statistical Analysis of the Mean Discrepancy between the Baseline Measurements and PO Evaluators Measurements

DISCUSSION AND CONCLUSION

The results validate that the model can be used as a learning tool for students. Improvements can be made, such as adding moving mechanical parts in order to palpate anatomical landmarks in a better manner. The learning Model was deemed as an effective, alternative educational tool for students in Physical Therapy, Prosthetics and Orthotics programs in the UERMMMCI.



5.435 Discipline-Based Education Research Priorities for Prosthetics and Orthotics

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BACKGROUND

Discipline-based education research (DBER) explores learning and instructional methods and outcomes, such as gaps in learners understanding, the instructional resources used to facilitate learning, and program assessment.^[1] Given the paucity of education research in prosthetics and orthotics and the opportunity for growth, an evaluation of research priorities may facilitate scholars.

AIM

To identify education research priorities in prosthetics and orthotics and to evaluate the resources needed to support education researchers.

METHOD

The researchers used a mixed-methods and participatory action research approach. Focus group sessions were conducted at the 2022 ISPO Global Educators Meeting (GEM) to determine items on a survey regarding discipline-specific education research priorities. The survey was disseminated to international stakeholders, and the results were reviewed, discussed, and re-ranked at the 2023 ISPO World Congress.

RESULTS

Seventy-six respondents from 25 countries participated and identified as educators, clinicians, technicians, and researchers. They indicated a spectrum of education research priorities, with emphasis on providing feedback to students, program evaluation, and clinical education and internship. Those interested in pursuing research and scholarship in education identified needs for protected time and funding, faculty development, and program resources. Conference attendees revisited the survey results and emphasized the need for research to address academic preparation versus clinical practice, program resources, and program evaluation.

DISCUSSION AND CONCLUSION

The intent of DBER is to understand and improve teaching and learning practices. Released before the 2024 ISPO GEM, this work informed a call for education research proposals focusing on the top 10 priority areas. Furthermore, promotion of the most important priorities in prosthetic and orthotic can guide scholars to advance the profession and its impact. Future studies should investigate important priority differences based upon geography and the status of the prosthetic and orthotic profession and education landscape regionally.

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5.436 Digital skill development in Prosthetic and Orthotic education: development of a constructively aligned digital workflow training pathway

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BACKGROUND

Digital workflows in Prosthetic and Orthotic practice are increasingly being adopted internationally with proponents reporting increased efficiency, client experience and repeatability of product design and manufacture.^{1,2} However, many clinicians also report a reluctance to fully embrace digital pathways with reported barriers to adoption including the identification of a steep learning curve, a disconnection between physical and digital skill sets and scepticism of financial and efficiency claims.^{1,2}

In addition, many educators are faced with the challenge of integrating digital workflow processes within time and resource constrained curriculums whilst still maintaining a balance between traditional 'analog' hand-on skillsets.

AIM

This project seeks to explore and share best practice examples and propose a model for a comprehensive constructively aligned digital workflow training pathway.

METHOD

Taking a critical scholarly approach, initial conversations with Prosthetic and Orthotic educators across 7 programs (United Kingdom, North America, Europe, Asia) were undertaken to identify current approaches to digital workflow training and to explore both barriers to uptake and successful models of teaching. An initial set of 4 key factors were identified as follows.

- Safe use of digital data and storage to ensure client safety and confidentiality
- Shape Capture and rectification processes
- Digital output and fabrication processes
- Evaluation and Quantification of device design and technical safety

An iterative collaborative snowball approach involving ongoing discussions, on-site and virtual visits with educators, technology providers and clinical practices who have successfully applied digital workflows was implemented to further inform the development of constructively aligned learning outcomes and detailed teaching activities.

RESULTS

This project is currently ongoing. Detailed reporting of key project findings including a constructively aligned curriculum framework and best practice teaching examples will be presented.

DISCUSSION AND CONCLUSION

Digital workflows are anticipated to increase in scope, capability and accessibility over the coming years. As such, education programs need to address these skill sets in a comprehensive and structured approach which effectively targets key learning outcomes, supported by well designed teaching activities. Applying a constructively aligned curriculum utilising and sharing best practice examples will support educators provide this key training to current and future students.

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Prize nominee session | Advancing clinical treatment

5.441 Therapists' use of motor learning principles while training activities of daily living in upper limb prosthesis users

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BACKGROUND

Learning how to operate a prosthesis in daily life is challenging and often results in device abandonment. Training guided by a therapist should provide the necessary tools to optimally use the prosthesis in activities of daily living (ADL). Training efficiency might be enhanced when therapists use motor learning principles (MLPs) such as random training [1], implicit learning [2], external focus of attention (FoA) [3], positive feedback [4] and prescriptive knowledge of performance (KoP) [5].

AIM

In this study we aimed to determine the use of MLPs by therapists during ADL prosthesis training using a qualitative analysis on preliminary data.

METHOD

Therapists and prosthesis users of two rehabilitation centres were included. Therapists were included if they had more than one year experience in training prosthesis users. Only users who received training to use their myoelectric prosthesis in ADL tasks were included. Video data was collected of therapy sessions and analysed using Noldus The Observer® XT. Five MLPs were included in the analysis: practice variability (blocked/random/mixed), learning (explicit/implicit), FoA (internal/external/internal on muscles), feedback (positive/negative), knowledge (Knowledge of Results (KoR)/descriptive KoP/prescriptive KoP). Percentage of duration was calculated for implicit/explicit learning and practice variability and percentage of statements was calculated for events such as FoA, feedback and knowledge.

RESULTS

Four video's (Figure 1) were included from two occupational therapists (mean age=56±5 years; mean experience with prosthetic training=21±6 years) and two prosthesis users. A total of 477 MLPs were observed and coded. Practice variability was used as random (49.0%±28.0), blocked (29.4%±26.2) or mixed (21.6%±35.5). Learning was implicit (45.0%±37.4) or explicit (55.0%±37.4). FoA was directed external (76.3%±4.8), internal (23.3%±4.8) or internal on the muscles (0.4%±0.8). Feedback was positive (86.5%±13.8) or negative (13.5%±13.8). KoP was prescriptive (34.2%±13.0), descriptive (47.3%±14.3) or KoR (18.5%±19.1).

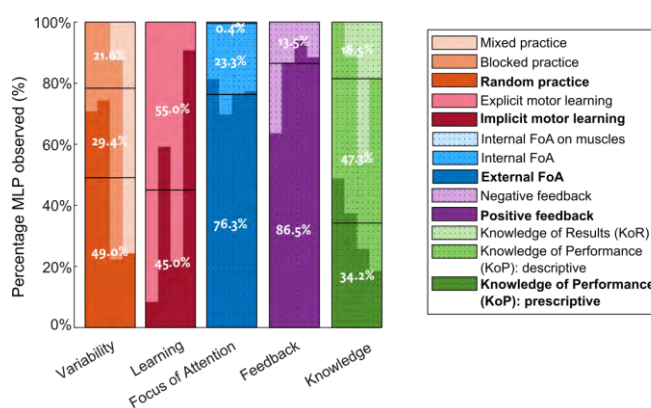


Figure 1. Percentage use of motor learning principles during training activities of daily life. Percentage taken from the total number of statements (pattern)/duration (solid pattern) in the same category. Each column within a bar represents one observation. MLPs in bold are known to be beneficial for learning. FoA = Focus of Attention; MLP = Motor Learning Principle.



DISCUSSION AND CONCLUSION

According to the results, all MLPs are used during ADL training. While positive feedback and external FoA were clearly preferred, the other three categories showed more variability. Although previous research showed advantages of certain MLPs, some cannot be used consistently at the same time due to their properties, e.g. prescriptive KoP and implicit learning. Future research could attempt to elucidate the relation between each MLP and the effect it has on the efficiency of prosthesis learning. This knowledge would help to find an ideal combination of MLPs for optimal prosthesis usage during ADL training.

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5.442 Preliminary effect of a virtual reality-based therapies for phantom limb pain and sensations and exploration of effect modifying factors

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BACKGROUND

Phantom Limb Pain (PLP) affects many amputees, significantly impacting their quality of life. Traditional ways to manage PLP have shown limited efficacy. Virtual Reality (VR) has emerged as a promising non-pharmacological delivery tool for PLP management, as there is a high demand for new management strategies to be less invasive with minimal side effects for managing participants with PLP. However, there is currently no research into whether changing the visual look of a limb within VR can influence phantom pain and sensations.

AIM

This study explores what virtual limb type is preferred by people with lower limb PLP and which limb type results in the greatest decrease in PLP and/or increases in positive phantom sensations during the VR experience: Realistic, Prosthetic, or Block-shaped appearing virtual limbs?

METHOD

Sixteen lower limb amputees experiencing PLP were recruited. A Meta Quest 2 VR headset was used with custom holsters allowing hand controllers to attach to the intact lower limb and the residual lower limb to track motion. Participants completed an intervention using three VR limb types (Realistic, Prosthetic or Block-shaped) in a randomised order, performing a 5-minute movement sequence of the lower limbs while seated. The 5-minute sequence was repeated for each virtual limb type. During each condition, PLP intensity and positive phantom limb sensation intensity were self-reported before the intervention, and after each minute. User experiences were assessed post-intervention using semi-structured interviews and validated scales relating to the strength of embodiment.

RESULTS

Overall, qualitative feedback from participants was positive but variable. There were no overall statistical differences in PLP across the course of the intervention and between each virtual limb type. However, at the individual level, 4 individuals reported pain relief. There was an increase in positive sensations from pre-intervention to minute 4 (Test Statistic = -2.000, $p = .011$ before adjustment) and minute 5 (Test Statistic = -1.833, $p = .020$ before adjustment) for the Realistic limb, which aligned with the preference for the Realistic limb reported by most participants ($n=11$). Participants gave varying reasons for their preferred virtual limb type.

DISCUSSION AND CONCLUSION

There were no statistical differences in pain reduction across the participants and limb types, but there were clinically significant changes in positive sensations for the Realistic virtual limb. While most participants preferred to use the Realistic virtual limb, some did not, making it important to maintain a variety of limb options within the software.



5.443 The Patients' Perspectives on Two Novel Treatment Practices for Phantom Limb Pain

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BACKGROUND

Phantom limb pain (PLP) is a neuropathic pain perceived in an absent limb, which occurs often after amputation. The innovative phantom motor execution (PME) and phantom motor imagery (PMI) treatment aim to diminish PLP by training movements of the phantom limb, which result in muscle contraction in the remnant limb (PME), measured with EMG-electrodes, or are imagined (PMI). These treatments use extended reality to provide visual feedback. PME and PMI treatment have proven to cause a clinically meaningful reduction in PLP of over 60%. [1] As these treatments seem to be promising, understanding the patients' perspectives on these treatments is essential.

AIM

To explore the patients' perspectives on PME and PMI treatment.

METHOD

Semi-structured interviews were conducted among Swedish and Dutch patients who participated in the randomized controlled trial evaluating PME and PMI treatment. [1] Twenty-one participants (mean age 57 years, 16 lower limb amputations) receiving PME treatment were interviewed, [2] as well as eight participants (mean age 63 years, all lower limb amputations) receiving PMI treatment. Qualitative data analysis was performed using the framework method.

RESULTS

In both the PME- and the PMI-group, most participants experienced a reduction in PLP after treatment, and consequently an increase in quality of life. Both treatments resulted in improved control over the phantom limb for most participants, which became a tool for managing PLP. Participants of both groups mentioned that the treatment was mentally demanding and required focus. Several participants expressed a lack of knowledge on PLP. PLP returned in some after finishing the treatments. Participants in the PME-group expressed increased self-agency due to a sense of control over the phantom limb and PLP. They also mentioned that the therapists' approach was crucial. A barrier for the PME-treatment was difficulty with placement of EMG-electrodes. The participants of the PMI-group mentioned their perseverance as a facilitator.

DISCUSSION AND CONCLUSION

From the participants' perspective, the PME and PMI treatments are considered valuable. The reduction of PLP led to improved quality of life, both due to less pain, as well as due to improvement of sense of self and state of mind. It was striking that many participants had little knowledge about PLP, which may have influenced their perception on PLP and coping strategies. We therefore advise professionals to educate their patients on PLP. Controlling the phantom limb improved self-agency and patients should be advised to continue practicing their phantom limb regularly after the amputation.

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Prize nominee session | Advancing P&O

5.444 Investigation of The Relationship Between Plantar Flexor Stiffness and Plantar Pressure in Type 2 Diabetic Individuals with Neuropathy

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BACKGROUND

In Type 2 Diabetes Mellitus (T2DM), peripheral neuropathy is a significant risk factor for amputation.¹ Due to impaired autonomic regulation and non-enzymatic glycosylation, the flexibility of the foot and ankle joints decreases.² Increased stiffness in soft tissues impairs the foot's rocker functions, leading to elevated plantar pressure.³ While reduced ankle mobility is known to negatively affect plantar pressure, the relationship between stiffness of the plantar flexors and plantar pressure distribution remains unclear.

AIM

We aimed to investigate the relationship between plantar flexor stiffness and plantar pressure distribution in T2DM with neuropathy.

METHOD

A total of 48 individuals with peripheral neuropathy associated with T2DM were included in the study. Neuropathy was assessed using a biothesiometer. Plantar pressure distribution during gait was evaluated using a pedobarograph platform, recording peak pressure (N/cm²) in 10 regions of the foot and the forefoot/rearfoot pressure ratio. Plantar flexor stiffness was assessed using an isokinetic dynamometer set at 60°/s in passive movement mode, calculated as the force applied to dorsiflexion divided by the degree of movement. The relationship between plantar stiffness, plantar pressure, and neuropathy values was analyzed using Pearson's correlation test.

RESULTS

The study included 48 individuals with a mean age of 59.0 ± 2.4 years and a body mass index of 28.8 ± 1.9 kg/cm². A significant positive correlation was found between plantar flexor stiffness and the peak pressure under the 2nd metatarsal head ($r=0.383$, $p=0.007$), the 3rd metatarsal head ($r=0.372$, $p=0.009$), and the forefoot/rearfoot plantar pressure ratio ($r=0.653$, $p<0.001$). A significant positive correlation was also found between the average plantar neuropathy value and the peak pressure under the 2nd metatarsal head ($r=0.316$, $p=0.028$). No significant correlations were observed between stiffness and disease duration, HbA1c levels, or neuropathy values ($p>0.05$).

DISCUSSION AND CONCLUSION

Increased plantar flexor stiffness in individuals with T2DM and neuropathy is associated with higher plantar pressure under the 2nd and 3rd metatarsal heads and an imbalance in forefoot-rearfoot plantar pressure distribution. To reduce pressure in high-risk areas for diabetic foot ulcers, preventive strategies should include exercises and orthotic interventions to reduce plantar flexor stiffness as part of the treatment program.

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5.445 Development of the Assisting Hand Assessment for Individuals with Upper-limb difference with or without using a Prosthesis: internal scale validity

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BACKGROUND

There is not one same instrument that measures how effectively a person with unilateral upper limb difference (UULD) uses the affected arm and hand with or without different prosthetic types, pre-post-surgery, and over the years from child to adult. In 2009, the Upper-Limb Prostheses Outcome Measures working group ⁽¹⁾ concluded that the Assisting Hand Assessment (AHA) ⁽²⁾ was potentially useful but was not yet evaluated on its psychometric properties.

AIM

To develop an UULD version of AHA and investigate the internal scale validity and aspects of reliability when used in people with UULD with or without use of a prosthesis.

METHOD

A cross-sectional, instrument development design was used and performed in two steps. First, four expert occupational therapists investigated the original Assisting Hand Assessment items for their relevance to the target group and identified potentially new items. Next, upon ethical approval a clinical convenience sample of patients was invited. Written informed consent was obtained from all participants: 136 persons (96 male) aged 1.5–75 years (mean 17.64) with unilateral (72 right-sided) upper-limb below-elbow amputation (n=33) or limb difference. Scale validity was evaluated, together with the original items, using the Rasch partial credit model for polytomous data with two facets ⁽³⁾.

RESULTS

Two new items were identified: *Distal use* and *Readjusts stabilization*. After adding these potential new test items, video-recorded test sessions were scored on the research version of the AHA-UP, that is, on the original 20 AHA 5.0 items minus two not relevant items and including the two newly generated items, in total 20 items. Analysis of the original 4-point rating scale was indicating disordered thresholds and limited use of one category. Consequently, the rating scale was changed to a 3-point scale for all items. One misfitting item was removed. The remaining 19 items showed goodness-of-fit. Seven individuals (4%) showed underfit to the model. Test reliability was 0.97 for items and 0.91 for persons. The items can separate persons into six ability strata. Items and person measures (mean 0.05) were well targeted.

DISCUSSION AND CONCLUSION

The AHA-UP was developed for use in people with UULD with or without use of a prosthesis. This is the first test providing a measure of efficiency in two-handed performance for children from 18 months to older adults with all variants of upper-limb amputation or difference. It can help clinicians improve rehabilitation by identifying skills that require more training or compare the outcome from patients' prosthesis use or non-use.

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5.446 Reduction of low back loading during repetitive lifting: Effects of a supportive exoskeleton and of different lifting strategies

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BACKGROUND

In many areas of physical labor, employees are often affected by musculoskeletal disorders that are associated with pain symptoms in the lower back. For everyday work, specific aids such as passive and active exoskeletons or the use of “back-friendly” lifting techniques are recommended as a preventative measure, particularly for repetitive lifting activities. These are intended to significantly relieve the strain on the lower back [1,2].

AIM

To biomechanically analyze a lifting activity performed repetitively using two movement strategies, each with and without the use of an exoskeleton. Furthermore, low back loading was calculated using biomechanical modeling.

METHOD

Ten subjects without known musculoskeletal disorders participated (22.7 ± 1.3 y, 69.6 ± 6.6 kg, 172 ± 7 cm). To simulate a lifting activity, they lifted a box (10 kg) 10 times using two different strategies: with upright trunk (“vertical technique” - VT) and with forwardly leaning trunk (“horizontal technique” - HT). Both sequences were completed randomized without (WOE) and with (WE) an exoskeleton (PaexoBack, Ottobock, D). Biomechanical parameters were determined using an optoelectronic system coupled with two force plates (VICON, GB; KISTLER, CH). Muscle activities were measured using an EMG system (Noraxon, USA). Joint compression forces in the L4/L5 and L5/S1 areas were calculated using modeling software (AnyBody, DK).

RESULTS

With HT, the average maximum trunk extension increased by 23° compared to VT ($p < 0.01$), and mean maximum knee flexion angles were 18° (HT) and 95° (VT) with no significant differences between WOE and WE for both strategies.

The average integrated EMG of the erector spinae muscle and the multifidi muscles was 15% higher with VT than for HT. Correlating with the knee angles, VT showed a drastic increase in muscle activity for the knee extensors compared to HT.

The most striking effect of the exoskeleton was a significant reduction in muscle activity between 8 and 11% for both back muscles in both VT and HT ($p < 0.05$).

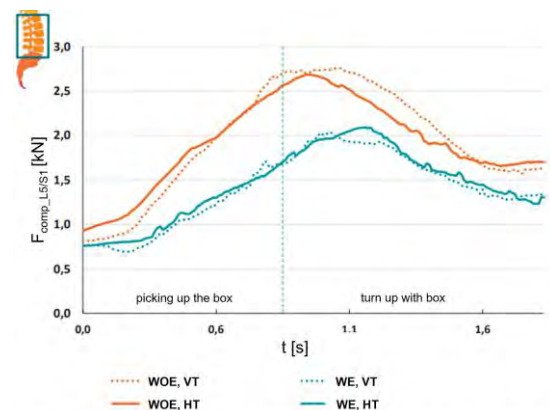


Fig. 1: Mean joint compression force in the area L5/S1, calculated for one lifting cycle

Significant reductions in the mean compression force of around 20% were calculated for the effect of the exoskeleton, while the differences between the lifting techniques were small (Fig.1).

DISCUSSION AND CONCLUSION

The results showed the exoskeleton relieved the lower back by around 20% regardless of the strategy, which concurs with an earlier study [3]. The comparison of the two lifting strategies led to results comparable to those of current studies [4] and may be considered surprising since performing the “vertical” lifting is generally considered “back-friendly” [5]. This contradiction between conventional wisdom and actual study findings indicates a need for further research.

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Free paper session | Prosthetics: lower limb transfemoral – Device design

5.451 Suitability of a Transfemoral Prefabricated Adjustable Socket During Rehabilitation

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BACKGROUND

Early mobilization is a critical factor in regaining independence after lower limb amputation, and only 50% of the elderly that are provided with a prosthesis are found to achieve mobility of a household ambulator ⁽¹⁾. Prosthetic delivery time plays a crucial role in early mobilization ⁽²⁾ and hand-casted sockets versus prefabricated sockets are expected to reduce delivery time while achieving acceptable rehabilitation outcomes.

AIM

The objective was to show if the prefabricated socket technology can be fit in one session and achieve the acceptable rehabilitation.

METHOD

The study followed a cohort of seventeen transfemoral amputees (K1-K3). The study, following standardized rehabilitation protocol, included 2 events: Baseline evaluation (BL) and discharge evaluation (DC). BL included subject evaluation, 6 Minute Walk test, Comprehensive Lower- limb Amputee Socket Survey (CLASS), and usability except for those (n=4) who were not admitted with a prosthesis. The prefabricated socket (CTF) was fitted and adjusted if needed, during the rehabilitation. The data collected at DC included the logging of the rehabilitation milestones and the repetition of the data capture at BL. Descriptive statistics were applied showing differences between evaluation points of patients admitted with a prosthesis (n=4) and patients who were admitted without prostheses (n=9).

RESULTS

All included participants were fitted in one session. However, due to stump volume reduction patients needed one or more rectification sessions to achieve acceptable socket fit. A total of 17 (10 male, 7 female) amputee participants were enrolled, with an average age for male 74.0 and female 68.3 years. Four patients dropped out due to health reasons. Thirteen patients completed the rehabilitation. The CLASS score improved after rehabilitation (34.2%±24.1%). On discharge twelve patients preferred CTF compared to their previous socket.

Figure 1

Enrolled patients n=17	Activity level	Age [year] ± SD	Fitted in one session [patients]	6MWT at BL [m] ± SD	6MWT at DC [m] ± SD	Milestone ¹ [days] ± SD	CLASS at BL [%] ± SD	CLASS at DC [%] ± SD
with functional socket n=4	K1-K3	69,5 ± 5,4	4	141,8 ± 114,1	262,2 ± 222,3	3,8 ± 5,7	55,9 ± 6,7	81,6 ± 9,9
without functional socket n=9	K1-K3	70,3 ± 13,9	9	N/A *	112,4 ± 74,6	5,0 ± 4,7	48,5 ± 13,6	73,6 ± 4,2
dropouts n=4	K1-K3	76,3 ± 5,1	4	N/A	N/A	N/A	69,7 ± 12,2	N/A

Figure 1: Overview of the data collected with the CTF.

* = no walkable prosthesis on enrolment or not capable to walk six minutes.

DISCUSSION AND CONCLUSION

The results showed that the CTF improved socket fit and provided a functional prosthetic solution within the first day at the rehabilitation facility. Patients could use their prosthesis more often during their rehabilitation time. Acceptable rehabilitation outcomes were achieved at DC. The shortened time for socket fitting and rectification has a potential to provide amputees with an improved rehabilitation outcome, in sync with satisfaction improvements seen in other studies of a single session fitting solutions ⁽³⁾.

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5.452 Clinical and Biomechanical Evaluation of a new Prosthetic Knee Joint – How do Users benefit from entirely new Functions?

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BACKGROUND

Microprocessor-controlled knee joints (MPKs) have been developed since the 1990s. Due to different technological principles, embedded sensors and control strategies, overall performance of MPKs in daily-life situations can differ significantly^{1,2}. The Genium (Ottobock) introduced new functions in 2011 offering increased functionality and clinically relevant advantages^{3,4}. The latest generation, Genium X4, offers entirely new functions that users may benefit from in daily-life situations, including: walking initiation, walking backwards, and walking up ramps.

AIM

Evaluation of the new functions and overall user satisfaction with the Genium X4.

METHOD

8 subjects were enrolled with above-knee amputation (6 unilateral, 2 bilateral), and all were active users (K3 and K4) fitted with a Genium (1) or Genium X3 (7) as their everyday prosthesis. The subjects were fit with the new MPK, Genium X4, to evaluate in everyday life for 1-3 years. Patient-reported outcomes were collected and biomechanical analysis was conducted in comparison with the Genium X3.

RESULTS

All subjects preferred the Genium X4 over their everyday MPK and frequently reported advantages from the new functions. The tasks walking initiation (7/8), walking backwards (6/8) and walking up ramps (5/8) were rated as better with the Genium X4. In the biomechanical analysis, several improvements were observed. Initiating walking with the prosthetic side could be performed with a higher knee flexion angle (Figure 1A) as well as reduced compensatory movements of the pelvis and upper body. When walking backwards, anterior-posterior ground reaction force was higher during prosthetic side push off, indicating an improved acceleration phase. Walking up ramps was performed with a more natural movement pattern of the prosthetic leg (Figure 1B).

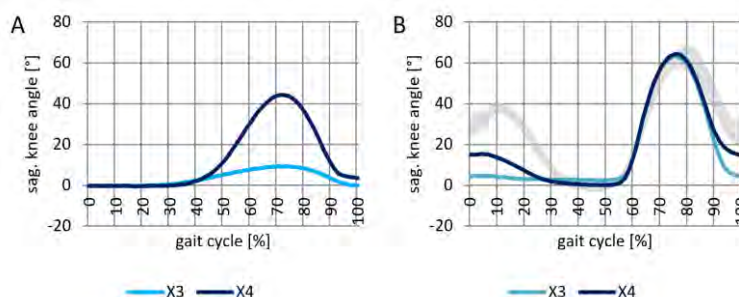


Figure 1. Mean sagittal knee angle of the prosthetic side for the unilateral subjects during initiating walking (A) and ramp up walking (10°) (B). Reference sag. knee angle from the contralateral side in grey for ramp up walking (standard deviation).

DISCUSSION AND CONCLUSION

The novel functions from the Genium X4 allowed users to improve walking initiation, walking backwards, and walking up ramps, and this resulted in higher preference for the novel MPK over their everyday prosthesis. Clinically relevant improvements in daily activities are possible with new functions in the Genium X4. MPKs have been in development for more than three decades, and improvements can still be achieved, particularly by refining the control algorithm.

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5.453 The effect of prosthetic foot design on functional outcomes in individuals with lower limb amputation

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BACKGROUND

Dynamic response feet are designed for high-activity or daily high-impact users ⁽¹⁾. However, Thailand's universal coverage healthcare scheme for prosthesis wearers does not include these technologies. The solid ankle cushioned heel (SACH) and single axis foot remains the standard of care in Thailand ⁽²⁾. The sSpace dynamic response prosthetic foot is designed by engineers and prosthetists in Thailand to enhance mobility, comfort, and adaptability ⁽²⁾.

AIM

This study aimed to compare the functional outcomes of users wearing a commercial health coverage foot (SACH and single-axis foot) to the locally designed sSpace dynamic response prosthetic foot among users living in Thailand.

METHOD

This study was approved by the Siriraj Hospital Faculty of Medicine Institutional Review Board (379/2566(IRB4)). Each participant signed an informed consent form before participation. Sixty-five individuals with lower limb amputations, age 48.6 (range 22–75), participated in this study without limb issues or underlying conditions. Functional outcome measures were administered to all participants while wearing the sSpace and the commercial health coverage foot (SACH and single-axis foot). We conducted twenty-meter walk tests (20MWT), a two-minute walk test (2-MWT), and an uneven surface walking test.

RESULTS

The sSpace dynamic prosthetic foot had improved physiologic performance compared with the commercial health coverage foot (SACH and single-axis foot). The results of functional outcome measures from the twenty-meter walk tests (20MWT), the two-minute walk test (2-MWT) and an uneven surface walking test (Table 1) showed that the group of people who used dynamic prosthetic feet performed better than the group who used a commercial health coverage foot. This difference was statistically significant.

Table 1. Results from 20MWT, 2-MWT and uneven surface walking test

Task	A commercial health coverage foot (n=65)	Dynamic sSpace (n=65)	P-value
20MWT (s)	18.2 ± 4.1	16.9 ± 3.5	<0.001
2-MWT (m)	134.0 ± 26.4	142.5 ± 26.3	<0.001
Uneven surface (s)	7.0 ± 2.5	6.2 ± 1.8	0.001

*Significant difference ($\alpha = 0.05$), * *Indicates significance level of $p < 0.05$

DISCUSSION AND CONCLUSION

This study compared the functional outcomes of individuals wearing a commercial health coverage foot (SACH and single-axis foot) to the locally developed sSpace foot among Thai residents. Participants using the sSpace foot showed notable improvements in their functional activity performance compared to those using the commercially available health coverage foot (SACH and single-axis foot).

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ACKNOWLEDGEMENTS

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5.454 Developing a Standardized Brim Set with a Scalable Hybrid Design to Streamline Transfemoral Prosthetic Socket Production: A Feasibility Study

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BACKGROUND

Effective rehabilitation for individuals with transfemoral amputations relies on a well-fitting prosthetic socket. However, achieving optimal socket fit largely depends on the prosthetist's expertise, making quality assurance challenging. Given the consistent geometric characteristics of transfemoral residual limbs, there is potential for standardizing socket brim design to improve fit and reproducibility. Past efforts in standardization have been limited by the absence of defined design principles, comprehensive data analysis, and evaluation methods (1).

AIM

To investigate the feasibility of developing a standardized brim set with a scalable design for the hybrid socket type to streamline transfemoral prosthetic socket production.

METHOD

The study was conducted in two phases. In phase 1, brims currently used in practice were analysed to create a standardized set. Participants with hybrid transfemoral prosthetic sockets were selected, and the 3D-scanned brims were registered using the MeshMonk algorithm (2). Key brim dimensions were determined, including circumference, approximate ischial-trochanteric distance, ischial support area, and trimline heights. Statistical analysis identified correlations to guide the scalable brim design. In phase 2, the designed brim set was tested on participants with a unilateral transfemoral residual limb, and the fitting of each brim section was evaluated both by a research team member and the participant using a custom-designed questionnaire.

RESULTS

Phase 1 led to the development of a standardized brim set (Figure 1) using thirteen brims, with a significant correlation found between the circumference of the brim and the approximated ischial-trochanteric distance. In phase 2, which included 8 participants, most brim sections received satisfactory fitting scores; however, for 6 participants some discomfort in the groin area was reported, and for one participant issues with ischial support placement was noted.

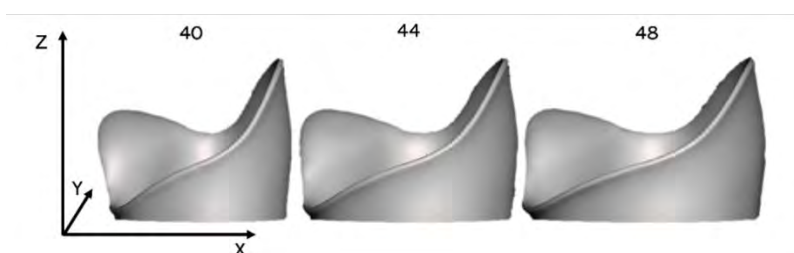


Figure 1. Anterior view of three brim sizes (40, 44 and 48 cm) from the standardized brim set. Since no significant correlation was found between the circumference of the brim and the ischial support area or the height of all four trimlines (Z direction), these parts were kept constant. The remaining brim was scaled in the X and Y directions.

DISCUSSION AND CONCLUSION

Although the dataset was limited, developing a scalable brim design that fits a wide range of transfemoral residual limbs appears feasible. Further validation using a larger dataset and additional fittings is needed, where the brim is supplemented with a distal portion to complete the transfemoral socket. This proposed approach has the potential to enhance the consistency, efficiency, and quality of transfemoral prosthetic socket fittings, especially in resource-limited settings.

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5.455 Exploring Sex-Based Residuum Size Fluctuations in Above-Knee Prosthesis Users

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BACKGROUND

Socket fit is a common cause of prosthesis dissatisfaction among people with lower limb loss [1]. Changes in residual limb size within a day and between days are commonly reported as affecting socket fit [1], however, they have been largely studied in transtibial prosthesis users, and in predominantly male cohorts [2], despite higher levels of dissatisfaction in female users [3], potentially partially attributable to hormonal fluctuations during the menstrual cycle [4]. In addition, previous studies have focused on total volume changes and have not explored localised size changes [5], which can affect comfort disproportionately due to pressure points on the limb remnant [6].

AIM

This study measures residual limb size and shape changes, both within-day and between-day, in male and female transfemoral prosthesis users (with sex-disaggregated results).

METHOD

A total of 15 adult above-knee prosthesis users (5 male, 5 pre- and 5 post-menopausal female) will be recruited to complete a month-long study; preliminary results are presented here. Participants were asked to measure circumferences at 5cm intervals along the length of the residuum (measured from the distal end), twice daily, for 28 days, using a tape-measure. They were also asked to record (dis-)comfort levels and locations, usage hours, volume management methods, exercise, alcohol consumption, and menstrual cycle.

RESULTS

Preliminary results show that both between-day and morning-to-evening circumference changes occur (Figure 1), and that the magnitude of these changes varies between locations along the residuum. Factors such as alcohol consumption the previous day, or exercise during the day, did not appear to affect limb size or within-day size changes at most locations on the limb. Other factors that were recorded, such as socket comfort score and discomfort locations, showed very little variation across the measurement period, so are not presented here.

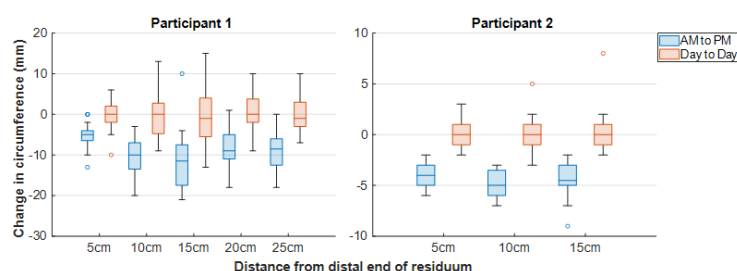


Figure 1. Within-day and between-day changes in circumference in two non-menstruating participants.

DISCUSSION AND CONCLUSION

These preliminary results agree with previous findings, that there are morning-to-afternoon residual limb size changes [5]; prior work has shown inter-session changes between days [5], but these results confirm the existence of changes between one day and the next. They also support the hypothesis that size changes can vary along the limb remnant. The measurement of circumferences is subjective; this is mitigated through normalisation when comparing between participants. Further participants are being recruited to allow for more scientifically rigorous (including sex-based) analysis.

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ACKNOWLEDGEMENTS

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5.456 Design and evaluation of KASPER: A lightweight knee-ankle prosthesis for sit-to-stand support

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BACKGROUND

For elderly transfemoral amputees, standing up can be a hard and demanding task. Most available leg prostheses for this group are passive knee prostheses that cannot provide support in standing up, making the sit-to-stand movement a single-legged task. Earlier research focussed on supporting the knee joint while keeping the ankle joint fixed. A fixed ankle makes it hard for the user to put his/her centre of mass above the foot which is needed for a stable stand up procedure.

AIM

The aim is to design a lightweight knee-ankle prosthesis that can support the user in a stable standing up motion.

METHOD

Design: A new prosthesis called KASPER (Knee Ankle Stand up Prosthesis with Energy Recuperation) was developed. The prosthesis contains a knee and ankle joint that are actuated by a gas spring. While sitting down energy is stored in the gas spring that can be used to support the user in standing up. During both movements the ankle and knee can make the full range of motion for stand-to-sit and sit-to-stand movements.

Evaluation method: A first proof of concept of KASPER was built and preliminary tests were done. To evaluate the stability of the proof of concept a weight was attached to the upper leg of the prosthesis and the sit-down movement was analysed. The weight can be attached to different heights of the upper leg. The prosthesis was free standing and unsupported so that an instable configuration will result in the prosthesis falling over. The results of KASPER were compared with a monocentric knee prosthesis with fixed ankle.

RESULTS

First qualitative results show that KASPER is able to flex and extend in a free standing unsupported set-up without falling over, by keeping the weight in the range of support. The monocentric knee prosthesis was unstable for most test conditions, resulting in falling over.

DISCUSSION AND CONCLUSION

The results show that the principle is promising, the concept needs further validation with actual users. A first proof of concept of KASPER proves that a prosthesis with functioning knee flexion and ankle dorsiflexion movement maintains stability while providing support during stand-to-sit and sit-to-stand movement.



Free paper session | Health care, policy, sustainability – Natural guidelines, policies, and practice

5.461 The Government's Role in Coordinating National Policies for Prosthetics and Orthotics in Emergencies: The Gaza Strip Experience

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BACKGROUND

Individuals with amputations require comprehensive rehabilitation services. The ongoing conflict in Gaza results in thousands of amputees and people with complex injuries as well as considerable interest of various international and local organizations to provide prosthetic & orthotic services. Unfortunately, a lack of coordination among service providers results in poor resource allocation, overlap in services and unmet needs. The government has felt the need for stronger involvement in policy development and implementation and the organization of service delivery.

AIM

This project was initiated to emphasize the vital role of the government in forming a national framework for prosthetics and orthotics to ensure alignment among all stakeholders in their pursuit of shared goals.

METHOD

The government's role was enhanced through the Ministry of Health, which coordinated prosthetic and orthotic services through the establishment of a dedicated national committee. This committee, led by the Ministry of Health, includes experts from both local and international institutions. Additionally, external expertise and resources were utilized, with contributions from the World Health Organization and the International Committee of the Red Cross enhancing discussions and collaboration among relevant experts and through structured consultations. These inputs were essential in developing national policies and strategic plans, setting targets, and guiding implementation efforts.

RESULTS

The Ministry of Health has successfully formed a national committee focused on prosthetics and orthotics, backed by strong government support which meets every two weeks. The diverse committees have coordinated the development of national policies, legislation, and strategic plans in response to the ongoing emergency in the Gaza Strip. The strategic plan's procedures have been announced, highlighting four key priorities for service delivery standards: policies, products, workforce, and service provision. These legislative updates have been disseminated to all professionals in the field through the rehabilitation task force group, which plays a crucial role in monitoring services to ensure alignment with the national objectives. Further developments are expected based on the successful project launch.

DISCUSSION AND CONCLUSION

This experience has underscored the government's effectiveness in establishing a national committee to oversee institutions providing P&O services during conflicts and emergencies. It emphasized the necessity for all stakeholders to collaborate efficiently under the authority of the Ministry of Health to ensure a comprehensive response that guarantees the delivery of high-quality and sustainable services.

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5.462 Developing National Priority Assistive Products Lists: Experiences from Seven Sub-Saharan African Countries

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BACKGROUND

The World Health Organization's Priority Assistive Products List (APL) aims to improve global access to assistive technology. The application of the APL has varied across countries and regions. This study examines the experiences of seven Sub-Saharan African countries in developing National APLs between 2020-2024, addressing a critical gap in knowledge for improving assistive technology access.

AIM

The aim of this work was to identify barriers, facilitators and learnings for developing National Priority Assistive Products Lists across seven Sub-Saharan African countries.

METHOD

A mixed-methods approach was employed, to undertake the study. A comprehensive desktop review of a range of documentation related to the development of specific Country APL's including the final APL lists was undertaken to provide a broad understanding of the processes and outcomes of APL development. These findings were used to develop a question guide that was utilised in semi- structured interviews with key stakeholders who had been involved in the APL development incountry. Qualitative analysis of these interviews was undertaken to identify common themes, country specific factors and lessons learned.

RESULTS

Key findings include:

- All countries utilized multi-stakeholder engagement, involving government, OPDs, and healthcare professionals
- APL sizes varied from 32 to 70 products, reflecting different prioritization approaches
- Common challenges included limited disability prevalence data and AT needs assessment
- Integration with health systems and local manufacturing potential were key considerations

DISCUSSION AND CONCLUSION

The study reveals both common approaches and country-specific adaptations in National APL development. Key lessons include the importance of inclusive stakeholder engagement, government led processes. data-driven prioritisation, and integration with broader health system strengthening efforts. These findings provide valuable insights for other nations seeking to develop National APLs and improve assistive technology access.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the time and expertise of subject matter experts providing an understanding of country-specific approaches.



5.463 Development of an AI-Driven Interactive Platform for Data Registry in Lower Limb Prosthetics: A Pilot Study

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BACKGROUND

Clinical data are vital for optimizing treatment outcomes and guiding clinical decisions. In prosthetic care, clinical data are crucial for optimizing treatment outcomes and guiding decisions in prosthetic care. However, capturing and managing patient information systematically remains challenging, especially in low-resource settings ^[1]. Despite ISPO guidelines on core datasets and outcome measures ^[2], standardized data collection tools are lacking. This study aims to fill this gap by developing an AI-enhanced, interactive platform for lower limb prosthetic data registry.

AIM

This study aimed to design and develop a pilot platform for a lower-limb prosthetic user registry, integrating AI-driven interactivity for data analysis and statistical reporting to enhance clinical insights and user engagement.

METHOD

This pilot study was conducted in two phases. In phase one, core datasets and outcome measures were identified based on ISPO recommendations ^[2]. Three expert prosthetists validated the registry's content using the Content Validity Index (CVI) ^[3], which guided the development of the platform. In phase two, the platform was built using Django as the backend framework, with HTML and CSS for frontend design, and SQL for database management. The platform was structured to include modules for the homepage, login, dashboard, data visualization, and patient registry pages. A custom AI-powered assistant, powered by OpenAI GPT-3.5 Turbo ^[4], was integrated to provide users with real-time statistical insights. Functionality tests were conducted to evaluate system performance and AI integration.

RESULTS

The platform's core dataset and outcome measure contents initially achieved a Scale-Level Content Validity Index for Universal Agreement (S-CVI/UA) of 0.825, which improved to 0.975. The Scale-Level Content Validity Index for Average (S-CVI/Ave) increased from 0.933 to 0.991, exceeding the recommended threshold of 0.90. Functionality tests demonstrated smooth navigation and efficient data processing. The AI-powered assistant achieved a correct response rate of 81%, accurately answering 22 out of 27 questions.

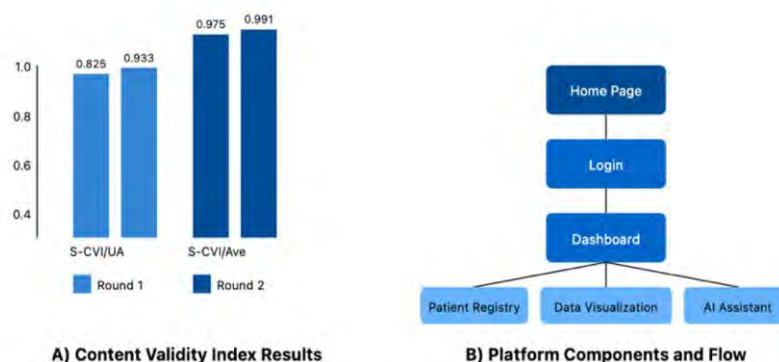


Figure 1. Content Validity Index and Platform Components Overview for Lower Limb Prosthetic Data Registry



DISCUSSION AND CONCLUSION

The initial results indicate that the developed platform has a strong foundation with validated content, aligning with clinical standards ^[2,3]. The integration of an AI-powered assistant shows potential to enhance user experience by providing on-demand statistical insights, although further testing is needed to confirm these effects ^[5]. Attention to data security is crucial as the platform scales, with measures such as encryption and access controls being vital ^[6]. Future work will focus on integrating predictive analytics and machine learning capabilities to provide deeper insights into patient outcomes and better guide practitioners in making informed clinical decisions ^[7].

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5.464 Sustaining Participation: The impacts of Prosthetic Treatment on the Lives of People with Limb Absence

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BACKGROUND

People with limb absence (LA) can experience decreased participation in their lives, leading to social isolation, decreased health and reduced quality of life.^{1,2} In Canada, 1/3 of people with dysvascular lower LA experience high levels of social isolation, leading to decreased quality and satisfaction with life.³ In response to LA, individuals must adapt physically, psychologically and socially.⁴ Prosthetic treatment is one aspect of rehabilitation that impacts this adaptation and can be a facilitator or barrier to participating in meaningful things. Access to prosthetic treatment is influenced by many factors including funding and geography, which has a direct influence on participation, health, and wellbeing.

AIM

This study examines how prosthetic treatment impacts the ability of someone with LA to participate in things that are meaningful to them, as well as to their health and psychosocial wellbeing.

METHOD

Semi-structured interviews were conducted with individuals over the age of 18 years with upper and/or lower LA who live in British Columbia, Canada. Participants were recruited through prosthetics clinics, rehabilitation hospitals and social media. Reflexive thematic analysis was used to develop themes inductively⁵, with consideration given to the meanings behind the discussion and the connections between participant's experiences.

RESULTS

Fifty-nine people participated: mean age 41.9 (SD 16.1) years old; 30 men, 27 women, 2 others; 44 lower LA, 13 upper LA and 2 both upper and lower LA. Access to prosthetic treatment had an influence in five areas - positively for those who have access to the treatment they need and negatively for those who did not. These 5 themes are:

1. Maintaining physical health and wellness though restoring mobility and managing pain
2. Ensuring financial stability through sustainable employment
3. Reducing isolation through social engagement and interpersonal connections.
4. Adjusting to parenting with and the effects LA has on children
5. Coping with the changes associated with LA and the influence on mental health

These areas are interconnected with each area influencing others.

DISCUSSION AND CONCLUSION

To sustain participation, every effort must be made to match the prosthetic treatment to the needs of the individual. This may include incorporating specific prosthetic components (e.g. microprocessor knees, waterproof joints), providing secondary prostheses, or supplying activity-specific devices. It is only by doing so that people with LA can sustainably participate in their lives and mitigate negative repercussions to health or psychosocial wellbeing.

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ACKNOWLEDGEMENTS

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5.465 An exploration of the need for Lower Limb Prosthetic Protocols in the South African private healthcare sector

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BACKGROUND

Protocols, informed by evidence, provide guidance during prosthetic component selection and clinical intervention to help optimise user care. If protocols are comprehensive and implemented effectively, they can enhance the quality and consistency of care to prosthetic users. Limited evidence on the existence and use of lower limb prosthetic prescription protocols could be identified in the South African private health care sector.

AIM

To explore the need for a lower limb prosthetic prescription protocol in the South African private healthcare sector.

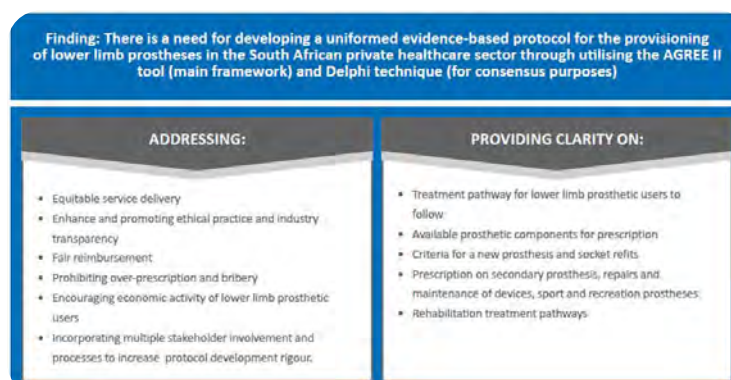
METHOD

Three cases, Road Accident Fund (RAF), Workmen's Compensation Fund (WCA), and Council of Medical Schemes (CMS) were explored using a case study design. Data was collected from six documents, seventeen prosthetic users and seven key informants. Documents were quantitatively evaluated with the Agree II instrument. Data was analysed descriptively. Data collected from key informants (through expert purposive sampling) and lower limb prosthetic users (through deviant purposive sampling) during semi-structured interviews was analysed thematically. The inclusion criteria for lower limb prosthetic users included: at least one major lower limb amputation, utilizing a prosthesis for at least six months funded by one of the cases.

RESULTS

The two authors appraised the documents from the three cases individually. Domain averages were calculated using the recommended formula in the Agree II instrument. Across cases the 'scope and purpose' domain scored the highest (50% (WCA), 47.2% (CMS), 22.2% (RAF). 'Editorial independence' scored 0% for all three cases. Other challenging domains were 'applicability' and 'rigour of development'. Two cases documents (WCA & CMS) were recommended for use with modifications, while the RAF documents were not recommended.

Three cross case themes emerged. 'Protocol availability and necessity': protocols could be beneficial, though minimal protocols are currently in use. 'Purpose of a lower limb prosthetic protocol': protocol can support accessible, equitable, ethical, transparent services. 'Protocol development requirements': An evidence based collaborative process, facilitated by an independent body should underscore protocol development.



DISCUSSION AND CONCLUSION

An evidence based, standardized, transparent protocol will be beneficial to guide prosthetic service delivery in the South African private healthcare sector with all stakeholders in the value chain, including persons with lower limb amputations.



5.466 Understanding Prosthetics and Limb loss rehabilitation variation between Low & High Resource settings for knowledge exchange, teamwork facilitation, and program development

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BACKGROUND

Following limb loss, timely prosthesis receipt and well-coordinated limb loss rehabilitation are vital for mobility, daily activities, and a good quality of life. However, there is much variation across the globe, both in baselines (patient populations, care practices and providers) and in outcomes (clinical, functional, programmatic). Understanding this baseline-outcomes relationship across low and high resource settings, as exemplified by India and USA, is vital for improving global health equity for people with limb loss.

AIM

The aim of this project was to understand differences in patient populations, prosthetic device provision, and lower limb loss rehabilitation care systems between India and USA.

METHOD

A narrative review of literature was conducted using keywords “lower limb”, “amputation”, “rehabilitation”, “prosthetics” in combination with “India” or “USA” in PubMed for the past 10 years. A validated implementation framework, the limb loss rehabilitation continuum (LLRC)¹ was used as the theoretical basis for data extraction by 2 reviewers /coauthors on 3 topics for India and USA: a) epidemiology of limb loss, b) limb loss rehabilitation systems of care, and c) prosthetic device prescription. A summary of recommendations developed by discussion, based upon the abstracted data as well as relevant clinical experiences.

RESULTS

Dataset: India (n=14 articles), USA (n=214 articles).

Epidemiology: Commonest etiology: trauma/road accidents (India), dysvascular-infection / clots (USA), Commonest level: transtibial (India, USA)

Care provider access: No reliable data (India), 5-15% prosthetic service access in low-&-middle income countries (per WHO). 40% access to PM&R, >50% for therapy. O&P professionals are a vital part of the rehabilitation team. (USA)

Limb loss rehabilitation systems of care: Limited data on rehabilitation, prosthetic services provided largely by non-governmental organizations (NGOs) outside purview of Department of Empowerment of Persons with Disabilities. (India) Coordinated systems include Veterans Healthcare System, and Limb Loss Rehabilitation Continuum programs. Preprosthetic and prosthetic rehabilitation occurs in inpatient rehabilitation facilities and outpatient therapy clinics. (USA)

Prosthetic devices: International manufacturers (India, USA). Clinics: big cities only (India), large multi-clinic O&P companies (USA). Prescription rate: unknown (India), less than 30% (USA). Coverage: government, NGOs (India), insurance -approval challenging (USA).

DISCUSSION AND CONCLUSION

Data for India are limited, stressing vital need for further study of the limb loss population, rehabilitation system, and outcomes using the LLRC framework. Strategies for improving outcomes include a) knowledge exchange between Indian and US limb care professionals, b) patient education materials development, and c) LLRC program development with O&P and PM&R as partners.

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Free paper session | Prosthetics and Orthotics: upper limb – Sockets and activity specific devices

5.471 Preliminary characterization of rectification for transradial prosthetic sockets

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BACKGROUND

Achieving an effective socket fit is essential for prosthesis users, as it directly impacts their ability to engage in daily activities and their overall quality of life. Yet digital socket design remains largely unstandardized and poses a steep learning curve for clinicians. While research has focused on digital socket design for the lower-limb population, upper-limb socket design remains underexplored, revealing a critical gap in addressing the specific needs of upper-limb prosthesis users.

AIM

This study characterizes the transradial socket design (rectification) process, specifically the three-quarter Northwestern-style design, to inform a systematic, data-driven framework.

METHOD

Fourteen participants (n = 14) with transradial upper-limb absence were recruited for this study. Each attended a single conventional shape capture session to create an unrectified positive plaster model, which was then modified by the prosthetist to produce a rectified socket design. Both unrectified and rectified models were subsequently digitized for 3D shape analysis.

RESULTS

3D shape analysis of fourteen pairs of unrectified and rectified models identified six common rectification zones, with their depth of modification, surface area, and volume calculated. A novel 3D vector mapping technique highlighted consistent shape changes in the anterior–posterior and proximal–distal directions. Across each rectification zone, the interquartile ranges for volume, surface deviation, and 3D vector representation were reasonably consistent.

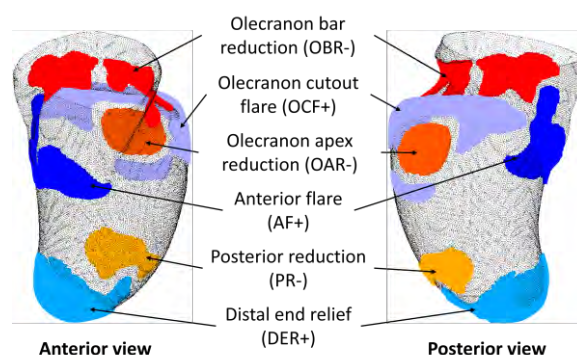


Fig. Common rectification zones found in the transradial socket design. The “+” and “-” signs at the end of each rectification zone denote an addition or reduction in volume, that is, the addition or removal of plaster, respectively.

DISCUSSION AND CONCLUSION

The findings of this study highlight the potential of quantitative modeling in transradial socket design, offering tools that improve accessibility and customization across diverse populations. By leveraging digital technology, we can enable automated design and local 3D printing, expanding access to effective prosthetic care, particularly in underserved areas worldwide.



5.472 Case Study: exploring 3d scanning and 3d printing TECHNOLOGIES to improve transradial prosthetic acceptance in cosmetic appearance and socket comfort

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BACKGROUND

Over 500,000 mobility-restricted PWD's are estimated in the Philippines. Upper extremity (UEP) amputees tend to experience more limitations on ADLs, which may be addressed by prostheses. However, UEPs especially functional devices and artisan silicone costs beyond the government insurance's coverage. The bulk of manufacturing costs can be attributed to expensive imported components. This may be addressed in part by modern fabrication technologies, which can also potentially improve cosmetic acceptance.

AIM

The main objective of this paper is to compare user acceptance and preference between a three-dimensional (3D)-printed trans-radial prosthesis and traditionally fabricated prosthesis, based on socket comfort and cosmetic appearance.

METHOD

We present the case of a 21-year-old right-handed female, who underwent a below-elbow amputation due to a giant cell tumor of the bone. She is an established prosthetic user but has outgrown the device. The patient primarily favors appearance followed by static usage of the device and usually covers her amputated side due to social discomfort from bullying. Two devices were fabricated: the first, using 3D scanning and printing, and a second limb using the conventional approach. Both were covered with cosmetic gloves to address the psycho-social preferences was adjusted until the patient was satisfied, followed by assessment of device appearance, comfort, and qualitative feedback.

RESULTS

The patient gave a similar score to both devices for ease of donning. The digitally-manufactured UEP scored higher by one point in terms of cosmetic appearance and two points in comfort score. Conventional thermoformed sockets increased in bulkiness due to the 4mm PP used, but allowed room for multiple adjustments, for an easier to fit. The passive, digitally-manufactured prosthesis had limitations in terminal device rotation, but was lighter due to the reduced infill. Fitting a ready-made cosmetic glove presented plenty of challenges, such as the visibility of rigid thumb, palmar, and forearm increases due to small mismatches with the printed hand's dimensions. Overall, the patient preferred the 3D-printed device, primary due to its size similarity vis a vis the unaffected side and its lighter weight.

Table 1: Comparison of patient feedback from the two manufactured transtibial prosthesis

	Conventional	Digitally produced
Device	 Ottobock Gloves Ottobock Passive Hand with Wooden attachment Terminal Device Friction Control Thermoplastic 4mm PPForearm Post Process: None	 Ottobock Gloves 3D Printed Socket until Hand EVA Foam Liner No Rotation allowed at terminal device, position can be adjusted by supination and pronation of forearm Post Processed: Laminated with Epoxy
Weight	541g	356g
SCS	7/10	9/10
Cosmetic	7/10	8/10
Appearance		
Ease of Donning	6/10	6/10
Price willing to pay	40k PHP (682 USD)	40k PHP (682 USD)
Qualitative Feedback	Heavier, and appears larger due to thermoformed plastic. Tight when worn with gloves.	Device is longer but the size appears more similar to the sound side. Light. Fit is loose without gloves but just right with gloves.

DISCUSSION AND CONCLUSION

The two approaches of manufacturing can produce good acceptance if factors related to cosmetic appearance and comfort are considered prior to fabrication. Conventional disadvantages can be addressed by experienced prosthetists and technicians but are limited to device components. Digitally-manufactured transradial prosthetic devices must be able to incorporate these factors prior to printing and throughout the design process, since there are limitations to what can be adjusted after the manufacturing process.

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5.473 A Review of the Provision of Prosthetic Socket Designs Utilised in Clinical Practice for Transradial and Transhumeral Limb Differences

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BACKGROUND

Transradial and transhumeral amputations are the most common upper limb presentations in prosthetics clinics ⁽¹⁾. Despite the variety of socket designs available, few studies address how these are selected in practice, and no consensus exists on preferred designs. Understanding prosthetists' socket design choices is crucial for advancing consistent and effective clinical practices, and this knowledge can help shape educational curriculum.

AIM

This study aims to identify the most commonly prescribed socket designs for transradial and transhumeral levels and understand the rationale behind these selections.

METHOD

An online survey was developed using Qualtrics, comprising three sections: participants' work and educational background, transradial socket designs, and transhumeral socket designs. Questions addressed participants' experience with specific socket designs, typical selections for various clinical presentations, and rationale for these choices. Upper limb prosthetists were recruited through social media to achieve broad geographic representation. Data analysis was conducted using Microsoft Excel and IBM SPSS. Ethical approval was obtained from the University of Strathclyde (DEC/BioMed/2024/371)

RESULTS

Forty-eight upper limb prosthetists from 19 countries participated in this study. Participants had trained at 31 different institutions with approximately two-thirds graduating between 2016 and 2024. In the three months prior to completing the survey, half reported treating 1–5 upper limb patients. For mid-length and short transradial residua, Muenster sockets were most commonly prescribed (17% and 43%, respectively), while the ¾ socket was most common for long transradial (18%). Open shoulder sockets were predominantly prescribed for mid-length (55%) and long transhumeral residua (60%), with 83% preferring over-the-shoulder sockets for short transhumeral cases. Although socket selection varied, no association was found between prosthetists' backgrounds and socket choice ($P > 0.05$). The most frequently chosen reason for selecting the socket designs for all levels was the length of the residuum.

DISCUSSION AND CONCLUSION

This study provides insights into the most commonly used socket designs in clinical settings, outlining both the primary reasons for their selection and the shape capture methods employed. Additionally, the study has identified key gaps in the current knowledge base, offering a clearer understanding of clinical practices. These findings provide opportunities for advancing best practice guidelines and informing the development of a standardized curriculum for education and training in upper limb prosthetics.

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5.474 PACT: A Predictive Algorithm for Automated Upper-limb Prosthetic Socket Design

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BACKGROUND

Prosthetic socket design significantly affects prosthesis comfort and abandonment [1]. However, current processes are time-intensive, relying on extensive clinician–patient interactions that can result in long lead times and reduced access to care. Advances in digital scanning, additive manufacturing, and machine learning present an opportunity to streamline this design process, freeing up clinicians' time to focus on where their expertise is most impactful [2]. However, there remains limited understanding of digital design applications for upper-limb prostheses [3].

AIM

To develop and validate the Predictive Algorithm for Customized Transradial socket design (PACT), which accurately and automatically approximates prosthetist-fabricated sockets (PFSs).

METHOD

Nineteen (n=19) participants with transradial limb absence were recruited during regular fitting appointments. Their limbs and corresponding PFSs were scanned using the Spectra scanner (Vorum, Canada) to create a limb–socket library. Our algorithm takes a new client's limb as the input, scaling and comparing it to all limbs in the library using the L2-Norm to determine the best match, whose corresponding socket is used as a basis for design. Critical areas affecting socket functionality—such as the distal end and supracondylar suspension—are then adjusted for optimal fit.

RESULTS

Using leave-one-out validation, sockets were predicted for all 19 limbs and compared to their respective PFSs. Strong Spearman's rank correlation ($\rho = 0.81$, $P < 0.05$) validated the accuracy of our scaling method. The algorithm consistently predicted reasonable approximations of PFSs, with a mean deviation of only 2.1 ± 0.6 mm across the dataset—within the acceptable range of typical inter-prosthetist variability observed during rectification for lower-limb [4] and transradial sockets [5]. Machine learning (DBSCAN) identified localized regions on the socket needing improvement, specifically in anterior–posterior compression and the trimlines. Preliminary client fitting sessions showed that the 3D-printed predicted sockets provided satisfactory fit and suspension.

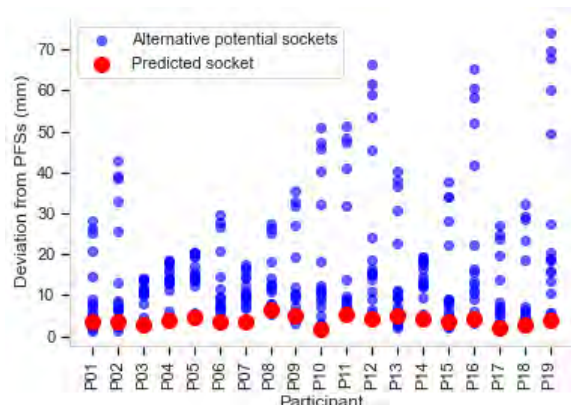


Figure 1. Deviations from PFSs across participants. Blue dots represent alternative sockets; red dots indicate predicted sockets, which always closely resemble their respective PFSs.

DISCUSSION AND CONCLUSION

The results show that PACT predicts reasonable approximations of PFSs, marking the first integration of clinician-created designs into predictive modeling for prosthetic sockets. Unlike prior research using genetic algorithms [6] and the eigenvector algorithm [7], PACT offers more tailored fit by incorporating clinician-informed adjustments. The widespread deployment of this algorithm could significantly reduce the burden of prosthesis provision on clinicians and patients. Limitations include a relatively small sample size: future iterations of this algorithm will incorporate additional fitting parameters to advance toward end-to-end modeling.

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5.475 Upper Limb Activity Specific Prosthetic Rehabilitation: Benefits and Impact on the Health of Persons with a Hand Absence

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BACKGROUND

Individuals with upper limb absence often experience pain, overuse, isolation and social stigma requiring physiotherapy. Activity-specific prostheses helps with these challenges improving quality of life. This technology has evolved since the 1960's. Initially it augmented physical capability in sports. Acceptance grew. Evidence revealed that benefits from this technology exceeded expectations. Many persons struggled accessing specialized care. Telehealth provides a platform to "reach" people facilitating positive social interaction, self-reliance and confidence.

AIM

The aim of this retrospective review is to identify, document and report the benefits that activity specific prosthetic use provides outside the realm of physical rehabilitation.

METHOD

Interviews were conducted by doctoral-level, occupational therapy students. Custom surveys incorporated the Role Checklist, QuickDASH and McGann Client Feedback Form. Participants met weekly to address modules in the *Unlimbited* Wellness© program. They explored prostheses engaging in recreational/sport activity including gym/fitness, yoga, and Pilates. Physical and mental health about ability/disability and quality of life were monitored. The *Unlimbited* Wellness© program is telehealth driven to improve peer access and facilitate sharing information about strategies to help prevent physical overuse, reduce social isolation and promote self-advocacy skills. Its aims were to promote health and well-being for people with upper limb absence.

RESULTS

Program participants stated that they felt empowered to participate in challenging activities that were previously inaccessible. Participants noted greater quality of participation and performance; the, expanded opportunities for bilateral function transcended recreation to include vocational, domestic, community and other spheres. Cross-over functions of many devices further enhanced the reported experiences. Results suggest that the remote support group concept was effective to connect and to educate participants of all ages, levels of ULA, and etiology. Overall, participant post-group perceptions of health, well-being, and prosthetic satisfaction, improved as compared to pre-group experiences. During the 1:1 interviews, all participants stated they felt empowered due to their engagement in peer discussions and collaborative exercises during the diverse foci of the *Unlimbited* Wellness© programs.

DISCUSSION AND CONCLUSION

Activity specific prostheses have benefits beyond physical rehabilitation. Participants overwhelmingly reported the access to recreation made them feel "whole", valued, and more empowered. Strengths of this study were most importantly the resilience of the participants. Weaknesses were the limited test population. Telehealth appears to be a viable option for rehabilitation. Activity-specific prostheses clearly support health, wellness, well-being and further enhance quality of life for persons with ULA.

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ACKNOWLEDGEMENTS

Efforts of Western New England Doctor of Occupational Therapy students



5.476 Upper Extremity, Activity Specific, Prosthetic Options: Existing and Emerging Technology

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BACKGROUND

Activity specific prostheses date back to before the 1960's. The first manufactured devices addressed bowling, catching a baseball and playing golf. In the 1980's new products and concepts began to evolve driven by consumer demand. Prostheses improved to handle the rigors of many sports. Changes in insurance incentivized the development of terminal device technology. Additive manufacturing offers new options. A history and summarization of these technological advances will be presented.

AIM

Review the technological evolution of "activity specific" prostheses to demonstrate how advances in materials, manufacturing and non-anthropomorphic, bio-mechanical designs have improved options and opportunity for persons with hand absence(s).

METHOD

Presenters researched academic, professional and popular literature, and manufacturer's product catalogs dating back to the early 1960's to identify and catalog evolving technologies and advances in prosthetic materials, designs, and manufacturing. Authors document the timeline of these evolving technologies to determine and identify the circumstances driving the prosthetic changes and evolution. The expertise of both authors, who use prostheses with over 100 years of experience between them and who have been involved in the development of upper limb activity specific, prosthetic technology for over forty years is relevant and will be an integral part of the presentation.

RESULTS

Activity Specific prostheses became available in the USA in the 1960's. New technology, however, did not premier before the 1980's. Interest improved through the 1990's, especially in Canada, but really expanded in the USA, in the early 2000's with recognition of the multitude of values that these prosthetic devices provided to a hand absent person. Consumer input and demand for activity specific prostheses and the Paralympics helped to drive technological innovation and expansion. Public acceptance evolved. Importantly, funding became more available. Activity specific prostheses expanded outside of North America to Australia, New Zealand, Europe and beyond. Material improvements, emerging manufacturing techniques and innovative, non-anthropomorphic, product designs based upon bio-mechanical principles created new markets. Extensive examples illustrating the evolution of activity specific prosthetic technology will be illustrated.

DISCUSSION AND CONCLUSION

The use of activity specific prostheses had a slow origin but accelerated significantly over the years between 2000 and today. Development was driven by multiple factors including consumer input and demand, advances in materials, manufacturing techniques, insurance coverage and prosthetic specialization. The conclusion is that activity specific prostheses have become and will remain an integral part of the rehabilitation solution and prescription for persons with hand absence.

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5.477 Evaluation of a golf, prosthetic, terminal device system for individuals with bilateral, trans-radial, hand absence

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BACKGROUND

The challenges of bilateral hand absence are extensive and simple daily activities can be difficult. Recreation is essential to foster wellness and life quality. Technology for accurately swinging a golf club using two prostheses has not existed. Three years ago researchers developed a terminal device and tested it for over 1.5 years, by seven persons with bilateral hand absence. Specific results of this pilot including video footage will be presented.

AIM

This project was a field test and evaluation of a prosthetic golfing device, designed specifically for persons with bilateral, trans-radial, upper extremity absence.

METHOD

Six individuals, 3 male, 3 female with bilateral, trans-radial hand absence, recruited from the Skills For Life Conference in 2022 volunteered. The females also had bilateral, trans-tibial, absence. Three had previous experience in golf. All exhibited the ability to use the initial prototype and were provided with a custom golf club driver, iron and putter in early 2023. Participants used the technology on a best efforts basis. 2 received professional coaching. Interim communications occurred to trouble-shoot individual challenges. All completed a comprehensive, on-line questionnaire and continue to evaluate the technology. Video was captured on several participants.

RESULTS

All participants were able to successfully control, swing golf clubs and hit balls. Two participants required initial assistance to attach the clubs. At the time the questionnaire was completed, three used the system less than five times, three used the system more than five times. 2 required shortening the club shafts. All used all three types of clubs that were provided. On a scale of 10 for rating "swing control", with 10 being very good, all rated 5 or less. On the same scale chipping rated 1-5 and putting 3-5. Two provided feedback related to improving control. Those improvements were successful. All six rated the project as "worthwhile". All six wished to continue with the field testing evaluation. All rated monetary value, willing to invest from \$500-\$1000 in the technology.

DISCUSSION AND CONCLUSION

Results are limited to the study. Most were able to independently used the system and exhibit success. Participants improved with practice. Several were observed driving a golf ball over one hundred yards. All were enthusiastic about their experience and wished to continue the evaluation and see the technology evolve. The conclusion is that the bilateral golf technology, for this population, appears to be viable and further development will be pursued.

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ACKNOWLEDGEMENTS

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Free paper session | Psychosocial issues – Supporting psychosocial wellbeing

5.481 More Than Meets the Eye – The Psychosocial Impact of Cosmetic Covers in Lower Limb Prosthetics

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BACKGROUND

Satisfaction with the appearance of a prosthesis is associated with psychosocial adjustment following an amputation^[1]. Levels of satisfaction with prosthetic aesthetics affect perceptions of body image, self-acceptance, prosthesis embodiment and social participation^[2, 3]. Over the past decade an increasing number of cosmetic options for lower limb prosthesis users have become available. Despite this, the effects of different aesthetic designs on user satisfaction and psychosocial wellbeing is poorly understood.

AIM

The objective of this randomised cross-sectional study was to evaluate the effects of two different cosmetic covers on levels of satisfaction and psychosocial wellbeing in lower limb prosthesis users.

METHOD

Participants were experienced prosthesis users who had not previously expressed a desire to receive a 3d printed cosmetic cover. All were randomly assigned into one of two groups. Group 1 was initially fitted with a foam cover while group 2 was fitted with a 3d printed cover. Participants wore the cosmetic cover for 12 weeks before switching to the alternate design. Outcome measures related to satisfaction and psychosocial wellbeing (ABIS-R, TAPES, QUEST) were collected on 3 occasions. Linear mixed effects models(LMM) were used to assess for differences between the cosmetic covers.

RESULTS

14 participants were recruited for the study (age range 30-84), 10 completed all outcome measures on all 3 occasions. LMM results indicated that TAPES general psychosocial adjustment scores were significantly higher than the baseline condition when participants tested the 3d printed cover (est. = 2.1; $p=0.03$) (Fig 1A). Results for ABIS-R scores indicated that, when the 3d printed cover was tested first, body image disturbances were significantly reduced (est. = -6.38; $p=0.025$) (fig 1B). No differences were observed in QUEST scores. Covariates (age, time since amputation, extroversion scores) did not show any significant effects ($p>0.05$).

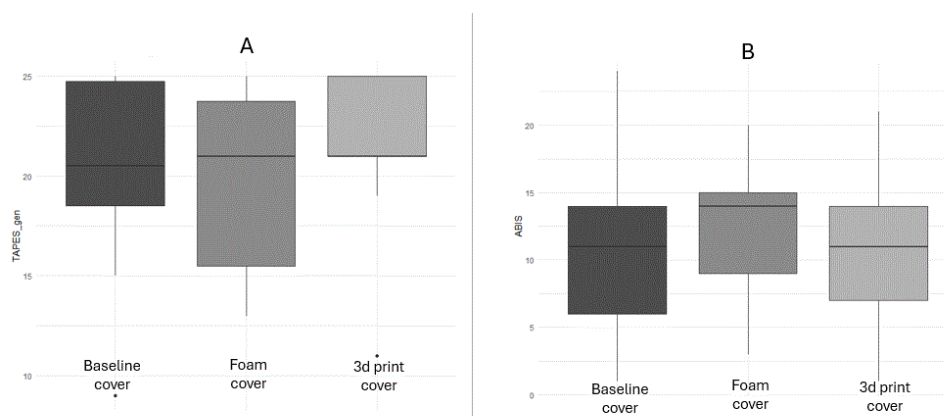


Figure 1: Distribution of TAPES general adjustment scores (A) and ABIS-R scores (B) for each cosmetic cover.



DISCUSSION AND CONCLUSION

Results from this study suggest that cosmetic cover design can significantly affect the psychosocial wellbeing of lower limb prosthesis users. Variance between participants is high and care should be taken in clinical consultations to present alternate cosmetic options to end users, ensuring that they receive a prosthetic device that meets their individual aesthetic needs and desires.

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ACKNOWLEDGEMENTS

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5.482 Moving on in life after leg amputation - Experiences from a psychosocial rehabilitation program

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BACKGROUND

The psychosocial challenges of amputation can be at least as great as the physical ones. However, rehabilitation often lacks sufficient psychosocial support, and more research is needed to understand these issues and develop effective interventions.

AIM

To explore psychosocial difficulties following major lower limb amputations and to examine various psychosocial interventions that may be adapted for use in municipal rehabilitation.

METHOD

In 2023 a group including health professionals, researchers, and patients, developed a five-day residential rehabilitation program, including ten different sessions building on each other. The program builds on a bio-psycho-social model and is group-based. The individual sessions address the psychosocial and palliative aspects of rehabilitation. The participants were adults with a self-assessed need for help to move forward in life, not being dependent on physical assistance. All participants completed questionnaires on physical, psychological, existential, and social problems. Participants evaluated the sessions in an anonymous questionnaire, assessing the relevance of the topics, the content, the dissemination, and whether they could recommend the session to others living with amputations. The participants' experiences were further explored in semi-structured online group interviews.

RESULTS

In total, 48 people participated in one of four courses. In total 62 % were men, mean age were 65 years (40-92). Most amputations were performed above the knee (79 %), and due to chronic diseases (76 %). On average, 11 months had passed since the amputation and 75% had a prosthesis.

Participants showed symptoms of anxiety, depression, loneliness, fatigue, and sexual problems. A total of 36 % had concerns about their role towards family and friends, and 42 % felt that they could not share feelings as desired with their loved ones.

The participants generally considered the sessions relevant and useful. They highlighted the crucial importance of fellowship with like-minded people. Furthermore, they wished their relatives could have participated, as the amputation had also affected their lives, and they were in this together.

DISCUSSION AND CONCLUSION

The participants had psychosocial problems at a level comparable to what is found in patients with cancer or heart disease, Highlighting the need to offer psychosocial rehabilitation. This study presents how a psychosocial rehabilitation program after leg amputation can be designed, which was considered meaningful and relevant by the participants. It is stressed that social community with peer support is essential and can be a valuable resource.



5.483 Back to Work: Exploring Barriers and Facilitators to Return to Work and Work Participation following Traumatic Amputation

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BACKGROUND

Traumatic amputation is a profound and life-changing event. Its physical, psychological and psychosocial impacts can affect an individual's activities of daily living including employment and work participation. Returning to work after injury can promote individuals' psychological, social and financial well-being and quality of life, with broader societal benefits of minimising indirect economic costs of unemployment.

Rates of re-employment following major amputation are variable across the literature from 40% to 75%. Predictive factors have been widely investigated, yet there is a paucity of research investigating the lived experience of individuals returning to work.

AIM

The purpose of this study is to explore and better understand people's lived experience of returning to work following a traumatic amputation, including the influence of various barriers and facilitators.

METHOD

Grounded within a constructivist epistemology, this exploratory and inductive qualitative study utilised semi-structured interviews and reflexive thematic analysis to investigate barriers and facilitators to return to work. Data was collected from nineteen adults who had sustained a major upper or lower limb amputation secondary to trauma within Australia.

RESULTS

The role of a worker was entrenched in the participants' identities, its value reflected in the sense of loss and destabilising of self they felt following amputation. Lack of productivity and routine was distressing, but also motivating for returning to work. Participants felt secondary health complications, complexities of return to work systems, and perceptions of unemployability due to their amputation hindered returning to work. Adaptations and strategies effective in facilitating participation included prosthetic use, environmental modifications, delegation of tasks, and transition to less physically demanding roles. Re-establishing one's capacity and identity in the workplace was a process of adapting not just environments and tasks, but re-negotiating workplace relationships. Supportive workplace culture and colleagues were invaluable to this process. Whilst some participants were unable to return to work, for others the process was an opportunity for positive career and lifestyle changes.

DISCUSSION AND CONCLUSION

The findings support existing literature on predictors for return to work, whilst providing a qualitative perspective on how these factors are experienced by individuals. Effective vocational rehabilitation relies on identifying, understanding, and addressing barriers and facilitators for an individual to successfully return to work. This study shares key themes from the lived experience of returning to work, and provides clinical recommendations that may improve vocational rehabilitation service delivery and outcomes.

ACKNOWLEDGEMENTS

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5.484 Experiences of attending a mobility clinic: Challenges, confidence and peer support

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BACKGROUND

Mobility clinics aim to extend gait and mobility training beyond initial rehabilitation for people with limb loss. Mobility clinics are offered in a number of countries and play a crucial role in ongoing rehabilitation and community integration. Research into participants' experiences remains limited, especially when considering differences in the format of the clinic, regional and country context and rehabilitation programs available across these countries. Recent studies have highlighted the importance of peer support and the need for tailored information in post amputation rehabilitation.^{1,2} Understanding attendees' motivations and experiences is essential to ensure clinics meet their intended goals and to inform strategies for improving participation.

AIM

To explore the motivation of people with limb loss to attend mobility clinics, their experiences of participation, and their perceptions of the clinics' benefits and challenges across different countries.

METHOD

Semi-structured interviews were conducted with nine mobility clinic attendees: three each from Australia, South Africa, and the USA. This qualitative methodology used a naturalistic inquiry approach, aligning with the study's aim to explore participants' experiences and perceptions. Interviews were conducted following participants attendance at the clinic to capture their reflections and experiences. The interviews were audio-recorded and transcribed verbatim. Data analysis followed a thematic analysis approach, which involved iterative coding and theme development using NVivo

RESULTS

Three main themes emerged from the data analysis:

1. Overcoming Challenges & Building Confidence: Participants described how the clinics helped them confront daily challenges and build self-assurance in their abilities.
2. The Value of Peer Support and Learning: The importance of peer interaction was emphasized, with participants reporting valuable exchange of advice and a sense of belonging.
3. Expanding Mobility Skills and Possibilities: Participants noted opportunities to learn additional mobility skills beyond basic gait training, opening up new possibilities for daily living.

DISCUSSION AND CONCLUSION

Mobility clinics attracted individuals seeking to overcome challenges and provided an invaluable source of learning and peer support. The importance of peer interaction was emphasized across all three countries, highlighting its potential as a key component of rehabilitation programs. Participants reported positive changes in mobility and overall function. These findings suggest that mobility clinics can play a crucial role in ongoing rehabilitation and community integration for people with limb loss across different cultural contexts. Future clinics should prioritize peer education and cater to a range of skill and fitness levels.

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ACKNOWLEDGEMENTS

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5.485 Rehabilitation of Major Amputations with Comorbidities: Impact on Daily Function and Physical Performance in an Austrian Cohort

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BACKGROUND

In Austria, about 2,500 major amputations are performed annually, mainly due to arterial circulatory disorders like peripheral arterial occlusive disease (PAD) and infections. PAD, where leg arteries become calcified, often results from diabetes. Other risk factors, such as hypertension, smoking, high cholesterol, obesity, and hyperlipidemia, can contribute to secondary conditions like coronary heart disease, cerebrovascular disease, infections, and kidney failure. These comorbidities create complex rehabilitation challenges for major amputation patients.

AIM

The study aims to assess physical function and daily life coping through functional tests, mobility classes, gait parameters, and daily functioning, considering the impact of age and comorbidities.

METHOD

Since 2013 up to 2023, over 1094 amputation patients have been treated and assessed at the Pension Insurance (PV) Rehabilitation Center in Gröbming, Austria. The patients participated in a four-week interdisciplinary inpatient program tailored to their needs and led by a multidisciplinary team of specialists (orthopaedics, trauma surgery, internal medicine, nursing, physiotherapy, occupational therapy, psychology, dietetics). Functional improvements were measured using the 6-minute-walk-test (6MWT), the timed-up-and-go-test (TUGT) and the 10-meter-walk-test (10MWT), taking comorbidities into accounting. Gait analysis tracked mobility changes, while the Barthel Index and walking aid use assessed improvements in everyday skills. A before to after comparison was carried out.

RESULTS

The study found a 26% improvement in physical function/activity in major amputation patients during rehabilitation, as measured by the 6MWT, which showed the largest effect size compared to the 10MWT and TUGT (6MWT: $d = 0.579$; 10MWT: $d = 0.235$; TUGT: $d = 0.287$). Patients aged 50-69 years showed the best improvements (35% in 50-59 years, 31% in 60-69 years). The 10MWT had a lower effect size, especially in patients over 80 (10MWT: $d = 0.105$ vs. 6MWT: $d = 0.552$). Rehabilitation also led to improved mobility classes and gait parameters, with significant increases in cadence and walking speed up to age 80. The Barthel Index (BI), assessing daily activity, improved significantly at discharge (BI admission: 76.8 ± 20.6 , BI discharge: 82.1 ± 18.4 ; $p < 0.001$).

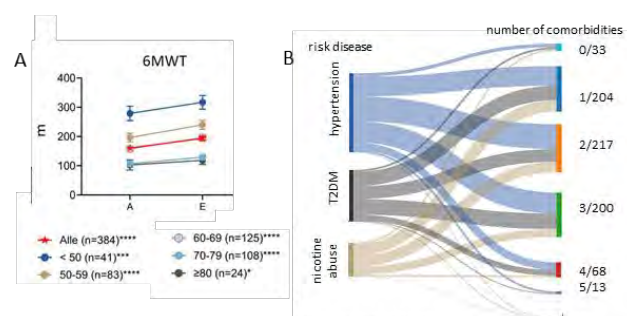


Figure 1 Functional test in different age groups (A) at admission A and end E of the reha stay, and number of comorbidities corresponding to risk diseases (B)

DISCUSSION AND CONCLUSION

The goal of rehabilitation is to prepare patients for life with their prosthesis by restoring strength, endurance, coordination, and teaching prosthesis use. The data indicates that rehabilitation improvements are not age-dependent. In addition to functional gains, participation in daily life can also be improved, in accordance with ICF criteria. These results highlight the importance of rehabilitation for leg amputees of all ages to improve function, mobility, and daily life coping.

ACKNOWLEDGEMENTS

This work is supported by the great cooperation of the multidisciplinary prosthesis team at the Gröbming rehabilitation center.



5.486 Examining potential psychological protective and risk factors for psychological distress and PTSD amongst persons with physical disabilities in Cambodia

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BACKGROUND

Persons using Prosthetic and Orthotic devices in Cambodia are at an increased risk of psychological distress and PTSD symptoms. In low-and middle-income countries, such as Cambodia, psychological distress and PTSD place a significant psychological, social and economic burden on citizens, most of whom receive no treatment. There are very limited prevalence estimates of the mental health of persons with physical disabilities in Cambodia. This is despite consistent calls for epidemiological research on the mental health and well-being of the vulnerable groups in Cambodia, including persons with comorbid mental health and physical disabilities.

AIM

The aims of this study were to determine: a) the rates of psychological distress and PTSD amongst 283 prosthetic and orthotic (P&O) service users who reported a lifetime exposure to a traumatic event, and 2) examine potential psychological protective and risk factors for these outcomes.

METHOD

A cross-sectional study was performed using data collected from three clinics offering services (prostheses and orthoses) to people with physical disabilities in Cambodia. This included one clinic in Phnom Penh, the capital of Cambodia, and two clinics located in Sihanouk Province and Kampong Chhnang. From March 2023 to June 2024 data were collected as part of a mental health screening programme for P&O service users across Cambodia. Using the clinically modified Buddhist psychological model (CBPM) as a theoretical framework, this cross-sectional study examined a range of potential psychological protective and risk factors for psychological distress and PTSD symptoms among 283 P&O service users, using structural equation modelling.

RESULTS

Our study found high rates of psychological distress and PTSD symptoms in this patient cohort. Acceptance, non-attachment, and mindful observation/attention regulation skills could act as protective factors against psychological distress and PTSD in P&O service users. Our results also indicate that these protective factors could also reduce the extent to which P&O service users worry or ruminate, further reducing the risk of psychological distress and PTSD symptoms (See Figure 1).

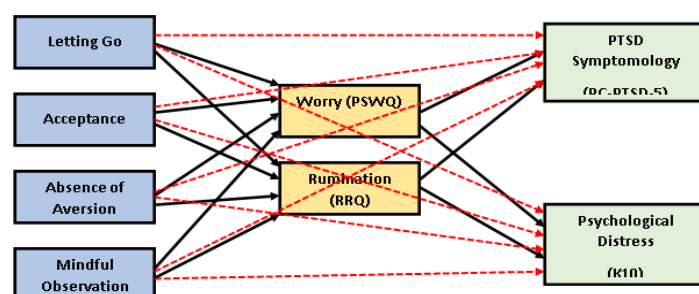


Figure 1. Combined direct and mediated effects CBPM model

DISCUSSION AND CONCLUSION

Our study's findings highlight that integration of mental health interventions are required within P&O services in Cambodia to address co-morbid psychological distress and PTSD symptoms. This study's results indicate that if P&O users engage with mental health interventions which have the capacity to increase acceptance, non-attachment, mindful observation, and reduce worry and rumination, they are likely to experience reduced psychological distress and PTSD symptoms.

ACKNOWLEDGEMENTS

This work was completed with support from the Exceed Research Network (ERN) and from funding from the Swedish Research Council.



5.487 The effects of a task shifted multi-component intervention to support prosthetic and orthotic service users's mental health in Cambodia

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BACKGROUND

Research which has examined the prevalence of common mental health disorders in Cambodia have reported very high rates of depression (16.7%), anxiety (27.4%) and PTSD (7.6%) (Seponski et al., 2019). In order to reduce psychological distress amongst persons with physical disabilities in Cambodia, in a mixed methods study, Best et al. (2024) developed and culturally adapted a peer-led, group based, mental health intervention (named 'Friendship' group) which incorporated mindfulness meditation, delivered by trained Prosthetists and Orthotists (P+O), using a task shifted approach within a clinical setting in Phnom Penh. Best et al. (2024) provided some promising initial evidence of the feasibility and acceptability of Friendship groups in reducing psychological distress and worry among P+O service users.

AIM

The aims of this study were to:

1. Assess the effectiveness of the Friendship programme at reducing psychological distress and PTSD among an expanded cohort of prosthetic and orthotic service users.
2. Assess the effectiveness of the Friendship programme at reducing worry, rumination, and improve a number of mindfulness-based variables among an expanded cohort of prosthetic and orthotic (P+O) service users.
3. Assess and confirm differences between the Friendship and control group.

METHOD

A non-randomised control designed study with repeated measures (pre-post design) was conducted to assess and confirm the effects of the Friendship group on psychological distress, PTSD symptoms, worry, rumination and mindfulness-based variables. This study was conducted and reported in accordance with the CONSORT guidelines (Schulz et al., 2010).

RESULTS

The friendship group participants reported large significant reductions in psychological distress and worry from pre to post intervention compared to the control group. The Friendship group participants reported lower psychological distress and worry scores pre-post group completion. Both mean differences were statistically significant. There were no significant group differences between the Friendship group and the control group on PTSD symptoms, rumination or mindfulness-based variables.

DISCUSSION AND CONCLUSION

This study is the only controlled evaluation of a culturally appropriate task shifted multiple component mental health intervention for persons with physical disabilities in Cambodia. The results from this study evidence the acceptability, effectiveness, and durability of Friendship groups at reducing psychological distress and worry of P+O service users. Though more research evaluating Friendship groups is needed, particularly in other jurisdictions, the results from this study provide reasonably clear guidance that if P+O service providers deliver Friendship groups within their services, that their service users will likely experience improved mental health outcomes.

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ACKNOWLEDGEMENTS

This work was completed with support from the Exceed Research Network (ERN) and from funding from the Swedish Research Council.



Free paper session | Prosthetics: bone anchored limbs – Programmes and interfaces

5.491 Single versus two-stage implantation of bone-anchored prosthesis after transfemoral amputation: a two-center retrospective cohort study

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BACKGROUND

Implantation of an osseointegration implants (OI) for a bone-anchored prosthesis (BAP) is an alternative for users of a lower limb socket-suspended prosthesis suffering from socket-related problems. Historically, the OI was implanted in a two-stage procedure for safety reasons, however the single-stage stage procedure is increasingly used and might have similar safety, functional and health-related quality-of-life (HRQoL) outcomes.

AIM

To assess the single-stage and two-stage OI implantation in terms of adverse events and change in HRQoL and functional outcomes up to 2-year follow-up.

METHOD

Adverse events were ranked using a predefined grading system, including infection, implant failure, stoma problems, and peri-prosthetic fractures. In addition, surgery-related complications were obtained. HRQoL (questionnaire for persons with a transfemoral amputation global score (Q-TFA GS)), prosthesis wearing time (Q-TFA PUS), mobility (timed-up and go test), and walking ability (6-Minute-Walk-Test and K-level) were obtained at baseline (while using a socket-suspended prosthesis) and 2-year follow-up. Within- and between-group differences were analyzed using Wilcoxon signed rank test and the Mann Whitney U test, respectively.

RESULTS

We included 26 patients in the single-stage group and 62 in the two-stage group. Infection events occurred in 5 patients (19%) in the single-stage group and 19 patients (31%) in the two-stage group. More severe infections were reported in the single-stage group, with 30-day infections in 18% of the two-stage group and none in the single-stage group. Surgical site infections affected 6% of the two-stage group and 8% of the single-stage group. The average operation time was significantly longer in the single-stage group (139 minutes, SD40.5 vs. 101 minutes, SD11.9; $p < 0.001$). Rehabilitation sessions were also significantly higher in the single-stage group (21.6, SD2.4 vs. 17.5, SD8.6; $p = 0.02$). Both groups showed significant improvements in quality of life and functional outcomes over time, with greater improvements observed in the single-stage group despite lower pre-operative status.

DISCUSSION AND CONCLUSION

The single-stage BAP procedure appears to show similar outcomes as the traditional two-stage approach, and shows comparable HRQoL and functional outcomes after 2 years of follow-up without possibility of surgery-related complications in between stages. These findings might suggest that the single-stage procedure could become the preferred method for BAP treatment.



5.492 Influence of the surface structure of titanium implants on the adherence behaviour of human healthy osteoblasts

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BACKGROUND

Prostheses can be anchored directly in the bone by using osseointegration, which is beneficial in particular for the person using them. However, the anchoring of the prosthesis can also become loose or infected. The condition of the bone and implant is essential for long-term and resilient osseointegration.

AIM

This study investigated the influence of a rough surface structure of the anchored titanium compared to a smooth surface modification on the adherence behaviour of human healthy osteoblasts (hOB) in an in vitro model.

METHOD

Cell isolation was performed from femoral heads harvested after fractures. Titanium test specimens (Peter Brehm GmbH; diameter: 14.7 mm, thickness: 2.0 mm) with an implant-identical rough surface structure and a smooth, polished side were used. Adherence was investigated by means of scanning electron microscopy of the cell structures on the test specimens and fluorescence microscopy of the actin cytoskeleton by staining with a vinculin antibody, phalloidin and 4',6-diamidin-phenylindole (DAPI).

RESULTS

Both sides of the test specimens could be visualized well by scanning electron microscopy. After 48 hours of growth, the cells were adherent, whereby three-dimensional growth could be observed on the rough surface structure. After 21 days, both surface structures showed a flat cell carpet with very finely formed podocytes. In combination with the rough surface structure, more cell layers were formed. Using fluorescence microscopic staining, the cytoskeleton could be clearly visualised. This revealed different cell morphologies. While the cells on the smooth side were organised and planar, a disordered cell system developed on the rough side, in which more punctual cell-cell and cell-titanium contacts were formed. This order was still observed after 21 days, with a denser cell network on the rough side.

DISCUSSION AND CONCLUSION

Both surface modifications provided a good basis for the growth and differentiation of hOBs, as improved adherence of the hOBs to the titanium test specimen and more pronounced cell-cell-interactions were observed on the rough surface structure in particular. A disordered surface structure thus led to improved cell growth and, in the long term, to improved and more stable osseointegration. The elucidation of the molecular mechanisms is the subject of our further research.



5.493 Finite Element Analysis of Stress Distribution in a Tibial Bone-Anchored Prosthesis During Running

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BACKGROUND

Users of a bone anchored prosthesis (BAP) using a press-fit osseointegration implant are instructed to refrain from dynamic activities like running due to the unknown risks associated with high load/dynamic activities. However, it is unknown if running on a BAP is indeed unsafe. In a previous study by our group we computed loads on the transtibial osseointegration implant, during walking and running on a daily use prosthesis (DUP) and running on a running specific prosthesis (RSP), utilizing an experimental approach and multi-body modelling. However, interpretation of the results was difficult due to missing knowledge about the mechanical effects on the bone-implant system.

AIM

The aim of this study was to determine the bone-implant stresses and risk of bone failure in the tibia during both walking and running on a transtibial BAP.

METHOD

A subject specific 3D finite element (FE) model of the bone-implant system was developed. Mechanical properties and morphology of bone were obtained from a pre-implantation CT scan. The implant was modelled as rigidly connected within the tibia. Forces and moments during midstance, absorption and propulsion phases in the gait cycle were selected for peak forces or moments, resulting in multiple load cases for walking on DUP and running on DUP and RSP. Linear elastic simulations revealed von Mises (VM) stresses and local stress/strength ratio as a measure for risk of bone failure.

RESULTS

For all load cases, VM stress was concentrated in the cortical bone and at the bone-implant interface, higher stress/strength ratio values were located near the proximal tip of the implant. Peak stress/strength ratio was highest during early stance in walking (0.47) and substantially larger compared to running on both DUP (0.28) and RSP (0.34).

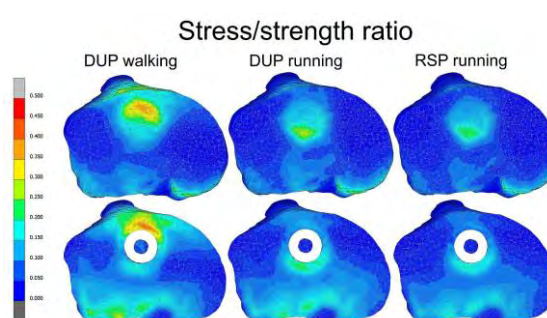


Figure 1: Stress/strength ratio in transverse cross sections at +70 mm and +75 mm offset from distal tip of tibia, for load cases where the highest peak values were found.

DISCUSSION AND CONCLUSION

The results indicate no increased risk of bone failure during running compared to walking. The failure mode of implant loosening could not be assessed due to limited knowledge of the in-situ interface. The simulated stress and stress/strength ratio coincide with results from a previous cadaver study [1]. Despite model limitations, a relative safety of running with respect to walking was determined, which contradicts that running on a BAP is unsafe.

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5.494 Rehabilitation of lower limb transtibial and transfemoral osseointegration patients with OGAAP-2 implants

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BACKGROUND

Osseointegration has many advantages over a traditional prosthesis, such as increased proprioception, increased bone formation due to mechanotransduction, and decreased pressure sores. However, osseointegration remains a relatively new technique, and many hospitals and rehabilitation centres remain uneducated and are shocked at the notion of an implant directly attached to bone. Crucially, many physiotherapists and clinicians remain ignorant of the requirements to rehabilitate these patients. There has been some research into rehabilitation for lower limb amputees with an osseointegration implant, however most have focused on establishing protocols and very little if any have actually evaluated the effectiveness of these protocols.

AIM

This study aims to evaluate the rehabilitation process that postulates three different stages, with further analysis with objective measurements such as QTFA and SF-36.

METHOD

A retrospective review of our osseointegration registry identifying patients who have undergone a two stage vs single stage surgery and their subsequent rehabilitation protocol. Analysis was performed of their preoperative and postoperative mobility (daily prosthesis wear hours, K-level, timed up and go (TUG), and 6 minute walk test (6MWT)) and QOL metrics (Questionnaire for Persons with a Transfemoral Amputation (QTFA) and Short Form 36 (SF36)). Complications and benefits specific to their rehabilitation protocol.

RESULTS

Previous rehabilitation protocols by other experts in addition to being two-stage operations were required to have prolonged periods of rehabilitation. The OGAAP-2 protocols condenses this post-operative recovery period, directing patients to begin load-bearing within days of their initial procedure. The OGAAP-2 process is designed to accelerate recovery and provide amputees with independent movement as soon as possible. Patients are encouraged to weight- bear daily on their prosthesis using two crutches for 6 weeks and then one crutch on the opposite side for a further 6 weeks and then unaided thereafter. Resulting in a total rehabilitation period of approximately 3 months.

DISCUSSION AND CONCLUSION

The OGAAP-2 protocol reveals lesser burden as on the hospitals, health care and patients as mobility is achieved quicker than a prolong rehabilitation. However, since the OGAAP-2 system has only been implemented in the last 8 years old makes it abundantly clear that much research has yet to be published. As the number of patients receiving this implant increases, and the locations that are providing it spreads worldwide, a study further evaluating the efficacy of the existing rehabilitation protocol and standardising it for centres around the world is absolutely necessary to further develop OI into a standard procedure.



5.495 Alignment of Bone-anchored Prostheses and its Control over the first post-surgery year

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BACKGROUND

Restoring the ability to stand and walk with a prosthesis is considered as fundamental rehabilitation goal after lower extremity amputations. An essential prerequisite for achieving this goal is adequate prosthetic alignment. In transfemoral amputees with bone-anchored prostheses the Mikulicz-line is a clinically proved guideline in the coronal plan. Sagittal alignment is challenging because of the changing hip angle extension limit over post-surgery period. What is the consequence for the treatment management of transfemoral amputees?

AIM

How does the hip extension limitation change over the first post-surgery year? Is there an impact on the sagittal alignment?

METHOD

Parameter: The hip contracture angle TW was determined clinically by one physiotherapist using the Thomas-Test. Independent of that test, two prosthetists checked the alignment and optimized the alignment if indicated ^[1]. The offset L_{ad} was measured (Fig.1).

Subjects: 25 unilateral TF-amputated persons with bone fixed prostheses. All amputees were significantly limited in their mobility due to residual limb problems or could not wear a socket prosthesis. Surgery took place between 02/2017 and 07/2019 at mean age of 45 ± 12 years.

RESULTS

Just one of the patients had no hip extension limitation. The hip contraction angle was pre-surgery $13,0 \pm 4,6$ degree and was reduced to $8,2 \pm 3,7$ degree after 12 months. Mean length between hip joint and abutment L_{TM-E} was measured to be $24,4 \pm 6,5$ cm. Figure 1 (right) shows the course of hip contracture angle and the adapter offset. There is a high correlation between the two parameters ($R=0,99$). The hip adduction angle did not change over the investigated period.

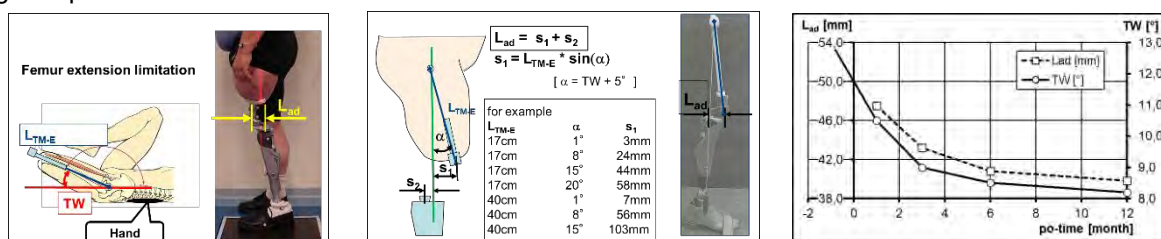


Figure 1: Measurement of hip contracture angle TW (left), adapter offset L_{ad} (middle) and course of hip contracture angle TW and adapter offset L_{ad} for 12 months post-surgery (right).

DISCUSSION AND CONCLUSION

In osseointegrated amputees the limited femur extension has to be considered for prosthetic alignment. Because of this changing limit in the first year post-surgery the adapter length should be adapted accordingly. Concluding on this investigation the prosthetic alignment should be checked after 3, 6 and 12 months and changed if indicated to avoid incorrect loading of postural and locomotor system.

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5.496 Transcutaneous Osseointegrated Prosthesis Systems for Rehabilitation of Amputees with short and ultra short Femur Remnants

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BACKGROUND

Transcutaneous osseointegrated prosthesis systems (TOPS) have been established over the last 20 years in Germany as an appropriate method for rehabilitation following limb loss. Short (140–90 mm) and ultrashort femur (90–60 mm) remnants are defined as amputation levels above the bottleneck of the diaphysis of the femur bone. At the distal end of such remnants, there is only a limited area of cortical wall available to fulfill press-fit conditions. To the proximal end, the diameter of the metaphysis is continuously expanding. In those cases, primary stability can optionally be achieved by the application of either a bicortical locking screw or an implant interlocking screw into the femur neck and head. Especially in ultrashort femur remnants, where the implant itself reaches the proximal end of the trochanter major, such interlocking devices have proven to be extremely effective ^[1].

AIM

In many cases, patients with short and ultrashort femoral cannot be satisfactorily rehabilitated with conventional socket prostheses. Can these patients be treated safely with bone-anchored, skin-perforating implants? Do the patients experience measurable gains in mobility and quality of life after successful osseointegration?

METHOD

Between July 2021 and June 2024, 15 patients were supplied with 19 custom-made implants developed by the firm OTN – Implants / Netherlands (4 bilateral transfemoral amputees). Due to the brevity of the femur remnants, interlocking screws were applied at the proximal end of the implants (120–60 mm) in a 130-degree position into the femur neck and head. One bilateral amputee, with only a residual femur neck and head on the right side, was supplied with an individually fabricated implant serving solely as an intramedullary force conductor in his residual bone. All patients are connected to their clinics and are available for follow-up examinations.

RESULTS

None of the 19 implants had to be removed yet. All patients are known to use their bone-guided prostheses with a significant improvement in their rehabilitation results, especially regarding their satisfaction with the prosthesis and the degree of mobility. As of now, neither aseptic nor septic loosening of an implant has been observed.

DISCUSSION AND CONCLUSION

So far, TOPS have proven to be a secure and successful treatment concept for regaining mobility. It is not yet clear how short the femoral implant can become concerning the stability of osseointegration and biomechanical aspects. A closer look at the specific challenges of this surgical procedure and the outcome data will be presented during the lecture

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5.497 Transcutaneous Osseointegrated Prosthesis Systems (TOPS) for Rehabilitation Following Bilateral Lower Limb Loss

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BACKGROUND

Patients with bilateral lower limb amputations often experience extreme restrictions in mobility due to their condition. In many cases, patients with short and ultrashort femoral and/or tibial remnants cannot be satisfactorily rehabilitated with conventional socket prostheses and are therefore dependent on wheelchairs. TOPS may provide a useful alternative for such cases ^[1].

AIM

Can these patients be treated safely with bone-anchored, skin-perforating implants? Do the patients experience measurable gains in mobility and quality of life after successful osseointegration and adjustment of the exoprosthesis?

METHOD

Between 2008 and 2024, a total of 21 patients with bilateral lower limb amputations were fitted with TOPS. Seventeen of them were outfitted with the Endo-Fix stem (ESKA Orthopaedic/Germany). The implantation was performed as a two-step surgery. Firstly, the implant was adjusted into the intramedullary space, followed by the creation of the stoma and the docking of the skin-perforating components. Four patients were supplied with TOPS from OTN (Netherlands), using a single-step surgical technique. This approach allows for more accurate shaping of the soft tissue around the stoma and leads to faster rehabilitation. The data collected during this period were analyzed retrospectively, with a particular focus on postoperative complications. Complications were subclassified into stoma-related problems, periprosthetic fractures, removals of implants, and technical issues with the prosthetic components.

RESULTS

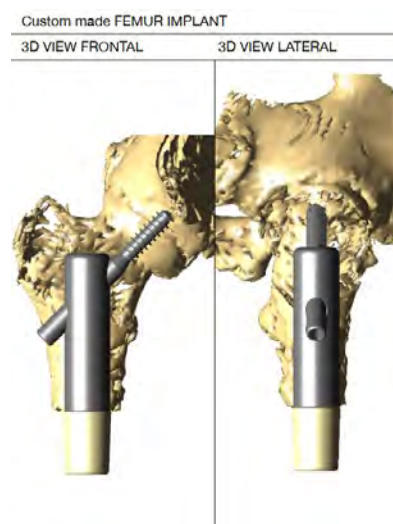
Thirteen bilateral transfemoral (TF), two transtibial (TT), and two bilateral TF/TT amputees were provided with Endo-Fix implants, while three TF amputees and one TT amputee received OTN implants. Nineteen out of 21 patients are permanently mobilized with their bone-anchored systems, exhibiting a gain in mobility between 1 and 3 points according to the K-level classification. Soft tissue problems around the skin-perforating area made four surgical interventions necessary. One patient suffered a bilateral femur neck fracture accompanied by a fracture of the os sacrum. All fractures could be stabilized and healed well. One bilateral TF patient needed a hip joint replacement following a femur neck fracture which led to implant failure after another 18 months. In one bilateral TT patient, the removal of implants was performed *alio loco*, possibly due to aseptic loosening. Three patients passed away with no relation to TOPS. The remaining 18 patients would opt again for the TOPS procedure and report significant benefits in quality of life and mobility.

DISCUSSION AND CONCLUSION

TOPS represent a valuable addition to the spectrum of rehabilitation following lower limb loss, especially after bilateral amputations. A significant improvement in rehabilitation outcomes was noted.

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Free paper session | Outcome measurements – Characterising patient outcomes 1

5.501 Determining the economic value of providing microprocessor-controlled prosthetic knees to the Medicare K2 population in the United States

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BACKGROUND

Many studies have examined the cost benefits of providing microprocessor-controlled prosthetic knees (MPKs) to designated patients with transfemoral amputations (TFA). However, these studies have typically been conducted outside the United States and used metrics that differ from the standard metrics utilized by the U.S. Center for Medicare and Medicaid Services (CMS) when making its coverage decisions and by the Congressional Budget Office (CBO) in determining its budget impact “scores.”

AIM

To analyze the economic impact of the provision of MPKs to TFAs with K2 mobility insured by Medicare in the United States.

METHOD

Retrospective analysis of the Medicare fee-for-service claims data of 10,147 K2 NMPK and 7,796 K3 MPK beneficiaries fitted between 10/1/2016 and 12/31/2020. We analyzed an 18-month period to determine the medical cost Medicare incurred. Propensity score weighting using inverse probability treatment weights was used to accurately compare and balance the K2 NMPK and K3 MPK cohorts. A generalized linear model with log link function and Gamma distribution was utilized to determine prosthetic and medical cost. Results were subsequently used to model the economic impact of MPK provision to K2 beneficiaries on the Medicare budget over a 10-year period.

RESULTS

The K2 NMPK cohort demonstrated adjusted per-member-per-month (PMPM) medical expenses totaling \$6,232 as compared to \$4,881 for the K3 MPK comparison cohort – a difference of \$1,351 per member per month. The difference prosthetic cost was \$25,075 (NMPK: \$3,778; MPK: \$28,853). Thus, the difference in prosthetic device cost would amortize within 19 months.

The adjusted injured faller rates for the K2 NMPK and K3 MPK cohorts after performing PSW and calculating a logistic regression analysis demonstrated a 16.9% percent reduction ($P < 0.05$) in fallers having an injury resulting in a medical claim in the K2 NMPK cohort.

Over the course of the 10-year CBO style score model, providing coverage of the MPK prosthesis to the K2 population would result in Medicare cost savings of \$410.3 million.

DISCUSSION AND CONCLUSION

The provision of MPKs to Medicare beneficiaries designated K2 mobility level demonstrates a fiscal benefit to Medicare based on adjusted PMPM medical costs. Due to savings in medical expenses, the initial high cost of the MPK would amortize within 19 months. These results suggest a good economic value of the MPK on a person level. In addition, the CBO score budget impact analysis showed that MPK coverage for the K2 population would also produce cost effectiveness at the population level as well.

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5.502 Comprehensive Database for Patient Follow-up in Primary Rehabilitation after Lower-limb Loss

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BACKGROUND

Patient follow-up, outcome prediction and clinical decision-making rely on comprehensive and standardised data. Previous attempts to establish comprehensive databases involving patients with lower limb loss (LLL) include the Scottish Physiotherapy Amputee Research Group (SPARG) ⁽¹⁾, Swedish Amputation and Prosthetic Registry ⁽²⁾, and the International Society for Prosthetic and Orthotics (ISPO) Reporting guide ⁽³⁾.

AIM

Our aim was to design and implement the comprehensive database for all patients with LLL admitted to inpatient rehabilitation in our hospital.

METHOD

The professionals working with patients after LLL held several meetings where the key data were identified and precise coding rules were defined. Microsoft® Excel was chosen for implementation because of its familiarity to the users, sufficient data validation, rapid development and zero costs of development and maintenance.

RESULTS

The database comprises 417 characteristics for each patient: 86 provided by the physical-and-rehabilitation-medicine specialist, 31 by the internal medicine specialist, 85 by the nurses, 25 by the physiotherapists, 54 by the occupational therapists, 31 by the social workers, 9 by the psychologist and 11 by the prosthetists. We have so far collected data on over 600 patients. The Excel workbook is shared over the intranet and all the professionals find it easy to use despite practically no training. It also provides easy data export and flexibility in case of subsequent changes.

DISCUSSION AND CONCLUSION

The collected data are used to compare the characteristics and outcomes between patients admitted in different years. In the future, we will try to identify the most important predictors of successful prosthetic fitting, wound development and falls. The main disadvantage of the project, which is at the same time its advantage, is the very large amount of data that has to be entered in the database for each patient.

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5.503 Patient-reported health outcome profiles of lower limb orthosis users

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BACKGROUND

Individuals with functional impairments are often prescribed lower limb orthoses (LLOs) to improve or preserve their mobility. LLOs may also benefit other areas of health that can impact the user's quality-of-life. Clinicians can measure different aspects of health when providing patient-centered care. Surveys developed by the Patient-Reported Outcomes Measurement Information System (PROMIS) initiative can be used to briefly assess multiple health domains and compare scores to normative reference values.¹

AIM

The goals of this study were to construct health profiles of LLO users and compare scores to the U.S. general population.

METHOD

Adults in the U.S. with at least six months of experience using a lower limb orthosis (e.g., AFOs, KAFOs) participated. The PROMIS-29 profile includes 4-items from each of the following domains: physical function, anxiety, sleep disturbance, fatigue, depression, pain interference, and ability to participate in social roles and activities.² Most PROMIS scores are referenced to the U.S. general population by gender, age, race, ethnicity, and education.³ Participants completed an online or mail-in cross-sectional survey. PROMIS scores were summarized for the overall sample, and for orthosis type and assistive device (AD) use subgroups. Mean scores were compared to U.S. general population scores using one-sample t-tests.

RESULTS

Survey responses were collected from 1036 LLO users (50% female; age: $M=59.7 \pm 14.5$ years). Most respondents used AFOs (91%). Nearly half (43%) did not use ADs, and fewer used them only in the community (20%) or both at home and in the community (37%). Relative to U.S. normative values (Figure 1), orthosis users report significantly worse anxiety, fatigue, pain interference, physical function, and ability to participate in social roles and activities ($p < 0.0001$). Differences in pain interference, ability to participate in social roles and activities, and physical function were all greater than five points (0.5 SD). KAFO users report significantly worse physical function ($p=0.0003$) but less (i.e., better) anxiety ($p=0.008$) and depression ($p=0.003$) compared to AFO users. Those who did not use AD had significantly better scores across all domains than community-only or home AD-user groups.

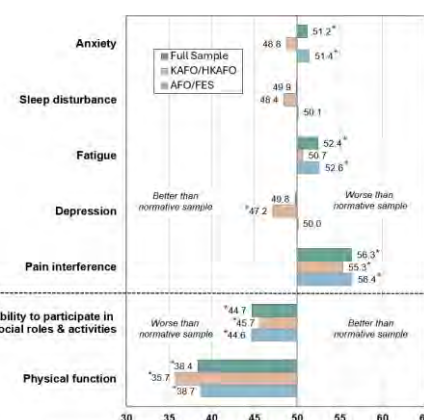


Figure 1. PROMIS-29 Profile scores for 1036 lower limb orthosis users. A T-score of 50 represents the mean of the U.S. general population.

DISCUSSION AND CONCLUSION

Differences in mean scores between LLO users and the U.S. general population reflect mildly (ability to participate in social roles and activities and pain interference) to moderately (physical function) worse health.⁴ Clinical interventions that address these domains could have a profound effect on LLO users' health. Clinicians can implement PROMIS instruments into routine orthotic care to holistically assess important areas of health that may be problematic for patients receiving LLOs.

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5.504 Characterizing the prevalence of pelvic floor disorders in people with unilateral lower limb amputation

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BACKGROUND

Pelvic floor disorders (PFDs) are major health burdens affecting millions of people. A broad term used to describe several impairments, PFDs manifest in a variety of ways, including urinary and fecal incontinence, and urinary frequency or urgency. In the non-amputee population, associations exist between spinal pain and urinary incontinence and fall risk [1]. Incidentally, individuals with lower limb amputation (LLA) experience increased rates of low back pain [2] and falls [3], provoking interest of a possible association to undiagnosed PFDs. Currently, no evidence exists regarding the prevalence of PFDs in people with LLA or any effect they may have on functioning and quality of life.

AIM

To provide novel data on the prevalence and severity of PFDs in males and females with unilateral LLA

METHOD

Surveys were administered nation-wide within the U.S. The primary outcome measure was the Pelvic Floor Disability Index-20 (PFDI-20) to determine the perceived distress and severity of urinary (UDI-6), colorectal (CRADI-8), and prolapse (POPDI-6) symptoms. Secondary outcomes included the Prosthetic Limb Users Survey of Mobility (PLUS-M) and Activities-specific Balance Confidence scale (ABC), to determine relationships of PFDs to perceived functioning, as well as reports of previous low back pain (LBP) and falls. Inclusion criteria: 18-80 years old, unilateral LLA above the ankle, and daily prosthetic use. Participants accessed the study website from their personal computer or phone. Mann Whitney U tests were used to compare groups based on sex, and low back pain and fall history. Spearman correlations tested associations of PFDs to perceived mobility and balance.

RESULTS

Preliminary results indicate that 98% of participants are experiencing some level of distress from pelvic floor disorder symptoms. Additionally, 72% of participants reported previous medical treatment for LBP and 59% reported a fall in the past year. Significant differences existed between males and females ($p < 0.01$) with females reporting higher distress related to PFD symptoms. Furthermore, participants with a history of LBP or falls scored significantly worse. Moderate correlations existed between PFDI-20, PLUS-M and ABC scores ($r_s = -0.50$ and $r_s = -0.60$, respectively).

Type of score	Previous LBP treatment (n=97) Median (IQR)	No previous LBP treatment (n=38) Median (IQR)	P value
PFDI-20 traditional			
Summary score	62.5 (34.4, 114.6)	28.6 (3.1, 72.9)	< 0.01
UDI-6	29.2 (8.3, 50.0)	10.4 (0.0, 33.3)	0.01
CRADI-8	16.8 (0.0, 40.6)	6.3 (0.0, 18.8)	0.02
POPDI-6	16.7 (0.0, 37.5)	0 (0.0, 25.0)	0.02
PFDI-20 new			
Total score	11.0 (7.0, 19.0)	8.0 (4.0, 13.0)	0.03
	Previous fall (n=80)	No fall (n=55)	
PFDI-20 traditional			
Summary score	58.2 (34.4, 115.6)	39.6 (0.0, 94.8)	< 0.01
UDI-6	33.3 (8.3, 50.0)	16.7 (0.0, 41.7)	0.03
CRADI-8	20.3 (3.1, 40.6)	6.3 (0.0, 25.0)	< 0.01
POPDI-6	16.7 (0.0, 37.5)	12.5 (0.0, 25.0)	0.09
PFDI-20 new			
Total score	11.5 (7.0, 19.0)	9.0 (4.0, 16.0)	0.02

Table 1. Comparison of previous low back pain and falls.

DISCUSSION AND CONCLUSION

This is the first study to explore the magnitude and impact of pelvic floor disorders in people with LLA. Our preliminary results indicate that a high percentage of people with unilateral LLA experience some level of distress due to PFD symptoms, with concomitant reports of LBP and falls. Continued investigation is warranted to further identify the occurrence and effects of PFD symptoms on functioning and quality of life.

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5.505 Phantom Limb, Residual Limb, and Bodily Pains in Persons with Unilateral Lower Limb Amputation

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BACKGROUND

Pain is common for individuals with major lower-limb amputation and can include primary post-amputation pain such as phantom limb or localized limb pain, as well as secondary bodily pain felt in locations beyond the residual limb. However, pain surveys typically do not differentiate between these different pain subtypes or their underlying characteristics, leaving the relationships between non-specific generalized and individual pain subtypes unclear. Overall, this leads to a lack of clinically relevant data to diagnose and treat patients' pain.

AIM

We characterized the current and recalled pain experiences of 59 individuals with unilateral transfemoral or transtibial amputation, differentiating between pain in the phantom limb, residual limb, and other parts of the body.

METHOD

We developed a pain survey characterizing post-amputation pain location, intensity, fluctuation, and duration, focusing on current pain and pain averaged over the past month, for generalized pain, phantom limb pain, residual limb pain, and bodily pain. We identified the strongest predictors of overall pain by means of multiple linear regression analysis. Variability in patterns of participant responses were characterized by identifying principal components between phantom limb pain, residual limb pain, and bodily pain. We also characterized these pains during rest, while performing light activities, and during maximum effort.

RESULTS

59 (16 female) participants completed the survey, of whom 30 had transfemoral and 29 had transtibial unilateral amputation (13.3±15.0 years prior). 30 individuals reported phantom limb pain, 39 reported residual limb pain, and 36 reported bodily pain. Residual limb pain most strongly predicted current generalized pain ($p<0.001$), and both residual limb and bodily pain predicted recalled generalized pain ($p<0.05$). Up to 28% of variability in pain was unaccounted for by primary principal components between pain subtypes describing typical patterns of experienced pain. All pain subtypes except for phantom limb pain ($p=0.371$) were higher during light activity compared to while at rest ($p<0.001$).

DISCUSSION AND CONCLUSION

While the experiences of phantom limb, residual limb, and bodily pain were generally correlated with each other, relying on a single overall pain outcome was insufficient to accurately describe a patient's pain experience. Meaningful differences in pain experience were found in the unaccounted variability between pain subtypes which may carry clinical importance. We instead propose that phantom limb, residual limb, and bodily pain should be evaluated simultaneously to capture a complete and holistic snapshot of post-amputation pain.

ACKNOWLEDGEMENTS

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5.506 ASsessing outCOMes with microprocEssor kNee uTilization in a K2 population (ASCENT K2): Trial results for 107 individuals with above-knee amputation

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BACKGROUND

Microprocessor-controlled prosthetic knees (MPKs) have helped countless individuals with above-the-knee amputation (AKA) overcome functional limitations.^[1-5] Individuals classified as limited, community ambulators (i.e., Medicare K2) are often restricted from access to MPKs due to payer coverage policies. The purpose of this clinical trial was to evaluate the impact of MPKs in a limited, community ambulator population with emphasis on fall-related psychological and functional outcomes.

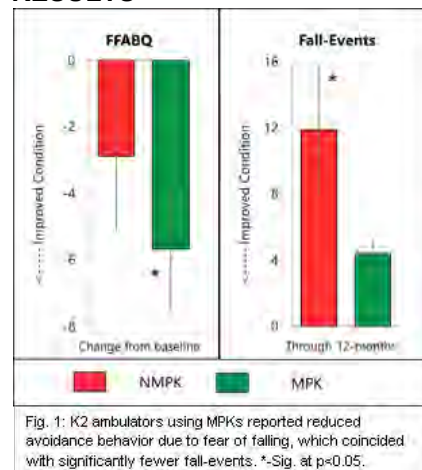
AIM

The purpose of this clinical trial was to evaluate the impact of MPKs in a limited, community ambulator population with emphasis on fall-related psychological and functional outcomes.

METHOD

Limited community ambulators with AKA with no prior history of MPK use were invited to participate in a two-arm randomized, controlled trial. Enrolled participants were randomized into either the intervention (i.e., MPK) or control (i.e., NMPK) arm using block randomization. Individuals randomized to MPK were all provided similar MPK (Kenevo, OttoBock). Primary and secondary outcomes related to falling, balance, mobility, and quality of life were evaluated after 12 months of use.

RESULTS



Individuals with AKA were enrolled ($n=107$; age: 73.7 ± 5.6 y; time since amputation: 41.5 ± 116.4 months; male: 76; amputation etiology-diabetes/vascular: 91, non-diabetes/vascular: 16; MPK: 54, NMPK: 53). Only participants in the MPK group experienced significant improvements relative to baseline in the primary outcome, FFABQ (MPK: -5.7 ± 1.9 , $p < 0.001$; NMPK: -2.87 ± 2.28 , $p = 0.104$; Fig. 1). Likewise, there were significantly fewer fall events reported by participants in the MPK group than in the NMPK group over the study period (Fig. 1, $p < 0.001$). Participants in the MPK group also demonstrated statistically significant improvements relative to baseline in multiple secondary outcomes (10mWT- MPK: 0.08 ± 0.03 m/s, $p = 0.001$, NMPK: 0.01 ± 0.03 m/s, $p = 0.327$; TUG- MPK: -10.1 ± 3.3 s, $p < 0.001$, NMPK: -0.5 ± 3.1 s, $p = 0.441$; CoF- MPK: -2.2 ± 1.3 , $p = 0.044$, NMPK: 0.0 ± 1.1 , $p = 0.500$). Significant declines in EQ-5D were observed in the NMPK but not the MPK group (EQ-5D- NMPK: -0.092 ± 0.044 , $p = 0.021$, MPK: 0.008 ± 0.041 , $p = 0.204$).

DISCUSSION AND CONCLUSION

Overall, MPK users reported a significant reduction in avoidance behaviors due to fear of falling in conjunction with a reduced number of fall events over a 12-month period. Individuals in NMPKs also reported reduced quality of life (QoL). In addition to improvement in patient-reported outcomes, individuals in MPKs also demonstrated superior performance on physical measures of balance and mobility (i.e., TUG and 10-meter walk test).

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DISCUSSION AND CONCLUSION

Previous work showed correlation between 6MWT and PA ^[1,2] contrary to results of the current study. This can be due to the rather homogeneously high level of mobility capacity of subjects in this study. Despite the high level of physical capacity, all but one subject would be considered sedentary according to the WHO guidelines. This work therefore suggests that mobility capacity is not sufficient to assess real life activity. In the future, it would be of interest to try to assess mental workload in parallel with mobility capacity.

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Free paper session | Orthotics: lower limb and footwear – Children and adolescents

5.511 Influence of Lower Limb Orthoses on Cortical Processing during Standing in Children with Cerebral Palsy

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BACKGROUND

Children with spastic Cerebral Palsy (CP) exhibit impaired balance as compared to typically developing children. Previous research has shown that the Ankle Foot Orthosis-Footwear Combination (AFO-FC) significantly improves static and dynamic balance over 3 months of wear [1]. Another study reported that assistance during upright mobility reduces cortical activity in adolescents with CP [2]. Perhaps orthotic management may decrease cortical brain activity and thus improve efficiency of standing.

AIM

This pilot work explores change in brain activity as a potential mechanistic factor for the improved balance observed with use of AFO-FC.

METHOD

124 channel electroencephalogram (EEG) was captured in barefoot and with AFO-FC [3] during sitting and standing at baseline and after 3 months of wear. Ten children with CP participated (7 males; age 9.9 yrs (5-13 yrs); 8 Diplegia, 2 Hemiplegia; Gross Motor Classification Functional Level = II). Paired t-tests ($\alpha \leq 0.10$) were used to examine within subject differences in brain activity between 1) barefoot sitting vs barefoot standing; 2) standing with AFO-FC vs standing barefoot; 3) standing with AFO-FC at baseline vs 3 month follow-up. EEG Mu bands tested for 8 to 10 Hz (Alpha Low) and 10 to 12 Hz (Alpha High).

RESULTS

Children with CP demonstrated (1) more brain activity when standing barefoot compared to sitting barefoot ($p < 0.1$) at baseline; (2) more brain activity when standing barefoot compared to with AFO-FC ($p < 0.1$, Table 1) at baseline (3) no change in brain activity in standing with AFO-FC after 3 months of wear (compared to standing with AFO-FC at baseline).

Table 1: EEG power (t values) comparing standing in AFO-FC vs barefoot for Low and High Alpha ($p < .10$) across sensorimotor regions.

AFO-FC Standing vs Barefoot Standing				t values	N=7
Alpha Low	Left	Middle	Right		
Frontal	1.06	1.89	1.55		
Central	0.59	1.44	1.88		
Posterior	0.89	2.24	2.46		

AFO-FC Standing vs Barefoot Standing				t values	N=7
Alpha High	Left	Middle	Right		
Frontal	1.13	1.78	1.92		
Central	1.75	1.80	1.75		
Posterior	0.22	1.96	1.49		



DISCUSSION AND CONCLUSION

Results suggest feasibility of EEG capture in sitting and standing in this population. Alpha power values for the CP group are similar in mean and range for the same task (sitting eyes open) as 239 children from 3 other populations (Autism Spectrum Disorder [ASD], neurotypical, siblings of children with ASD). Children with CP show increased brain activity when standing than sitting, consistent with the idea that standing increases mental load. The orthosis allows the child to stand with reduced mental load. One interpretation is that the neural response is more efficient/less demanding when standing with the orthosis. We propose that this modulation of neural activity may be associated with previously reported better control of standing balance with orthoses ^[1].

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5.512 Do authors and editors comply with best practice reporting guidelines for AFO interventions in studies involving children with cerebral palsy?

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BACKGROUND

Ankle-foot orthoses (AFOs) are a widely used intervention for cerebral palsy (CP), with designs and dosages tailored to support individual goals^{1,2}. Critical biomechanical parameters and alignments, including ankle angle (AA-AFO), shank-to-vertical angle of the AFO footwear combination (SVA-AFOFC), and the tuning or optimising process are essential for maximizing the effectiveness of these interventions^{3,4,5}. Best practice reporting guidelines and international consensus conferences have emphasised the need for detailed documentation of orthotic interventions^{4,5}.

AIM

To evaluate the extent to which authors and editors adhere to published best practice reporting guidelines⁴, specifically the reporting of the sagittal AA-AFO, SVA AFO-FC, and Tuning or optimisation.

METHOD

An electronic search was conducted of the following nine databases: Medline, CINAHL, Physiotherapy Evidence Database (PEDro), Embase, PubMed, Cochrane Database of Systematic Reviews (CDSR), Allied and Complementary Medicine Database (AMED) and Scopus. The searches used both MeSH terms and key words related to 'ankle-foot orthosis' and 'cerebral palsy'. Relevant truncation and wildcard symbols were employed to retrieve all possible suffix variations of these root words. No language restrictions were applied. Searches were adapted for each database and undertaken between 3rd-8th July 2024, with dates restricted to post-2010. A customised checklist was developed for data extraction.

RESULTS

The search yielded 558 records potentially relevant to AFOs and a diagnosis of CP. These records were screened according to predefined inclusion and exclusion criteria, to identify full journal articles that used AFOs designed to be rigid. The final selection comprised 64 articles by 49 authors, published across 33 journals, 1 involving adults. Only 9 of the 64 articles reported all three parameters, the AA-AFO, the SVA AFO-FC, and Tuning or optimising the AFO intervention used within the study. Thirty six articles did not provide any information regarding the 3 parameters. Five articles gave information about 2 parameters: SVA AFO-FC and Tuning or optimising. Fourteen articles provided information about 1 parameter: AA-AFO 7; SVA AFOFC 2; Tuning or optimising 5, of which 2 referred to tuning AFO stiffness rather than the SVA AFOFC.

DISCUSSION AND CONCLUSION

Despite best practice reporting guidelines and international consensus advocating for comprehensive documentation of orthotic interventions, reporting of the three key parameters was found to be inconsistent and inadequate. This lack of uniformity highlights the need for authors and editors to ensure detailed and precise reporting of AFO interventions. Improving the rigour and quality has the potential to advance the field towards more effective and evidence-based treatments for individuals with CP.

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5.513 Developing Evidence-Based Clinical Guidelines for the Orthotic Management of Children and Youth with Duchenne's Muscular Dystrophy [In Progress]

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BACKGROUND

Duchenne Muscular Dystrophy (DMD) is a progressive neuromuscular disorder affecting 1 in 3,500 male children, leading to muscle degeneration and functional impairments. Orthotic devices are commonly used to manage various aspects of DMD, including contractures, muscle weakness, and postural support. However, current orthotic practices are often inconsistent and lack evidence-based guidance. International guidelines do not provide specific recommendations, underscoring the need for comprehensive, evidence-based orthotic guidelines.

AIM

This study aims to establish evidence-based clinical guidelines for the use of orthotic devices in the treatment and management of children and youth with Duchenne Muscular Dystrophy (DMD) in Norway.

METHOD

Data were gathered from three main sources: scientific literature, patient preferences, and clinical expertise. A systematic review was conducted, focusing on six orthotic themes and 25 PICO questions. The quality of evidence was assessed using the GRADE approach. Patient preferences were collected via an anonymous questionnaire sent to children and families with DMD, exploring their experiences with orthotic use. Clinical expertise was obtained through a multidisciplinary panel of clinicians experienced in treating DMD. Data collection and analysis are complete, and the findings are currently being synthesized for publication as evidence-based guidelines for orthotic management in DMD.

RESULTS

The data from scientific literature, patient preferences, and clinical expertise revealed a lack of consensus in current orthotic practices for DMD. Literature review showed limited, low-quality research, with gaps in addressing the specific needs of DMD patients. Patient responses indicated varied experiences with orthotic devices, particularly night-time ankle-foot orthoses (AFOs), which were most commonly used to prevent contractures. Many patients reported issues with comfort, adherence, and sleep quality. Clinical expertise uncovered a range of approaches across regions, emphasizing the need for standardized guidelines. Standing devices were also frequently used for postural support, though recommendations for both AFOs and standing devices were inconsistent. The gathered evidence will guide the development of evidence-based, comprehensive orthotic guidelines for the management of DMD.

DISCUSSION AND CONCLUSION

The findings highlight significant variability in current orthotic practices for DMD and point to considerable gaps in the evidence base. While night-time AFOs and standing devices are commonly prescribed, inconsistent recommendations and patient-reported issues with comfort and adherence are evident. By developing comprehensive, evidence-based guidelines, this study aims to address these inconsistencies and improve clinical practices. The guidelines will standardize care and support better outcomes for children and youth with DMD in Norway and beyond.

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5.514 Alignment of Clinical Indications and Research Practice in AFO Studies for Children with Cerebral Palsy: A Scoping Review

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BACKGROUND

Ankle-foot orthoses (AFOs) are commonly prescribed to improve gait in children with cerebral palsy (CP). Despite significant research in this area, the recognized absence of participant characteristics and conflicting results limits translation to clinical practice. This deficit in research may, in part, be caused by a lack of consideration of heterogeneity of treatment effect, where individual characteristics are considered regarding how differences will illicit varying responses to treatments.

AIM

- Identify clinical indications and contraindications (CICs) for AFOs through a content analysis.
- To map the use of CICs in studies on AFOs in children with CP.

METHOD

Content analysis: Secondary sources related to AFOs and/or AFOs and CP management were identified from recommended texts for board certification exams in the United States and consensus documents. Themes of CICs for each AFO design generated a custom form for data extraction for the scoping review. Scoping review: Five online databases were searched for studies investigating how AFOs influence walking parameters in children with CP. Data related to participant characteristics, AFO design type, subgroup analyses, and study outcomes were extracted. The custom form from the content analysis helped map the use of CICs in each study.

RESULTS

Four themes of CICs were identified from eight secondary sources in the content analysis: 1) gait patterns, 2) muscle strength, length, and tone, 3) joint stability and/or foot posture, and 4) other. Several clinical indications overlapped between solid and hinged AFOs; however, there were distinct contraindications for each device type. Fifty-eight studies met inclusion criteria for the review. Treatment assignment methods were not consistently aligned with CICs. There were 25 instances where no indications or contraindications could be found for a given AFO design. In 12 instances, outcomes were assessed when participants may have been contraindicated for the AFO design utilized. Preliminary synthesis of outcomes across the studies was limited; however, assessment of subgroup analyses revealed provided better insights as to which participants benefited from different types of AFO intervention.

DISCUSSION AND CONCLUSION

Significant overlap of CICs in secondary sources related to AFO intervention and CP may explain the varied application of CICs in studies on this topic. Many studies still provide insufficient participant characteristics to assess whether the correct application of CICs influences study outcomes; however, subgroup analyses revealed important insights. There is a need for consensus on CICs so that future research can better inform clinical practice.



5.515 A Step in the Right Deception: Validation of a Sham Insole for Children

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BACKGROUND

There is a paucity of high-quality research investigating children's insoles, despite their routine prescription. One problem with conducting controlled clinical trials for insoles is poor standardisation of the sham.

AIM

This study aims to validate a sham insole for children.

METHOD

This study received ethical approval. Healthcare professionals, parents and children (7-17 years) were recruited. Three sham insoles were designed informed by previous trials, arch-height normative values, input from orthotic clinicians and patient/public involvement.

To test credibility, participants voted on whether insoles (three sham, two treatment) were sham or treatment, by sight and touch. The insoles used are demonstrated in Figure 1. To test treatment effect in children, walking data were collected using F-Scan64 pressure sensors for each sham and no insole. Collection order was randomised. An exact binomial test with exact Clopper-Pearson 95% CI was used to analyse credibility data. Walking data were compared using repeated measures ANOVA test; post-hoc pairwise analyses used a Bonferroni correction. The statistician was blinded to the insole.

RESULTS

Credibility was tested with 64 participants. Health professionals and parents cannot recognise shams by sight ($p=0.156$, 95% CI 28%-54%; $p=1.000$, 95% CI 38%-64%), but can by touch ($p<0.001$, 95% CI 84%-98%; $p<0.001$, 95% CI 71%-91%). Children believe shams are treatment insoles by sight ($p<0.001$, 95% CI 59%-82%) and cannot recognise shams by touch ($p=0.450$, 95% CI 43%-68%).

Walking data were obtained on 40 children's feet. Sham One significantly decreased forefoot ($p=0.032$) and rearfoot pressure ($p<0.001$). Sham Three significantly decreased forefoot ($p=0.026$) and midfoot pressure ($p=0.049$). Sham Two had no significant effect on pressures. No sham had a significant effect on peak pressure, stance time or centre of pressure.

DISCUSSION AND CONCLUSION

To maintain blinding, health professionals and parents can see, but should not touch, the insoles being tested. Children can be considered blinded to sham insoles. Some sham insoles have an unintended treatment effect by modulating plantar pressure. The most appropriate sham construction for children is $\frac{3}{4}$ -length, 4mm thickness, 65-shore density.

This study validated a sham insole for children and supplied recommendations for blinding. Implementation will improve clinical trials and the evidence-base supporting children's insoles.

ACKNOWLEDGEMENTS

We thank the clinicians, patients and the public who contributed to the design of the sham insoles.



5.516 Who Benefits from Dynamic Contracture Bracing? A Single-Centre Retrospective Case Series

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BACKGROUND

Since the COVID19 pandemic there has been an increasing reliance on conservative treatment to reduce joint contractures due to long surgical waiting lists. A common orthotic treatment to address joint contractures is a Controlled Dynamic Stretch (CDS)[®] brace supplied by Brace Orthopaedic.

Despite the potential benefits of CDS[®] braces, the evidence base supporting their efficacy remains notably underdeveloped. There is particularly limited guidance to support the use in children with neurological conditions; existing research primarily focuses on their use in adult populations with musculoskeletal conditions or static bracing.

AIM

The primary aim of this study is to identify if CDS bracing is effective, and identify factors which can predict a positive outcome of CDS bracing.

METHOD

This study was single centre, based at Oxford University Hospitals NHS Foundation Trust. This study was retrospective, utilising the routinely collected data by the clinicians.

The orthotics database was searched for patients who were supplied with a CDS brace over four years. The clinical notes were reviewed and relevant data gathered using a data collection form developed a priori. A positive outcome of bracing was considered 10 degrees improvement.

This project was reviewed and approved by Oxford University Hospitals NHS Foundation Trust (Audit Number:9557).

RESULTS

Over four years, 86 patients were provided with CDS braces to treat 126 joints. The mean age for children was 13.0 years (range 5.1-17.9 years), the mean age for adults was 47.3 years (range 18.0-85.8 years). Most braces were prescribed to treat knee contractures (knee:78.6%, elbow:17.5%, ankle:4.0%) and patients with neurological conditions (neurological:74.6%, musculoskeletal:25.4%).

There was no statistically significant difference between those with positive outcomes of bracing and those with no positive outcome for any variable. Tested variables included age, gender, diagnosis, joint treated, baseline range of motion, and brace tension.

A chi-square test of independence showed that there was no significant association between whether the patient is asked to wear the brace for an hour a day, or seven hours a day and successful bracing outcome ($\chi^2(1, N=55)=0.836, p=0.360$).

DISCUSSION AND CONCLUSION

The results show that CDS bracing are being prescribed routinely to children with neurological conditions, despite the limited evidence base. It also shows that there is no difference in outcomes of participants wearing the bracing for one hour vs up to seven hours a day. Unfortunately, it was not possible to use the data to predict which patients will have a good bracing outcome.



Free paper session | Prosthetics: lower limb transfemoral – Sockets

5.521 Vented Suspension Interface for Individuals with Lower Limb Transfemoral Amputation Improves User Perceived Residual Limb Skin Health

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BACKGROUND

Excessive perspiration is a highly prevalent side-effect from the use of a liner and socket interfaces and one of the primary complaints from lower limb prosthesis users [1]. Perspiration has been associated with residual limb skin pathologies such as maceration, dermatitis, fungal infection and ulceration [2]. Poor residual limb health has been associated with reduced performance, less time spent in the prosthesis [3], and to affect suspension [4]. Good residual limb skin health is critical for successful prosthesis use.

AIM

The primary aim of the investigation was to evaluate if using a vented lower limb prosthetic suction suspension interface would improve users' perceived residual limb skin health.

METHOD

The investigation design was a prospective, multicenter, open-label, block randomized controlled, cross-over (ABA/BAB). The subjects were randomized into two groups with two treatment conditions each. Group 1 started using the vented suspension system (VS), and Group 2 started using the non-vented suspension system (nVS). Then, they crossed over to the other system two times (ABA/BAB), which required four visits to the subject's clinic. Each treatment condition lasted 4-6 weeks. During each visit, the subjects completed questionnaires on their perceived residual limb health and other outcomes, and their treatment condition was crossed.

RESULTS

Fifty-six individuals with transfemoral amputation, 13 females and 43 males, were enrolled from seven prosthetic clinics in six states in the USA. Forty-nine were included in the data analysis. The average age at enrolment was 56.3±13 years (mean ± SD). Reasons for amputation were trauma (46.4%), vascular diseases (17.9%), cancer (3.6%) and other reasons (32.1%). The primary endpoint was evaluated using the Prosthesis Evaluation Questionnaire-Residual Limb Health (PEQ-RLH) scale. PEQ-RLH consists of six questions on sweat, smell, swollen limb, rashes, ingrown hairs, and sores or blisters and a mean score of the six questions was calculated. The results showed a significant improvement ($p<0.025$) in stump skin health for the VS. Other patient-reported outcomes, such as activity, prosthesis use, and quality of life showed similar results between the two systems.

DISCUSSION AND CONCLUSION

The investigation confirmed that the VS significantly improves perceived residual limb skin health for individuals with transfemoral amputation, as evidenced by higher PEQ-RLH scores. Previous study [5] confirmed the performance of the VS in reducing sweat build-up in the skin liner interface compared to nVS. The results of this study show the clinical user benefits of the interface, while indicating that other performance and safety parameters were not negatively affected.

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COI

The work was conducted by Össur R&D.



5.522 Review of Ossur Direct TF Sockets fitted in past 3 years, outcomes, patient and staff feedback

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BACKGROUND

Direct sockets were introduced to our regional prosthetic limb fitting service in December 2021 for established transfemoral amputees who predominantly had comfort issues with the more traditional socket designs.

AIM

To assess if the use of Direct Sockets has been a positive experience for patients in meeting the aims of increased comfort and satisfaction with the socket in the short and long term.

To assess lessons learnt from the review of the data and outcome measures used.

METHOD

Notes of all patients that had a Direct Socket manufactured in the last 3 years were reviewed to assess reasons for socket choice, patients satisfaction in the short and longer term (using the Comprehensive Lower-limb Amputee Socket Survey (CLASS) tool) and data such as how long these sockets had been used by the patients. Positive and negative experiences of patients and staff concerning the use of these sockets were examined by interviews with both groups.

RESULTS

25 transfemoral patients (one bilateral) had a total of 42 sockets made in the last 3 years, the majority with a main aim of improving comfort in the groin or ischial seating areas. 9 sockets made had immediate issues concerning the manufacturing process and these sockets could not be delivered, but lessons were learnt. 5 patients stopped using their sockets after an average of 209 days (range 8-534 days) and asked to return to more traditional type of socket. The bilateral patient later stopped limb use for other reasons. There was an average percentage change for each patients CLASS score of 62% (range 3-154) on the day of delivery. Patients have had to have further Direct Sockets made as their stump changes but 19 have wanted to continue with the same type of socket.

The patients continuing to use the Direct Sockets report that they are very satisfied with it and their average CLASS scores remain high at 90%. They particularly comment on the improved comfort in walking and sitting, improved range of movement of the stump and also the secure suspension. None of these patients would want to return to their previous socket type. Staff were overall positive in their feedback despite initial challenges concerning manufacturing process.

DISCUSSION AND CONCLUSION

Use of the Direct sockets has proved to be popular with patients and staff. Lessons have been learnt concerning the assessment and choice of appropriate patients as well as skills developed in manufacturing

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5.523 Situational Sockets – user specific preferences on trans-femoral socket brim designs for different situations of gait

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BACKGROUND

The body interface of the socket is crucial for the usability of the whole prosthetic system. It needs to provide stability to bear body weight and give control over the prosthesis, while users above all need maximized comfort. Socket individual geometry and material characteristics are a compromise between all situations of prosthetic use, as this static device cannot adapt to changed requirements. This compromise often contradicts simultaneous optimal stability and comfort.

AIM

This series of case studies evaluates the individual user preferences on material stiffness for specific sectors of trans femoral socket brims in dependency of different situations of gait.

METHOD

Nine subjects were fitted with adjustable ischial containment (IC) prototype sockets and went through the same test paradigm representing different situations (e.g. standing, walking, ascending stairs,...). The brim of those sockets was divided into different sectors which could deflect from a neutral position in a 'flexible' state and could be hold in place by attachable outer covers in a 'rigid state'. During the evaluation for all test situations each sector state was reversibly changed from 'rigid' to 'flexible'. The subjects were asked to assess every setup compared to their everyday socket. The most preferred setup for each situation of gait was taken as the individual optimum.

RESULTS

The evaluated tests clearly show that the user-selected optimal setup for an adjustable socket brim is different for varied situations of gait. The specific configurations are individually different across all included test subjects. Although the selected setups differ, common patterns were found in all cases. The subjects preferred a different socket brim characteristic for level ground walking than for ascending and descending stairs and ramps. Moreover, a specific setup was selected for sitting and standing. This setup was different to situations in which the subject ambulated. All subjects used the feature to reversibly change the material stiffness of specific brim sections. None of them selected a unique setup for all test situations.

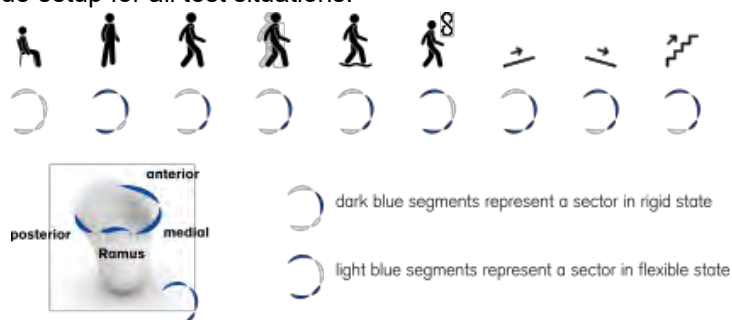


Figure 1. representative sequence of socket brim setups

DISCUSSION AND CONCLUSION

The presented results indicate that the optimal characteristics of a trans femoral socket brim are related to specific situations of gait. In conclusion, a static socket brim design does not meet the patient need for a perfect interface throughout the whole usage. An active socket that seamlessly adapts to different situations of gait would allow for an optimized balance between stability, control and comfort over all situations in everyday use.

COI

All tests were fully funded by Ottobock SE



5.524 Longitudinal Patient-Reported Outcomes when Transitioning Transfemoral Socket Designs: Initial Cases from a Clinical Trial

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BACKGROUND

Ischial containment (IC) sockets used by persons with transfemoral amputation (TFA) fit the thigh and pelvis intimately, often limiting hip motion and causing discomfort. Socket comfort is important, yet 44% of persons with TFA report sitting discomfort ^[1]. A subischial (SI) socket was developed with the intent of improving comfort and hip motion in people with TFA ^[2]. We propose that an SI socket that improves comfort in people with TFA and lower mobility can also improve residual limb health, mobility and balance, and satisfaction with prosthesis.

AIM

To evaluate changes in comfort, residual limb health, mobility, balance, and satisfaction with prosthesis when transitioning from an IC to SI socket in persons with TFA and low mobility.

METHOD

With IRB approval, individuals with unilateral TFA and low mobility (i.e. K2) who wore an IC socket were recruited from 2 sites to participate in a clinical trial with a 16-week baseline phase and a 24-week intervention phase. Between phases, participants were cast and fit with a SI socket (NU-FlexSIS ^[2]) by their prosthetist. Participants remotely completed assessment sessions every 4 weeks (11 total sessions). Socket Comfort Score (SCS) ^[3] and Prosthesis Evaluation Questionnaire-Residual Limb Health (PEQ-RL) ^[4] were evaluated at all timepoints; Prosthetic Limb Users Survey-Mobility (PLUS-M) ^[5] and Activities-Specific Balance Confidence Scale (ABC) ^[6] were evaluated at all timepoints except session 5; and Orthotic and Prosthetic Users' Survey Satisfaction with Device (OPUS-SWD) ^[7] was evaluated at sessions 1, 4, 6, 8 and 11.

RESULTS

Data from the first 11 participants to complete participation were assessed (7 male; age: 66.4±13.6 years; height: 169.8±9.7 cm; weight: 175.5±37.7 kg; time since amputation: 6.6±10.9 years; cause of amputation: 7 vascular, 2 infection, 1 trauma, 1 congenital). Figure 1 illustrates longitudinal data for each participant for each measure. Comfort, residual limb health and satisfaction with device generally demonstrated an improving trajectory after transitioning to the SI socket, while mobility and balance remained unchanged. Upon study completion, 9 participants indicated that they planned to continue wearing the SI socket.

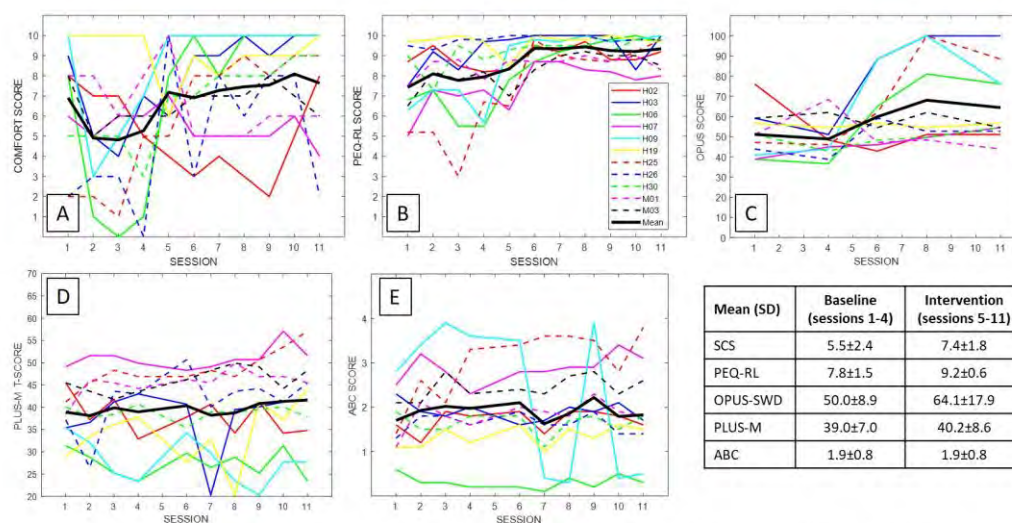


Figure 1 Longitudinal patient-reported outcomes for 11 participants for baseline (sessions 1-4) and intervention (sessions 5-11) phases: A) SCS, B) PEQ-RL, C) OPUS-SWD, D) PLUS-M, E) ABC.

DISCUSSION AND CONCLUSION

This ongoing trial is the first to longitudinally assess outcomes during transition in socket design. Participants varied in responses to these measures. While some measures demonstrate an improving trajectory with change to a SI socket, there was variation in which measures and the degree of change. Additional data and future assessment of comorbidities (e.g., back pain, depression, etc.) may provide insight as to differences in responses.

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5.525 Long-term comfort in transfemoral sockets: ischial containment vs subischial, after one year of daily use

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BACKGROUND

Prosthetic socket is key element for comfort. Various designs are available for above-knee amputees (AKA). Comfort is mostly studied on short term, from instantaneous feedback [1] to after 7-week acclimation [2]. Subischial sockets is one of the most recent designs for AKA [3]. It has been studied for about 10 years, but no literature reports long term feedback.

AIM

The aim of this study is to provide a first answer to the research question: How does the comfort of AKA evolve after more than a year of daily use of a subischial socket? How does it compare to long-term comfort in ischial containment?

METHOD

A previous clinical investigation, randomised cross-over trial, comparing comfort of AKA using ischial containment (IC) vs subischial (ISUB) sockets, was run in 2021-2022 [4]. Subjects participating in this previous study were contacted by the investigator. After giving their informed consent, they were asked which socket type they wore. In a single visit consisting of a phone call, they answered the same questionnaires as in the previous study (socket comfort scores (SCS) [5] in various situations, PLUS-M [6]), and SF-36 quality of life questionnaire [7].

The difference between SCS (current long-term ISUB – previous study long-term IC), was processed: after checking data distribution, Student or Wilcoxon tests are used. Significance is set for a $p < 0.05$. Long-term ISUB SCS was also compared to short-term ISUB SCS. Other variables are descriptive.

RESULTS

Among the 23 potential subjects having finished the previous clinical investigation, 16 were successfully reached out. 4 could not be included or did not wish to participate. 12 subjects were included: 10 males and 2 females, aged 62.67 ± 13.92 y.o, mass: 77.68 ± 15.15 kg, height: 1.76 ± 0.06 m, wearing their prosthesis 11.6 ± 3.04 h/day for 22.08 ± 9.51 months.

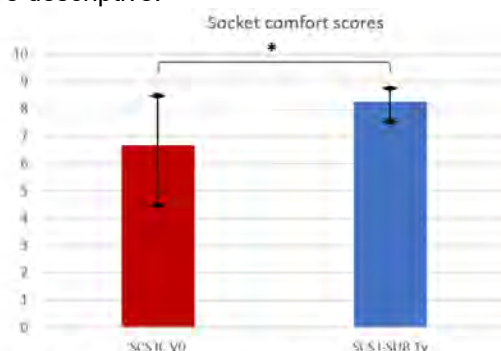


Figure 1: Long-term Socket Comfort Scores, with ischial containment (IC) and subischial (ISUB) sockets

After more than a year of use, socket comfort score with ISUB was significantly improved compared to long-term IC SCS: $+1.58 \pm 1.78$ ($p=0.005$). Compared to SCS with ISUB after 2 weeks of use, long-term ISUB SCS not significantly decreased: -0.50 ± 1.00 ($p=0.1$). No significant difference was shown on mobility. Quality of life scores, both mental and physical, are higher than the population.

DISCUSSION AND CONCLUSION

Comfort provided by subischial socket is still significantly improved on long-term, after more than a year of use, compared to ischial containment socket. Despite a slight decrease in time, comfort scores with ISUB are all above 7.5/10. Mobility is quite standard, and quality of life above the standard.

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5.526 Analysis of bone mechanostimulation during gait using a subischial socket provides potential reasons for bone mineral density recovery

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BACKGROUND

Osteopenia and osteoporosis immediately following transfemoral amputation have been deemed inevitable and irreparable [1, 2]. Interestingly, studies that demonstrate bone demineralization in the amputated femur seldom analyse the effect of the prosthetic socket. To analyse socket effects on bone strain and hip joint contact force, simulation-based approaches are useful to estimate these values given the considerable challenge of direct measurement.

AIM

The aim of this study is to assess the contribution the prosthetic socket makes in the demineralization pattern in individuals with unilateral transfemoral amputation.

METHOD

We constructed 558 finite element (FE) models to estimate the mechanical stimulus a residual femur is subjected to during walking while wearing an ischial containment socket (ICS) and a subischial socket (SIS). Models were assembled using retrospective data from two sources, 1) musculoskeletal geometries from computed tomography scans of 10 able-bodied subjects, and 2) motion analysis data from a clinical trial exploring the biomechanics of 7 users wearing both an ICS and SIS (NU-FlexSIV) [3]. Subjects were anthropometrically matched and tested at gait instances of early, mid and terminal stance. Model validation was performed through statistical comparison of hip force estimated using traditional inverse dynamics and those obtained through FE calculations.

RESULTS

Validation results showed no significant difference between hip force vector magnitudes computed from the FE models to estimates from inverse dynamics (early stance $p=0.94$; midstance $p=0.72$; and terminal stance $p=0.55$). Under the influence of an ICS, with ischium loading between 65 to 95% of body weight, models registered an attenuation of mechanostimulus load on the order of 7.9 ± 3.3 times compared to the SIS (Figure 1).

DISCUSSION AND CONCLUSION

The ICS is designed to shield the residual femur from potentially harmful distal forces through redirection of weightbearing forces to the ischium. Our study suggests this redirection of forces limits femoral head loading within the acetabulum and precludes bone resorption. Using a SIS with proximal trimlines that end below the ischium, forces are required to pass through the femoral head and mechanical stimulus of the femoral head returns, which could help prevent bone demineralization. Future studies should consider in-vivo evaluation of SIS use on femoral bone health.

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ACKNOWLEDGEMENTS

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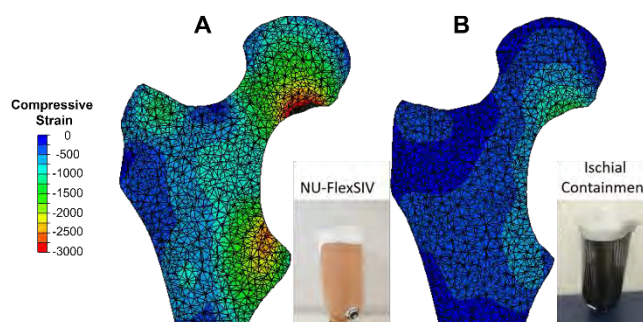


Figure 1. Femoral head estimated compressive strain during early stance while wearing A) the NU-FlexSIV and B) an IC



5.527 Elevated Vacuum Integrated System (ELVIS): An Electro-Mechanical Pump for Vacuum-Assisted Suspension of Prosthetic Sockets

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BACKGROUND

Vacuum-assisted suspension (VAS) has been a proven method for securing a prosthetic socket to the residual limb for persons with lower limb loss [1, 2], providing benefits for walking and supporting residual limb health [1]. Current VAS systems utilize either mechanical or electrical pumps to extract air from the socket-liner interface. Independently, both systems have limitations: mechanical systems require prosthesis loading and electrical systems require batteries to maintain proper suspension.

AIM

We assessed in-vivo functionality of a hybrid (electro-mechanical) vacuum pump for VAS, the Elevated Vacuum Integrated System (ELVIS) [3], which maintains proper suspension while offsetting disadvantages of each system independently.

METHOD

Twelve participants (4f/8m, 54.4±17.7yrs, 90.8±14.2kg, 7 transtibial/ 5 transfemoral amputation) completed the IRB-approved protocol. A prosthetist installed ELVIS within participants' customary prosthesis (Figure 1, left). After 20 minutes accommodation, socket pressure was stabilized to room pressure. Then, for each of five trials, ELVIS was activated with the participant standing to achieve a socket pressure between -20 and -21 in-Hg, at which time participants walked on a treadmill for 5 mins at their self-selected speed while digitally recording pressure. Time to initial minimum (i.e., max sub-atmospheric) pressure when standing and maximum/minimum pressure levels while walking were calculated across the five trials.

RESULTS

As designed, ELVIS generated vacuum suspension through a hinged mechanical system integrated with a motorized electrical system that includes a microprocessor and pressure sensor to ensure that vacuum level is maintained between preset thresholds of -15 and -20 in-Hg. ELVIS was successful in establishing and maintaining sub-atmospheric socket pressure for participants with transtibial or transfemoral amputation during walking. Representative pressure data for 5 trials of one participant are presented in Figure 1 (right). The median time to reach initial vacuum was 40.3s (range: 15.5 to 248.5s). The median maximum and minimum socket pressures during walking were -19.8 (range: -18.1 to 23.8) and -22.0 (range: -19.6 to -24.7) in-Hg, respectively.

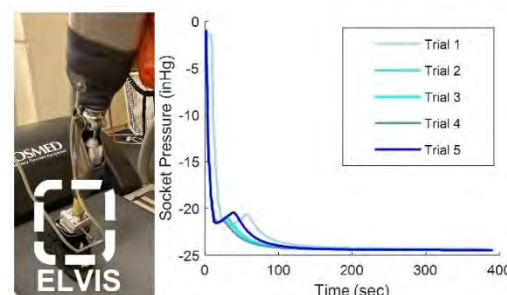


Figure 1 - Left: ELVIS installed in a transfemoral prosthesis. Right: Socket pressure during 5 walking trials.

DISCUSSION AND CONCLUSION

ELVIS demonstrated its ability to pull initial vacuum at a rate comparable to commercial electric pumps [4]. However, the ELVIS hybrid approach allows additional vacuum to be pulled and sustained during walking through engagement of the mechanical system without re-engagement of the electrical pump. ELVIS applies to the full range of prosthesis users irrespective of their activity level and allows them to continuously enjoy the health benefits associated with VAS.

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Free paper session | Gait and balance – Comparative

5.531 Intra- and Inter-Session Variability in Biomechanical Gait Parameters of TFA – Results of a Multicenter Study

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BACKGROUND

A certain variability in joint kinematics and kinetics during walking is natural [1]. In addition, there is a variability caused by the measurements themselves. How reliable different gait measurements, marker protocols and models work was frequently investigated for able-bodied subject e.g. [2,3]. However, such studies are rare for persons with a transfemoral amputation (TFA) [4].

AIM

To identify the variability in certain spatial-temporal and biomechanical parameters of TFA induced by different sessions and study centers.

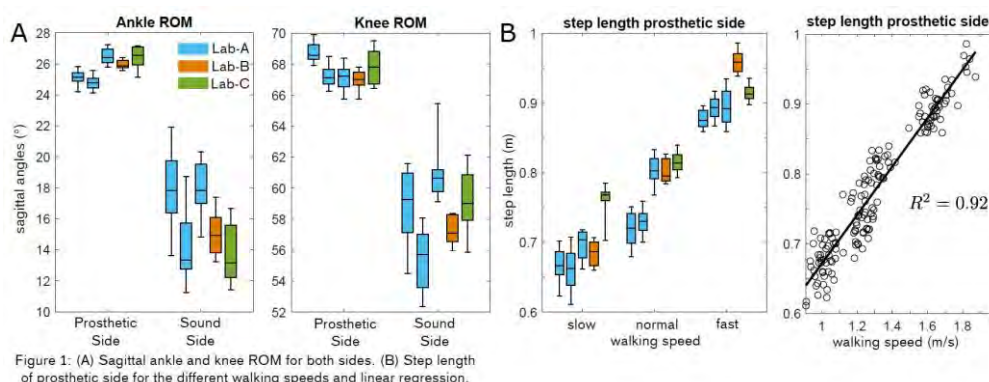
METHOD

As part of a multicenter study one TFA participated in total five times in a gait analysis, three sessions in Lab-A and one session each in Lab-B and Lab-C. Each laboratory was equipped with force plates and a 3D motion capture system. Level ground walking with three different self-selected speeds (normal, slow, fast) was measured and a 3D motion analysis performed afterwards.

For each session, the range of motion (ROM) of the sagittal leg angles as well as walking speed, step length, stance phase duration and vertical ground reaction forces (vGRF) were calculated. The variability of these parameters and the influence of the actual walking speed were analyzed.

RESULTS

Intra- and inter-session variability depends on the parameters and condition. E.g., during normal walking, the prosthetic side sagittal ankle and knee angles ranged from $25.1 \pm 0.4^\circ$ to $26.3 \pm 0.7^\circ$ and $67.2 \pm 0.8^\circ$ to $68.8 \pm 0.7^\circ$, respectively, in Lab-A, showing low intra-session variability. Sound side ankle and knee angles varied from $14.1 \pm 2.1^\circ$ to $17.9 \pm 1.6^\circ$ and $55.4 \pm 1.9^\circ$ to $61.3 \pm 1.9^\circ$ in Lab-A. Mean values from Lab-B and Lab-C were in the mean value range of Lab-A, figure 1A. The smallest standard deviations were found for the prosthetic ankle and knee ROM (below 1°). Values for the sound side and the residual hip were generally higher (0.8° to 2.4°). Another finding is that strong correlations ($R^2 > 0.9$) exist between walking speed and step length, prosthetic ankle ROM, and sound side vGRF, figure 1B.





DISCUSSION AND CONCLUSION

The difference between mean parameter values of different sessions can be interpreted as a measure of the inter-session variability. These differences were often larger than the mean standard deviations of the single sessions. Therefore, the between-session differences in some parameters reached statistical significance (post hoc tests), even though the conditions were similar. For some parameters, the variance can be reduced by considering walking speed (covariate).

These findings should be considered when interpreting gait data of individual subjects or small groups e.g., when comparing different prostheses.

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5.532 Does Transtibial Socket Shape Technique Influence Walking Performance?

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BACKGROUND

A “comfortable”, well-fitting prosthetic socket can influence an amputee's functioning. Traditional methods of hand casting and plaster modification to shape a socket are highly personalized and reliant on the clinician's skill and experience, as well as the user's preferences¹. Digital technology has been developed to address these challenges. It shows relatively high technical consistency² and improves patient-reported quality of life outcomes³, thus gaining favor among clinicians and users. Despite this potential, its effect on walking performance has yet to be explored.

AIM

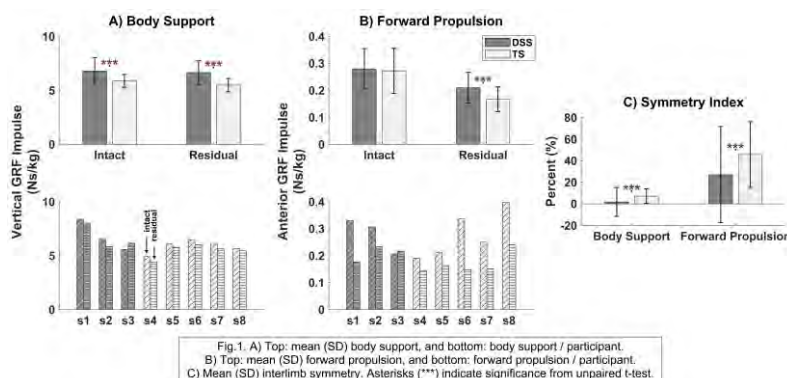
To investigate walking performance relative to interlimb symmetry in body support and forward propulsion between prostheses whose sockets were shaped via digital technology vs. traditional techniques.

METHOD

Eight participants with unilateral transtibial amputation were randomized into a digitally scanned socket (DSS) group or a traditional socket (TS) group (n = 3 vs. n = 5) in this ongoing study. The digital technology included an iPad-mounted Occipital structure scanner and Össur Design Studio software. Participants were given two weeks of acclimation at home and then walked with their prescribed passive-elastic feet on an instrumented treadmill at a self-selected speed. Ground reaction force (GRF) data from multiple strides (20 seconds x 3 walking trials) were collected at 1,200 Hz. Vertical and anterior GRF impulses were calculated (mass-normalized) as measures of body support and forward propulsion, respectively, for each limb. To quantify interlimb symmetry, a symmetry index (SI) was calculated as: $L_{\text{intact}} - L_{\text{residual}} / 0.5 * (L_{\text{intact}} + L_{\text{residual}})$, where zero indicates a symmetrical gait and positive values indicate intact limb dominance.

RESULTS

The DSS group demonstrated higher body support in both limbs and higher forward propulsion in the residual limb (Fig.1A & 1B) compared to the TS group. These changes resulted in smaller SI in both body support and forward propulsion for the DSS group compared to the TS group (Fig.1C).



DISCUSSION AND CONCLUSION

The interim results suggest that participants with DSS utilized their residual limb more for body support and propulsion. The increased interlimb symmetry indicates improved walking performance with reduced over-reliance on their intact limb. On average, participants reported better comfort with TS. Therefore, other contributing factors beyond perceived comfort (e.g., consistent fit and optimized pressure distribution) may play a role in gait symmetry relative to body support and forward propulsion, and the current findings will be confirmed with more enrolled participants. Future work will collect distal end pressure to give insights into pressure distribution between DSS and TS.

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ACKNOWLEDGEMENTS

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5.533 Studying Sex Differences in Gait Biomechanics of People with Transtibial Amputations during Level and Sloped Ambulation

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BACKGROUND

Females with lower limb amputations (fLLAs) are underrepresented in research despite their experiencing greater ambulation challenges,¹ higher fall-related injury rates,² and lower success with prosthetic fit when compared with males.¹ Previous research found sex differences in spatiotemporal gait parameters of people with transtibial amputations (pTTAs) on level-ground.³ fLLAs have also reported poorer ambulation ability on slopes.⁴ Further research is needed to investigate sex differences in gait biomechanics of pTTAs across different ambulatory modes to better understand these unique female challenges.

AIM

The purpose of this study was to investigate sex differences in gait biomechanics of pTTAs during level and sloped ambulation.

METHOD

Unilateral pTTAs and able-bodied controls were recruited and outfitted with 43 retroreflective markers. Participants completed trials walking up and down a 7-degree ramp and then completed trials walking across a level-ground walkway. An 8-camera Vicon system was used to collect motion capture data while ground reaction forces were recorded using force plates integrated in the ramp and walkway. Biomechanical analyses were performed using OpenSim,⁵ including scaling generic models and calculating gait biomechanics. Resulting gait biomechanics were compared between sexes using two sample t-tests ($\alpha=0.05$).

RESULTS

Ongoing efforts are investigating sex differences in joint kinematics, kinetics, and muscle activity across all participants. Presented are sex differences in gait kinematics of pTTAs on level-ground. Six pTTAs (3-female, 3-male) of comparable demographics were recruited. Key sex differences include females having a smaller knee-flexion range-of-motion (ROM) ($52.0\pm3.38^\circ$ vs $63.0\pm5.64^\circ$, $p=0.045$), smaller 2nd peak knee-flexion ($61.6\pm1.32^\circ$ vs $69.1\pm5.29^\circ$, $p=0.076$), smaller 1st peak ankle-dorsiflexion ($10.9\pm0.76^\circ$ vs $16.79\pm2.77^\circ$, $p=0.100$), and larger 2nd peak ankle-plantarflexion ($-19.2\pm2.96^\circ$ vs $-13.4\pm1.47^\circ$, $p=0.087$), on their non-amputated limb.

DISCUSSION AND CONCLUSION

Reduced knee-flexion ROM seen in fTTAs can impact mobility in broad range activities,⁶ presenting avenues for sex-specific rehabilitation considerations. Reduced ankle-dorsiflexion and increased plantarflexion, as seen in fTTAs, have been reported in able-bodied female populations.⁷ Further, such kinematics are linked with increased fall risk,⁸ offering possible insight into fLLAs' increased fall rates. While only one of the reported differences was statistically significant (i.e., knee ROM), this is likely a result of the study's small sample size.

Nonetheless, these preliminary findings demonstrate key differences in knee and ankle joint kinematics, offering insight into sex differences of how pTTAs walk and into the ambulation challenges experienced by females. These such findings present new research avenues and insight to consider sex-specific rehabilitation strategies and prosthetic design.

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ACKNOWLEDGEMENTS

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5.534 Impact of different insoles on gait kinematics and kinetics in patients with diabetes: A longitudinal randomized clinical trial

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BACKGROUND

Diabetic neuropathy can alter gait, increase soft tissue stiffness, limit joint mobility, cause muscle weakness and foot deformities, raising the risk for diabetic foot ulcers (DFUs) [1]. Proper shoes and insoles help redistribute pressure and prevent DFU recurrence [1, 2].

AIM

To explore gait characteristics, kinematics, and kinetics in patients with diabetes using different insoles.

METHOD

114 patients with diabetes type 1 and 2 were randomized to custom-made insoles (CMI) 35 shore, CMI 55 shore or prefabricated insoles. Three-dimensional gait analysis and plantar pressure analysis was performed at six follow-ups for ten years. Statistical analysis included ANOVA, Kruskal-Wallis, and chi-squared tests, with data reduced using principal component analysis (PCA) for simplified interpretation.

RESULTS

The average gait cadence for all visits and groups ranged from 104.7 to 113.4 steps/min., stride length 1.2-1.4 m., minimum foot progression 13.2 to 20.6 degrees outward., maximum foot progression 3.0 -7.7 degrees outward., maximum ankle flexion 13.0 – 18.9 degrees dorsi-flexion and minimum ankle flexion 7.9 – 15.4 degrees plantar-flexion. No statistically significant differences were shown in maximum or minimum ankle flexion angles (plantar/dorsi flexion) between Group 35, Group 55, and the Prefabricated group over six visits.

At the two-year follow-up, hallux valgus, hallux rigidus, and a low forefoot arch were associated with increased plantar pressure. Additionally, higher BMI was linked to increased pressure under the lateral forefoot, reinforcing the need for preventative interventions.

DISCUSSION AND CONCLUSION

This study highlights that custom-made or prefabricated options did not result in significant differences in maximum or minimum ankle flexion angles over time among patients with diabetes. It further describes gait kinematics and basic parameters in the group of people with diabetes. A limitation of the study is that no reference group was included, where ankle flexion in healthy individuals was recorded over time. Further research could compare gait data to increased plantar pressures areas, to further understand how ankle and foot movements influence DFU risk.

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ACKNOWLEDGEMENTS

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5.535 Is There Any Relationship Between Prosthetic Adherence and Balance With Fall Risk In Lower Extremity Amputees?

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BACKGROUND

Lower limb amputees have a higher risk of falls than the geriatric population, who often experience falls. Determining fall risk is challenging due to the multitude of risk factors and complexities in assessment. Previous studies have highlighted the impact of prosthetic fit and rehabilitation on fall risk in lower-extremity amputees ⁽¹⁾. However, the effects of amputees' prosthetic adherence and balance confidence on fall risk remain under-explored.

AIM

The purpose of this study was to investigate the relationship between fall risk in lower extremity prosthetic users and factors like prosthetic adherence and self-reported balance confidence, addressing a gap in fall risk influences.

METHOD

Twenty-two male lower extremity prosthetic users (mean age:37.09±11.75yrs) with traumatic amputations, and a dominant right lower extremity, were included in this study. Prosthetic adherence, balance confidence, and fall risk were assessed by using the Forgotten Joint Score (FJS), Activity-Specific Balance Confidence Scale (ASBCS), and Timed Up and Go Test (TUG), respectively. Non-parametric statistical tests were applied due to the non-normal distribution of data, as confirmed by Shapiro-Wilk test results. A p-value of < 0.05 was considered statistically significant for all analyses.

RESULTS

A moderate negative correlation was found between FJS and TUG ($r = -0.554$, $p = 0.008$), indicating that improved prosthetic adherence is associated with better functional mobility (Table 1). There was a strong negative correlation between ASBCS and TUG ($r = -0.822$, $p < 0.001$), highlighting that greater balance confidence may reduce fall risk. A multiple linear regression model analysis showed that FJS and ASBCS were significant in explaining the TUG with an $R^2 = 0.429$ ($p = 0.002$). The standardized beta coefficients for FJS and ASBCS were 0.019 and -0.189 (Table 2).

Table 1: . Correlation of prosthetic adherence and balance confidence with fall risk

Parameters	Forgotten Joint Score (FJS)	Activity-Specific Balance Confidence Scale (ASBCS)
Timed Up and Go Test p	0.008*	<0.001*
(TUG)	r -0.554	-0.822

Spearman correlation analysis, $p < 0.05$

Table 2: Multiple linear regression model for predicting the TUG

	B	Standard Error of B	Standardized Beta	p	R ²
			Coefficient		
Constant	22.970	3.153		0.002*	0.483
FJS	-0.119	0.038	0.108		
ASBCS	-2.761	0.054	-0.761		

DISCUSSION AND CONCLUSION

This study underscores the vital relationships between prosthetic adherence and balance confidence with fall risk in lower limb amputees. Higher balance confidence and good prosthetic adherence significantly enhances mobility, potentially reducing fall risk. These findings indicate that strategies focused on boosting balance confidence and proper prosthetic fittings could be key to lowering fall risk in individuals using lower extremity prosthetics.

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ACKNOWLEDGEMENTS

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5.536 Design of a bio-inspired foot based on the functional anatomy and biomechanics of the natural human foot

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BACKGROUND

Prosthetic foot users often face secondary physical complications such as lower back pain ^[1] and osteoarthritis in the hips and knees. Individuals with an amputation are particularly susceptible to knee osteoarthritis in their intact limb due to asymmetrical gait and resulting abnormal joint kinematics and kinetics ^[2]. Limited range of motion (ROM), comfort, and energy handling in the current prosthetic feet contribute to these issues, prompting a need for prosthetic foot designs that better mimic natural foot biomechanics.

AIM

The aim of this study was to develop a bio-inspired foot which is based on the functional anatomy and biomechanical principles of the natural human foot, with a specific focus on enhancing ROM (flexibility and adaptability) and energy handling (storage and return).

METHOD

A comprehensive literature review was conducted to understand the functional anatomy and biomechanics of the natural human foot. This knowledge was used to design a first prototype of the bio-inspired foot (Figure 1A), which was fabricated from PLA. Gait was simulated manually in a gait lab and motion tracking and force plate data were acquired to assess performance and functionality using different spring stiffnesses, thereby measuring e.g. ROM and energy handling.

RESULTS

The bio-inspired foot demonstrated plantarflexion and dorsiflexion angles of 14 and 21 deg, respectively, during stance. Maximum ROM tests, with low spring stiffness configurations, showed 21 deg of plantarflexion and 23 deg of dorsiflexion in the talocrural joint. The talocalcaneal joint reached 9 deg of eversion and 13 deg of inversion, whereas the first MTP joint reached a maximum ROM of 18 deg. In addition, the bio-inspired foot demonstrated varying energy storage across spring stiffness configurations (Figure 1B & 1C).

DISCUSSION AND CONCLUSION

This study resulted in the design of a bio-inspired foot with arches, plantar fascia, Achilles tendon and primary motion axes of the natural human foot by replicating the talocrural axis, talocalcaneal axis and MTP axes. The bio-inspired foot demonstrated notable ROM and storage of energy with adjustable spring stiffnesses for adaptability. Further research is needed to validate its performance under real-world conditions.

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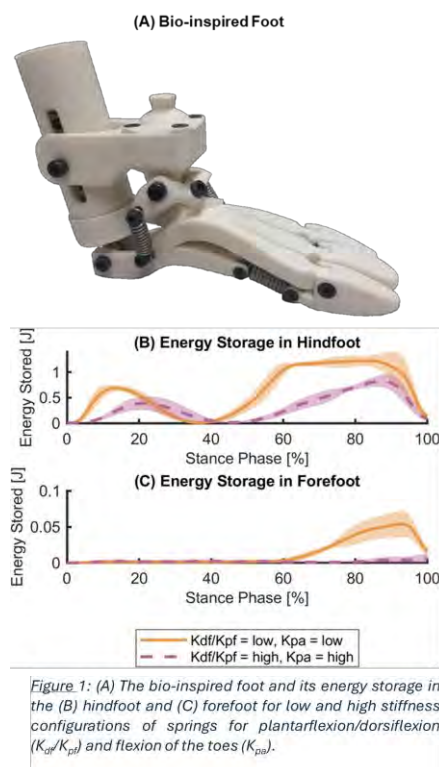


Figure 1: (A) The bio-inspired foot and its energy storage in the (B) hindfoot and (C) forefoot for low and high stiffness configurations of springs for plantarflexion/dorsiflexion ($K_{d/Kpf}$) and flexion of the toes (K_{pa}).



5.537 Effect of 12 Weeks of Insole Use on Plantar Pressure in Type 2 Diabetics with Peripheral Neuropathy

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BACKGROUND

Increased plantar pressure is a significant factor contributing to the development of ulcers in individuals with Type 2 Diabetes Mellitus (T2DM) and neuropathy.¹ The metatarsal heads are particularly at risk due to elevated plantar pressure.² In these individuals, using appropriate insoles can help reduce the risk of ulcers by normalizing plantar pressure.³ Although some studies indicate that insoles can normalize plantar pressure in T2DM patients, there is limited evidence showing changes in plantar pressure after insole use.

AIM

We aimed to investigate the effect of 12 weeks of insole use on plantar pressure in subjects with T2DM and peripheral neuropathy.

METHOD

A total of 25 subjects with peripheral neuropathy associated with T2DM were included in the study. Neuropathy was assessed using a biothesiometer, with subjects showing measurement results above 25 volts on the big toe considered to have peripheral neuropathy. Plantar pressure distribution during gait was evaluated using a pedobarograph, which recorded peak pressure (N/cm²) in 10 regions of the foot and the forefoot/rearfoot pressure ratio. CAD/CAM insoles were created, and participants were instructed to use them with appropriate shoes for 12 weeks. The Wilcoxon test was used to compare plantar pressure measurements before and after intervention. The research was conducted with ethics committee approval.

RESULTS

The study included 25 subjects with a mean age of 58.7 ± 2.2 years and a body mass index of 28.8 ± 1.9 kg/m². After 12 weeks of insole use, peak pressures significantly decreased at the 3rd metatarsal head on the dominant foot and at the 1st, 2nd, and 3rd metatarsal heads on the non-dominant foot ($p < 0.05$). The forefoot/rearfoot plantar pressure ratio decreased in both feet, while peak pressure increased at the midfoot and lesser toes ($p < 0.01$).

DISCUSSION AND CONCLUSION

In subjects with T2DM and peripheral neuropathy, 12 weeks of insole use reduced plantar pressure under the forefoot. The use of insoles in T2DM patients may help reduce the risk of forefoot plantar ulcers by normalizing plantar pressure distribution.

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Free paper session | Health care, policy, sustainability – Rehabilitation interventions and innovative protocols

5.541 Characterization of 24 Years of Amputations Performed in Portugal (2000-2023)

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BACKGROUND

The increase in the population's life expectancy necessarily implies an increase in costs, both due to the growth in the number of users and the increase in morbidity, especially among the elderly. Quantifying and characterizing the profile of amputees, knowing the numbers, establishing the prevalence and future trends in limb loss is important for health care planning and for the rational allocation of resources, as response to the growing indicators of demand for prosthetics and health related services.

AIM

Know the number of amputations performed in Portugal, classifying them and correlating them with the level of amputation, etiology, sex, age, creating a future forecast.

METHOD

This retrospective observational cross-sectional study was designed using the “Hospital Morbidity Database 2000-2023, for amputation episodes”. This document is the responsibility of the Central Administration of the Health System, IP. (ACSS), supervised by the Ministry of Health. All amputations (upper and lower limbs) were identified and stratified by sex, age, level of amputation and etiology. A correlation was performed between these variables in order to know the evolution of amputations in the different years.

RESULTS

In Portugal, between the years of 2000-2023, occurred 134.242 amputations. By gender 42.301 (31.51%) were female and 91.941 (68.49%) were male. Per year, the lowest total of amputations was reported in the year 2000 with 4.741 amputations, and the maximum value was reached in 2018 (6813). The distribution by gender remained at approximately the same values until 2015. It was reported an average of 1.800 amputations in females, decreasing in the next years to the lowest value of 1.557 in 2023. The total of major upper limb amputations was 1.109 and 15.376 minor. In the lower limbs the major amputations were 58.584 and 59.263 minor (87.79% of total amputations). The International Statistical Classification of Diseases and Related Health Problems 10th Revision- ICD-10 Groups with the most amputations recorded in ascending order are IX; IV; XIX; XVII. Amputations age vs

Year	Lower Limb						Upper Limb						Grand Total	%
	MAJOR		MINOR		Total	%	MAJOR		MINOR		Total	%		
	Total	%	Total	%			Total	%	Total	%				
2000	2300	49.91%	1570	33.12%	3930	83.02%	59	1.24%	740	15.74%	805	16.98%	4741	100.00%
2001	2408	48.24%	1682	33.69%	4090	81.93%	73	1.46%	829	16.61%	902	18.07%	4992	100.00%
2002	2481	50.02%	1654	33.55%	4145	83.57%	65	1.31%	750	15.12%	815	16.43%	4960	100.00%
2003	2429	49.03%	1816	36.66%	4245	85.69%	44	0.89%	665	13.42%	709	14.31%	4954	100.00%
2004	2621	50.08%	1893	36.17%	4514	86.24%	53	1.01%	667	12.74%	720	13.76%	5234	100.00%
2005	2560	48.98%	1924	36.81%	4484	85.79%	51	0.98%	682	13.24%	733	14.21%	5217	100.00%
2006	2565	47.71%	2072	38.54%	4637	86.25%	51	0.96%	688	12.80%	739	13.75%	5376	100.00%
2007	2687	49.31%	2019	37.05%	4706	86.36%	49	0.90%	694	12.74%	743	13.64%	5449	100.00%
2008	2782	51.12%	1920	35.28%	4702	86.40%	55	1.01%	685	12.59%	740	13.60%	5442	100.00%
2009	2719	50.85%	1946	36.39%	4665	87.25%	37	0.69%	645	12.00%	682	12.75%	5347	100.00%
2010	2785	48.91%	2276	39.97%	5061	88.88%	41	0.72%	582	10.40%	633	11.12%	5694	100.00%
2011	2647	46.50%	2297	40.35%	4944	86.85%	53	0.93%	665	12.21%	718	13.14%	5662	100.00%
2012	2652	46.68%	2344	41.26%	4996	87.94%	43	0.78%	642	11.30%	685	12.08%	5681	100.00%
2013	2579	44.81%	2423	42.10%	5002	86.92%	33	0.57%	720	12.51%	753	13.08%	5755	100.00%
2014	2287	41.69%	2417	43.80%	4703	85.49%	39	0.72%	701	13.96%	800	14.71%	5438	100.00%
2015	2257	43.13%	2380	44.66%	4637	87.81%	25	0.47%	624	11.72%	649	12.19%	5326	100.00%
2016	2383	42.73%	2583	40.32%	4966	89.04%	38	0.68%	573	10.27%	611	10.96%	5577	100.00%
2017	2233	38.00%	3087	52.20%	5300	90.20%	36	0.61%	540	9.19%	576	9.80%	5876	100.00%
2018	2465	36.18%	3701	54.32%	6166	90.50%	38	0.56%	609	8.94%	647	9.50%	6813	100.00%
2019	2339	36.19%	3551	54.94%	5890	91.13%	27	0.42%	548	8.45%	573	8.87%	6463	100.00%
2020	2181	34.23%	3698	57.38%	5879	91.62%	32	0.50%	502	7.88%	534	8.34%	6371	100.00%
2021	2208	35.45%	3489	56.01%	5697	91.46%	23	0.37%	509	8.17%	532	8.54%	6229	100.00%
2022	1995	33.83%	3389	57.13%	5384	90.96%	24	0.41%	509	8.63%	533	9.04%	5887	100.00%
2023	1935	33.90%	3250	56.94%	5185	90.84%	30	0.53%	493	8.64%	523	9.18%	5708	100.00%
Grand Total	58584	43.64%	59263	44.15%	117847	87.79%	1019	0.76%	15376	11.45%	16395	12.21%	134242	100.00%



group presents this distribution according to ICD-10: 00-04 years-XVII-total-1112-annual average (aa)-46; 05-49-XIX-7848-aa-327; 50-59-IV-10604-aa-442; 65-100-IX-43109-aa-1796.

DISCUSSION AND CONCLUSION

The number of major amputations of the lower limb has been decreasing since 2008 (51.12% to 33.90%), with minor amputations growing between the year 2000 and 2023 (33.12% to 56.94%). The more common types of lower limbs amputation, i.e., transfemoral and transtibial have been decreasing across the study period by 50.22% and 65.96% respectively. However, hip disarticulations showed an increase of 167%, since the year 2017.

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5.542 Quality of Life of People with Mobility-related Disabilities in Sweden: Results from Two Comparative Cross-Sectional Studies

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BACKGROUND

Quality of Life (QoL) and well-being cover wide aspects of life and do not rely on the absence of impairments. Little is known about QoL and how QoL is related to the social and economic situation of people with mobility-related disabilities in Sweden. The level of social inclusion and the economic situation may impact general health and well-being and may be important factors for sustainable rehabilitation.

AIM

To explore if there were differences in QoL between a group with and without mobility-related disabilities in Sweden.

METHOD

For both studies, cross-sectional data were collected through self-reported questionnaires. Recruitment was conducted through social media platforms in 2021 and 2022. WHOQOL-BREF was used to assess QoL. Comparisons were made between and within groups using the Welch t-test. Generalized linear models were used to predict score change for the WHOQOL-BREF items and domains accounting for sex, age, education, social inclusion, economic situation, and presence of additional or other disability.

RESULTS

The first study included 114 participants. 64 with lower limb amputation (LLA) and 50 without. Participants with LLA scored significantly lower compared to the persons without for General Health, General QoL, Health Satisfaction, and the WHOQOL-BREF domains of Physical Health and Environment, and reported a lower Community Inclusion Score. Within groups gender, education, and age had no significant influence on rated QoL.

For the second study, 381 participants were included, 143 with mobility-related disabilities and 238 without. Participants in the mobility-related disability group scored significantly lower than those without for General Health, General QoL, Health Satisfaction, and the WHOQOL-BREF domains. The group with mobility-related disabilities also reported a lower Social Inclusion Score (SIS) and a higher proportion of people without a cash margin. An increased SIS indicated higher QoL in the generalized linear model, whereas the absence of cash margin and mobility-related disability negatively influenced the QoL scores.

DISCUSSION AND CONCLUSION

Both persons with LLA and other mobility-related disabilities had lower QoL compared to groups without. The first study indicated that a higher perception of community inclusion and higher self-related gait ability improved QoL. In the second study, a lower QoL was also related to a lack of cash margin, a lower social inclusion score, and if there were additional or other disabilities present.



5.543 Global Prosthetic Prescription Rates after Major Lower Extremity Amputation in Dysvascular Populations: A Scoping Review

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BACKGROUND

Lower extremity amputation (LEA) is a global public health issue leading to large disability burdens and healthcare costs. For people with major LEA, prostheses improve functional mobility, social participation, and quality of life. However, prosthetic costs are high and provision varies world-wide. A preliminary literature search identified no prior reviews of prosthetic prescription rates after LEA.

AIM

This scoping review mapped the global evidence for prosthetic prescription rates after major vascular LEA. Specific aims were to identify research designs, populations, and healthcare models; determine prosthetic prescription rates across healthcare models, country income and health indices; and identify gaps in the literature.

METHOD

This review followed JBI Evidence Synthesis Manual and Preferred Reporting Items for Scoping Reviews guidelines. Scoping reviews catalog type, volume, and research characteristics to identify gaps in the literature; and exclude risk of bias appraisals. The search strategy used Medline, AMED, CINAHL, Embase, Scopus, and CLIO-Journal Prosthetics Orthotics databases; with 20-year but no language limits. The librarian-guided bibliographic process identified search terms (MESH, keywords), customized using polyglot search translation per database, with truncation and double-quoted word combinations to capture global terminology variations. Peer-reviewed articles with surveillance timelines from dysvascular major LEA were included. Two reviewers used Covidence™ to compile and independently review records, a 3rd reviewer resolved any conflicts. Data extracted to established database; descriptive statistics compiled.

RESULTS

609 abstracts screened, 33 full-texts reviewed, 18 articles included (17 cohort, 1 case-control; 5 prospective, 12 retrospective, 1 hybrid) Of the total 31,982 people (7.8% women), mean age 68.1 y after vascular LEA (62.2% transtibial, 32.2% transfemoral, 5.6% other), the prosthetic prescription rate was 48.5% (prescription, fitting, or provision). Studies included high (16/18) and middle (2/18) income countries and all defined healthcare models. Rates for 6 USA hybrid healthcare model studies was 48.8%, 1 private insurance Bismarck model was 73.7%, 4 National Health Insurance models was 59.3%, 6 government financed Beveridge models was 41.2%, and 1 out-of-pocket model was 32%. Rates in high (48.6%) and middle (39.2%) income countries varied. Country health indices (73.3-83.1) correlated with prescription rates ($R=0.21$).

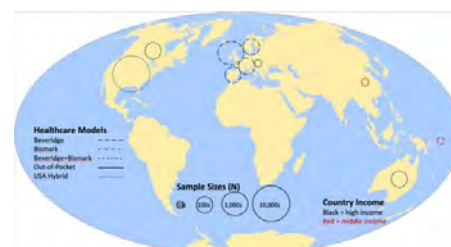


Figure 1: Source of Evidence Map by Healthcare Model, Sample Size & World Bank Country Income Classification

DISCUSSION AND CONCLUSION

Fewer than half receive prostheses after major vascular LEA. Evidentiary gaps include low income and African and South American countries; private and out-of-pocket models, and women. Low global prosthetic prescription rates enhance awareness of healthcare, prosthetic, and functional mobility needs for people after LEA. Country income level, healthcare model, and health index may be related and future research to clarify any relationships is warranted.

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5.544 Parents' experience of their own, other peoples', and their shared knowledge of congenital limb reduction differences

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BACKGROUND

Congenital limb reduction difference is a rare diagnosis. Knowledge about this condition, its consequences and treatment options to support parents in their future decision for their child, is expected to be gained by health care providers. However, according to previous research^{1,2} this has not been implemented regarding children with congenital limb reduction differences. Here, we want to study what level of knowledge parents encounter when requesting interventions for their child.

AIM

The aim of this study was to describe parent's experiences of the knowledge they have acquired and managed concerning their child with limb difference.

METHOD

We used a descriptive design with a qualitative approach. Participants were recruited through the Swedish association for children with limb difference. Purposive sampling was used to identify parents from a variety of geographical settings, representing different experiences of treatments and encounters with health care providers. A study specific interview guide was developed. Upon ethics approval and informed consent online video telephony ($n=14$) or face-to-face ($n=3$) semi-structured interviews were conducted with 17 parents (12 mothers) of children with upper and/or lower limb difference (age 2-12 [md 5] years). The interview data were analysed using qualitative content analysis with an inductive approach.

RESULTS

The overall theme describe *A need to know but also to understand*, and the four underlying categories are:

1. *Request knowledge to trust (facts)* - Describes parents' demand for trustworthy information to rely on for reaching an understanding of why their child has a limb difference and for knowledge about appropriate interventions.
2. *Reaching own knowledge and understanding* - Different ways of how to reach knowledge and understanding of what the limb difference will mean for the child.
3. *Differences in knowledge – between levels of care and one's own knowledge* – Describes experiences of knowledge received from different health care providers, in relation to their own knowledge.
4. *Shared perspective and understanding – more than facts* - Opportunities for the parents to exchange experiences, information, knowledge are sometimes of greater value than facts.

DISCUSSION AND CONCLUSION

The parents' experiences show both positive and challenging aspects regarding the knowledge of their child's condition and treatment interventions. Based on information and knowledge received from different sources, the parents develop their own understanding on which to base their parenting and decisions. The findings in this study support the need for specialized units with multidisciplinary competences offering information about potential causes for the condition and evidence-based treatments for the children.

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5.545 How can Prosthetic Services be Improved to meet Women's Needs? A Narrative Review

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BACKGROUND

Women report difficulties in accessing and obtaining prosthetic devices and have poorer outcomes than men [1-3]. The extent of these issues is uncertain, with their root cause rarely examined, especially not from a holistic, systems-level viewpoint. This narrative review provides an overview of the literature on prosthetic services for women and provides recommendations on improvements to facilitate an equitable, evidence-based prosthetic service that meets their needs.

AIM

To describe and explore the current state of prosthetic services for women and the factors influencing how services meet their needs.

METHOD

An initial search was conducted using OVID (01/07/2024) to acquire journal articles which mentioned women and prosthetic limbs (or synonyms thereof) in their title or abstract. These articles were screened for relevance: discussions on sex differences in prosthetic services or experiences as a person with limb difference. Further articles were sourced through snowballing and prior knowledge of the field. Additionally, blogs relating to prostheses and women were sourced using a conventional Google search.

The 172 papers and 11 blogs were read in full before data around women's experiences and perspectives of services were extracted. Thematic analysis was performed in Nvivo [4], coding against a biopsychosocial framework consisting of three themes: physical, psychological and social.

RESULTS

Women are less likely to receive, use and be satisfied with a prosthesis than men, whilst being more likely to abandon their device, attributed to lack of comfort and function. Prosthetic devices are reported as designed for men and unsuitable for women due to poor fit, excess weight, and poor cosmesis.

Physically, women experience poorer outcomes relating to residual limb pain, and the impact of menopause, pregnancy and the menstrual cycle on their residual limb is significant. Prosthetic services do not always consider these topics, and information or guidance on best practise for these is limited.

Women also have poorer psychological outcomes than men, with depression and body-image-related issues common, attributed to societal norms and the definition of femininity. The social and cultural impact of limb differences varies globally, with discrimination and stigma prominent, as well as the impact of expected gender roles and patriarchal societal norms.

DISCUSSION AND CONCLUSION

Providers for women with limb loss must consider the woman holistically and have an appreciation and understanding of their individual needs and wants. Women with limb difference require a user-focused service, with access to sensitised prosthetists who understand the needs of women, to ensure an appropriate and beneficial service.

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5.546 Comparison of Spine Bone Quality among Adolescents with/without Idiopathic Scoliosis with using Ultrasound measurement

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BACKGROUND

Recent research has indicated that bone mass density (BMD) is important in estimating the curve progression of Adolescent Idiopathic Scoliosis (AIS). [1] It was found that there is a correlation between the BMD and Cobb angle in patients with AIS. Clinical ultrasound has lately been used to assess the properties of both soft and hard tissues in patients with AIS. Reflected ultrasound echoes from spine scans can be used to evaluate bone quality.

AIM

This study aims to quantify and compare the bone quality of patients with AIS and normal teenagers using non-invasive ultrasound measurement.

METHOD

X-ray images in AP view were processed to measure Cobb angles. To evaluate bone quality, the reflective coefficient (R) was collected from a portable ultrasound system (Clarius, USA) using two customized software: MIASX (Version 2.1, University of Alberta, Canada) and MIAS 3D software Professional edition (Version 10.3.41, University of Alberta, Canada). [2]

The settings for the ultrasound system were adjusted to a frequency of 3.3 MHz, a gain level of 50%, and an imaging depth between 6 and 10 cm (depending on the thickness of soft tissue). The lamina of the lumbar region (at the level of the L5 vertebra) was located for data captured by the ultrasound system.

RESULTS

Data analyses were performed using the IBM SPSS Statistics (Version 26.0, USA). According to the X-ray Cobb angle measurement, participants were assigned to either the normal or AIS groups. An Independent Sample T-test was used to compare the ultrasound reflective coefficient between the normal and AIS groups. A significant difference was found between the two groups ($p < 0.05$).

One-way ANOVA was used to compare the reflective coefficient among four groups: teenagers with normal and three groups with different levels of severity. Significant differences were found between the normal group and the three scoliotic groups of different severities ($p < 0.05$) (Table 1).

Table 1: Distribution of subjects into different severity groups.

Severity Group	Cobb Angle	Number	Mean $\pm$ SD	Mean Difference	<i>p</i> -value
Normal	0° -10°	15	0.599 $\pm$ 0.94	/	/
Mild	10° -20°	38	0.334 $\pm$ 0.25	0.266	$p < 0.05$
Moderate	20° -45°	44	0.303 $\pm$ 0.25	0.296	
Severe	>45°	4	0.157 $\pm$ 0.01	0.441	

DISCUSSION AND CONCLUSION

This study's method of measuring bone quality relies on non-invasive clinical ultrasound. The use of this clinical measurement method further substantiates its practicality for clinical applications. The study identified a correlation between AIS and bone quality, with a significant difference noted between healthy individuals and those with AIS. Clinical ultrasound measurements have been used as a non-invasive tool for assessing bone quality by comparing healthy individuals and patients with AIS.

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5.547 Rehabilitation of the upper limb congenital disorders requiring prosthesis : common problems in healthcare management

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BACKGROUND

Complex rehabilitation is a necessary key for the functional use of a prosthesis. However, several issues have been identified in the organization of effective rehabilitation for the children requiring prosthesis^[1].

AIM

The aim of the study is to evaluate the prevalence and provide a detailed overview of the challenges faced by children in need of upper limb prosthetics during rehabilitation.

METHOD

Quantitative prospective study with a survey method. The survey took place in August 2021-September 2023. By the time of the survey, all participants had prior experience with using an active upper limb prosthesis. The survey included open (n = 10) and closed (n = 27) questions. The questions were designed to quantitatively assess the effectiveness of rehabilitation based on availability, proper timing, complex approach, individualized approach, active patient involvement, phased progression, and regularity.

RESULTS

A total of 192 parents of children aged 1 to 16 from 34 regions of the Russian Federation participated in the survey. 90 respondents (47%) reported that their children had never undergone rehabilitation. Among the 102 respondents with rehabilitation experience, 61% had received rehabilitation in only one stage. Individual rehabilitation goals, tailored to the specific needs of each child, were established for only 17% of families. Only 27,5% received rehabilitation multiple times a year or annually. Additionally, a clinical psychologist and a medical rehabilitation doctor assisted only a third of the respondents (35% and 33%, respectively). An occupational therapist was involved in the rehabilitation team in 7 cases (7%). The criterion of early prosthetics was also not fully implemented. The frequency of rehabilitation and the age at which the first rehabilitation session began varied significantly among the participants. Only 18% of parents were putting efforts into regular home exercises and training with the device. 85% of the parents did not have any suggestions on the improvement of the rehab quality. Only 26% of parents included themselves in a rehabilitation team around the child.

DISCUSSION AND CONCLUSION

47% of children in need of upper limb prosthetics do not receive even the minimum amount of rehabilitation. In other cases, the rehabilitation provided does not meet the necessary effectiveness criteria. Common issues include delays in starting rehabilitation and prosthetics, a lack of an interdisciplinary and individualized approach, and violations of the principles of phased, continuous care. Additionally, there is a low parental involvement in the rehabilitation process and a lack of timely information from doctors regarding the need for and possibility of prosthetics.

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5.551 Outcomes after a transtibial amputation, a comparison between patients receiving the prosthesis early or late – a Swedish registry study

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BACKGROUND

Early prosthetic provision may create better conditions for good mobility with a prosthesis ⁽¹⁾. The Swedish national register for lower limb amputations and prostheses (SwedeAmp) collects data on the number of days from surgery to first prosthesis, which currently was Md 66 days after a transtibial amputation (TTA), with large variation ⁽²⁾. As SwedeAmp also collects patient-based data regarding mobility before amputation, surgical and prosthetic details, and patient-reported outcome the dataset can shed further light on time to prosthetic fitting.

AIM

To compare, on a national level, the outcome at 12-months follow-up in patients with a unilateral transtibial amputation who received their first prosthesis earlier versus later, using data from SwedeAmp.

METHOD

From a large dataset, patients with a unilateral TTA between 2011-2023 and with date for first prosthesis registered were extracted (n=4374). In this group Md time until prosthetic fitting was 64 days. Further, the dataset was narrowed down to only include cases with data registered for 12-months follow-up as well as preoperative mobility data. The final sample (n=359) was divided into two groups: Early prosthetic fitting (<64 days) or Late prosthetic fitting (≥64 days). The groups were comparable based on demographic data and baseline mobility. Thereafter, surgical technique, prosthesis details and outcomes (Prosthetic use score (PUS), LIC-5 and TUG-test) at 12-months were compared between the groups.

RESULTS

In the Early group (n=176, mean age 71, 83% diabetes/vascular causes) time to prosthetic fitting was Md 37 (16-63) days. In the Late group (n=183, mean age 72, 87% diabetes/vascular causes) time to prosthetic fitting was Md 95 (64-323). At 12-months the Early group reported more prosthetic use (PUS 56 versus 41, p<0.001) and better prosthetic mobility (LCI-5 40 versus 31, p=0.02) as compared to the Late group. Differences in the TUG-test were non-significant. In the Early group a sagittal/scREW flap as opposed to a long posterior/anterior-posterior flap was more common (p=0.05) and a direct laminated socket as opposed to a hand casted socket was more common (p<0.001) compared to the Late group.

DISCUSSION AND CONCLUSION

The cut-off value of 64 days to define the groups can be discussed. More prosthesis-related variables and outcomes will be analysed. This far, results show more prosthetic use and better prosthetic mobility at 12-months follow-up in patients receiving a TTA prosthesis before 64 days. The results indicate that surgical technique and socket process method play a role for less days until prosthetic fitting in Sweden.

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5.552 Analysis of Early and Late Outcomes in Patients Following Transtibial Amputation

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BACKGROUND

Transtibial amputation is a common procedure for lower limb loss, where early and long-term outcomes are crucial for recovery. Factors like early mobilization, comorbidity burden, and complications can greatly impact functional recovery and survival ⁽¹⁾. Analysing these determinants is essential to improving patient management and prognosis.

AIM

This study aims to assess the effects of age, comorbidities, mobilization timing, and early complications on one-year survival and three-month functional outcomes in transtibial amputation patients.

METHOD

This retrospective study analysed data from 27 patients who underwent transtibial amputation. Patient demographics, preoperative comorbidities, mobilization timing (categorized as early mobilization, delayed mobilization, and non-mobilized), early postoperative complications, one-year survival, and three-month Katz scores (a measure of daily living independence) were recorded ⁽²⁾. Age groups were categorized as under 65, 65-79, and over 79 years. Statistical analyses included descriptive statistics, chi-square tests for categorical data comparisons, and three-month Katz scores were compared across age groups using Kruskal-Wallis test, to assess the impact of age on functional outcomes with significance set at $p < 0.05$.

RESULTS

The mean age of participants was 70.2 ± 1.44 years. Seventeen patients had at least one preoperative comorbidity, including conditions like chronic obstructive pulmonary disease, hypertension, or diabetic foot. Postoperative mobilization varied: eight patients achieved early mobilization (within 24 hours), five were mobilized later, and fourteen were bedridden. Early postoperative complications, such as hypoxia or metabolic disorders, occurred in 12 patients within 72 hours. Among 22 patients with three-month Katz scores, the average was 1.86 ± 1.75 . One-year survival was 48.1% (13 individuals). A significant difference in one-year survival was observed across age groups ($p < 0.001$): all individuals under 65 survived, compared to seven in the 65-79 group and only two over 80. The Kruskal-Wallis test showed a significant difference in three-month Katz scores across age groups ($p = 0.005$), with pairwise comparisons showing differences between those under 65 and those over 65. Chi-square analysis indicated a significant association between mobilization and survival ($p < 0.001$), as only one of the 14 bedridden patients survived at one year.

DISCUSSION AND CONCLUSION

The findings indicate that early mobilization and younger age are associated with improved one-year survival and functional outcomes in transtibial amputation patients. These results align with previous studies emphasizing the benefits of early mobilization and age on recovery. However, the study's limited sample size may affect generalizability. Further research with larger samples is needed to validate these findings. In conclusion, promoting early mobilization may enhance postoperative outcomes in this patient group.

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5.553 “It's time consuming and demoralizing”: Navigating the emotional aspects of the prosthetic coverage journey

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BACKGROUND

Emotions are not only physiological processes, but also cultural practices that are experienced by our bodies and minds and shape our relationship with objects, policies, and environments. Prosthetic technology has historically been associated with progress and the positive emotions. The framework of affect informed by critical disability studies¹ provides a lens for focusing on the link between access to prosthetic technologies through different governmental programs and insurance plans and the emotional journeys of people with limb loss engaging with these systems.

AIM

The study focused on understanding how people with limb loss navigate the system of prosthetic funding and what emotional and material impact it has on them.

METHOD

We interviewed 59 people with limb loss who were over the age of 18 and lived in BC, Canada. Semi-structured interviews were used. Prosthetics clinics, hospitals and social media was used to recruit participants. We developed themes through using reflexive thematic analysis.³ The analysis relied on an inductive-deductive approach. The inductive analysis drew on the rich participants' stories. The deductive analysis incorporated the principles of the social model of disability⁴ and the discourse analysis that focuses on the language and the ways in which participants express their emotions.

RESULTS

1. Negotiating eligibility, navigating biocertification².
Biocertification describes the bureaucratic and medicalized process of proving you are indeed disabled. Participants describe the emotional toll of having to prove their disability.
2. Postponing the present and the future. Participants described how prosthetic coverage shape their life trajectories and how they make choices based on their access to prosthetic technology.
3. Calculating the worth of fighting for what you need. Participants found it was stressful having to navigate the system to secure a prosthetic funding that puts many people with limb loss in a position of having to choose their battles.

DISCUSSION AND CONCLUSION

Our analysis focuses on the emotional aspects of navigating the system of prosthetic coverage. From having to prove their disability and the need for prosthetic equipment to having to make certain life choices depending on the coverage reflects the affective impact of the systems and bureaucratic processes on people with limb loss. The policies are not neutral and result in people having an emotional response to their experiences of engaging with inequitable funding structures.

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5.554 Evaluation of the SwedeAmp Database: Focus on Coverage and Amputation Levels Rate

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BACKGROUND

The National Board of Health and Welfare manages several national registers in Sweden. This includes the Swedish National Inpatient Register (IPR), covering all surgical operations, and SwedeAmp, focusing on outcomes after lower limb amputations (LLA). The coverage rates, regarding amputation levels, between them have not been externally analyzed.

AIM

This study aims to compare SwedeAmp's coverage with IPR for LLA cases and assess SwedeAmp's accuracy in capturing LLA data. The goal is to identify potential discrepancies and establish benchmarks for common amputation levels.

METHOD

Data from both registers (2018–2023) was compared regarding the amputation levels and patient demographics. The SwedeAmp register's coverage rate was calculated using SwedeAmp data as the numerator and IPR data as the denominator.

RESULTS

The SwedeAmp documented 5,246 LLAs covering 17 regions (36 hospitals), leaving 5,542 amputations unaccounted for, mainly due to regions or hospitals not participating in the SwedeAmp registry and lower registration rates in some areas.

- To achieve full coverage in SwedeAmp (17 regions), 9,305 LLAs would need to be registered.
- Both men and women over 85 years were significantly underrepresented.
- Thirteen regions in SwedeAmp obtained more than 40% coverage rate.
- 5 regions had more than 50% rate of above-knee amputations ($r=50.9\%-68.2\%$) and
- 8 regions reporting more than 50% rate of below-knee amputations ($r=53.1\%-88.9\%$)
- Among the 67 hospitals performing LLAs, 36 reported to SwedeAmp. Six of these hospitals performed fewer than 10 LLAs over a six-year period.

Table 1: A systematic overview of the registered material. *12 excluded due to missing information

	IPR		SwedeAmp*		Missing data	
	n	%	n	%	n	%
TF (%)	4534	42.1	1828	34.9	2706	59.7
KD (%)	800	7.5	438	8.3	362	45.3
TT (%)	5454	50.4	2980	56.8	2474	45.4
Sum	10788	100	5246	100	5542	*51.4

• Corresponding to the total % of missing data, not the sum of the column

DISCUSSION AND CONCLUSION

SwedeAmp captured 48.6% of initial LLAs in Sweden, highlighting the need for improved data completeness in LLA records, especially as only 13 regions achieved over 40% coverage. For hospitals performing regular amputation, the proposed benchmark - coverage of $\geq 60\%$, with $\leq 36.3\%$ for transfemoral amputation (TF), $\leq 8.4\%$ for knee disarticulations (KD), and $\geq 55.3\%$ for transtibial amputations (TT) – could serve as a target to enhance consistency and accuracy in reporting. Expanding coverage can improve the register's utility in tracking outcomes, setting national standards, aiding research, and supporting clinical decision-making

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5.555 Exploring Rehabilitation Outcomes in Substance Use Related Amputations: A 10-Year Retrospective Analysis

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BACKGROUND

Limb amputation (LA) is a life-altering condition associated with substantial health challenges and reduced autonomy ⁽¹⁾. Extensive rehabilitation is usually crucial to improving outcomes. While diabetes and vascular complications are the primary causes of LA ⁽²⁾, substance use, defined as the use of alcohol, illicit drugs, or cannabis, is a recently observed cause. ⁽³⁾. In British Columbia, Canada, clinical observations suggest a spike in substance use related amputations, with affected individuals facing considerable barriers to care. Mental health and housing instability may be contributing to prosthetic rehabilitation challenges.

AIM

To identify trends in substance use related LA over the past decade, assess related rehabilitation, and explore associations between housing stability, mental health challenges, and rehabilitation outcomes.

METHOD

A 10 year (2014-2023) retrospective chart review was conducted using GF Strong Rehabilitation Center medical records. Extracted data included sociodemographics, mental health (present/absent), housing status (stable/unstable), prosthetic prescription (yes/no), discharge with a prosthesis (yes/no), frequency of physiotherapy and physician visits, and mortality. Summary statistics were used to describe the population, Fisher's exact tests and Mann-Whitney U tests were applied to examine associations between housing stability or mental health and rehabilitation outcomes.

RESULTS

Fifty-four (13.6%) of 397 individuals had amputations linked to substance use. This group comprised 76% men, mean age of 48 years (SD = 11), 83% having lower limb loss. Notably, 48% had documented mental health challenges, 65% experienced unstable housing, and 36% died during the study period.

The incidence of substance use related amputations increased annually from 4 to 12 patients per year. Mental health challenges rose from 2 to 7 cases per year, and unstable housing increased from 3 to 8 cases over the 2014-2023 period. Individuals with stable housing attended more physiotherapy sessions ($p < 0.01$). However, no statistically significant associations were found between housing stability or mental health and other rehabilitation outcomes.

DISCUSSION AND CONCLUSION

The referral rate for substance use-related LA at GF Strong has tripled since 2014, while prosthetic prescriptions have not kept pace, indicating some individuals do not receive a prosthesis. Unstable housing status may partially explain the relationship as adequate housing is important for learning to use and maintain a prosthesis. Mental health may also contribute although no statistically significant association was found. A prospective study following individuals from amputation to discharge is recommended to better understand the impact of housing and mental health on rehabilitation outcomes and long-term independence.

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6.001 Prevalence of neuropathic pain in patients with limb amputation in a health facility in Bogotá, Colombia; 2024

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BACKGROUND

Neuropathic pain is a common complication in amputation patients. The prevalence was 69%, this type of pain can be severe and debilitating, negatively impacting the quality of life of patients

AIM

to determine the prevalence of neuropathic pain in patients with amputation in a health entity in Bogotá, Colombia

METHOD

Observational, descriptive, cross-sectional study. The study population consisted of 110 adult patients with a diagnosis of amputation. Inclusion criteria: Patients with amputation of any limb, over 18 years of age, with the ability to understand and answer the questionnaire. Variables: The main variable of the study was the presence of neuropathic pain, defined according to the diagnostic criteria (IASP) greater than 12 on the LANSS objective scale.

RESULTS

males (87%) compared to 13% of females. 76 people were found with pain with neuropathic characteristics, which corresponded to 69.1%, with a higher percentage of neuropathic pain for partial hand amputations (35.5%), followed by symptoms of neuropathic pain in transfemoral and transtibial amputation (21%)

From the results obtained with the application of the LANSS scale with a mean of 14.57 points (CI: 14-16) it was identified that 33.6% of the patients scored the maximum value of 24 and 12.7% scored over 19.

In the analysis of the abbreviated pain scale with a mean pain intensity rating, rated as moderate on the VAS scale of 6.5 (CI: 5.96-6.97) and for the average quality of life impairment 5.23 (CI: 4.58-5.88).

In the bivariate analysis of the BPI questionnaire, when correlating the average intensity of pain with the compromise in quality of life, a high positive association is obtained with a Pearson correlation of 0.914 (P less than 0.01), in the same way a positive association is found between the scores of the LANSS scale and the compromise in quality of life with a Pearson correlation of 0.725 (P < 0.01)

DISCUSSION AND CONCLUSION

neuropathic pain is a prevalent and significant problem. For the case in question, the null hypothesis was demonstrated with a prevalence of 69% for this population. It is important to highlight that the prevalence may vary according to the etiology of the amputation, the time elapsed since it and the characteristics of the population studied. It is more frequent in partial hand amputations (35.5%) and transfemoral (21%)

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6.002 Cycling with a knee disarticulation prosthesis or a transfemoral prosthesis: barriers and their solutions

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BACKGROUND

Cycling is a sustainable way of transport. It has a number of benefits, especially for users with a knee disarticulation (KD) prosthesis or a transfemoral (TF) prosthesis because cycling is joint friendly, as most of the body weight is supported by the bicycle's seat, and consequently relieving the load on the residual limb. However, barriers and the possible solutions in cycling are not well known for them¹.

AIM

To explore the barriers in cycling experienced by users with a knee disarticulation prosthesis or a transfemoral prosthesis, and to gather solutions to overcome these barriers.

METHOD

Participants who were regular cycling persons with a knee disarticulation or a transfemoral amputation were recruited (N=8). To consider the opinion of the prosthetist with expertise in working with persons who cycle with their prosthesis, also some experienced certified prosthetists/orthotists were recruited (N=3). They were asked to complete a self-developed questionnaire, comprising open questions about barriers in cycling, barriers in the interaction between prosthesis and bicycle, and recommendations for diminishing these barriers.

RESULTS

Barriers and possible recommendations mentioned were

- *physical domain*: skin damage in the region of the groin and complaints of back and hip. A recommendation was the use of a crank shortener or to adjust the saddle in order to overcome asymmetry in cycling.
- *psychological domain*: fear of falling, or fear of balance disturbances.
- *prosthetic domain*: problems to switch the cycle mode of the knee, and the fitting of the socket. The first item has to be overcome by the manufacturers of the microprocessor prosthetic knees by integrating an automatic detection of cycling of the prosthetic knee. To improve the fitting of the socket, recommendations discussed were the wear of a TES-belt
- *bicycle domain*: slipping the prosthetic foot off the pedal. Anti-slip pedals or a block heel under the shoe were suggested.

DISCUSSION AND CONCLUSION

For fear of falling, or fear of balance disturbances, no recommendations were proposed. Literature suggests task- and context-specific training and/or graded exposure with cycling as soon as possible during the prosthetic training²; moreover a more sophisticated bike (adapted lower frame, adaptation of the height of the saddle) with more balance is discussed³.

Conclusion: There are several barriers in cycling experienced by users with a KD prosthesis or a TF prosthesis. With the recommendations suggested and solutions discussed in this study, these barriers can (partly) be overcome, in order to encourage cycling, with all the benefits of it.

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6.003 Preliminary Gait Evaluation of a Power Hip Prosthesis

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BACKGROUND

To improve gait for people with hip disarticulation amputations, a microprocessor-controlled powered hip prosthesis (PHP) was developed to provide appropriate hip joint moments at the correct time¹. The intelligent PHP implements a novel rope and pulley driven transmission system to transmit power from an actuator at the prosthetic thigh to an anterior hip centre of rotation. Following successful ISO 15032:2000 and hip prosthesis simulator testing, preliminary evaluation with a hip disarticulation prosthesis user is required to advance PHP development.

AIM

Fit the PHP to a hip disarticulation prosthesis user, complete preliminary training and adjustment, and complete a preliminary gait evaluation.

METHOD

One male participant with a unilateral hip disarticulation amputation volunteered to participate in this project. After fitting and seven practice and adjustment sessions with the PHP, he completed a L test walking trial with smartphone video capture. Stride parameters were extracted from the video and kinematics were calculated from the PHP sensors, for the straight walking sections.

RESULTS

The participant was able to complete the L test route without any external assistance or walking aids. Results for 12 strides are listed in Table 1. The participant took advantage of the extra range of motion for the hip, with some strides reaching 19° extension and 27° flexion. Pelvic tilt range of motion (ROM) remained larger than expected and could be attributed to the participant still using their habitual gait pattern. Double support time of 35% was better than results in the literature. Swing initiation started before foot off, which is typical of normal gait.

Table 1: Mean and standard deviation for twelve strides when walking with the PHP

Parameter	Mean	SD
Hip extension (°)	16.93	2.51
Hip flexion (°)	17.00	6.37
Pelvic tilt ROM (°)	26.75	9.22
Pelvic obliquity ROM (°)	13.54	7.20
Stride time (s)	1.58	0.17
Step time (s)	0.96	0.17
Double limb support time (s)	0.55	0.12

DISCUSSION AND CONCLUSION

The PHP enabled effective walking that provided better range of motion and swing initiation than mechanical hip joints. While being heavier than other hip disarticulation prostheses, the participant did not notice the weight difference when using the PHP. More time using the PHP is needed for the person to change his habitual pelvis and ankle plantarflexion gait patterns (for limb progression and foot clearance); therefore, full gait analysis for this device would be best after an extended acclimation period with the powered hip.

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6.004 Prosthetic ambulation outcome and return-to-work(RTW) rate of lower limb amputees in a single rehabilitation center in Japan: 2013-2023

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BACKGROUND

Independence in prosthetic ambulation and return-to-work(RTW) are important outcomes in lower limb amputees. Various authors have reported a return-to-work rate of approximately 60% after lower limb amputation ⁽¹⁾. In Japan, there have been few reports examining return to work after lower limb amputation. We conducted a study on prosthetic gait outcomes and RTW rates of lower limb amputees who were admitted to our hospital and underwent prosthetic rehabilitation.

AIM

To examine prosthetic walking outcomes and RTW rates in specialised prosthetic rehabilitation facilities, and to obtain suggestions on appropriate support for lower limb amputees.

METHOD

We retrospectively reviewed the medical records of patients with lower limb amputation who were admitted to our hospital and underwent prosthetic rehabilitation between 2013 and 2023. The following data were collected: age at amputation, sex, cause of amputation (vascular /non-vascular), level of amputation (transtibial: TT, transfemoral: TF, above-transfemoral: ATF, bilateral lower limb amputation: BLA), whether or not the patient was able to walk independently with their prosthesis, whether or not they were employed before their amputation, whether or not they were RTW one year after discharge, and the reason for not RTW for those who were unable to RTW.

RESULTS

There were 172 cases with a mean age of 51.0 ± 18.3 years (median 51.5 years) and 138 males (80.2%). The cause of amputation was vascular in 47 cases (27.3%) and non-vascular in 125 cases (72.7%). The amputation levels were TT: 72 cases (41.9%), TF: 74 cases (43.0%), ATF: 12 cases (7.0%) and BLA: 14 cases (8.1%). 133 cases (73.3%) were able to walk independently with their prosthesis. 110 patients (64.0%) were employed before amputation, and 64 of these (58.2%) were still employed one year after discharge. The RTW rate was not related to the cause of amputation. The most common reason for not returning to work was problems with the work environment or inadequate social support.

DISCUSSION AND CONCLUSION

The RTW rate of this study was approximately 60%, which was almost the same as previous reports. The rate of successful independent ambulation was over 70%, and the cause of amputation was not related to the rate of return to work, so it seems that appropriate prosthetic rehabilitation and the ability to ambulate independently with prosthesis are important for RTW, regardless of the cause of amputation. Appropriate environmental adjustment and support of the employer are also important for RTW following lower limb amputation.

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6.005 Are temporal and loading asymmetries relevant biomechanical parameters for differentiating between different microprocessor-controlled knees?

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BACKGROUND

Over the past 30 years, various microprocessor-controlled knee (MPK) systems have been used by above-knee amputees (AKA), offering clinical benefits from variable walking speeds to stumble recovery. MPK users report higher mobility and quality of life compared to those using mechanical alternatives ⁽¹⁾, and biomechanical studies generally confirm MPK's advantages ⁽²⁾. However, studies comparing different MPK systems yield mixed results on biomechanical parameters ⁽³⁾, making it difficult to identify consistent clinical performance differences. Lower-limb amputees often show gait asymmetry, spending more time and exerting more load on the intact limb ⁽⁴⁾. Temporal and loading asymmetry could be useful in differentiating MPK systems, though these parameters remain underexplored.

AIM

This study aims to assess whether temporal and loading symmetry during level walking can differentiate between MPK models in above-knee amputees.

METHOD

The Quattro prosthetic knee is a new MPK designed to control both stance and swing phases through unique motion resistance technology. A randomized controlled trial was conducted across five rehabilitation centers in France to examine whether Quattro's specific characteristics can differentiate it from other MPK solutions. Patients with K3-K4 activity-level were divided into two groups: one started with Quattro, then switched to their current MPK, while the other group did the reverse. Patients wore both prostheses for a minimum of four weeks in daily use to allow for adaptation. Using Loadsol insoles, gait asymmetry was assessed through the 6-Minute Walk Test, focusing on temporal and loading asymmetries measured by ground reaction force (GRF) data ⁽⁴⁾.

RESULTS

This study analyzed fifteen unilateral transfemoral amputees (13 men, 2 women) using OTTOBOCK C-Leg, ÖSSUR Rheo knee, or BLATCHFORD Orion prostheses. Results showed that Quattro's stance and step symmetry were similar to other MPKs. A lower first peak in GRF was found, indicating slightly greater symmetry during loading response with Quattro, though not statistically significant. With similar GRF impulse, cyclic loading asymmetry was also comparable across MPKs (see figure 1).

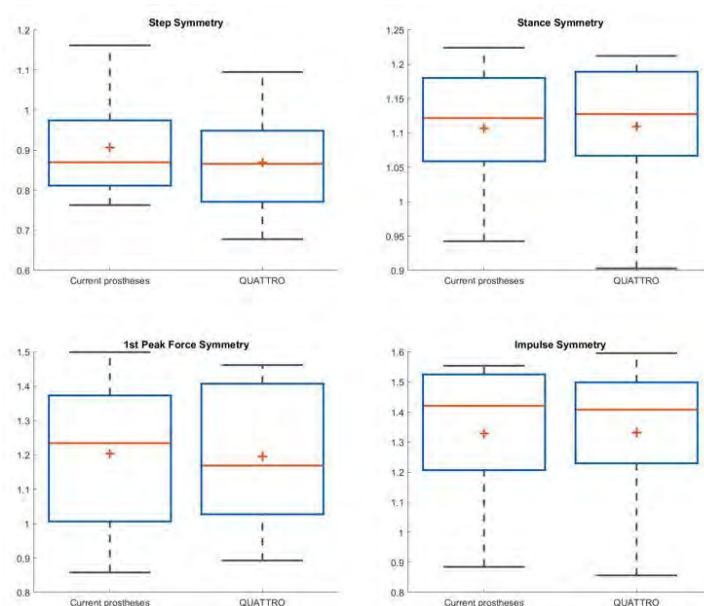


Figure 1. Biomechanical parameters assessing gait symmetry



DISCUSSION AND CONCLUSION

This study analyzed gait asymmetry in transfemoral amputees using different MPK solutions and found no significant differences in temporal and loading asymmetry. Although asymmetry indices help distinguish MPK from non-MPK solutions, they are not effective for differentiating between MPK models. Previous research also suggests that biomechanical parameters fail to capture gait differences between K3 and K4 amputees ⁽⁵⁾, probably due to patient's adaptability to the prostheses. Therefore, subjective criteria, like quantitative survey, may be more relevant than objective biomechanical measures for differentiating MPK models.

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6.006 Complex Regional Pain Syndrome Treated with Above Knee Amputation and Osseointegration

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BACKGROUND

Severe cases of CRPS may necessitate amputation as a desperate remedy to manage the disease. However, rehabilitation with traditional socket-mounted prostheses can result in new manifestations of the syndrome. In this case report, osseointegration was used as the main rehabilitation strategy which significantly improved her clinical outcomes.

AIM

To report on 11 year follow up outcomes of a 24- year-old woman with unremitting complex regional pain syndrome type I (CRPS-I) who underwent a trans-femoral amputation, then reconstruction with osseointegration surgery.

METHOD

Radiographs revealed profound osteopenia of the involved limb, and the presence of the right patella was difficult to determine due to severe osteoporosis. Radiographs and CT scans also revealed good delineation of the proximal and distal shaft of the right femur with no definite bony abnormality or irregularity other than osteopenia. Bone scans demonstrated dramatically increased uptake and tracer activity in the right patella, consistent with the prior diagnosis of CRPS-1.

RESULTS

In December 2013, the patient received a regional epidural several days preceding the surgery. This resulted in the CRPS-1 being well demarcated, accompanied by significant erythema and hyperaemia. The patient then underwent an above knee amputation one hand's breadth proximal to the visible level of demarcation, followed by first-stage osseointegration as previously described. Nine weeks later, the second-stage osseointegration surgery took place, which entailed the creation of a stoma and insertion of a transcutaneous adaptor for connecting an external prosthetic limb.

DISCUSSION AND CONCLUSION

This unique case demonstrated that amputation followed by osseointegration may become an effective treatment for some CRPS patients, improving their function, mobility, and quality of life. We believe this treatment strategy holds genuine potential as a definitive option for therapy- resistant pain in dysfunctional limbs resulting from CRPS.



6.007 Prosthetic Gait Analysis using a Wearable Motion Capture System

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BACKGROUND

Three-dimensional motion analysis is one of the powerful methods for objective evaluation in rehabilitation medicine. Currently the most widespread method in research field is the motion capture system using optical cameras. Recently, some markerless motion capture systems have been developed ⁽¹⁾, in which small motion sensors combined with accelerometers and other sensors are attached to the body to measure motion. This method has the advantage of not limiting the measurement space.

AIM

The purpose of this study is to clarify the potential of the e-skin MEVA motion capture system, which is developed by Xenoma Inc., for 3D motion analysis of prosthetic gait.

METHOD

Subjects were 24 individuals with lower limb amputations who walk with prostheses on daily activities. Measurements were taken wearing an e-skin MEVA shirt and pants, and movements of the lower limb, trunk, and upper limb during level walking were recorded.

Analysis was carried out using the dedicated application software. The calculated parameters were stride length, step length, step distance, swing phase period, stance phase period, support period of both legs, and lower limb joint angles (ankle, knee, and hip), and their symmetries.

RESULTS

All the data from one subject could be obtained in 15 minutes, including preparation.

The data obtained showed characteristics of prosthetic gait of subjects with transfemoral amputation and were almost same as compared with the results of the conventional method (MAC3D).

The result of the simultaneous measurement of a person with a transfemoral amputation are showed in Figure1.

Both methods were able to measure characteristic knee joint motion. The e-skin MEVA tended to have a slightly larger maximum knee joint angle.

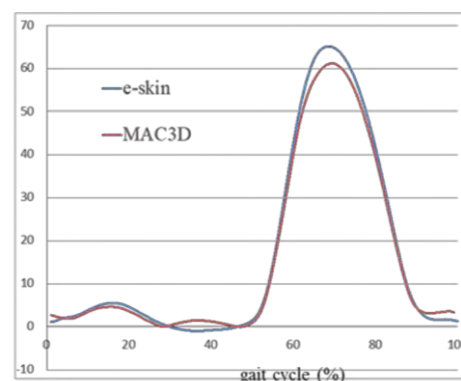


Figure 1 The knee joint angle of the gait of the transfemoral amputee with genium (ottobock)

DISCUSSION AND CONCLUSION

Wearable motion capture systems make it much easier to measure prosthetic gait. The characteristic features of e-skin Meva are easy to put on and take off shirts and pants with sensors attached, automated analysis and feedback to subjects. Compared to the conventional method, this method was able to be performed in a shorter time and with less burden on the subject, which were major benefits of this method.

Further verification of the reliability of the measurement data will be needed for other joint angle measurements.

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ACKNOWLEDGEMENTS

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6.008 Optimization of Extension Moment Magnitude in a Transfemoral Prosthetic Knee for Sit-to-Stand and Stand-to-Sit Transitions to Reduce Motion Asymmetry

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BACKGROUND

Sit-to-stand and stand-to-sit transitions are frequent daily activities. Previously, we developed a passive transfemoral prosthetic knee mechanism in which an embedded spring compresses during sitting, generating an extension moment. A ratchet mechanism maintains the spring's compression to keep the prosthetic knee flexed while seated. When the prosthetic user manually releases the ratchet to stand, the spring extends, again creating an extension moment.

AIM

Asymmetrical movements in unilateral prosthetic users may increase the risk of joint injuries or degenerative disease. This study aimed to demonstrate an optimization method for the spring constant of the proposed mechanism to reduce motion asymmetry.

METHOD

Motion asymmetry was assessed during sit-to-stand and stand-to-sit transitions using four different spring constants: no spring, weak (9.02 N/mm), moderate (19.09 N/mm), and strong (35.00 N/mm). Three able-bodied subjects were fitted with a simulated thigh socket and a prototype of the passive knee mechanism. Reflective markers were placed on both the body and prosthesis, with their positions recorded using a 3D motion capture system. Ground reaction forces were measured using a force plate. Knee joint moments were calculated through inverse dynamics. A symmetry index was calculated for knee joint angles, ground reaction forces, and knee joint moments, with the average symmetry index across the motion defined as motion asymmetry.

RESULTS

The measured knee extension moment differed from the theoretical value due to friction within the mechanism. During stand-to-sit motions, the no-spring condition and the middle spring condition (measured maximum moment: 0.51 Nm/kg) produced less asymmetry in the kinematic and kinetic parameters, respectively. In sit-to-stand motions, the no-spring condition showed the lowest asymmetry for kinematic parameters, while the middle condition (measured maximum moment: 0.29 Nm/kg) produced less asymmetry in kinetic parameters. Thus, different spring conditions minimized motion asymmetry across kinetic and kinematic parameters. A Pareto optimization for multi-objective analysis was conducted, with six evaluation functions modeled as second-order equations in terms of the spring constant. The optimal spring constant, minimizing the distance between the Pareto surface and the origin in the objective function space, was calculated to be 10.6 N/mm, with estimated maximum moments of 0.42 Nm/kg for stand-to-sit and 0.22 Nm/kg for sit-to-stand.

DISCUSSION AND CONCLUSION

The optimization of the prosthetic knee function that minimizes the motion asymmetry was demonstrated. Although optimal values may change with improvements to the prototype and testing on actual amputees, this multi-objective optimization approach would have shown promise in enhancing prosthetic knee performance.



6.009 Comparative Study on the Quality of Life of Lower-Limb Amputees between Portugal and Spain

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BACKGROUND

Characterising the perception of unilateral lower limb amputees and increasing information and data on their rehabilitation will help to fill the information gap, contributing to the construction of new studies with greater scientific and methodological rigour. This knowledge will make it possible to optimise rehabilitation and rationalise costs, enabling the creation of health policies that are appropriate to needs.

AIM

To compare the perception of unilateral lower limb amputees on the quality/functionality of life with the prosthesis in Portugal and Spain.

METHOD

This was an observational study with a convenience sample of unilateral major lower limb amputees living in Portugal or Spain, of both sexes and aged 18 or over, who were given the PEQ questionnaires, validated in Portuguese and Spanish. Data was collected by applying the questionnaire online or in person at orthopaedic and similar centres, at the same time as the questionnaire to collect sociodemographic data, with the independent variables of gender, chronological age, aetiology, time and level of amputation, laterality and use of walking aids. The study was approved by ESTeSL's Ethics Committee under number CE-ESTeSL-Nº 37-2024.

RESULTS

The sample consisted of 30 individuals in each country. When comparing the sample, no statistically significant differences were detected in relation to the PEQ subscales. We tried to understand the influence of sociodemographic data in the general population, $n_{PT} + n_{ES} = 60$, and detected statistically significant differences in the gender variable in the FR subscale; in age in the AP and AM subscales; in time since amputation in the UT, FR, SB and WB subscales; and in time since prosthesis in the UT, SB, AM and WB subscales. As for the level and cause of amputation, no significant differences were detected in any subscale.

Subscales/Test statistics	Country		Sex		Age		Level of amputation		Amputation time		Prosthesis time	
	Mann-Whitney U	p	Mann-Whitney U	p	Correlation Coefficient	p	Mann-Whitney U	p	Correlation Coefficient	p	Correlation Coefficient	p
Utility Scale (UT)	323,000	0,060	249,500	0,072	0,139	0,209	297,000	0,098	,301*	0,019	,363**	0,008
Appearance Scale (AP)	420,500	0,751	270,000	0,145	,292*	0,023	312,000	0,157	0,143	0,275	0,093	0,509
Frustration Scale (FR)	444,500	0,935	208,000	0,012	0,241	0,064	281,000	0,054	,287*	0,026	0,248	0,073
Social Burden Scale (SB)	418,000	0,634	350,500	0,913	0,035	0,709	304,000	0,796	,398**	0,002	,392**	0,004
Ambulation Scale (AM)	416,000	0,615	356,000	0,987	-,257*	0,047	309,000	0,143	0,240	0,065	,205*	0,038
Well being Scale (WB)	442,500	0,912	302,500	0,361	0,131	0,319	304,000	0,122	,355**	0,005	,390**	0,004
** Significant correlation at 1% significance level.												
* Significant correlation at the 5% significance level.												
p>0.05 there is no statically significant difference												
p<0.05 there is a statically significant difference												

Figure 1- Summary of the results obtained in SPSS.

DISCUSSION AND CONCLUSION

When comparing the PEQ averages with sociodemographic data in the two countries, even though there were no statistically significant values, there were differences in QoL, a fact corroborated by some authors and not by others. Living in Portugal or Spain does not interfere with the QoL of unilateral major lower limb amputees aged between 18 and 99, since no statistically significant differences were found between the two countries in terms of the PEQ subscales.

ACKNOWLEDGEMENTS

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6.010 Wound complications after Lower Extremity Amputations, with and without Prevena Closed Incision System

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BACKGROUND

Wound complications after Lower Extremity Amputations (LEAs) are frequent. Patients treated with amputations are fragile and suffering from a variety of comorbidities as diabetes, arteriosclerosis, cardiovascular disease and the majority are receiving anticoagulation therapy. LEA patients are in high risk for readmissions and the rate of wound complications are high, compared to other procedures. Prevena incision management system for closed surgical incisions has previously been reported in a cohort of 54 patients, who underwent amputations due to ischemia.

AIM

To examine the efficacy of the Prevena closed incision system, in a cohort of orthopaedic patients amputated due to infections, non-healing fractures and diabetic foot ulcers.

METHOD

Medical charts from amputee patients was reviewed from 2015-2016 and compared to the data from the Safe Journey Database 2019-2021. 200 patients was included in the study, and 176 patients had Prevena Closed Incision system applied directly after surgery. Patient demographics, amputation levels, comorbidities, wound complications and length of stay was retrieved from the database. Data was analysed using STATA.

RESULTS

176 patients received the Prevena treatment, and 24 patients was treated with a dry dressing and a compression stocking. Mean age 73 years (64-80). 152 patients had a transfemoral amputation, 48 transtibial amputation and 1 patient a knee disarticulation. 69% was ASA classification 3, 24 % ASA classification 4 and 7 % ASA classification 1 or 2. 52% had diabetes, and 24 % reduced kidney function prior to surgery. 61 patients suffered from wound complications, and 31 had to be re-admitted for revision surgery.

		All (n=200)		Prevena (n= 176)		No prevena (n=24)		
		median	(IQR)	median	(IQR)	median	(IQR)	
Age (years)		73.2	(64-80)	75.2	(67-81)	60.7	(56-70)	0.02
Sex		n	(%)	n	(%)	n	(%)	
	Female	75	38%	68	39%	7	29%	0.50
Amputation level								
	Transtibial	48	24%	11	6%	2	9%	
	Transfemur	152	76%	115	69%	15	68%	
	Knee-ex	1	1%	41	25%	5	23%	0.00
ASA (n=189)								
	I-II	13	7%	5	4%	8	11%	
	III	130	69%	84	70%	47	67%	
	IV	46	24%	31	26%	15	22%	0.86
Comorbidities								
	Diabetes	103	52%	89	51%	14	58%	0.52
	Kidney disease	48	24%	44	25%	4	17%	0.45

DISCUSSION AND CONCLUSION

Discussion: LEA patients are in high risk of surgical wound complications, and more than 1/3 are amputated due to infections. Postoperative compressions treatment is proven to be effective, to reduce wound complications. Negative pressure bandages are proven effect full in ischemic patients, after amputations, but our study does not find the effect of Prevena in an orthopaedic cohort of amputees.

Conclusion: The Prevena closed incision system, is costly and limits the patients from liner treatment or compressions stockings, in the postoperative phase. In our study, the wound complication rates and re admission rates was high, and the Prevena did not seem to reduce the risk compared to normal dressings. Even with regular visits by a nurse after discharge, inspecting the wound for complications, the reoperation rate was high.



6.011 Retrospective review of factors associated with transfemoral prosthesis use at and beyond 1 year at a tertiary centre in Australia

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BACKGROUND

Amputee services assess transfemoral amputation patients (TFA) prior to limb prescription to those most likely to be functional users. There is limited research on long term TFA prosthetic use with focus of research on clinical factors eg wound healing, pain, prosthetic fit, health affecting prescription and prosthetic prescription using screening tools. The case numbers are small and often a mixed transtibial and transfemoral amputee cohort.^{1, 2, 3}

AIM

1. To look at the success or otherwise current approaches to TFA limb prescription, at and beyond 1 year of amputation.
2. To determine demographic and social factors that modified functional outcome.

METHOD

This was a retrospective cohort study of a 6-year data of TFA (2015-2020) at a metropolitan tertiary hospital in NSW, Australia. The data was collected from electronic medical records, rehabilitation medicine database and affiliated prosthetic company. The outcomes of interest were frequency (daily, not daily) and duration of prosthetic wear (<4 or >4 hours/day). The data was analysed using descriptive stats using multiple regression analysis and adjusted for clinical and social characteristics.

RESULTS

There were 63 TFA patients, Male: Female 53:10 with mean age 48 years(7-80, SD 19.8), predominantly English speaking and ~50% living with a partner in the study cohort. Forty four percent were traumatic amputees with overall 55% K3 and above prosthetic user on screening. Majority of TFA were using the prosthesis at and beyond 1 year with 85% wearing their prosthesis daily and 76% wearing it for >4 hours/day.

Factors associated with increased frequency and duration of wear were younger age, higher K rating on screening, mobilizing with nil aids after physiotherapy ($p<0.001$) and being employed post amputation ($p=0.005$). The traumatic amputees and those living at home wore their prosthesis daily but not for longer duration ($p=0.03$, $p=0.01$). Availability of formal services and absence of co-morbidities were associated with increased duration of prosthetic wear ($p=0.008$, $p=0.006$). The presence of a partner or informal supports, postoperative complications were not associated with prosthetic use.

DISCUSSION AND CONCLUSION

The majority of TFA wore their prosthesis daily and for long periods of time at and beyond 1 year of amputation in the study cohort. A higher K rating, younger age and independent mobility on discharge were clinical factors associated with more use. Postoperative complications e.g. delayed wound healing did not affect prosthetic wear.

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ACKNOWLEDGEMENTS

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6.012 Criteria for success in new patients with MPKs – a service evaluation

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BACKGROUND

Microprocessor knees (MPKs) have been available on the NHS for established prosthetic users since April, 2017. Observations at our centre in an established cohort saw patients decreasing risk of falls and improving energy expenditure, alongside other physical and psychological benefits. This raised the question of whether MPKs should be considered for new post-amputation patients who also meet the NHS inclusion criteria (Clinical Commissioning Policy, 2016).

AIM

This poster aims to review one service's experience with prescribing MPK's to patients as their first prosthetic prescription to determine what selection criteria might ensure successful MPK use at 12 months.

METHOD

New post-amputation patients were selected using the inclusion criteria outlined in the MPK Clinical commissioning policy (2016). Successful and non-successful MPK trials were recorded and the following information was collected: demographics (age, gender), cause of amputation, level of amputation, predicted mobility at initial assessment and actual mobility (SIGAM grade) at 12 months. Results were presented to outline key patient characteristics in both the successful and non-successful groups. Key characteristics were then identified in order to generate a 'criteria for success' when selecting patients to undergo MPK trials as a first prosthetic prescription.

RESULTS

The cohort that were selected for MPK consideration consisted of 23 male and 12 female patients. The age range of patient's from both successful and unsuccessful trials combined was 11-71 years. The average age of successful patients was 39 years, with the average age of unsuccessful patients being 62 years. Causes of amputation included vascular, sarcoma, orthopaedic infection, congenital limb difference, trauma and chronic regional pain syndrome. Approximately 54.3% of successful patients' cause of amputation was due to sarcoma. With approximately 50% of unsuccessful patients' cause of amputation being due to vascular issues. Based on the initial findings, patients who were predicted to achieve a higher SIGAM mobility grading at initial assessment, went on to be more successful in attaining/exceeding this level after 12 months.

DISCUSSION AND CONCLUSION

This information was used to review our service and consider what our 'criteria for success' is when considering MPK's as an initial prescription. This may also to identify patients who may not benefit from an MPK prescription. Successful characteristics appear to include younger age and higher predicted mobility, whereas unsuccessful characteristics include older age and a vascular background. Further research would be required to compare these results across other prosthetic services.

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ACKNOWLEDGEMENTS

I would like to thank the patients and staff at the RNOH, Stanmore, for their support in data collection.



6.013 Patient-specific factors contributing to low back pain in people with a unilateral transfemoral amputation

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BACKGROUND

Low back pain (LBP) is a highly prevalent condition among individuals with a unilateral transfemoral amputation (TFA). The patient-specific factors contributing to LBP include physical, psychological, biomechanical and prosthesis-related factors. While the influence of psychological and social factors on back pain-related disability has been identified, the effects of mobility-related assistive devices on back pain are unknown.

AIM

The purpose of this study was to determine which factors related to patient demographics and assistive mobility devices could predict low back pain in people with a TFA.

METHOD

Eight individuals with a unilateral TFA (mean age 55.7 ± 14 years) completed the Oswestry Disability Index (ODI) questionnaire for back-pain related disability. The demographic information collected from the subjects included – age, gender, body mass index (BMI), cause of amputation, time since amputation and length of residual limb. Subjects also completed an assistive device use questionnaire which included information on the use of prosthesis, wheelchair, walker, crutches and cane, indoors as well as outdoors. A forward, step-wise regression analysis was conducted to identify the factors that best predict ODI scores. Due to the small sample size, a significance level of $p < 0.1$ was adopted.

RESULTS

From a total of 8 independent variables used in the regression analysis, only 2 variables were identified as significant. A model created with BMI and “Indoor assistive device use” predicted 94% of the variance ($R^2 = 0.947$) in ODI scores ($p < 0.01$). While these preliminary results are statistically significant, they simply indicate trends and are not generalizable to the TFA population due to the small sample size ($n=8$). The regression model does not account for other potential contributors of back pain, e.g. socket fit, type of prosthetic device, movement biomechanics and muscle strength. This is an ongoing study and additional subjects are being recruited.

DISCUSSION AND CONCLUSION

Results indicate that TFA subjects, who had a higher BMI and who frequently used assistive device indoors, had higher back-pain related disability. While a causal relationship between the dependent and independent variables cannot be inferred, results suggest that lower BMI and reduced use of assistive devices in the patient’s home could potentially reduce LBP. The two predictors of LBP are both modifiable factors that can be managed by clinicians during rehabilitation. When treating back pain, clinicians could also address BMI and indoor assistive device use, for improved outcomes in patients with TFA.



6.014 Enhancing Functional Walking Ability in Individuals with Lower Limb Amputations: An AR-Based Exercise Intervention

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BACKGROUND

People with lower limb amputations often have reduced activity levels, impacting their ability to walk with prosthetics and leading to health issues. To address this, an AR-based exercise protocol is proposed to improve muscle strength and walking ability ^[1]. This study aims to design and evaluate this protocol, providing valuable insights for developing comprehensive exercise programs for amputees.

AIM

This study aimed to investigate the effectiveness of an AR-based exercise intervention in improving functional walking ability in patients with lower extremity amputations.

METHOD

This study included four individuals with lower limb amputations (three transfemoral, one transtibial) who underwent a 12-session AR-based exercise program. The program, lasting four weeks, focused on improving upper and lower body flexibility and strength. To assess the effectiveness of the training, functional walking ability was evaluated before and after the intervention using the Timed Up and Go Test(TUGT), Four Square Step Test(FSST), 8 Figure Walking Test(8FWT), and Sit to Stand Test(STS). These tests measure dynamic balance, agility, coordination, and lower extremity strength. To analyze the data, the mean and standard deviation values before and after training were compared.

RESULTS

The results of this study indicated that AR training significantly improved balance ability, agility, and coordination during walking in lower extremity amputees. Specifically, the TUGT showed a significant decrease of 1.4 seconds (11.5%) post-training, indicating improved dynamic balance. The FSST demonstrated a 1.6-second (9.4%) reduction, suggesting enhanced agility during walking. Additionally, the 8FWT exhibited a 1.7-second (3.4%) improvement, highlighting improved coordination. Furthermore, the STS revealed a 0.6-times (6.1%) increase, suggesting enhanced lower extremity muscle strength.

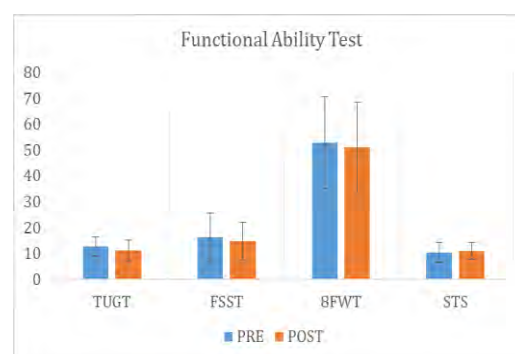


Figure 1. Results of functional walking ability test

DISCUSSION AND CONCLUSION

This study demonstrates that AR-based exercise improves functional walking ability in lower limb amputees. It enhances dynamic balance, agility, and coordination, reducing fall risk. The developed AR protocol holds promise for maintaining walking ability in aging amputees. Future research will explore additional exercise content and expand the study population.

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ACKNOWLEDGEMENTS

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6.015 The Impact of Microprocessor-Controlled Knees on Falls and Injuries is meanwhile visible in Epidemiologic Studies – results of a literature review

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BACKGROUND

Numerous clinical studies showed individuals with transfemoral amputation (TFA) experience significantly fewer falls when using microprocessor-controlled prosthetic knees (MPKs) compared to non-MP controlled prosthetic knees (NMPKs) (e.g., ¹). Based on Medicare utilization (²), MPK adoption among TFAs with K3 mobility in the U.S. can be estimated at 65%. That raises the question whether the impact of MPKs can be seen in recent epidemiologic studies on falls in the amputee population.

AIM

To analyze whether the high adoption of MPKs among TFAs in the U.S. has resulted in fewer falls and injuries in recent epidemiologic studies compared to the pre-MPK era.

METHOD

A literature search with search terms pertaining to transfemoral/above-knee amputation and epidemiology of falls and/or fall-related injuries was conducted in Pubmed and Google Scholar. Identified publications were screened for pertinence and date of publication in the pre-MPK (data collection prior to 2001) and MPK eras (data collection 2015 or later). Findings of the epidemiologic studies were extracted and will be presented descriptively as a narrative literature review.

RESULTS

Three epidemiologic studies on falls and/or fall-related injuries in lower-limb amputees were identified, one from the pre-MPK era (³) and two from the MPK era (6,7). In the pre-MPK era study, 66% of all TFAs had fallen in the previous 12 months. Patients with TFA were 2.78-times more likely to have fallen than those with transtibial amputation (TTA) (CI: 1.71-4.51) (³). Across all amputation levels, 40% of the fallers had sustained injuries (³).

In the studies from the MPK era, the rate of fallers among TFAs (76%) was still higher than among TTAs (60%), but vascular comorbidities (OR: 3.46, CI: 1.4-8.5) and better balance (OR: 23, CI: 3.2-170) turned out to be much more important risk factors than amputation level (OR: 0.08, CI: 0.01-0.82) (⁴). TFAs sustained fewer fall-related injuries (11%) than those with TTA (23.5%), and TTAs were 2.3-times more likely to experience a fall-related injury than TFAs (CI: 1.01-4.89) (⁵).

DISCUSSION AND CONCLUSION

Epidemiologic studies from the pre-MPK era (2001) and MPK era (2018/2019) showed a dramatic shift in risk factors for falling and fall-related injuries in patients with TFA. In the MPK era, patients with TFA are no longer more likely to fall and sustain injuries than those with TTA. Based on the prevalence of MPKs in the U.S. (²), this change can likely be attributed to the impact of MPKs.

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6.016 A Comparison of Open-Source Motion Analysis Programs to Marker-Based Systems for Transfemoral Prosthesis Users

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BACKGROUND

Disabilities affect one billion people [1]. Rehabilitation treatments, such as prostheses to restore mobility, are crucial [2], and evaluating their outcomes is important for clinical success [3]. Technological developments have led to the frequent use of 3D marker-based optical systems in biomechanics for kinematic analysis. [4]. However, OpenCap, a more user-friendly option, uses two iOS devices for data collection and automatic processing [5].

AIM

This study examines the validity and reliability of the OpenCap system for collecting kinematic data from transfemoral amputees by comparing with the gold-standard 3D marker-based optical system for motion analysis.

METHOD

For this study, The Siriraj Ethical Review Board approved study number Si 418/2023. All of 15 transfemoral prosthesis users (14 males and 1 female), ages 49.67 ± 12.95 years, weight 67.70 ± 11.24 kg, height 1.67 ± 0.07 m, participated in this study. Data collection utilized optical motion analysis with 10 Vicon cameras [Vicon Motion Capture Camera Ltd, UK] and M-Gait [Motek Medical B.V.], along with OpenCap using two iPhone 14 Pro Max (Apple Inc., USA), all operating at a 200 Hz sampling rate. Each participant completed three walking trials at a comfortable speed while data was collected simultaneously.

RESULTS

All analysis of statistic has been performed by using Paired t-test with a significance level of 0.05 to compare kinematic gait data between 2 motion analysis instruments. Regarding Table.1, there is a significant difference shown in peak degrees of knee extension on both sides, peak knee flexion on contralateral side and range of motion of knee flexion/extension on amputated side. For ankle joint was a significant difference in peak ankle dorsiflexion on amputated side, peak plantar flexion, and range of motion of ankle dorsiflexion/plantarflexion on contralateral side. Conversely, the remaining parameters show no significant differences.

Parameter	Mean $\pm$ SD (n=15)		P-value	P < .05	P < .001
	3D Marker Based Optical System	OpenCap			
Cadence (step/min)	82.20 $\pm$ 8.00	82.00 $\pm$ 8.03	.073		
Kinematic joint parameter (degrees)					
Hip joint on contralateral side					
Peak hip flexion	26.53 $\pm$ 5.41	26.02 $\pm$ 4.48	.750		
Peak hip extension	12.27 $\pm$ 6.98	11.31 $\pm$ 5.84	.498		
Range of motion of hip flexion/extension	40.03 $\pm$ 7.84	38.35 $\pm$ 7.34	.365		
Hip joint on amputated side					
Peak hip flexion	24.07 $\pm$ 10.37	22.93 $\pm$ 9.04	.261		
Peak hip extension	13.36 $\pm$ 7.33	14.85 $\pm$ 4.70	.335		
Range of motion of hip flexion/extension	37.43 $\pm$ 10.41	37.77 $\pm$ 9.53	.767		
Knee joint on contralateral side					
Peak knee flexion	55.61 $\pm$ 4.47	57.68 $\pm$ 4.95	.006	*	
Peak knee extension	3.75 $\pm$ 2.77	1.01 $\pm$ 0.50	.002	*	
Range of motion of knee flexion/extension	59.33 $\pm$ 5.38	58.93 $\pm$ 4.60	.717		
Knee joint on amputated side					
Peak knee flexion	49.04 $\pm$ 12.84	49.33 $\pm$ 12.92	.584		
Peak knee extension	3.97 $\pm$ 2.81	1.14 $\pm$ 1.10	<.001	*	*
Range of motion of knee flexion/extension	53.01 $\pm$ 13.01	50.57 $\pm$ 12.74	.002	*	
Ankle joint on contralateral side					
Peak ankle dorsiflexion	12.25 $\pm$ 5.81	13.13 $\pm$ 3.52	.581		
Peak ankle plantarflexion	15.24 $\pm$ 7.67	10.34 $\pm$ 5.39	.004	*	
Range of motion of ankle dorsiflexion / plantarflexion	27.49 $\pm$ 5.01	23.47 $\pm$ 5.37	<.001	*	*
Ankle joint on amputated side					
Peak ankle dorsiflexion	7.78 $\pm$ 3.95	11.09 $\pm$ 3.52	<.001	*	*
Peak ankle plantarflexion	2.49 $\pm$ 1.91	1.42 $\pm$ 0.85	.131		
Range of motion of ankle dorsiflexion / plantarflexion	11.77 $\pm$ 4.48	13.65 $\pm$ 3.55	.096		

Table 1. Kinematic parameters of fifteen transfemoral prosthesis users on the contralateral side and the amputated side using a 3D marker-based optical system and OpenCap.

* Significant difference ($\alpha = 0.05$)



DISCUSSION AND CONCLUSION

Across all parameters, the results showed a mean absolute error between the two motion analysis systems of no more than 5 degrees, which met the acceptance level ^[6]. Therefore, in comparison to a 3D marker-based optical system, OpenCap presents precise sagittal plane measurement capabilities in the hip, knee, and ankle joints. Furthermore, the researcher plans to investigate OpenCap's reliability and validity in other planes as part of our comprehensive investigation.

Future clinical settings can use OpenCap to assess an amputee's mobility. OpenCap requires less equipment to operate, is less expensive, and is available for everyone to use.

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ACKNOWLEDGEMENTS

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6.017 Health economic evaluation comparing microprocessor-controlled knees to non-microprocessor-controlled knees

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BACKGROUND

Use of a microprocessor-controlled knee (MPK) compared to a non-microprocessor-controlled knee (NMPK) can lead to improved walking ability, confidence and satisfaction. However, the MPK is more expensive than the NMPK and it is unknown whether the higher costs outweigh the potential benefits for the prosthesis user. A health economic evaluation (HEE) can be used to quantify the additional costs of an intervention in relation to the additional health effects.

AIM

Perform a HEE to assess the cost-utility and cost-effectiveness of MPKs and NMPKs from a societal perspective in the Netherlands among adult lower limb prosthesis users.

METHOD

Adult lower limb prosthesis users who used a socket prosthesis with MPK or NMPK were included. Participants completed the EQ-5D-5L to assess health-related quality of life, the ambulation, utility and well-being subscales of the Prosthesis Evaluation Questionnaire (PEQ) to assess prosthesis-related quality of life and a cost-questionnaire from societal perspective. Incremental cost-utility ratios and incremental cost-effectiveness ratios (ICUR/ICER) were calculated with the EQ5D-5L and PEQ respectively, to assess the costs relative to the potential benefits of the MPK and NMPK. The bootstrapping method was used to estimate statistical uncertainty and multiple imputation was applied to account for missing values.

RESULTS

In total, 111 participants were included (age 64.1 ± 13.1 years). The ambulation subscale score was significantly higher for the MPK group compared to the NMPK group and exceeded the minimal clinically important difference (MCID).

The cost-utility analysis (CUA) demonstrated that the MPK yielded an increase of ± 0.03 QALYs, but at considerably higher costs. The mean cost difference was €14,674, resulting in a mean ICUR of €489,133 per QALY gained. The cost-effectiveness analysis (CEA) demonstrated an increase of ± 16 points on the ambulation subscale for the MPK, resulting in a mean ICER of €921 per unit gained. The cost difference was mainly driven by acquisition costs: €4,417 (NMPK) versus €21,018 (MPK). This difference was partially compensated by lower costs of work absence (€351 versus €156) and household care (€1,989 versus €261).

DISCUSSION AND CONCLUSION

Based on the CUA, the MPK was determined not to be cost-effective compared to the NMPK. However, the EQ-5D-5L is a generic questionnaire and does not reflect all aspects of prosthesis use. The CEA demonstrated improvements with the MPK that were outside the scope of the EQ-5D-5L. The bootstrap results suggest that the probability of achieving the MCID for the PEQ ambulation subscale was 85%.



6.018 User Experience of Microprocessor Knee Provision in an NHS service: A service evaluation

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BACKGROUND

Demand for microprocessor controlled knees (MPKs) through the NHS has been high since being commissioned from April 2017. This inevitably led to creation of waiting list for patients to access a trial due to limited clinical resources. As clinicians have seen the benefits of MPK's, the service have started to prescribe them to new patients as a first prescription. Little is known about the patient experience of this process.

AIM

The aim of the study was to explore the patient experience of the provision of MPK within an NHS setting for both established and new limb users.

METHOD

Convenience sampling of 5 patients (3 who had previously used a mechanical knee, and 2 new patients receiving their first limb) with a unilateral transfemoral amputation who had received an MPK under the NHS England Commissioning of MPK policy (2016) and who were in clinic on a selected week in August 2023. Individual semi structured interviews were carried out on MS Teams to allow recording and transcription, with the verbal agreement of all participants. Data was stored in line with Trust policies. All interviews were undertaken by one person. Thematic analysis was undertaken by 3 individual and results compared to confirm identified themes.

RESULTS

Table 1. Key Themes

Theme	Example
Acceptance of waiting list	"I was expecting to wait"
Choosing an MPK	"happy going of recommendation of the team" "I wish there was a comparison chart", "Ability to speak to another user"
Trial Process	"I understood why you had to do it", "I didn't find any of them (questionnaires) too onerous or demanding"
Impact on the individual	"It felt more a part of me and felt more natural", "getting the mpk has changed my life for the better"

DISCUSSION AND CONCLUSION

Patients understood the need for a waiting list and for a trial and within this cohort the longest wait was 28 months. Bias was minimised in that the interviewer had provided clinical rehabilitation to only one of the respondents. Insights gained about individual benefits from MPK provision builds on the work of Strafella (2021) and highlights the need for inclusion of qualitative methods when evaluating the benefits of MPKs.

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6.019 State of the Art: Prosthetic treatments after amputations in the pelvic area

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BACKGROUND

The prosthetic fitting with pelvic amputations is a challenge for orthopedic technology as well as for the user. Novel procedural and manufacturing techniques have been bringing new qualities of care to prosthetic user.

AIM

The lecture presents different options for prosthetic treatment. This shows that the use of individual silicone interfaces as skin protection and as a compressing medium to prepare the residual limb/abdomen for the prosthesis socket plays a key role.

METHOD

The silicone interface can have different designs to meet the needs of the user. The prosthesis socket in carbon pre-preg technology can be implemented in a two-part design with dorsal closure technology and in a two-part design with a dorsal, semi-elastic intermediate piece and ventral closure technology. The lecture will go into the advantages and disadvantages of both systems.

RESULTS

The conventional construction of a classic hipbasket prostheses using lamination resin technology has almost completely given way to the socket techniques described in our company. The fit results achieved convince with a reduced stump-socket pseudarthrosis, with an optimized stress situation on the skin surface, with the good cleaning options and the associated socket hygiene. Furthermore, users report improved adaptation to different volumes and better control options for the prosthesis.

DISCUSSION AND CONCLUSION

The authors see the socket systems presented in a special position compared to conventional systems. The outcome of the treatment is excellent. These systems involve increased production costs, a high degree of expertise, the necessary operating equipment to implement the manual tasks, and thus higher costs compared to conventional socket systems.



6.020 Ischial Containment Versus Quadrilateral Sockets Satisfaction for Unilateral Transfemoral Amputee

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BACKGROUND

In Iraq, the most using socket design for above-knee prostheses is the quadrilateral socket (QL) design which is describe as flatter and more open shape ^[1]. While there are many new sockets designs such ischial contentment (IC) socket which is a device designed to provide intimate contact with the ischial tuberosity in the pelvis that bears a significant portion of the body's weight when sitting ^[1].

AIM

To compare the superiority or inferiority of (IC) socket with (QL) for persons with unilateral transfemoral amputation regarding the comfort, functional performance, and preferability of using for the client.

METHOD

This study compares 2 socket designs utilized for patients with above-knee amputations. The samples were 25. The participants selected from: Governmental and Private centers specializing in prosthetics. Data was collected between November 2023 and February 2024. Their feedback regarding 2 prosthetic designs, the old one (QL), and the new one (IC) socket, focusing on comfort and daily usability. The data obtained through interviews by structured questionnaire designed for data collection ^[2].

It comprised three sections: Biographical information., Assessment of satisfaction with the sockets., Evaluation of the ease or difficulty experienced by users. The socket use period ranged from 6-18 months.

RESULTS

Total sample: 22 participants were included for data analysis

Demography: 86% male, 14% female; Age 50 ±14.41 years.

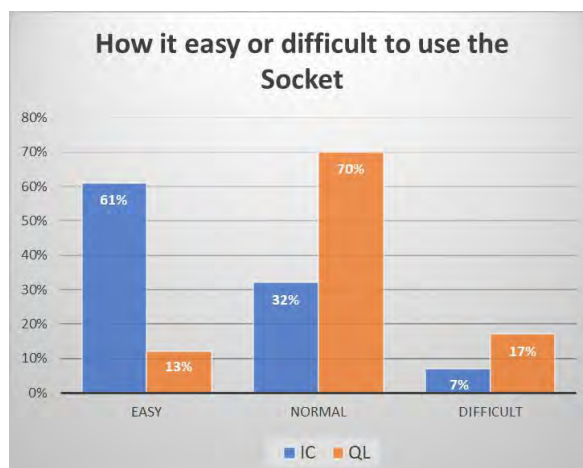
The average results of participants who responded to 16 questions on how it was easy or difficult to use sockets:

IC: Easy 13.375, Normal 7.0625, and difficult 1.5625

QL: Easy 2.6875, Normal 15.5, and difficult 3.8125.

While the results by percentage for the 16 questions were:

As shown in the figure below, 61% of participants answered that the IC is easier than QL and 17% of them answered that the QL was difficult. Regarding the results of to 8 questions, participants' responses on which one is more satisfactory for use found that 95% of participants answered that the IC was more satisfactory in comparison to 5% of participants they satisfied with the QL.



DISCUSSION AND CONCLUSION

Results found that 95% of participants were more satisfied using the IC socket than QL.

Klotz et al. and Fatone et al. found that IC was preferable to QL sockets ^(3,4).

This study evaluated the effectiveness of IC versus QL sockets for unilateral transfemoral amputation in Iraq, focusing on user comfort and functionality.

The findings demonstrate that participants clearly preferred the IC socket over QL.

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6.021 Management of Verrucous Skin Lesions in Amputees: A Successful Case Study

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BACKGROUND

The skin of prosthesis-wearing amputees faces various stresses, including volume fluctuation, localized pressure, and disrupted blood and lymph flow (S. William Levy). The socket, essential for weight bearing, can intensify stress on stump skin. Improperly fitted sockets often aggravate a warty skin condition on the distal stump, commonly observed in such cases. This highlights the importance of precise socket fitting to prevent dermatological complications in amputees (HEJ Meulenbelt, 2006).

AIM

This case wants to describe an effective management of warty dermatitis in a transfemoral amputee through suspension socket modification and targeted medication, resulting in significant improvement in limb health.

METHOD

A 39-year-old male, a traumatic transfemoral amputee, a k-level 3, presented with a warty lesion on his residual limb. He had been using a Direct Socket for 8 years, paired with a pneumatic polycentric knee and a carbon fiber foot.

The patient was referred to the MGOrtopedia clinic, where, in collaboration with a psychiatric team, a new socket with a pin suspension interface liner (model 6Y80 from OttoBock) was designed and manufactured. The patient also received specific medical treatment targeting the skin condition, Fucicort® cream.

The fitting process began with a check socket to ensure compatibility and comfort. After a six-month evaluation period, a final custom socket was fabricated and fitted.

Throughout this period, photographic documentation was conducted regularly to monitor the progression and healing of the stump lesions.

RESULTS

A 39-year-old male, a traumatic transfemoral amputee, a k-level 3, presented with a warty lesion on his residual limb. He had been using a Direct Socket for 8 years, paired with a pneumatic polycentric knee and a carbon fiber foot.

The patient was referred to the MGOrtopedia clinic, in collaboration with a psychiatric team, a new socket with a pin suspension interface liner (model 6Y80 OttoBock) was designed and manufactured. The patient also received specific medical treatment targeting the skin condition, Fucicort® cream.

The fitting process began with a check socket to ensure compatibility and comfort. After a six-month evaluation period, a final custom socket was fabricated and fitted.

Throughout this period, photographic documentation was conducted regularly to monitor the progression and healing of the stump lesions.



Figure 2. Distal stump A (distal view) and B (lateral view) – after one month of wearing prosthesis with new system socket

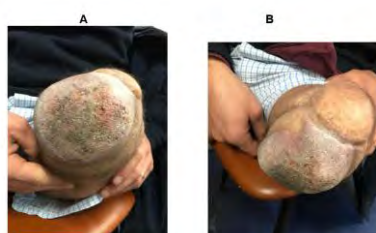


Figure 1. Distal stump A (distal view) and B (lateral view) – wearing prosthesis with Direct Socket



Figure 2. Distal stump A (distal view) and B (lateral view) – after one month of wearing prosthesis with new system socket



DISCUSSION AND CONCLUSION

Results show significant improvements in stump condition and prosthesis comfort. Amputees often face skin issues from socket pressure and contact, making the socket a crucial component. Efficient, well-fitting socket design is essential to enhance comfort and reduce skin complications for prosthetic users.

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6.022 A case study of lower limb prosthesis fabrication for a male patient in his 60s with bilateral transfemoral amputations

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BACKGROUND

For patients with transfemoral amputation, lower limb prostheses are essential assistive devices for daily living. Lower limb prostheses should be fabricated considering the individual characteristics and potential functional level of the patient.¹ The fabrication process involves several stages, from assessing the patient's characteristics to manufacturing the socket and prosthesis, fitting, and wearing.

AIM

The aim is to fabricate lower limb prostheses for bilateral transfemoral amputees, enabling independent sitting, standing, and walking.

METHOD

The residual limb lengths are 20 cm (L) and 22 cm (R), and the flexion contractures measured by the Thomas test are 17° (L) and 15° (R). As changes in the size of the residual limbs are expected in the future, a silicone liner suspension was used, and the socket is an Icelandic-Scandinavian-New York socket, which is an ischial containment and flexible inner socket supported by a rigid outer frame with cut-out sections. Additionally, to enable the patient to stand up and sit down independently, the prostheses were fabricated using the OSSUR Power Knee, which is a motor-powered microprocessor knee.

RESULTS

The socket is Icelandic- Scandinavian-New York socket: the outer socket is laminated with carbon material, while the inner socket is made of flexible material. The silicone liner used is the OSSUR Iceross Seal-In X5, and an OSSUR knee rotation adapter was used to facilitate floor-sitting lifestyle. To assist with standing and walking, the OSSUR Power Knee and Pro-Flex XC foot were used.



DISCUSSION AND CONCLUSION

Gait training and physical therapy were conducted while wearing the OSSUR Stubby foot, which helped prevent flexion contractures of the residual limbs and developed a sense of balance for weight-bearing. Considering the changes in the residual limbs, a silicone liner and an ischial containment socket were fabricated. The prostheses were made using an active knee joint to assist the patient in sitting down and standing up independently.

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6.023 Measuring the Metabolic Energy Consumption: Which is an Appropriate Study Design for Prosthetics and Orthotics?

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BACKGROUND

The metabolic energy consumption (MEC) of locomotion is increased for prostheses and orthoses users. As an example, the MEC is increased significantly the higher the amputation level is. The aim of a technological intervention is providing a metabolic efficient and natural gait. Next to established biomechanical and clinical methods, the MEC seems to be an adequate addition. Nevertheless, the study design used influences the validity of the results.

AIM

Investigating an adequate methodological approach to ensure quality and validity of the results and to further allow for correct interpretation of the clinical relevant outcomes.

METHOD

A literature analysis was conducted to identify appropriate reference numbers of repeated measurements with prostheses and orthoses users. Additionally, a case study with a repetitive design was performed with one transtibial amputee (TTA) and one transfemoral amputee (TFA). Level ground walking and ascending a 5° inclination with an active foot optimally adjusted with (ON) and without (OFF) active push-off was analyzed on a treadmill using spiroergometry (Cortex MetaMax 3B). Four measurement sessions with three examinations each were completed within 2 weeks. The order of the three foot settings (ON or OFF) within each session was randomized.

RESULTS

Former studies measuring the MEC while using prosthetic or orthotic interventions were not designed as repetitive and randomized investigations. Some studies eliminate possible adaptation effects as walking on a treadmill or wearing portable measurements system by randomization [1,2,3,4].

Table 1: Metabolic energy costs [ml O₂/min/kg] of TTA and TFA for walking on level ground and a 5° incline.

situation	transtibial (TTA)				transfemoral (TFA)			
	foot OFF		foot ON		foot OFF		foot ON	
	max	min	max	min	max	min	max	min
level ground	13,3	12,5	12,1	11,7	12,7	11,3	12,4	10,6
5° ascent	17,1	15,7	15,5	15,3	15,7	14,0	14,9	14,0

But some study designs did not consider these effects influencing the validity of the data significantly [5,6]. For this case study, the uptake of oxygen [ml O₂/min/kg] was used for measuring the MEC. The mean values for the four daily sessions including three trials with foot ON or OFF are shown in table 1. Additionally, a continuous stepwise reduction of the MEC could be found over the period of all four sessions for both subjects. Thus, the individual adaptation to the measurement set-up led to a subsequent lower MEC after a series of repetitions.

DISCUSSION AND CONCLUSION

The study design of measuring the metabolic energy consumption of prosthetic and orthotic users is crucial in terms of data validity. Thus, repetitions of specific measurement situations seem to be essential. A previous test trial for adaptation to the test set-up is mandatory. But the number of repeated measures should not exceed the capabilities of the individual subject. A repetitive, randomized cross-over design (A-B-B-A or B-A-A-B) is recommended.

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6.024 Prosthetic gait reconstruction for a person with average length transfemoral residual limb with very short femur – A case study

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BACKGROUND

Length of the transfemoral residual limb may affect outcomes of prosthetic rehabilitation because the shorter the residual limb is, the less effectively it acts as a lever arm for transmission of force and coronal stabilization. Therefore, it may be difficult to reconstruct the gait of a person with an average length transfemoral residual limb with very short femur.

AIM

The aim of this study is to present the process of gait reconstruction using a prosthesis for a person with an average length transfemoral residual limb with very short femur.

METHOD

This is the case of a 45-year-old male, 180cm in height, 87kg in weight. He underwent a left transfemoral amputation due to trauma and skin grafts were performed. After the wound healed, he was transferred to our hospital for rehabilitation. The residual limb was 196mm in length, but the femur was only 90mm. A demo transfemoral liner was applied to reduce edema and to confirm liner indication. After that, a temporary cast socket with a locking liner, a knee joint, and a foot was built for standing/walking exercise. On the 13th week, an IRC check socket was fitted. On the 15th week, the definitive prosthesis was delivered and he was transferred back to his original hospital.

RESULTS

Upon discharge, he could walk 350m with a cane and 80m without a cane. His average gait speed was 0.57m/s. He did not use a wheelchair in daily life, but used one when travelling long distances. The gait was similar to that of persons with hip disarticulation.



DISCUSSION AND CONCLUSION

The cast socket was useful in evaluating prosthetic indication. A Silesian belt was applied to the IRC socket to reduce lateral instability, though, its effect was limited and the stance duration on the amputated side was shorter than that of the non-amputated side. To avoid falling due to limited transmission of force, a knee joint with a weight-activated friction brake was adapted successfully. It is concluded that these devices were effective for gait reconstruction of this case.



6.025 Post-mortem rat model for assessing tissue viability and Deep Tissue Injury force thresholds using an Organ Perfusion System

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BACKGROUND

Deep-tissue injury (DTI) is a type of pressure ulcer (PU) where damage begins in the deep tissues and spreads outward, eventually affecting the superficial skin ^[1]. Limited understanding of the force thresholds leading to DTI underscores the need for experimental models to investigate this injury process, which is essential for preventing deterioration and enhancing prosthetic design to protect lower limb amputees ^[2,3].

AIM

To examine the effects of mechanical loads on DTI development in a post-mortem rat using a universal organ perfusion system.

METHOD

A universal organ perfusion system, modified to function like an Extracorporeal Membrane Oxygenation (ECMO) circuit, will perfuse a Sprague-Dawley rat. After euthanasia via Schedule 1 (lethal injection), the aorta and cava will be cannulated for system connection. Firstly, the system will be tested on a deceased rat, maintaining stable circulation through a reservoir with air pumps for oxygenation. Blood flow will pass through a reservoir, roller pump, windkessel bubble trap, and heat exchanger, then return to the artery. Continuous monitoring of parameters like arterial pressure, oxygen saturation, pH, and flow rate will validate functionality before applying mechanical loads to simulate DTI.

RESULTS

Data collection is ongoing with a post-mortem ECMO rat model to assess DTI thresholds. Preliminary results will focus on verifying the stability of perfusion, oxygenation, and tissue viability under mechanical loading. Initial validation of perfusion parameters will provide a basis for evaluating force thresholds that lead to DTI. Expected outcomes include a stable perfusion system in the rat model, with consistent blood flow and oxygenation, aligned with previous studies on mechanical loads ^[3] and post-mortem ECMO models ^[4].

DISCUSSION AND CONCLUSION

This project establishes an ECMO-based model that preserves post-mortem tissue viability, enabling precise mechanical loading to simulate DTI in amputees. Findings are anticipated to identify force thresholds that lead to DTI, supporting advances in prosthetic design by guiding decisions on pressure redistribution, dynamic adjustment and material selection. Preliminary data will refine the methodology and contribute to future live models once licensing is secured, enhancing the model's clinical relevance and applicability for amputee care.

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6.026 Assessment of Health-Related Quality of Life and Mobility Performance among Lower Limb prosthesis Users in Northern Zone Tanzania

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BACKGROUND

Studies show that lower limb amputation mainly affects a person's physical health, such as their ability to move and carry out everyday tasks. While mental health can also be affected, the physical challenges are usually more visible. Concerns like pain, limited movement, and the need for prosthetics are more directly felt, while emotional or psychological challenges may not be as obvious but are still important to address. (Shaw et al., 2018)

AIM

- To assess health-related quality of life among lower limb prosthesis users
- To assess mobility performance among lower limb prosthesis users
- To Correlate between health-related quality of life and mobility performance

METHOD

The selected approach for this research involves a multidimensional investigation into the quality of life and mobility performance of individuals fitted with lower limb prostheses. The study will use various tools to systematically evaluate subjective and objective aspects of their experiences.

The Euro Quol-5D (EQ-5D-5L) self-reported questionnaire will be used to measure the quality of life among prosthetic users. Also, the study will examine the mobility performance of prosthetic users using three separate metrics: The Amputee Mobility Predictor with Prosthesis (AMPPRO), Prosthetic Limb Users Survey of Mobility (PLUS-M) and Two-minute walk test (2MWT).

Lastly, the research aims to explore the Correlation between quality of life and mobility performance among individuals with lower limb prostheses. By analyzing the relationship between these two key factors, the study seeks to uncover potential correlations and identify factors that may influence overall well-being and mobility outcomes.

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Posters | Prosthetics lower limb: transtibial, ankle, foot

6.027 Design and mechanical validation of a modular system for pediatric lower limb prostheses

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BACKGROUND

In Mexico, pediatric prosthetics pose a financial burden on the patient's family, as lower limb prosthesis costs between 2.8 and 20 times the average monthly income [1]. Additionally, children grow 1-2 cm annually, requiring frequent replacements to avoid pathological gait [2], [3]. This study presents a modular prosthetic system, designed to expand by 7 cm, addressing cost and adaptability, validated through mechanical testing for technical feasibility.

AIM

Design and mechanically validate a modular system for pediatric lower limb prostheses by conducting static compression tests on Acetal and Aluminum 6061 using a Universal Testing Machine (UTM).

METHOD

A mechanical testing protocol was designed to conduct static compression tests. A uniaxial load was applied to the top of the modular system, calculated using the maximum weight of the user (96 kg) minus 16% accounting for lower limb weight loss.

Three static compression tests with a maximum load of 800N were conducted on each material at 7 cm extension, using speeds of 1.3 mm/min and 0.127 mm/min, per ASTM standards. A fourth modular system was tested to determine the failure point.

RESULTS

In the Stress vs. Displacement graph for Acetal vs. Aluminum 6061, the Acetal modular systems show a displacement of 0.41 mm with stresses between 2,292,211.62 and 2,296,461.44 Pa (N/m²). On the other hand, the Aluminum samples registered displacements of 0.02 to 0.04 mm with stresses between 2,292,312.72 and 2,298,890.02 Pa. For both materials, it can be inferred that they remain in their elastic region, indicating that the displacement from the applied stress did not result in permanent deformation.

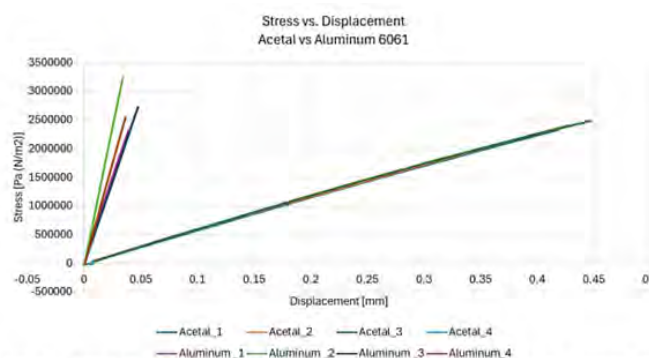


Figure. 1 Stress vs. Displacement graph of static compression for four modular systems of Aluminum 6061 and Acetal on the UTM

DISCUSSION AND CONCLUSION

After reviewing Stress vs. Displacement data and failure points for Acetal and Aluminum 6061, static compression tests validated the modular prosthetic system. Acetal reached 14.2561MPa with 4.47 mm displacement, while Aluminum 6061 reached 77.7597MPa with 2.3497 mm displacement. Both materials met technical requirements, however Acetal was chosen for its lighter weight—221 grams less—making it more suitable for prosthetic use with connectors like Ottobock 4R21.

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6.028 Project bike leg: a potential answer for those without proper prosthetic services

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BACKGROUND

The need for prosthetic services in developing nations is staggering. Roughly 75% of amputees worldwide do not have access to prosthetic services and are left to either make their own or go without. There are many programs operating throughout these regions with the goal of establishing a sustainable training program and logistics flow to address this gigantic health need.

Although these programs offer the most time tested way of approaching the subject, the process of implementing a lasting solution with semi modern techniques takes immense time/energy/resources. The statistics are not likely to change but by a few percentage points per year at this rate, and they may not be changed at all in certain regions without luxuries like electricity or thermoplastics.

What if there was a method to create a prosthesis with items/resources at hand that did not require electricity or advanced equipment? What if this device was also highly adjustable and dependable? What if the process of making such an open source device could be presentable on the internet for all to see?

AIM

Project Bike Leg aims to provide a safe, sustainable, and highly adjustable below the knee prosthesis made from a bicycle frame to those amputees in extremely limited settings. The goal would be to leverage the internet to provide a feasible fabrication guide via video to educate the users/technicians on proper construction/adjustment.

METHOD

A prototype design was established and implemented on a below the knee amputee. He ambulated within the leg for a time to determine design flaws and to demonstrate the capabilities that the design would allow for.

A video was created detailing the process with supporting verbiage to allow watchers to fabricate the design themselves. Follow up videos will be created to review potential adjustments that can be made for various scenarios.

RESULTS

The Amputee did well in the bike leg and demonstrated its abilities on variable terrain. The video successfully detailed the design protocol and was posted on YouTube for all to see

(<https://www.youtube.com/watch?v=XK4iO8wf2h4>).

DISCUSSION AND CONCLUSION

Although the prototype was successful, there is much more to be done. This methodology is very early in its development and will take more time/users to further hone the design. As easy as it can be to disregard this method as crude or unmanageable, it is nonetheless a step in a new direction for the field of prosthetics.

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6.029 Regulating the Testing of Load Bearing 3D Printed Socket Distal Ends According to ISO10328

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BACKGROUND

ISO10328 is commonly used as a standard to test 3D printed load bearing sockets ^[1]. Test rigs are custom-made by each researcher, leading to difficulty when comparing data across studies ^[2]. Our aim is to develop a standardised method for testing 3D printed sockets distal ends, allowing for the creation of a consistent test rig to be used for a variety of attachment componentry in accordance with ISO10328 ^[3].

AIM

The aim of this study is to design a standard test rig that can observe the efficacy of a load bearing trans-tibial socket distal end, per condition_II-ISO10328.

METHOD

The following conditions are within the scope of this study:

- Trans-tibial socket with neutral alignment.
- Height and offsets of the distal end were calculated according to formulae provided in the standard.
- Adhering to the standards' test condition_II (patients up to 150kg).
- Four-hole adapter and pin locking system components are included in the distal end test sample.

The offsets and alignments were achieved by using custom-made steel offset. The residual limb was recreated using a custom-made mild steel interior, and silicone with a shore hardness of 00-30 for soft tissue replication.

RESULTS

A predetermined distal end height of 294mm was deemed suitable for comparison purposes. As per figure 1, components 1 & 2 were created to satisfy the positional offsets and angles required for condition II of the standard when using a universal testing machine (UTM). Component 3 was created to apply loading to the distal end sample walls and not the direct distal surface, simulating the relief of the residual limb distal end. To further enhance the simulation of a residual limb, this steel components was designed to allow for the addition of a silicone skin replication layer and/or a prosthetic liner with/without a pin attachment. All steel samples were CNC machined. Holes were added to attach each part to predetermined adapter componentry, the UTM base and load cell.

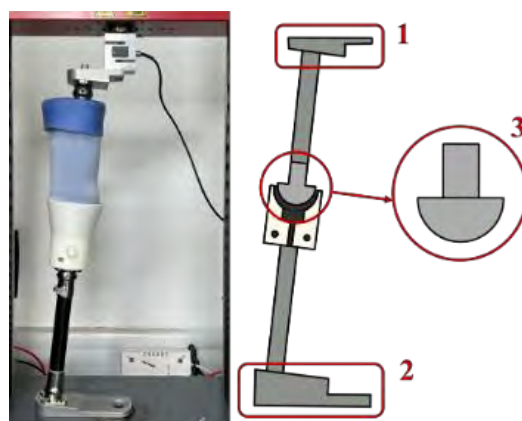


Figure 1. Achieved test rig, created according to ISO10328, with custom steel componentry highlighted & numbered in red.



DISCUSSION AND CONCLUSION

By utilising the identified steel componentry created for this study, this rig can test a wide range of trans-tibial sockets according to condition II (ISO10328). Variables can include, but are not limited to: distal adapter changes, pin lock exclusion, valve additions, distal sample density, distal sample topology. By adding a universal joint to the upper steel componentry, a variety of distal end offsets and alignments can also be tested.

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6.030 Evaluating Hybrid Socket Versus Total Surface Bearing Techniques in Unilateral Transtibial Amputation: Rotational Control, Socket Fit Satisfaction and Interface Pressure

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BACKGROUND

A key factor in the success or failure of the prosthesis is its socket properties, which include efficient fitting, appropriate load transmission, stability, and control. So, to achieve functional and comfortable prostheses, great attention must be paid to the socket design, which represents a critical interface between the stump and the prosthetic.

AIM

This study aimed to evaluate the outcomes of unilateral transtibial amputees utilizing hybrid socket casting and molding technique in comparison to total surface bearing (TSB) socket.

METHOD

Eight individuals with unilateral transtibial amputation (female= 2, male= 6) participated in this cross-over design trial. Each participant used both the TSB and hybrid socket casting and molding designs. Four weeks after the utilization of each socket, the assessment was conducted on socket fit satisfaction (measured through the Comprehensive Lower Limb Amputee Socket Survey), socket rotation (evaluated using a standard meter), socket/liner interface pressure (monitored with ten force-sensitive resistors), and the amputees' decision regarding the retention of one of the sockets following the trials (gauged via a numerical rating scale).

RESULTS

The amputees experienced greater stability ($p=0.02$) and improved lateral rotational control ($p=0.01$) during prosthetic gait when using the hybrid socket, compared to the TSB socket. Local pressure on the anterodistal tibia and the head of the fibula was not statistically significant ($p>0.05$) between two socket types. The decision of participants to retain the hybrid socket was significantly higher than that for the TSB socket following the trial period ($p=0.03$).

DISCUSSION AND CONCLUSION

The hybrid socket design may offer advantages by providing improved socket stability and rotational control during walking and also reducing local pressure on the anterodistal tibia and fibula head. Additionally, it maintains the total surface contact concept.



6.031 Impact of mobility training for people with lower limb amputation: an international perspective

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BACKGROUND

Improving mobility has been shown to have a positive influence on quality of life in individuals with lower limb amputations ^{1,2}. Programs designed to enhance mobility have the potential to significantly improve quality of life, particularly given that mobility is one of the few influencing factors that is readily modifiable. Organizations have sought to improve quality of life through the introduction of mobility clinics for people with limb loss, which aim to increase mobility through participation in activities designed to improve confidence, balance, strength, and prosthetic skill ². This study examines the impact of mobility clinics across different countries.

AIM

The aim of this project is to determine changes in mobility scores and investigate the relationship between mobility and quality of life in people living with lower limb amputation across three countries.

METHOD

Participants were recruited from Australia, South Africa, and the United States from 2018 to 2024. A total of 55 participants with complete data sets were included in the study: 26 from Australia, 12 from South Africa, and 17 from the United States. Participants completed an online survey containing the PlusM, SF-36v2, along with demographic and other outcome measures. The survey was administered three times: before a mobility clinic, one week following the clinic, and three months post-clinic. Data collection was finalized in September 2024. Analysis is currently underway, examining changes in PlusM T scores, SF-36 scores, and correlations between various factors including quality of life, mobility scores, and demographic items.

RESULTS

Analysis of the data is ongoing. Preliminary results suggest variations in mobility and quality of life scores across the three countries. The study population includes a diverse range of amputation causes and levels, with participants from various socioeconomic backgrounds. Detailed statistical analysis of changes in PlusM T scores and SF-36 scores over time, as well as correlations between mobility, quality of life, and demographic factors, will be presented.

DISCUSSION AND CONCLUSION

This multi-national study provides a comprehensive examination of the relationship between mobility and quality of life in lower limb amputees. The inclusion of participants from three countries offers a unique perspective on how cultural and healthcare system differences may influence outcomes. Preliminary findings suggest complex interactions between mobility, quality of life, and various demographic factors. The results of this study will contribute to a more nuanced understanding of how mobility interventions can be tailored to improve the quality of life for people living with lower limb amputation across different global contexts.

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6.032 An anthropomorphic design of an adaptive artificial foot

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BACKGROUND

Falls remain prevalent among individuals with lower-limb loss, and uneven terrains often destabilise prosthetic users. Many adopt compensatory strategies that increase fatigue and exacerbate gait asymmetries^[1], overloading the sound limb. This instability stems from the limited ground adaptability of most commercially available foot prostheses, typically composed of carbon fibre laminates, which can only offer a stiff interaction with the ground, behaving like cantilevers on irregular surfaces^[2].

AIM

This work addresses the need for prosthetic feet capable of adapting to all terrains while ensuring stability through the design of a novel anthropomorphic adaptive prosthesis.

METHOD

Adaptability in current prosthetic feet is usually addressed with split toes in carbon laminates, and passive or active ankle impedance adjustments for slope navigation and swing ground clearance, disregarding sole deformation^[2]. Our approach diverges by drawing inspiration from the human foot anatomy and functionality, and exploiting soft robotics for a compliant interaction with the environment. The human foot modulates its stiffness based on gait phase and terrain, softening for ground impact absorption and stiffening for push-off propulsion^[3,4]. It filters terrain irregularities: the soft tissues of the sole absorb minor roughness, while joint flexibility handles larger ones, optimizing ground contact area^[4].

RESULTS

We developed the SoftFoot: an adaptive, passive, artificial foot, initially designed for robots (Figure 1)^[5]. Its unique sole features five flexible chains made of modular components connected through an inextensible link and elastic bands. The intelligent design allows the sole to conform to ground profiles, while passively stretching and stiffening under load, providing stability, shock absorption, and contributing to push-off propulsion. Preliminary simulations and tests with a healthy subject using customized walking boots showed that the prosthetic SoftFoot increased the stable contact area with obstacles, leading to a mean stance load on it greater than that on a rigid foot (Figure 1)^[6]. Tests with a prosthetic user indicated that the flexible sole eased obstacle negotiation while supporting body weight, reducing the user's mental burden and compensatory movements.



Figure 1 On the left, SoftFoot prototype for robots. In the middle, a comparison between a prosthesis with a rigid sole and the SoftFoot prosthesis^[5]. The SoftFoot also offers a more natural aesthetic, even with shoes. On the right, sagittal force measured by a load cell placed between the prosthetic foot and the walking boot worn by a healthy subject. The force profile when stepping on an obstacle (dotted line) with the SoftFoot (red line) remains closer to that for level walking (solid line) than with the VariFlex (an Össur carbon foot - blue lines), and it is on average greater than that of the VariFlex.



DISCUSSION AND CONCLUSION

The SoftFoot enhances ground adaptation, thus stability, reducing compensatory strategies and potentially fall risk. Experimental data from prosthetic user will be published (post-processing ongoing) to substantiate these findings, with larger experiments planned. The passive design reduces weight, size, maintenance, and costs, thanks also to 3D-printed components. An open-source release is planned ^[7]. Therefore, the SoftFoot exemplifies “innovation towards sustainable rehabilitation”, providing an accessible option, especially for users in challenging environments.

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ACKNOWLEDGEMENTS

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6.033 The effect of build height on a LLTE-optimized prosthetic keel design for pediatric use

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BACKGROUND

Designing prosthetic feet for pediatric users presents unique challenges due to rapid growth rates and high activity levels, requiring designs that balance affordability with biomechanical functionality (Postema, 2016). When designing for children, accommodating a longer residual limb is important due to the preservation of limb length in pediatric amputations (Krajbich, 1998). The Lower Leg Trajectory Error (LLTE) Framework enables systematic optimization of prosthetic keel geometry and stiffness to replicate able-bodied gait patterns. Olesnavage (2018) introduced LLTE as a method to enhance gait fidelity, with subsequent prototypes performing comparably or superior to commercial carbon fiber ESR feet in gait lab settings (Prost, 2022).

AIM

To evaluate the feasibility of the LLTE framework for pediatric keel design, focusing on the relations between LLTE, energy return potential, and prosthetic build height.

METHOD

Using LLTE as a primary metric within a computational optimization framework, this study explores the biomechanical impact of various build heights and keel topologies for pediatric prosthetics. A representative pediatric kinematic and kinetic dataset informed the generation of multiple design configurations. Each configuration was subjected to biomechanical simulation to assess its impact on stiffness, trajectory accuracy, and energy return. Structural analysis of the prosthetic foot model quantified the lower limb position and orientation, providing insights into each design's ability to support gait-like biomechanics.

RESULTS

Reconfiguring the optimization constraints to fit a representative pediatric user yielded physically feasible keel topologies for a variety of build heights. Initial results suggest that lower build heights are associated with increased LLTE. When compared to adult data, pediatric keel designs were able to achieve relatively higher energy return and decreased LLTE at shorter build height configurations.

DISCUSSION AND CONCLUSION

Though decreasing build height may increase the LLTE value, the effect is less dramatic for children than for adults. As children have a proportionally shorter shank length, less of a moment arm is present than for adults. Initial findings imply that the LLTE framework shows promise in the pediatric field through its ability to produce keels with good energy return despite a low build height. This work can be used to inform future development of pediatric prosthetics that are cost-effective and biomechanically advantageous.



6.034 Towards an Actuated In Vitro Model for Studying Skeletal Muscle Adaptation under Mechanical Loading

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BACKGROUND

Prosthetic devices impose unnatural mechanical stresses on residual limb muscles, causing tissue remodelling that can lead to pain, deep tissue injuries, and pressure ulcers ^[1]. Understanding muscle remodelling is essential for improving prosthetic design, yet research on injury mechanisms under dynamic, cyclic loading is limited ^[2]. To address this gap, we aim to develop a compressible, tissue-mimicking cell culture system to investigate cellular behaviours driving muscle adaptation under mechanical stress.

AIM

To develop a 3D *in vitro* model that can be subjected to mechanical loading conditions that mimic those experienced by muscles during prosthetic use, enabling investigation of muscle tissue adaptation.

METHOD

3D cell culture skeletal muscle models were created from freshly isolated mouse tibialis anterior muscle tissue, from which satellite cells were obtained by enzymatic digestion and mechanical dissociation. Cell suspensions were mixed into collagen gels (Collagen I from rat tail, Ibbidi) and seeded into 3D microwell plates (μ -Plate 96 Well 3D, Ibbidi). Optimisation of proliferation and differentiation culture media was performed using 2D culture, with cells seeded on collagen-coated substrates and supplemented with varying concentrations of basic fibroblast growth factor (bFGF) and serum. Immunocytochemistry was used to assess the presence of markers of skeletal muscle maturation.

RESULTS

Satellite cells freshly isolated from tissue demonstrated strong proliferation and differentiation in both 2D and hydrogel-supported 3D cultures. By day 7, MYoD-positive myoblasts indicated early differentiation, and by day 14, MYF6-positive contractile myofibers with organised sarcomeres and spontaneous contractions confirmed the onset of a mature phenotype. Higher bFGF concentrations (≥ 8 ng/ml) significantly enhanced cell proliferation ($p < 0.05$) and supported functional development, as seen in increased myoblast fusion and improved sarcomeric alignment. 3D hydrogel cultures displayed promising structural organisation, laying a solid foundation for further refinement, including through tailoring of the mechanical properties of the culture by altering hydrogel composition.

DISCUSSION AND CONCLUSION

Hydrogel-based 3D cultures can be readily implemented within organ-on-a-chip platforms, miniaturised systems that offer several advances upon traditional cell culture techniques, including the ability to incorporate the controlled application of mechanical forces, alongside microfluidic networks for controlled tissue perfusion. Ongoing work is focussing on integrating the 3D culture model into such a system to enable cyclic loading, ultimately providing insights into tissue remodelling in response to prosthetic-induced mechanical stresses.

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ACKNOWLEDGEMENTS

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6.035 Investigation of Fiber Orientation of Composite Prosthetic Running Blade Foot using Finite Element Analysis

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BACKGROUND

Running prosthetic legs use carbon fiber composites with energy storage and return (ESR) systems that absorb energy during mid-stance and release it during push-off for propulsion ^{[1][2]}. The mechanical properties of carbon fiber reinforced composites (CFRPs) are anisotropic, showing different strengths based on fiber alignment ^{[3][4]}. Unidirectional carbon fibers offer superior tensile strength and stiffness along the fiber direction, enhancing performance during running.

AIM

This study evaluates carbon fiber orientation in running prostheses using FEA to identify the most suitable orientation for optimal mechanical performance tailored to the prosthesis's intended use.

METHOD

In this study, a C-type running prosthetic foot was designed using SolidWorks and its finite element model was developed in Ansys. Boundary and loading conditions were applied following ISO 10328 guidelines. Epoxy Carbon Woven from the Ansys library was chosen as the material. The analysis was conducted in two positions, aligned with positions I and II of the gait cycle, per ISO 10328. Four different fiber orientations were applied to simulate the material in the FEA, measuring total deformation, equivalent stress, strain energy, and safety factor values to evaluate the prosthetic design's performance.

RESULTS

In the finite element model, four different variations of the fiber orientation of the composite material were compared. Although the amount of force and the loading line changed in the analyses performed according to positions I and II, similar mechanical behaviors were observed according to the positions in terms of fiber orientation. Fiber orientation changes affected the mechanical response. In the analysis with fiber orientation $[0^\circ, 90^\circ, 45^\circ, -45^\circ]$, it was observed that the total deformation amount was minimum and the safety factor value was maximum. In terms of equivalent stress value, $[45^\circ, -45^\circ]$ fiber orientation is the highest. $[0^\circ, 90^\circ]$ orientation gave the highest data in terms of Strain Energy value.

DISCUSSION AND CONCLUSION

The results identified optimal carbon fiber orientations for runner prosthetic foot production. For strength, a specific orientation is recommended, while another is preferable for energy storage. The analysis showed that fiber orientation can be adapted to meet the functional needs of amputee athletes. This methodology offers valuable insights for evaluating and modifying different runner prosthesis designs based on performance requirements.

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6.036 The possibility of muscle activation facilitation with sensory-stimulating insoles in a patient with flaccid paralysis after a stroke

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BACKGROUND

Immediately after the onset of a stroke, patients often present with flaccid paralysis, which gradually transitions into spastic paralysis. However, the timing and progression of this change depend on the individual. During the flaccid phase, the absence of muscle activity can lead to muscle atrophy and contractures, making early facilitation of muscle activation important. It is also known that painful stimuli can exacerbate spasticity, contributing to increased muscle tone.¹

AIM

In this report, we describe the case of a patient with severe flaccid paralysis following a stroke. We used sensory-stimulating insole to facilitate muscle contraction and conducted standing training. Muscle contraction was objectively evaluated using surface electromyography (EMG).

METHOD

The patient was a 37-year-old man who underwent a craniotomy following a left putaminal hemorrhage. He exhibited severe motor aphasia and severe right-sided hemiplegia, and rehabilitation was initiated on the second day post-stroke. Although he still had severe paralysis at Brunnstrom stage (BRS) I, his ability to follow instructions improved. As a result, standing training with a metal knee-ankle-foot orthosis began on the 8th day. By the 17th day, no increase in muscle tone was observed in the affected limb. We therefore performed standing training with a sensory-stimulating insole to facilitate muscle tone.

To evaluate muscle activity during standing, surface EMG of the rectus femoris, semitendinosus, tibialis anterior, and lateral gastrocnemius was measured and compared between the use of a smooth insole and a sensory-stimulating insole.

RESULTS

When the patient stood on a smooth insole, contraction was observed only in the semitendinosus. However, with a sensory-stimulating insole featuring protrusions, muscle activity was detected in the semitendinosus, tibialis anterior, and lateral gastrocnemius, with amplified activity in the rectus femoris. By the 22nd day, the patient's BRS improved to stage II, and he was transferred to another facility on the 27th day.

DISCUSSION AND CONCLUSION

Sensory-stimulating insoles may facilitate muscle contractions in flaccid, paralyzed limbs. Their use could help prevent muscle atrophy and promote early gait acquisition, thereby supporting the patient's recovery.

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6.037 Complications After Using Transtibial Prostheses in Diabetic Patients

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BACKGROUND

Diabetes mellitus is a global health issue that affects millions of individuals, prevalence significantly increased, contributing to an increase in the number of cases related complications. Poor blood circulation cause tissue damage and increase risk of amputation. For individuals with transtibial amputations satisfaction with the prosthesis is essential and influences the optimization of use in managing treatment with prostheses, it important to identify the complications faced by diabetic amputees ⁽¹⁾.

AIM

Research aims is investigating complications experienced by diabetic patients using patella tendon bearing-supra condylar (PTB-SC) transtibial prostheses. and will adopt a multi approach to provide recommendations for newly designed prostheses.

METHOD

This retrospective study assesses key outcome measures and complications associated with the use of transtibial prostheses in diabetic patients attending the Erbil Physical Rehabilitation Centre (EPRC) of International Committee of the Red Cross (ICRC).

The participants were diabetic patients with a history of using (PTB-SC) transtibial prostheses.

All participants provided informed consent.

Demographic information and stump properties were collected.

Twenty-seven participants were included in the study.

A modified OPUS questionnaire, a 2-minute walk test, and the Visual Analogue Scale (VAS) were utilized to evaluate satisfaction and complications, walking ability, and average pain at rest, respectively.

RESULTS

The sample size was 27 (20 males and 7 females).

The complications observed among participants were volume change (11.1%), pain during activity (59.26%), and redness (14.8%). No-complications accounted (14.8%). The mean walking ability (94 meters per 2 min), pain at rest (21.85%), and satisfaction (66.82%) are affected by the type of complications.

The walking ability is one of the important items influenced by the type of complication. In below figure (A) is shown when there was no complication, the ability to walk was more and the person walk for longer distance. In addition, the correlation between the type of complications and satisfaction is shown also in figure (B) when there is no complication, the percentage of satisfaction is higher.

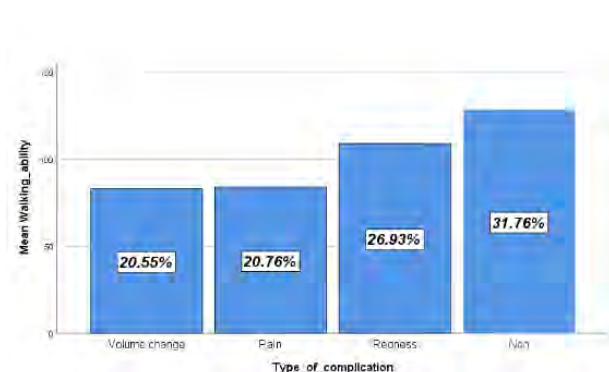


Figure A: Complications and Walking Ability

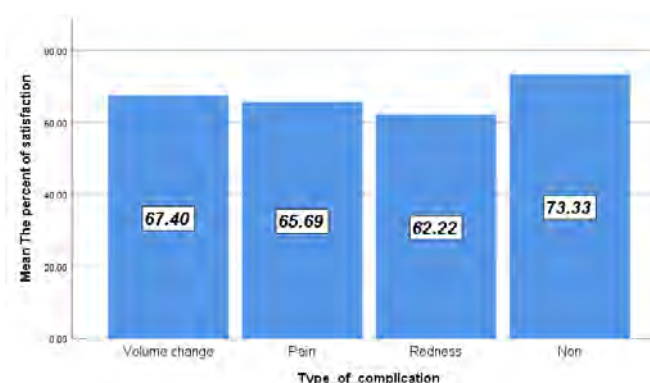


Figure B: Complications and Percent of Satisfaction

DISCUSSION AND CONCLUSION

Complications an important consideration in prosthetic management.

The study identified pain, redness, and volume change as primary complications experienced by participants. Pain was the most prevalent complication. These findings highlight the need for monitoring and intervention to ensure optimal prosthetic usage⁽²⁾.

In conclusion this study provides valuable insights into the experiences of individuals with diabetic amputations using transtibial prostheses. Despite experiencing mentioned complications participants demonstrated satisfactory walking ability.

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6.038 Time course Human Adaptations during Human-in-the-loop Optimization of a Prosthetic Foot

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BACKGROUND

Human-in-the-loop optimization could enhance the effectiveness of prosthetic devices by individually optimizing prosthetic foot parameters, while also taking into account the natural behaviour of humans to simultaneously optimize their coordination pattern with respect to gait performance. However, it is unknown at what time scale humans adapt to changing prosthetic device settings, and therefore what optimization time would be required.

AIM

We aimed to investigate the time course of human adaptations during the human-in-the-loop optimization process of a tuneable prosthetic foot to lower the metabolic cost of walking.

METHOD

10 transtibial amputees underwent an optimization protocol to tune stiffness and alignment of an experimental prosthetic foot. The protocol consisted of a pre-test, optimization period (6 times 6 iterations), and post-test. During optimization, we aimed to minimize the metabolic cost of walking by optimizing the stiffness and alignment of the prosthetic foot, while allowing the user to adapt to these changes. After each 6 iterations a motor adaptation test was performed. The metabolic cost during the pre-test, 6 adaptation tests, and post-test, all using the same prosthetic foot with standard settings, was estimated based on 2 minutes of continuous measurement of energy cost^[1] and compared.

RESULTS

Metabolic cost of walking differed significantly in the adaptation tests over the course of the optimization process ($p=0.01$; Figure 1). Post hoc tests with simple contrasts showed that from the 4th adaptation test (i.e., 56 minutes of optimization), metabolic cost was significantly reduced compared to the pre-test ($p<0.05$). Helmert contrasts showed that from the 3rd generation (i.e., 42 minutes of optimization), the metabolic cost did not significantly differ from the mean of all subsequent trials ($p>0.05$).

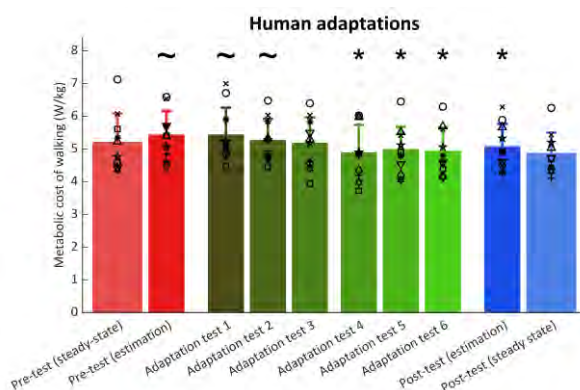


Figure 1: Metabolic cost of walking estimated during the pre-test, motor adaptation tests, and post-test ($n=10$). The coloured bars and error bars show mean $\pm$ standard deviation. Steady-state values of pre-test and post-test, and individual observations are also shown. *Trial is significantly different from pre-test ($p<0.05$). ~Trial is significantly different from the mean of all subsequent trials ($p<0.05$).



DISCUSSION AND CONCLUSION

Metabolic cost of walking during the motor adaptation tests decreased significantly during the optimization process of the prosthetic foot. Human adaptations were only noticeable/seen the first 24 iterations, i.e., 48 minutes of optimization. This study shows that human adaptation has a significant impact during prosthetic optimization and extends over at least one hour in the context of our optimization experiment. This should therefore be taken into account when optimizing prosthetic devices on metabolic cost.

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ACKNOWLEDGEMENTS

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6.039 Telerehabilitation on Health-Related Quality of Life and ICF Frame Paramaters in Persons with Lower Extremity Amputation

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BACKGROUND

Telerehabilitation delivers intervention services remotely via information and communication technology, supporting exercise adherence, improving cost-effectiveness, and enhancing rehabilitation accessibility ^[1]. On February 6, 2023, two catastrophic earthquakes in Turkey's Kahramanmaraş region caused over 50,000 deaths, making it the deadliest disaster in modern Turkish history. The quakes leading to countless new disabilities besides amputation, which among the most significant ^[2]. Overwhelmed healthcare facilities faced severe delays, deteriorating patients' conditions and prolonging rehabilitation timelines.

AIM

This systematic review purpose to evaluate the effectiveness of telerehabilitation on ICF parameters in individuals with lower extremity amputation, providing evidence to guide future outcome measures for research and clinical practice.

METHOD

MEDLINE, PUBMED, SCOPUS (Elsevier), and Web of Science were searched up to June, 2024. A literature search was performed under the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The keywords term used for the searches included 'amputation', 'lower limb', and 'telemedicine' to develop the search template. The terms in each category were connected with "OR," and the two main categories were connected with "AND". The Cochrane Risk of Bias 2.0 tool and GRADE approach were utilized.

RESULTS

Out of 2134 articles screened, eight randomized controlled trials with a total of 487 participants were included. The review found very low level evidence for telerehabilitation interventions in increasing activity levels, social participation, prosthetic use and satisfaction, personal factors and health-related quality of life. There were no adverse events reported as a result of telerehabilitation interventions. Additionally, a notable variation in the characteristics of telerehabilitation programs was observed.

DISCUSSION AND CONCLUSION

Heterogeneity and methodological weaknesses across existing studies limits the conclusions that can be drawn on the effects of telerehabilitation based interventions. As a result, more high-quality clinical trials are needed to confirm the effectiveness of telerehabilitation on Body Structure and Function, Activity, and Participation, as well the inclusion of Contextual Factors in future studies.

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6.040 A collection of 800+ broken prosthetic feet from Sri Lanka (2019-2024)

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BACKGROUND

Prosthetics are used differently by different communities and cultures, leading to disparate modifications and failure mechanisms. A large sample of broken prosthetics is necessary to understand variation in prosthetic use and failure, yet no large-scale collection of used prosthetics exists. This prevents a comprehensive understanding of how prosthetics are used and their designs can be improved, and leads to an intergenerational loss of data.

AIM

We describe a collection of 800+ prosthetic feet from Sri Lanka (2019-2024) replaced due to failure, mostly from Jaffna, and focus on modifications and failure mechanisms.

METHOD

Locally manufactured and imported prosthetic feet were gathered opportunistically from 9 prosthetic and orthotic (P&O) organisations across Sri Lanka and shipped to London for analysis. Prosthetic feet were chosen as upper limb prosthetics are largely not provided in Sri Lanka, and feet are the component of lower limb prosthetics most replaced. Gathering feet at the time of replacement maximizes the time that modifications could have occurred and ensures feet have failed. As replaced feet are “trash” and would be disposed of accordingly, collecting replaced feet allows for feet to be collected without affecting prosthetic provision. Information on each prosthetic was recorded, including place of manufacture, size, and colour, along with type of alterations made to the foot and reason for replacement.

RESULTS

Most prosthetic feet were locally manufactured, and nearly all prosthetic feet were solid ankle cushioned heel (SACH; mostly locally manufactured versions of the International Committee of the Red Cross's foot). All SACH feet experienced wear under the distal end of the keel. Fracture failure sometimes occurred secondarily to wear failure near the site of wear, and toes were occasionally lost. The only cosmetic alteration was nail varnish on the toenails. Structural modifications were only observed on prosthetic feet which had fractured, where local materials including nails, string, and wire were used to hold the foot together. All prosthetic feet had some level of surface degradation which somewhat/severely altered cosmetic properties.

DISCUSSION AND CONCLUSION

To our knowledge, we present the first collection of broken prosthetic feet. This collection reveals information on supply chains (local vs imported resources), manufacture, and provision of prosthetic feet in Sri Lanka. Understanding how these feet are used, modified, and fail reveal information on prosthetic use, the role of prosthetics in society, and how prosthetic feet can be improved to better meet end-user needs.

ACKNOWLEDGEMENTS

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6.041 Defining User and Technical Requirements for a Paediatric Adjustable Transtibial Socket: Data from Qualitative Interviews, Anthropometric Database and Fieldwork

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BACKGROUND

Amputation in children presents additional challenges compared with adults due to growth. Growth affects prosthetic socket fit, which often requires frequent adjustments or replacements [1]. Socket fit issues are exacerbated for children living in humanitarian settings as access to prosthetic care is limited [2]. Although adjustable sockets have been developed, they are currently designed only for adults in high resource environments [3].

AIM

The aim of this study is to identify the unique user requirements of this cohort and translate these into technical requirements to inform the design of an adjustable paediatric socket.

METHOD

A literature review was conducted and complemented with fieldwork in Cambodia, the UK, Nepal and Türkiye to identify user and technical requirements. Qualitative interviews with children and prosthetists were used to define user needs through thematic analysis. Recurrence of themes was used to create a hierarchy of user requirements. From the user requirements, technical specifications were identified and informed by other sources including an anthropometric database, fieldwork and literature review. Anthropometrics of the residual and intact limb collected during casting appointments were utilised to build regression models predictive of residual limb girths, lengths and joint line bone widths.

RESULTS

Prosthetists and children identified overlapping and non-overlapping user requirements, reflecting their different perspectives. Table 1 provides key examples that illustrate the relationship between user and technical requirements. A single user requirement may lead to multiple technical requirements, and likewise one technical requirement can fulfil multiple user requirements as shown by highlighted rows in table 1. Regression models predictive of residual limb girths, condylar widths and length were used to inform the size and degree of adjustability of the socket throughout childhood growth. Girth size increases by 0.9 cm/year and condylar widths by 0.2 cm/year. To date 25 preliminary user requirements have been identified and 30 technical requirements leading to detailed specifications have been developed.

User	User Requirement from Interviews	Technical & Material Requirement	Additional Source to inform Technical Requirements
Children and Prosthetists	Socket Comfort	Socket adjustability to maintain fit	Anthropometric Analysis
		Socket shape does not push on bony prominences	Based on classic TSB/PTB designs
		Soft Material as interface	Fieldwork inventory
Children and Prosthetists	Hiding disability	Socket Size matches intact limb	Anthropometric Analysis
		Adjustable mechanisms embedded in the socket/not bulky	-
		Skin-coloured cover/material	Fieldwork inventory
Children	Running/Playing sports	Socket adjustability to maintain fit	Anthropometric Analysis
		Socket shape does not push on bony prominences	Based on classic TSB/PTB designs
		Trimlines do not interfere with range of motion	-
		Light weight (< current)	Fieldwork inventory
Prosthetists	Ability to fit different residuum and ages	Modular system for different residuum (all parts available in different sizes)	Fieldwork inventory & Anthropometric Analysis
		Adjustability also within the assembled socket for growth	Anthropometric Analysis



DISCUSSION AND CONCLUSION

Technical specifications have been defined for the first time for an adjustable paediatric socket. Anthropometric numerical models were developed to ensure appropriate design sizing, a key factor for both user comfort and adjustability. From this work, a proof-of-concept paediatric socket has been designed, with several design iterations expected based on ongoing feedback from children, prosthetists and engineers to ensure the design meets the user and technical requirements.

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6.042 Effects of Lindhe Xtend Prosthetic Foot on Gait and Prosthetic Mobility – Preliminary Results

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BACKGROUND

An integral part of an individual's prosthetic setup is the prosthetic foot. It is important in clinical practice to fit the right foot for the individual patient's needs. To do this, the expectations of the foot's effects must be clear and based on evidence. Evaluating individuals' gait can be made using motion capture.

AIM

The aim of the study was to evaluate the effects on gait and experience of changing to the Lindhe Xtend[®] prosthetic foot (XF) from the participants' regular prosthetic foot.

METHOD

Inclusion criteria were unilateral transtibial amputation, able to walk 10 meters non-aided, aged ≥ 18 . Recruitments were from prosthetics clinics. Data was collected at two time points, three weeks apart, and included instrumental 3D gait analysis, PLUS-M 12 questionnaire, two-minute walk test (2MWT) with perceived exertion (BORG) and timed-up-and-go (TUG). First assessment was with each participant's regular prosthetic foot before switching to XF, which was used until assessment two. Second assessment included the same protocol with XF. Gait analysis data was analysed using Statistic Parametric Mapping (SPM) (Pataky 2010, Pataky 2015). The study holds an ethical approval.

RESULTS

12 participants (2 women, 10 men) were recruited, 10 completed the study protocol. Mean age was 55,4 years (SD 15,9), mean weight 83,2 kg (SD 24,5) and mean height 1,8 m (SD 0,1). No statistical difference was found for the PLUS-M, TUG or 2MWT. However, BORG at the end of the 2MWT was generally lower when using XF. With XF, the knee showed a significant increase compared to the regular foot in knee extension at later part of the stance phase, and a slightly lower, but still significant, maximal value in ankle dorsiflexion at terminal stance. These changes are closer to the gait pattern of a non-amputated individual, however not statistically significant.

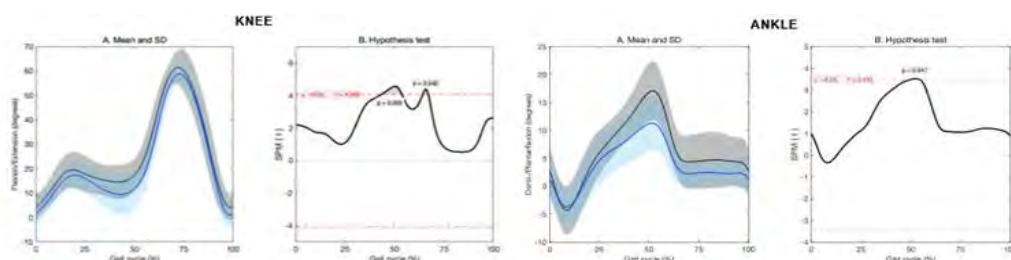


Figure 1. Knee flexion/extension and plantar dorsi-/plantarflexion for prosthetic side comparing visit 1 (black line) and visit 2 (blue line). The line represents the mean value, and grey respectively blue field maps out the standard deviation.

DISCUSSION AND CONCLUSION

The study is recruiting more participants. The current participants and their prosthetic set ups were heterogeneous which complicated aggregation of data. Preliminary results from the first 10 participants indicated that the ankle and knee angles moved towards a more normal gait pattern with the XF, with less perceived effort expressed during 2MWT.

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6.043 Improved Design of A Temporary Transtibial Prosthesis

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BACKGROUND

Before receiving a prosthesis, people with amputations often rely solely on wheelchairs or crutches for mobility within the first one to three months post-amputation ^(1,2). In our previous study, multiple iterations of a temporary training prosthesis were designed and fabricated to enhance the device's functionality and adjustability ⁽¹⁾. We successfully tested the device on five able-bodied individuals, making design refinements as needed before proceeding with trials on individuals with amputations.

AIM

To test this temporary training prosthesis on experienced prosthesis users who can provide informed feedback on device fit and function.

METHOD

After receiving approval from the University of Ottawa Research Ethics Board, initial testing was conducted on two male individuals with transtibial amputation to ensure the device functioned as intended before recruiting additional participants. The patients wore the device and walked within the parallel bars.

RESULTS

During the trials, we found that enhancing the thigh and shank sections was necessary to improve joint stability and mobility, allowing for better performance and comfort during the swing phase, especially for patients with short residual limbs. Additionally, optimizing the suspension in the shank section can further enhance performance ⁽¹⁾. In response, we revised the design for improved adjustability, incorporating a three-piece shank (Figure 1) and modifying the shank and thigh shells to include two pieces for easier width adjustments. These changes reduced force on the knee joint and facilitated movement during swing phase. We also improved suspension system by changing the design and adding a supracondylar suspension feature.

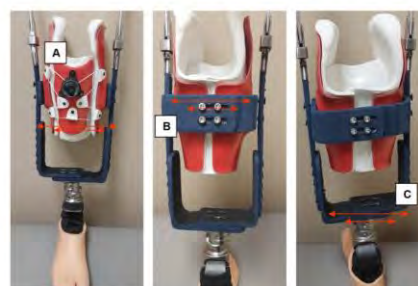


Figure 1: The socket (A), shank shell (B), and the bars (C) connected to the foot feature a sliding mechanism that allows for fine-tuning of the width based on the residual limb dimensions.

DISCUSSION AND CONCLUSION

The initial testing highlighted some issues with the prototype and we have successfully revised the design to enhance adjustability and functionality. We are planning to test the new device on 10 experienced prosthetic users.

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6.044 Mechanical Characterization of Running Specific Prostheses: Development of Testing Methods for Evaluation

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BACKGROUND

Comprehensive and standardized testing methods already exist for prosthetic feet. In contrast, sports prostheses are currently evaluated only through field tests or highly abstracted mechanical tests that do not reflect the actual loads on the prosthesis. Field tests primarily focus on athletics, particularly sprinting and long jumping, while other sports such as tennis or badminton are not represented.

AIM

The aim of this thesis is to develop a set of methods on a test bench that enable standardized functional characterization of running specific prostheses (RSP) on a testbench.

METHOD

This effort is based on an extensive literature review. Based on the gaps in the field of testing of RSP, a study for gather motion data (Oqus7+, Qualisys, Göteborg, SE) and ground reaction forces (GRF) (iPecs, rtcelectronicsinc, Ypsilanti, USA) of predefined motions has been planned and performed for one subject and three different RSP. The recorded data is processed for the transfer to the hydraulic test bench (Foot Prosthesis Test Load Frame System, Shore Western, City of Industry, USA). A selection of motions is performed on the test bench with the same RSP and the resulting data will be compared.

RESULTS

The subject test reveals similar biomechanical data for the three different RSP; however, minor differences in joint angles and GRF during identical movements are observed. Seven different movements are performed on the treadmill and on the floor. These consist of running forwards, backwards, sideways in both directions and three combined movements. Based on the biomechanical data, three tests are developed and implemented on the hydraulic test bench. These include testing torsional stiffness, walking sideways, and determining the roll-over shape. It is possible to distinguish the three RSP specimen based on the data collected from test on the hydraulic test bench. Further, a higher reproducibility of GRF has been observed with the hydraulic test bench when compared with subject testing.

DISCUSSION AND CONCLUSION

This paper presents a method for functional characterization of RSP based on actual motion, showing high reproducibility and accuracy. While some performance differences among the three specimens are noted, further research is needed to understand their biomechanical impact on users. This article serves as an initial exploration of RSP functional characterization on a test bench, with limitations in the number of test subjects, motions, and specimens.



6.045 Proof-of-concept: A novel prosthetic device to enhance foot power of people with minor foot amputation

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BACKGROUND

Despite an increasing number of minor amputations [1], research activities for the care of such patients and the development of new devices is limited. These amputations impair mobility due to altered gait. The push-off at the end of the stance phase is particularly affected by the amputation [2]. To address these patients' special needs and promote propulsion, an interdisciplinary team has developed a new prosthetic carbon fiber device for energy storage and release.

AIM

The aim was to examine the novel device concept on a patient with a hallux amputation in the instrumented 3D-gait laboratory.

METHOD

Inspired by ESAR (Energy Storing And Returning) prosthetic feet, a two-spring carbon fiber geometry was designed and fitted under a standard diabetic shoe. Combined with a 3D-printed heel part and a rubber sole, this configuration created a complete spring-sole unit, which was customized by an orthopaedic technician for the patient (f, 42 years, 1.72 m, 84 kg). Functionality was assessed by analyzing distal shank and rearfoot power [3] and foot pressure at normal and increased gait speed and compared to both a standard sole and the patient's diabetic shoe.

RESULTS

The peak power of the foot-shoe complex is 75% higher with the novel device than with the patient's daily diabetic shoe (Figure 1). The part of the foot-shoe complex in the total ankle-foot work is highest with the novel device during fast walking with a percentage of 20%. The maximum mean pressure values are lowest in the midfoot, central, and lateral forefoot areas with wearing the novel device. In contrast, they are higher in the heel and medial forefoot areas in both conditions with the test shoe than with the daily diabetic shoe.

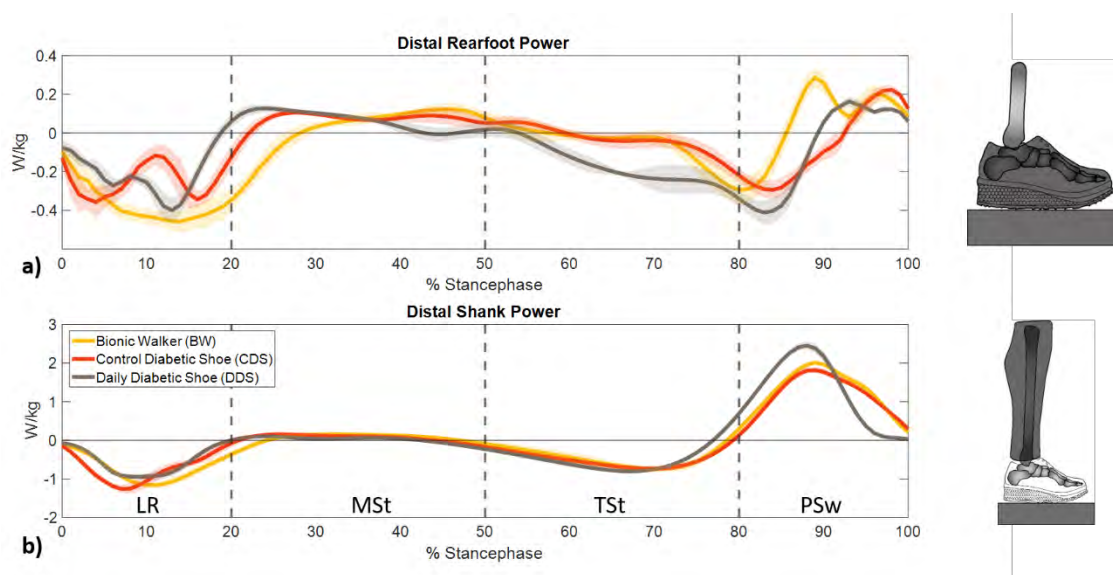


Figure 1: Comparison of the novel concept (Bionic Walker) with control shoes: a) Distal Rearfoot Power (Foot-Shoe-Complex), and b) Distal Shank Power (Ankle-Foot-Complex) at normal walking speed subdivision into loading response (LR), mid stance (MSt), terminal stance (TSt), and pre-swing (PSw).



DISCUSSION AND CONCLUSION

The results show the potential to support the push-off at the end of the stance phase of a patient with a hallux amputation through the energy recoil of a carbon fiber spring. In addition, a pressure reduction can be achieved in critical foot areas for amputees. A prospective study to investigate the new prosthetic device is planned.

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ACKNOWLEDGEMENTS

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6.046 Evaluating Power Response and Biomechanical Adaptations of two Prosthetic Feet at Varying Walking Speeds, in People with a Trans-Tibial Amputation

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BACKGROUND

For people with transtibial amputation (TTA), the development of prosthetic feet highlights the importance of balancing activity levels with appropriate stiffness. Prosthetic feet are designed for typical walking speeds, such as 1.15 m/s [1], and often lack the responsiveness needed for faster walking, to adapt to uneven terrain or in light sporting activities. Therefore, there is a need for feet that offer a good compromise between range of motion and stiffness [2] for higher activity requirements.

AIM

Comparing two prosthetic feet at three walking speeds. It is hypothesised that foot B will increase power at self-selected speed, maintain power at slow, and provide greater power at fast speeds.

METHOD

Two participants have been enrolled in a larger prospective study (n=20) comparing foot-A (Pro-Flex XC) and foot-B (Pro-Flex Terra, both Össur-hf, Iceland). Both male, unilateral TTA participants are high activity users (K-Level 4) and have lost their limb due to a tumour. One (ID 53516, 33y, 80kg, 183cm) walked with foot A, the other (ID 52605, 34y, 74kg, 181cm) with foot B. Both walked along a 15 m walkway at three speeds: self-selected, 20% faster, and 20% slower. Participants received visual-feedback to adjust their speed. Slow and fast conditions were randomised. Gait-Data was recorded using a motion-capture-system (Vicon, UK, T40s, @ 120Hz; AMTI, USA, @ 1080Hz). Conventional biomechanical modelling routines were applied (Vicon, Plugin-Gait).

RESULTS

All results refer to the affected side of the two participants and are calculated around an imaginary prosthetic ankle joint. Foot A showed a decreased range of motion (Table Figure 1) in all three conditions in comparison to foot B. The rotational moments showed almost comparable results between foot A and B in all conditions (Table Figure 1). Ankle power graphs are shown in Figure 1.

DISCUSSION AND CONCLUSION

In comparison to foot-A, foot-B demonstrates a greater range of motion and a higher power return in all conditions (self-selected, slow and fast). As a consequence of the enhanced range of motion, foot-B appears to dissipate less energy in single support, while concurrently, the stiffness of foot-B progressively increases in order to return the stored energy at the end of stance, even at faster speeds. It should be noted that the study is still in its early stages, and results have to be interpreted with care. It is necessary to confirm results on an intra-individual basis in the larger study cohort (N=20).

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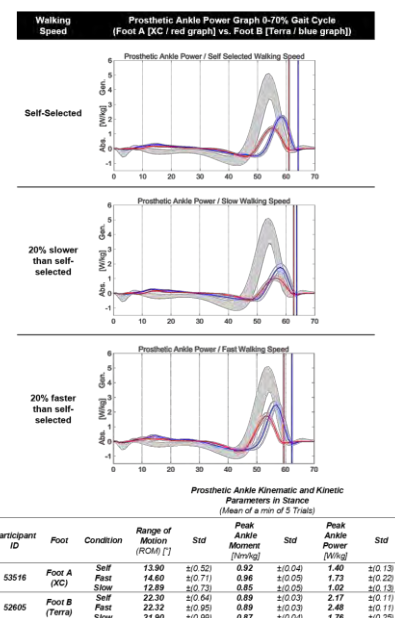


Figure 1.: Prosthetic ankle power graphs during 0%-70% of the gait-cycle in different conditions and table of discrete Prosthetic ankle kinematic and kinetic parameters. All parameters are calculated around an assumed prosthetic ankle joint and refer to the involved side of both participants.



6.047 Investigating the Heel-to-Toe Roll-Over Behavior of Prosthetic Feet in a Machine Test

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BACKGROUND

Prosthetic foot performance is assessed not only through motion analysis but also using outcome measurements derived from test machines. Besides classical quasi-static stiffness measurements, advanced walking simulations [1] can provide further insights into prosthetic foot performance. New advanced key performance indicators (KPIs) can be developed to describe prosthetic foot functionality in a more comprehensive way that might correlate with user perception.

AIM

This paper investigates the heel-to-toe roll-over behavior of prosthetic feet, emphasizing the roll-over radius and 'smoothness' of the foot contact point (FCP) measured in a machine test.

METHOD

Three prosthetic feet (ESAR 1-3) of the same size (27) and intended for the same user weight (80 to 100 kg) were set up according to a modified test protocol in alignment with the ISO 16955 test standard. Machine sensor data was used to calculate the resulting 3D force-contact point (FCP) throughout the heel-to-toe rolling behavior of the foot under both the minimum and maximum intended body weight (BW). The 'smoothness' was assessed by calculating the FCP every 2 degrees of the dynamic foot platform angle between -10° to +10° and calculating the distance between these points.

RESULTS

Different transitional behaviors were found for all foot designs tested (see Figure 1). The shapes identified relate to the smoothness of the transition, with a larger gradient in spacing indicating a change in transition speed. Additionally, for ESAR 2 and ESAR 3, higher loads at the upper end of the intended body weight resulted in smoother behavior of the same test sample than at with lower body weight. For ESAR 1, the roll-over behavior was found to be rather constant throughout both weight ranges. The results correlate well with comments from user testing, suggesting that machine testing might help increase confidence in outcomes from user testing.

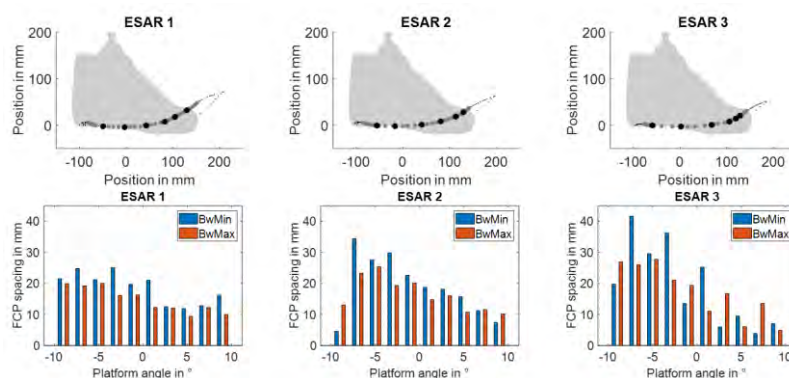


Figure 1. Transitional behavior of three ESAR feet tested at different dynamic loads (blue minimum intended vs. red maximum intended bodyweight)

DISCUSSION AND CONCLUSION

The rolling behavior of a prosthetic foot is a relevant aspect for prosthetic users. The FCP spacing allows for the description and distinction of smooth or non-smooth transitions of prosthetic feet based on a machine test. Larger clinical studies are needed to confirm that these implications also correlate with outcome measures and the perception of different prosthetic user groups.

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6.048 Computational Fluid Dynamics to Study the Vasculature in the Residual Limbs of Transtibial Amputees

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BACKGROUND

The soft tissue of the residual limb in transtibial prosthetic users encounters unique biomechanical challenges. Although not intended to tolerate high loads and deformation, it becomes a weight-bearing structure within the residuum-prosthesis-complex. Consequently, deep soft tissue layers may be damaged, resulting in Deep Tissue Injury (DTI). Whilst considerable effort has gone into DTI research on immobilised individuals, only little is known about the role of the vascular perfusion in this system. Since the aetiology of DTI is related to physiological fluid processes (ischemia, ischemic reperfusion, impaired lymphatic drainage), using Computational Fluid Dynamics (CFD) as an investigation tool is a promising approach.

AIM

This project will investigate the role of vascular perfusion in DTI development in transtibial prosthetic users by recreating the environment via mathematical and computational methods.

METHOD

A patient-specific 3D model of the femoral artery and its bifurcation was created using the complete segmentation pipeline of the SimVascular software. The larger blood vessels in the system were captured using T2-weighted Dixon Magnetic Resonance Imaging that has longer Echo Time and Repetition Time. Geometric adaptations (smoothing and extending the inlet and outlets) were carried out using the Autodesk Meshmixer and VMTK software respectively to ensure accurate CFD results.

RESULTS

The research hypothesis is that the severing of blood vessels after transtibial amputation may reduce the numerous pathways of blood and may increase the total impedance of the altered section of the blood tree network. This diminishes flow rates and redistributes both blood flow and blood pressure, offering a possible explanation for the development of deep tissue injury. A link between ischemia (reduced blood flow) as a result of pressure from the socket onto the residual limb may also be established.

DISCUSSION AND CONCLUSION

By providing insight into the effects that amputation surgery has on blood flow dynamics and its implications on DTI development, the current model could serve as a surgical planning tool. Using this methodology, for cases such as diabetes where the amputation is planned ahead, the negative effects could be reduced by assessing patient-specific responses to the available surgical strategies. The CFD approach could also be insightful for prosthetic socket design by helping consider configurations that limit the ischemic effect on peripheral circulation.

ACKNOWLEDGEMENTS

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6.049 Exploring transtibial prosthetic coupling (Part 2): Utilising knee axis estimation to investigate population trends between prosthesis characteristics and coupling movements

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BACKGROUND

Prosthetic coupling, primarily pistoning, has been widely used to measure prosthetic fit quality. In lower-limb prosthetics, socket comfort and ambulatory function are key priorities for user satisfaction. However, the true influence of different components is still ambiguous due to the low participant numbers included in studies (median 7.5 participants¹). Therefore, there is a strong need to analyse coupling with larger datasets to verify prosthetic socket and component design decisions.

AIM

To analyse existing motion capture data and investigate the influence of prosthesis components, gait, and user characteristics on prosthesis movements in each degree of freedom (DoF).

METHOD

An open-source dataset of walking gait for 30 transtibial prosthesis users² was used to investigate the statistical influence of each reported prosthesis, user, and gait parameters against prosthesis movements. Prosthesis coupling movements were calculated in four DoFs, a fifth is estimated³, and the knee axis was optimised through a sphere fitting algorithm with noise reduction⁴. Linear model analyses were used, ANOVA for discrete and regression for continuous variables, with sample size calculations conducted to suggest database sizes required to power any findings.

RESULTS

Three participants each were a sole component user and, therefore, were excluded from the linear model analyses as singularities. The strongest influencers were socket and foot type to anterior displacement; liner type, prosthetic leg step length, and user sex to pistoning; and prosthesis suspension to transverse rotation. Common patterns of prosthesis movements were seen throughout the stance period of gait regardless of prosthesis or user characteristics (Figure 1). Age, height, and weight showed weak-to-no correlation to all prosthesis movements. Over 20 different measurements suggest a sample size of between 10 and 85 to achieve a statistical power of 0.8 and a significance of ≤ 0.05 .

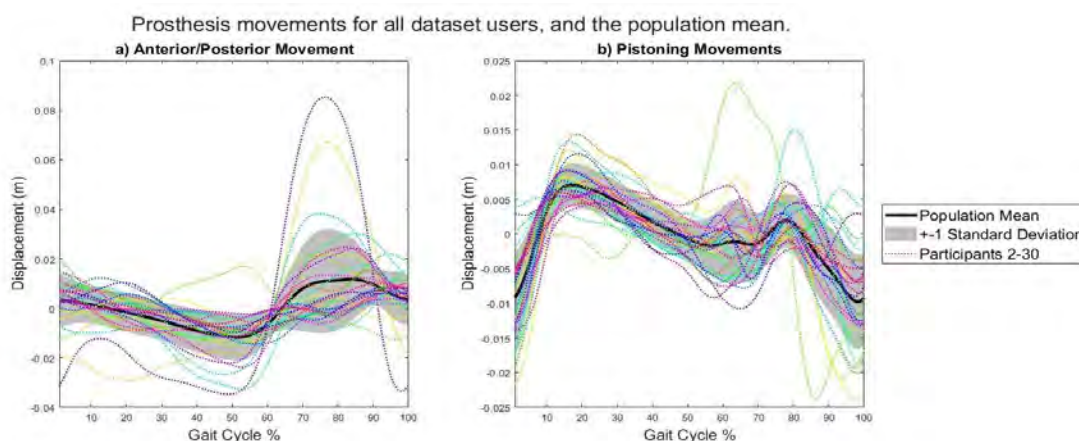


Figure 1: Prosthesis movements for all dataset users, and the population mean and standard deviation.



DISCUSSION AND CONCLUSION

The knee axis calculation from gait data showed deviations in anterior/posterior displacement during high knee flexion phases, which could explain the high displacements measured for some participants. The range of prosthesis movements measured in other DoFs was comparable to existing literature¹. These results show that with larger datasets of users' gait, more confidence can be assigned to prosthesis design decisions around their performance. This work is limited to linear model analyses only, as not enough data is present for full interaction modelling. Future work around obtaining datasets from different cultures could remove any prosthesis bias, such as increased use of different component combinations.

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MB's studentship (EP/S02249X/1). We would like to thank Samala² for publishing an open-source dataset allowing this work to be possible.



6.050 Moisture Mitigation Using a Vented Liner-Socket System (VS) Improves Transfemoral Amputee Limb Skin Health by Objective Measures (TEWL)

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BACKGROUND

Prosthesis perspiration is a most striking issue affecting people with lower-limb loss. Our recent publication showed a significant reduction in moisture using a vented liner socket (VS) compared to a non-vented system ^[1]. There is a gap regarding the effects on residual limb skin health. Prior publication established the significance of monitoring limb health using trans-epidermal water loss (TEWL) which is a reliable predictor of skin barrier function ^[2].

AIM

In this clinical pilot study, we sought to investigate whether effective moisture mitigation at the limb liner interface improves residual limb skin health.

METHOD

Unilateral transfemoral amputees (n=5) participated in a pilot study where the participants used either a standard of care (SoC) non-vented liner-socket system or a vented liner-socket system (VS, Össur). The TEWL measurement was performed from multiple anatomical locations at the amputated and sound side limbs following 4-weeks of use of SoC or VS.

RESULTS

In this study, the room conditions were consistent on all visits. The subjects received SOC on the first visit followed by the VS on the second. Data showed a significant reduction in TEWL values as measured in the skin from the residual limb when using a VS versus an SoC liner-socket system. TEWL values from the same anatomical locations of the sound side, however, showed no such changes. Since a lower TEWL value indicates better skin barrier function. Measurement was performed on multiple anatomical locations to find localized effects on the limb.

DISCUSSION AND CONCLUSION

This pilot study indicated that VS improves residual limb skin health by improving the barrier function as indicated by lower TEWL. While our prior study ^[1] reports a moisture reduction by VS, this study showed improvement in residual limb skin barrier function and therefore, skin health of the limb supporting prior outcomes. Such improvement may be due to moisture reduction by the ventilated system at the skin-liner interface.

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ACKNOWLEDGEMENTS

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Posters | Prosthetics: bone anchored limbs

6.051 Medium-Term Outcomes of Transfemoral Osseointegration in association with Total Hip Replacement

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BACKGROUND

Transfemoral osseointegration (TFOI) for amputees has substantial literature proving superior quality of life and mobility versus a socketed prosthesis. Some amputees have hip arthritis that would be relieved by a total hip replacement (THR). No other group has reported performing a THR in association with TFOI (THR+TFOI).

AIM

To report the outcomes of eight patients who had THR+TFOI, followed for an average 5.2 years.

METHOD

Our osseointegration registry was retrospectively reviewed to identify all patients who had TFOI and also had THR, performed at least two years prior. Six patients had TFOI then THR, one simultaneous, one THR then TFOI. All constructs were in continuity from hip to prosthetic limb. Outcomes were: complications prompting surgical intervention, and changes in subjective hip pain, K-level, daily prosthesis wear hours, Questionnaire for Persons with a Transfemoral Amputation (QTFA), and Short Form 36 (SF36). All patients had clinical follow-up, but one patient did not have complete mobility and quality of life survey data at both time periods.

RESULTS

Four (50%) were male, average age 52.7 ± 14.8 years. Three patients (38%) had amputation for trauma, three for osteosarcoma, one each (13%) infected total knee and persistent infection after deformity surgery. One patient died one year after THR+TOFA from subsequently diagnosed pancreatic cancer. One patient had superficial debridement for infection with implant retention after five years. No implants were removed, no fractures occurred. All patients reported severe hip pain preoperatively versus full relief of hip pain afterwards. K-level improved from $0/8=0\%$ $K \geq 2$ (six were wheelchair-bound) to $5/8=63\%$ ($p=.026$). At least 8 hours of prosthesis wear was reported by $2/7=29\%$ before TOFA vs $5/7=71\%$ after ($p=.286$). The QTFA improved in all categories, but not significantly: Global (40.0 ± 21.6 vs 60.0 ± 10.9 , $p=.136$), Problem (50.2 ± 33.2 vs 15.4 ± 8.4 , $p=.079$), and Mobility (35.9 ± 26.8 vs 58.3 ± 30.7 , $p=.150$). The SF36 also improved minimally and not significantly: Mental (53.6 ± 12.0 vs 54.7 ± 4.6 , $p=.849$) and Physical (32.5 ± 10.9 vs 36.3 ± 11.2 , $p=.634$).

DISCUSSION AND CONCLUSION

THR+TFOI is a successful reconstruction option for amputees who desire relief from pain related to hip joint degeneration, and the opportunity for improved mobility and quality of life that TFOI typically confers. In our cohort, the procedure proved safe: no associated deaths, no removals, one soft tissue debridement. Mobility improved markedly. Quality of life improved, but not to significant thresholds. THR+TFOI appears safe and reasonable to offer to transfemoral amputees with painful hip joint degeneration.



6.052 Medium-term Outcomes of Transtibial Osseointegration in association with Total Knee Replacement

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BACKGROUND

Transtibial osseointegration (TFOI) for amputees has limited but clear literature identifying superior quality of life and mobility versus a socketed prosthesis. Some amputees have knee arthritis that would be relieved by a total knee replacement (TKR). No other group has reported performing a TKR in association with TFOI (TKR+TFOI).

AIM

To report the outcomes of nine patients who had TKR+TFOI, followed for an average 6.5 years.

METHOD

Our osseointegration registry was retrospectively reviewed to identify all patients who had TFOI and who also had TKR, performed at least two years prior. Four patients had TKR first the TFOI, four patients had simultaneous TKR+TFOI, and one patient had 1 OI first then TKR. All constructs were in continuity from hinged TKR to the prosthetic limb. Outcomes were: complications prompting surgical intervention, and changes in daily prosthesis wear hours, Questionnaire for Persons with a Transfemoral Amputation (QTFA), and Short Form 36 (SF36). All patients had clinical follow-up, but two patients did not have complete survey and mobility tests at both time periods.

RESULTS

Six (67%) were male, average age 51.2 ± 14.7 years. All primary amputations were performed to manage traumatic injury or its sequelae. All patients who had transfemoral amputation elected for and received transfemoral osseointegration, and no infections occurred, although one patient sustained a periprosthetic fracture which was managed with internal fixation and implant retention and walks independently. The proportion of patients who wore their prosthesis at least 8 hours daily was $5/9=56\%$, versus $7/9=78\%$ ($p=.620$). Even after proximal level amputation, the QTFA scores improved versus prior to TKR+TFOI, although not significantly: Global (45.2 ± 20.3 vs 66.7 ± 27.6 , $p=.179$), Problem (39.8 ± 19.8 vs 21.5 ± 16.8 , $p=.205$), Mobility (54.8 ± 28.1 vs 67.7 ± 25.0 , $p=.356$). SF36 changes were also non-significant: Mental (58.6 ± 7.0 vs 46.1 ± 11.0 , $p=.068$), Physical (34.3 ± 6.1 vs 35.2 ± 13.7 , $p=.904$).

DISCUSSION AND CONCLUSION

TKR+TFOI presents a high risk for eventual infection prompting subsequent transfemoral amputation. Although none of these patients died, in general, TKR infection can lead to patient mortality. Given the exceptional benefit to preserving the knee joint to preserve amputee mobility and quality of life, it would be devastating to flatly force transtibial amputees with severe degenerative knee joint pain and unable to use a socket prosthesis to choose between TFOI but a painful knee, or preemptive transfemoral amputation for transfemoral osseointegration. Therefore, TFOI for patients who also request TKR must be considered cautiously.



6.053 Osseointegration Outcomes following Amputee Lengthening

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BACKGROUND

Percutaneous EndoProsthetic Osseointegration for Limbs (PEPOL) facilitates improved quality of life (QOL) and objective mobility for most amputees discontent with their traditional socket prosthesis (TSP) experience. Some amputees desiring PEPOL have residual bone much shorter than the currently marketed press-fit implant lengths of 14-16 cm, potentially a risk for failure to integrate.

AIM

To report on the techniques used, complications experienced, the management of those complications, and the overall mobility outcomes of seven patients who had femur distraction osteogenesis (DO) with a Freedom nail followed by PEPOL.

METHOD

Retrospective evaluation of a prospectively maintained database identified nine patients (5 females) who had transfemoral DO in preparation for PEPOL with two years of follow-up after PEPOL. Six patients had traumatic causes of amputation, one had perinatal complications, one was performed to manage necrotizing fasciitis and one was performed as a result of osteosarcoma.

RESULTS

The average age at which DO commenced was 39.4 ± 15.9 years, and seven patients had their amputation more than ten years prior (average 25.5 ± 18.8 years). The residual femurs on average started at 102.2 ± 39.7 mm and were lengthened 58.1 ± 20.7 mm, $98 \pm 45\%$ of goal ($99 \pm 161\%$ of the original bone length). Five patients (56%) had a complication requiring additional surgery: four events of inadequate regenerate were managed with continued lengthening to desired goal followed by autograft placement harvested from contralateral femur reaming; one patient had the cerclage wires break which required operative replacement.

All patients had osseointegration performed, at 355 ± 123 days after the initial lengthening nail surgery. One patient had K-level ≥ 2 before DO, at a mean of 3.4 ± 0.6 (2.6-4.4) years following osseointegration six patients had K-level ≥ 2 . The 6 Minute Walk Test remained unchanged (267 ± 56 vs 308 ± 117 meters). Patient self-rating of prosthesis function, problems, and amputee situation did not significantly change from before DO to after osseointegration. Six patients required additional surgery following osseointegration: six to remove fixation plates placed to maintain distraction osteogenesis length at osseointegration; two required irritation and debridement for infection.

DISCUSSION AND CONCLUSION

Extremely short residual femurs which make TSP use troublesome can be lengthening with externally controlled telescoping nails, and successfully achieve osseointegration. However, it is imperative to counsel patients that additional surgery to address inadequate regenerate or to remove painful hardware used to maintain fixation may be necessary. This may improve the amputee's expectations before beginning on a potentially arduous process.



6.054 30 years down the the road for an osseointegrated femoral fixture - a case report

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BACKGROUND

Percutaneous bone-anchored prostheses (BAP) are today an established treatment. The first surgery on a patient with amputation was performed in Gothenburg, Sweden, in 1990. It was not until 1999 that the OPRA™ (Osseointegrated Prostheses for the Rehabilitation of Amputees) system and treatment protocol were established ⁽¹⁾. Up to this timepoint a low number of patients were operated with the first generation of implants ⁽²⁾.

AIM

To report the 30-year follow-up of a patient with a unilateral transfemoral amputation operated with a percutaneous osseointegrated implant and with an unrevised fixture.

METHOD

The patient has been routinely followed up by the outpatient clinic of our hospital. With the patient's consent we have reviewed his medical records and radiographs and report the clinical findings of the 30-year follow-up visit. Electronic records were available from year 2003 and to this day, the older analogue records are scanned in an electronic archive. The records of the patient were found to be incompletely saved between 2002 and 2014. Radiographs from 1994 and onward were available.

RESULTS

The case presented is a male patient born in 1942, who sustained a traumatic unilateral transfemoral amputation in 1967. He used a socket-suspended prosthesis for 26 years, needing numerous socket revisions.

The two-stage surgical treatment started in 1993 by insertion of a 17x90 mm titanium screw fixture. Since 1994 he has used a BAP on a daily basis, except for short periods of time due to complications. The percutaneous implant parts have been exchanged several times (>13 abutments, the last in 2023), and custom made abutments have been used since 2009. There has been no evidence of deep infection, but surgical treatment of stoma infections in 2001 and 2007.

After 30-years this man reports being completely satisfied with the treatment, using the BAP all day long, walking indoors with a cane and outdoors with crutches. His radiographs show a well-anchored fixture, with some bone resorption at the distal end of the residual bone.

DISCUSSION AND CONCLUSION

To the best of our knowledge, this is the first reported case with an unrevised osseointegrated femoral fixture for over 30 years. The treatment was performed before the OPRA treatment protocol was set ⁽²⁾. The indications, risks and benefits of bone-anchored prostheses are currently being discussed. Although the patient has undergone multiple surgical procedures, he is still, after 30 years, using his prosthesis on a daily basis and reports regretting "not having had this surgery earlier".

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6.055 Bone-anchored Prostheses - 7 years of experience in the upper and lower extremities

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BACKGROUND

After major amputations of the extremities, satisfactory permanent reintegration into the private and professional environment is the primary goal of exoprosthetic treatment. Socket-guided prosthesis systems are considered the standard concept. However, complicated soft tissue conditions of the amputation stump are a limiting factor for long-term good function. Voluminous or rotationally unstable soft tissue conditions, recurrent inflammation, stump conditions that are too short or inadequate soft tissue coverage are typical reasons why socket-guided exoprostheses are not used sufficiently or not at all.

AIM

May TOPS provide a very good alternative treatment in cases of insufficient rehabilitation success with socket-guided prostheses?

METHOD

Since April 2018, 38 patients with major amputations have been cared for. We are treating 33 transfemoral, 3 transtibial and 2 transtibial amputees (age: $\bar{x}$ 55.6 $\pm$ 12.5 years, m: 27, f: 11. In 21 patients (amputation level: 17 transfemoral, 1 transtibial, 3 transtibial), 4 patients were excluded from TOPS placement based on the results of the preoperative evaluation (3x due to comorbidity, 1x poor compliance). 3 further patients are currently awaiting the first stage of surgery. In addition, 10 further patients are receiving orthopaedic care close to home at our clinic following external surgical treatment.

RESULTS

In two patients, 2 fissures occurred when the implant was inserted. Both fissures healed during the osseointegration period.

We saw two implant losses, once as a result of an implant-associated infection after the first surgical step with transtibial TOPS and once due to implant fracture after 10 years of wear. In addition, 2 peri-implant fractures occurred, which were treated with plate osteosynthesis while retaining TOPS. 1 patient cannot be mobilised with a prosthesis due to unspecific load-dependent residual limb pain.

Stoma channel revisions were required 5 times in 4 patients. In 7 patients, superficial stoma canal infections occurred without jeopardising the implant, which were healed with antibiotic therapy.

Of the 31 patients treated with TOPS for longer than 6 months, 26 (83 %) use their bone-guided prosthesis predominantly all day. 2 patients are no longer fitted with TOPS after implant loss. 3 (9.7 %) patients can only use the prosthesis to a limited extent or not at all.

DISCUSSION AND CONCLUSION

Like stem-guided prosthesis systems, TOPS have various complications that restrict the use of the prosthesis. However, the vast majority of patients can use their prosthesis almost all day with TOPS. TOPS are therefore a good addition to exoprosthetic treatment for major amputations.



6.056 Osseo running trial

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BACKGROUND

Transtibial limb reconstruction following lower limb amputation via transcutaneous osseointegration implant has provided users with a wide range of functional outcomes such as the ability to easily transfer from a wheelchair to a vehicle, through to multi day self-supported hikes. As Osseo users progress through their amputee journey, some desire to return to higher level activities such as running. This has typically not been advised by the users' surgical team. A small cohort have been determined to build running back into their lifestyle. A cross functional team of prosthetists, physiotherapists, surgeons, biomedical engineers, and biomechanical researchers have put together a controlled observational study to outline and monitor Osseo users through their return to running experience

AIM

The aim of this study was to establish a repeatable protocol to assist Osseointegration tibial implant patients to get back into running safely.

METHOD

We composed a practice consisting of 7 steps:

1. Bone scans and surgical assessment to establish a baseline
2. Physio & Prosthetics joint assessment session
3. Gait assessment and loading profile obtained (gait lab assessment for alignment and loading)
4. Training plan agreed upon and monitored
5. Adverse event management; pain, infection, broken parts
6. 6 weeks and 12 weeks Bone scans and surgical assessment
7. Assessment of overall user outcomes.

RESULTS

A total of 4 Osseointegration tibial implant patients participated in the study. Initial baseline bone quality assessments were completed through scans and surgical evaluations, with all participants showing sufficient bone density for weight-bearing activity. Gait analysis conducted revealed mild asymmetries in most participants, which were addressed in joint physiotherapy and prosthetic sessions.

At the 6 and 12-week follow-up, 100% of participants reported improvements in mobility, with no major adverse events (e.g., infection, fractures, or significant pain).

In terms of overall outcomes, all participants expressed a high level of satisfaction, particularly regarding increased confidence and improved functional capacity in daily activities. Additionally, all participants reported a significant increase in activity levels, as evidenced by the ability to engage in recreational sports or prolonged walking without pain or discomfort

DISCUSSION AND CONCLUSION

This study represents an important early step in evaluating the safety and feasibility of returning to running for Osseointegration tibial implant users. While the results are promising in the short term, longer follow-up is essential to assess the long-term sustainability and safety. We plan to continue monitoring these participants over the next years to gather more comprehensive data before making any clinical recommendations regarding high-impact activities



6.057 Learning from listening to personal experience with bionic bone-anchored prosthesis: barriers of patient journey analysis

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BACKGROUND

Bone-anchored prosthesis (BAP) can improve stability, function, mobility and the quality of life of well selected individuals suffering from limb loss.^[1] Evidence of safety and efficacy of BAP are generally collected at pre-specified points of time that are considered the most important. There is a need to map the patient surgical, medical, rehabilitation, and prosthetic care journey to retrace holistically their true personal experience across the fitting of bionic BAP.

AIM

This presentation shares the lessons learnt from a preliminary retrospective analysis of BAP end-users, particularly the barriers to the design and application of a digital recording platform.

METHOD

This exploratory retrospective case-series study involved three participants with transfemoral BAP. Their journey was retraced up to 12 years after the fitting of BAP using ad-hoc questionnaire and semi-structured interviews. Each journey was organized around selected episodes of care characterized by: cause, type, and providers of care; relative impact on pain, comfort and quality of life; and estimate of out-of-pocket costs. Information was tabulated, analysed and reported using a purposely designed Electronic Mapping of Amputation Care platform (eMAC) following the four iterative steps of Plan-Do-Check-Act cycles. Barriers to the development of the eMAC were identified during the Check step.

RESULTS

Approximately 200 episodes of surgical, medical, rehabilitation or prosthetic care were considered. In addition to the typical intrinsic limitations of interviews (e.g., lack of validity, high risks of recall bias), the extraction and digital recording of the individual journeys were challenging, particularly for complex case-mix, because of several barriers associated with:

- The selection of “relevant” episodes of care given the regular co-occurrent care related to comorbidity, such as weight control (e.g., gastric bypass) or musculoskeletal disorders of contralateral joints (e.g., osteoarthritis, replacement),
- The high inter-participant variability to differentiate and select the most “impactful” episode of care considering either pain, comfort or quality of life,
- The extraction of relevant care costs, particularly out-of-pocket expenses, for specific episodes of care, given the complexity of reimbursement schemes (e.g., healthcare systems, insurance, workcover).

DISCUSSION AND CONCLUSION

Clearly, the development of data collection tools to capture retrospectively patients' stories is challenging. More prospective studies are needed. Meaningful analyses of actual flow between touch points of care are required to allow stakeholders to allocate proper resources to warrant adequate continuum of care (e.g., end-user, clinicians, decision makers).^[2, 3] Practically, this information will be valuable for health economic analyses, particularly cost-utility studies using evidence-based scenarios for Markov modelling.^[4]

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6.058 The Rotterdam Osseointegration Experience: Short-, mid- and long-term outcomes of patients with Bone-Anchored Protheses following lower-extremity amputation and socket-related issues

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BACKGROUND

Amputation of a lower limb significantly affects patients' self-perception and quality of life (QOL). While patients can use socket prostheses, many experience socket-related issues, which limit prosthesis use, activity levels, and overall QOL. Bone-Anchored Protheses (BAPs) offer a potential solution. These prostheses are directly anchored to the skeleton and are now used worldwide. In January 2017, we established the Osseointegration Center Rotterdam to provide BAP care with a multidisciplinary team.

AIM

We report our experience with BAP treatment from January 2017 to January 2025, focusing on surgical and rehabilitation outcomes, changes in general and disease-specific QOL, functional outcomes and complication rates.

METHOD

Descriptive statistics are provided for patient, implant, surgical, and rehabilitation-related outcomes. General QOL changes are reported for each domain using the 6-Dimensional Health State Short Form and the EuroQoL 5-Dimension 5-Level. Disease-specific QOL changes are assessed using the Questionnaire for Persons with a Transfemoral Amputation. Functional outcomes are evaluated with the Timed Up and Go test and the 6-Minute Walk Test. Complication rates are scored and reported.

RESULTS

From January 2017 to April 2024, the 100th patient was operated. All patients followed a 2-year rehabilitation protocol.



Posters | Prosthetics & Orthotics: upper limb

6.059 Which Devices Help the Functioning of a Person with Bilateral Amputation the Most – A Case Report

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BACKGROUND

The number of people with bilateral upper limb amputation is low. Most studies present case reports or small series. Functioning of these people can be improved by different types of prosthesis as well as different adaptive equipment for different activities. The best solution depends on activities that the person would like to perform.

AIM

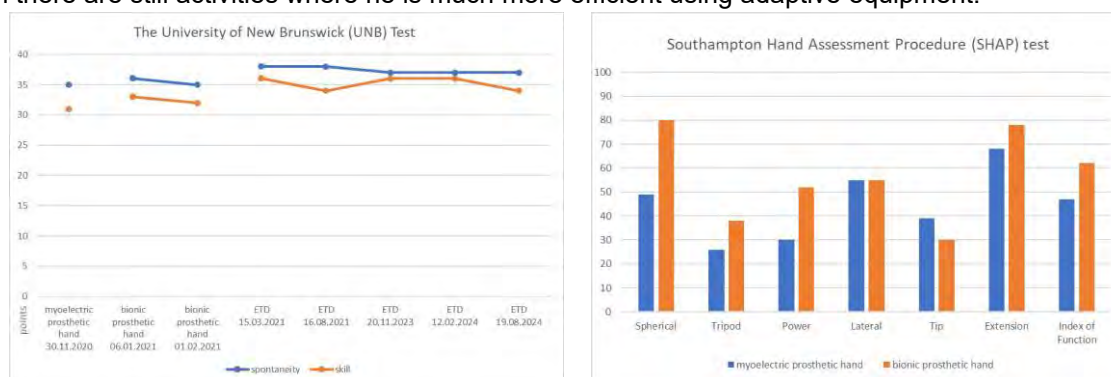
Our aim is to present how different devices improve functioning of a 17-year-old boy who was injured in a farming accident and rehabilitated at our institute.

METHOD

The patient was admitted to our institute for comprehensive rehabilitation in December 2020 and was then regularly followed through outpatient check-ups. His last checkup was in August 2024. During all the visits, we used the University of New Brunswick Test of Prosthetic Function (UNB test); during in-patient treatment, we also used the Southampton Hand Assessment Procedure (SHAP) and the Canadian Occupational Performance Measure (COPM). The patient first tested the classic myoelectric hand, followed by bionic prosthetic hand and finally electronic terminal device (ETD).

RESULTS

The patient had left trans-radial amputation and amputation of all fingers of the right hand. Range of motion in his right wrist was greatly decreased: dorsiflexion 0°, palmar flexion 10°. The results on UNB and SHAP test (figure 1, 2) were better with bionic hand, so he was fitted with Bionic prosthetic hand and - due to the work he wanted to do on the farm - later also with ETD. Individual adaptive equipment (protection of stump for heavy work, writing, eating) for right limb was also made. During the outpatient examination, the UNB test results showed good prosthesis use. Bionic prosthetic hand was prone to damage and strain due to the physically demanding nature of the patient's work. ETD was much more useful and the patient successfully uses it at home and in the broader environment, although there are still activities where he is much more efficient using adaptive equipment.



DISCUSSION AND CONCLUSION

The patient was initially equipped with a bionic prosthetic hand and ETD. Despite successfully mastering the bionic hand and effectively using it, he found out that the ETD allows him to perform a wider range of activities more efficiently. However, the patient mentioned that there are still some activities that he finds easier and more efficient to perform without the prosthesis.



6.060 Using Augmented Reality to Train Multi-Joint Prosthetic Control

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BACKGROUND

Learning to control multiple degree of freedom myoelectric prostheses can be difficult despite advancements in control such as pattern recognition [1]. Most training occurs after provision of the prosthesis and can lead to user frustration if they are unable to master control. Training using functional tasks in an augmented reality (AR) environment can improve performance for 2 degree of freedom control [2]. However, the optimal measures to assess skills in extended reality environments that indicate skill transfer to physical prosthesis performance need further investigation [3].

AIM

To determine (1) whether AR training prior to provision of a prosthesis improves the ability to control a transradial prosthesis with wrist rotation and a multifunction hand, and (2) which performance measures are similar between AR and physical prosthesis assessment.

METHOD

4 participants with transradial amputation (no prior experience with pattern recognition) were enrolled after informed consent. They had 8 training sessions in AR performing 2 functional tasks, with pre- and post-training assessments in AR with an additional task. They were fit with a prosthesis with pattern recognition, wrist rotation and a multifunction hand. Immediate post-fitting assessment with the physical prosthesis and after 3 weeks of training with the device occurred. Changes in performance during training and performance differences between the AR and physical prosthesis were analyzed.

RESULTS

Skill acquisition with the AR task: completion rate improved from 0% at baseline to 46-87% post training. Completion times reduced over sessions. Skill transfer occurred to a new task within AR: 0-20% success at baseline to 53-100% post-training. The PROS-TLX score decreased in the post-training assessment. With the physical prosthesis, the participants performed the tasks faster compared to AR, with similar success rates. AR had more grasp adjustments, wrist rotation, and visual fixations to hand compared to the physical prosthesis. ACMC scores indicated users were somewhat capable with the physical prosthesis and scores further improved after an additional 2-3 weeks of using the physical prosthesis.

DISCUSSION AND CONCLUSION

Training in AR resulted in skill acquisition and skill transfer to a new AR task. Less mental workload indicated participants could control their muscle signals with less cognitive effort. Participants were able to perform functional tasks similar to those learned in AR but interacting with the physical prosthesis (weight, socket fit) affected performance. Overall, the control skills trained in AR may have helped with controlling the physical prosthesis, but additional study needs to be done to compare outcomes to a group without AR training.

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6.061 Exploring Gaze Behaviours While Learning to Use a Multifunction Hand

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BACKGROUND

Multifunction prosthetic hands provide increased dexterity for people with upper limb loss (ULL) over single degree of freedom (DOF) prosthetic hands; however, they can be more cognitively demanding to learn. Eye tracking technology can unveil underlying cognitive processes involved in learning to use a multifunction prosthetic hand. Fixation duration has been shown to increase when cognitive processing becomes more effortful ^(1,2), and saccade amplitude decreases with increasing difficulty or cognitive load ⁽³⁾.

AIM

The aim of the study was to explore the use of eye tracking to assess learning progress of multifunction hands at two different time points, using a standardized test and a self-chosen task.

METHOD

Three people with ULL were recruited for the study who were receiving either a new multifunction hand or a new control strategy. They each learned at least three grips using a standardized control training protocol. They wore Tobii Pro2 eye-tracking glasses and performed the SHAP test (switched to different grips for each task) and a self-chosen ACMC task (asked to perform the task as they would normally do at home) at two different time points. The gaze data were analyzed using Tobii Pro Lab and the following metrics were extracted: fixation duration, saccade amplitude, fixation count and time to first fixation.

RESULTS

During control training, the subjects learned 3 to 4 grips. Some grips were easier, and others were more difficult because they forgot or were confused with the switching strategies. At the one-year-follow-up, a decrease in performance time, fixation duration, and an increase in saccade amplitude was observed indicating an improvement in the ability to control the multifunction hand and a reduction of cognitive load (see Table 1). During the standardized tasks, the first fixation of all three subjects was on the multifunction hand. During the self-chosen tasks, the first fixations were mostly on the objects.

Table 1: Completion time and eye tracking metrics during the 12 abstract objects from the Southampton Hand Assessment Procedure

	1 day	Subject 1 1 year	Difference	1 day	Subject 2 1 year	Difference	Subject 3 1 day	Subject 3 1 year
Completion time of all 12 tasks (seconds)	422.58 (m=35.22, SD=23.35)	274.74 (m=22.90, SD=18.58)	35% less	212.33 (m=17.68, SD=29.18)	85.34 (m=7.11, SD=1.19)	60% less	130.64 (m=10.89, SD=4.36)	-
Total fixation duration on the prosthetic hand (seconds)	104.25 (m=8.69, SD=7.00)	84.43 (m=7.04, SD=6.99)	19% less	101.18 (m=8.43, SD=14.70)	35.85 (m=3.02, SD=1.92)	65% less	83.76 (m=6.98, SD=3.75)	-
Total saccade amplitude during the tasks (degree)	66.49 (m=5.54, SD=2.12)	82.71 (m=8.31, SD=3.37)	24% higher*	38.14 (m=3.84, SD=2.71)	91.06 (m=8.09, SD=2.46)	138% higher*	88.51 (m=7.38, SD=2.20)	No data due to problems with the socket

* Higher values indicate a wider shift of gaze between objects

DISCUSSION AND CONCLUSION

The qualitative data from control training and the quantitative eye tracking data from SHAP and ACMC confirmed our clinical observations about learning to control a multifunction hand.

Switching grips in multifunction hands is more cognitively demanding, however, the cognitive demands decrease over time. Prosthesis users switch grips less frequently in self-chosen tasks and the need for visual feedback to control the hand decreases over time.

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6.062 A review of the application of artificial intelligence on performance and quality of life in people with upper limb prosthesis

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BACKGROUND

Introduction: Significant advances in upper limb prostheses have been possible with bioengineering, robotics and artificial intelligence. Upper limb prostheses, traditionally designed to restore basic functions, are now becoming highly advanced devices capable of replicating complex hand and arm movements, providing users with a level of dexterity and control previously unattainable. It was evolution. Prosthetics has reached a remarkable stage, driven by rapid advances in artificial intelligence (AI) and brain-computer interface (BCI) technologies. Modern prostheses, enhanced by artificial intelligence and BCI, respond to users' needs seamlessly and mimic natural body movements with unparalleled accuracy. By incorporating artificial intelligence, prostheses are now able to interpret users' movements, improve in real-time, and provide feedback that significantly enhances experience and control. Fully synthetic prostheses use machine-intelligent algorithms and sensory inputs such as electromyography (EMG) to perform precise movement control.

AIM

analyze the role of new technologies such as artificial intelligence and brain-computer communication in improving the performance and increasing the compatibility of upper limb prostheses and improving the quality of life of upper limb amputees.

METHOD

Google scholar, PubMed, Scopus and Web of Science databases were searched using keywords Prosthesis, Prostheses, AI, upper limb, and amputation from 2000-2024, with PEDro score & after conducting the search, among 34 papers, 11 articles were selected and reviewed.

RESULTS

The reviewed articles refer to the transformative change of artificial intelligence (AI) and brain-computer interface (BCI) technologies on upper limb prostheses. Prosthetic intelligent protocol-based systems equipped with electromyography (EMG) sensors enable precise decoding of muscle signals, allowing users to control their prosthetic limbs with precision that mimics natural movements. The integration of BCI technology also furthers the control of the prosthesis, as it allows users to intuitively control their prosthesis through thought alone, by creating a direct neural connection. This increases responsiveness and ease of use dramatically. (Click to see [table](#))

DISCUSSION AND CONCLUSION

The integration of artificial intelligence (AI) and brain computer communication (BCI) technologies have made a significant improvement in upper limb prostheses. In fact, artificial intelligence allows these prostheses to precisely coordinate complex muscle decisions with the user's movements. the potential for artificial intelligence and BCI-equipped prostheses to dramatically improve performance and quality of life. These technologies provide a higher degree of function, independence, and for able-bodied individuals. This integration is shifting towards prosthetics that act on a part of the human body. Future developments of these systems are expected to empower more developers and users with more adoption and autonomy.

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6.063 Towards Comprehensive Prosthesis Training using Mixed Reality

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BACKGROUND

Learning to use a prosthetic hand is a daunting task. Today, prosthetic training is performed in steps such as pre-prosthetic training and control training, and not in a continuous and comprehensive manner. Existing training guidelines have been found to be inadequate, providing poor guidance to clinicians and patients (Widehammar et al., 2021). A training environment based on Mixed reality (MR) might overcome limitations of current training paradigms. MR refers to environments that combine virtual and real objects which can potentially offer a seamless training experience combining the best from virtual and physical prosthesis training.

AIM

The aim is to test a prototype of a MR platform for prosthetic training and prosthetic research.

METHOD

Using MR, real objects can interact with virtual objects and vice versa. For prosthetic training, MR means that a virtual prosthesis can place virtual objects in the real environment (e.g. on a real desk), or a physical prosthesis can interact with virtual objects. Training can start with a virtual prosthesis in the real environment encompassing all elements of prosthesis use while keeping the difficulty of the training task at an appropriate level. Training can then continuously advance towards real prosthesis use by exchanging virtual elements with their physical counterpart and reducing the amount of augmented guidance.

RESULTS

The MR prototype is under development and will be presented with the poster at the conference.

DISCUSSION AND CONCLUSION

Better user training for prosthetic hands is needed, especially for state-of-the-art hands utilizing machine learning-based control (Franzke et al., 2019). MR offers an opportunity for closing the gap between training and real-life use of a prosthesis, which is needed to ensure skill transfer (cf. van Dijk et al., 2016). In addition to training, an MR platform could be used to create a “digital twin” of the prosthesis and as such be used in the design and development of prosthetic hands, algorithms, and even as a decision support for patients.

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6.064 Effect of Prosthetic Hand's Opposition Position on Compensatory Movement for Pick-Up Task from a Desktop

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BACKGROUND

One of the priorities in suppressing compensatory movements of prosthetic hand use is to precisely aligning the prosthetic hand's position and direction with the target object. To address this, we propose a method to predict the position and direction of graspable objects based on limited upper limb ROM, the type of terminal device, and the wrist unit.

AIM

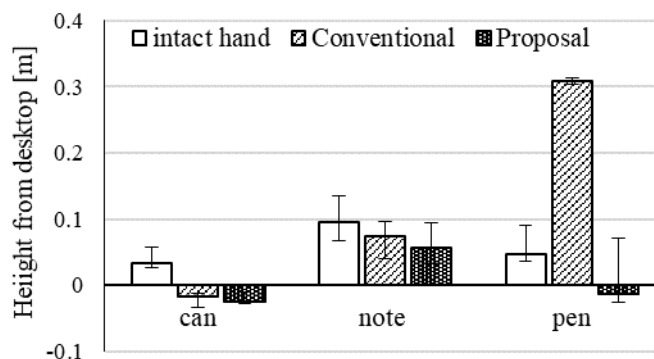
A prosthetic hand focused on desk-based grasping tasks is designed and the magnitude of compensatory movements during pick-up task is compared between our hand and traditional 3-digit myoelectric hands.

METHOD

The Ottobock 8E38 was selected as Conventional Hand. The Proposal Hand was equipped with a thumb opposing to the little finger fixed to the middle finger of the 8E38. The original thumb of the 8E38 is neglected. Three non-amputees performed pick-up tasks of a standing 350-ml aluminum can, a flat stacked notebook, and a depth direction aligned (the pen-nib pointing forward) pen from a desktop, while donning a simulated transradial socket. The compare indices for Conventional, Proposal, and intact hands were the maximum height of the olecranon and the acromion during the tasks, measured by 3-D motion capture system.

RESULTS

With the desktop height set to 0 m, the acromion heights of the three participants measured while seated in stationary position were 0.29 m, 0.32 m, and 0.33 m, respectively. In the can and notebook pick-up tasks, the olecranon positions in all conditions remained low. In the pen pick-up task, the olecranon position in the Proposal Hand remained low, similar to that of the intact hand, whereas in the Conventional Hand, the olecranon height rose to approximately 0.3 m. The Mann-Whitney U test indicated no significant difference in the median of the highest olecranon between the Conventional and Proposal conditions for the can and notebook pick-up tasks; however, during the pen pick-up task, the olecranon height in the Proposal Hand was significantly lower.



DISCUSSION AND CONCLUSION

All recorded tasks were consistent with the movements predicted by the prosthesis functions and the object's positions and directions. Unlike the Conventional Hand, the Proposal Hand maintained a grasping direction aligned with the pen, allowing it to perform the pick-up task without requiring compensatory movements, similar to the intact hand. Further research comparing the performance with prosthetic hand capable of multi-grasp forms, e.g. i-limb hand, is necessary.

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6.065 Power-Assisted Hybrid Upper-Limb Prosthesis

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BACKGROUND

Despite the numerous advancements in the myoelectric control of upper-limb prostheses, devices utilising this method often lack the necessary level of functionality ^[1]. This is partly due to the absence of sensory feedback from the terminal device and their high reliance on visual feedback for effective operation ^[2]. Body-powered devices feature intrinsic proprioceptive feedback as they are actuated directly by the user's musculature, however, they require significant effort from their users to activate, leading to pain and fatigue ^[3].

AIM

We aimed to design a haptic controller that emulates body-powered devices with reduced actuation effort, to provide active proprioceptive feedback with reliable control to battery-powered upper-limb prostheses.

METHOD

The prosthesis' terminal device motor assists in grasping objects based on the user's movement and the haptic device provides resistance when obstructions are present through a harness akin to a body-powered device. Preliminary testing was completed through a qualitative assessment with a prosthesis user, using a battery-powered split hook terminal device. Manipulation of a set of common everyday items was investigated, and feedback on the design was provided.

RESULTS

The haptic device demonstrated an ability to track the motion generated by the user and provide feedback when obstructions occurred for the terminal device. The total weight of the controller was 180 g without a battery. As seen in Figure 1, the participant could pick and place an apple within a mug and lift the mug to pour the apple out successfully. They reported a positive experience due to the intuitiveness of the control they perceived compared to systems they had used previously. Overall, they described the device as comfortable as it requires significantly lower force input (1 to 2 N), compared to traditional body-powered devices (33 to 131 N ^[3]).



Figure 1: Participant wearing the device and handling apple and mug.

DISCUSSION AND CONCLUSION

Compared to other non-invasive feedback modalities (e.g. vibrotactile feedback) this method requires a larger actuator and, therefore, has higher power requirements and weight. However, the homotopic application of the feedback and control input results in an intuitive and reliable control paradigm that shows clear benefits to the user experience. The method also benefits from its simple implementation as it utilises low-cost commercial components, and the employed control law reduces the problem to a selection of a stiffness value through user feedback. The potential impact is highlighted for users who prefer body-powered control, expanding their options to battery-powered devices to assist their actuation effort.

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6.066 Redesign and validation of a tool holding system for a transradial prosthesis for a stomatology student

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BACKGROUND

A stomatology student at the Benemérita Universidad Autónoma de Puebla approached the Universidad Iberoamericana Puebla in order to help him acquire a customized transradial prosthesis that would be able to allow him to use his stomatological instruments. Seven specific adapters were made for seven instruments. Despite the efforts made since autumn 2023, the current prototypes do not meet the user's needs in terms of durability and functionality.

AIM

Redesign and validate a system for holding stomatological tools for a transradial prosthesis

METHOD

The design process for the holding system began by gathering feedback on two previous prototypes. The user identified essential adapters, for a dental mirror, high/low-speed dental burrs, and a mixing bowl support, while highlighting the need for more durable materials. Material selection focused on strength, weight, durability, and biocompatibility, resulting in the use of Siraya Tech Blu Tough Resin for the tool adapter (with an AISI 304 stainless steel part) and PETG filament for the bowl support. Using SolidWorks, 3D models were created and evaluated via finite element analysis to simulate load conditions.

RESULTS

The clamp experiences the highest stress in the study, along with the screw connecting it to the assembly (ScrewUD). Stress values for the clamp range from 19.1 MPa to 22.3 MPa, primarily where it contacts the mirror, while ScrewUD experiences stresses between 44 MPa and 86 MPa. The linkage inside the fixation system (Link F), which provides angle adjustment, endures stresses between 6.1 MPa and 11.7 MPa. Additionally, the screw serving as a fixing axis for the assembly shows stress levels of 8.5 MPa to 28.9 MPa, with the rest of the assembly experiencing between 0.17 MPa and 10 MPa. The clamp's safety factor (FOS) varies from 2.9 to 6.5, ScrewUD ranges from 10 to 46, and Link shows FOS between 37 and 60. The minimum assembly FOS is 2.883. Fatigue analysis shows a minimum of 101.99 cycles in the clamp, with edge nodes at 588 to 524 cycles.

DISCUSSION AND CONCLUSION

The redesigned tool-holding system for a custom transradial prosthesis has successfully met the user's specific needs, facilitating their clinical practices in stomatology. This prototype provides a functional and durable solution; fatigue analysis shows a lifespan of up to 5 years. Additionally, with a safety factor exceeding 12 throughout the assembly, the selected materials are confirmed to withstand forces up to 50 N, ensuring the design's strength and effectiveness.

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ACKNOWLEDGEMENTS

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6.067 Enhancement of EMG Monitoring Devices through Generative AI

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BACKGROUND

At the request of occupational therapists at Hyogo Rehabilitation Center, we developed a wireless EMG monitor system about ten years ago. It was designed to observe children's muscular activity during myoelectric prosthetic training. However, the wireless modules available at that time were considerably large compared to pediatric sockets, and due to wireless module requirements, the system could only be used with PCs.

AIM

The aim of this project is to develop a more compact device with enhanced features focused on user convenience, utilizing accelerated development approaches.

METHOD

We designed a system allowing EMG signal waveform observation through web browsers on smartphones and tablets. The newly available compact wireless module requires three functions: 1) acquiring EMG signals through built-in analog-to-digital conversion, 2) displaying these signals as graphs accessible via web browsers through a web server, and 3) developing software enabling the wireless module itself to function as a WiFi router for simple wireless connectivity. We plan to generate source code implementing these three functions by providing appropriate prompts to generative AI (Copilot, Microsoft) to meet these specifications.

RESULTS

Through software development utilizing generative AI, we ultimately created program code for the wireless module implementing the three required functions via Japanese-language prompt inputs. The generated code was tried to compile and to write to the wireless module. In case of a compilation error, I created prompts that aligned the error message with the direction of the source code correction and iteratively improved them. When compilation succeeded without errors, we verified all intended functions through practical testing. For any missing or inadequately performing functions, we iteratively enhanced the prompts with more detailed specifications. This process was repeated until the implementation reached a practical level of functionality.

DISCUSSION AND CONCLUSION

By leveraging the knowledge learned by generative AI, we were able to generate practical code by created prompts that incorporated thoroughly considered and detailed content. This significantly reduced development time for custom measurement systems.

Utilizing generative AI, the program coding time that took around six months ten years ago could now be completed in about fifteen minutes. And the auto-generated program met the required functionality.

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6.068 Control of Motor and Imagery Tasks for Prosthetic Upper Limb Using EEG Data

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BACKGROUND

Brain-computer interfaces using EEG-based motor imagery activities are advancing prosthetic limb control. Recent trends focus on implementing efficient algorithms to be integrated with 3D-printed prosthetic hands [1]. Researchers are optimizing signal processing and machine learning techniques for real-time execution on embedded systems, aiming to improve the responsiveness and naturalness of prosthetic movements. Current work focuses on integrating these systems with advanced sensory feedback mechanisms to enhance user experience and functionality in daily activities.

AIM

This research advances prosthetic hand control technology by optimizing EEG-based motor imagery activities, facilitating real-time control of 3D-printed limbs.

METHOD

The study utilizes a 16-channel OpenBCI [2] system to collect EEG data from 60 subjects [3] performing motor imagery tasks designed to control a custom 3D-printed prosthetic hand. To achieve this objective, preprocessing steps such as normalization and RMS feature extraction were implemented. Three classification tasks were designed: distinguishing between the right hand and rest, the left hand and rest, and comparing the right hand (RH), left hand (LH), and rest. The classification tasks are carried out using machine learning algorithms. The focus of optimizing AI algorithm performance on embedded systems is to integrate these algorithms into low-power hardware using a microcontroller.

RESULTS

The results demonstrate high classification accuracy in EEG-based control for prosthetic hands, targeting both motor and imagery tasks. The proposed algorithm achieved 92% and 88% accuracy in distinguishing right-hand movements from rest, while left-hand vs. rest conditions reached 87% and 84%, respectively. In a three-class setup (left vs. right vs. rest), 85% and 82% accuracy were attained for motor and imagery tasks, as shown in the figure below. These findings align with recent trends emphasizing semi-autonomous prosthetic limbs. Our research underscores the potential of brain-controlled prosthetic hands to facilitate the tasks related to opening and closing. The consistently high accuracy, especially in right-hand control, marks a significant advancement, offering hope for more responsive, precise prosthetics that could substantially enhance the quality of life for individuals with upper limb disabilities.

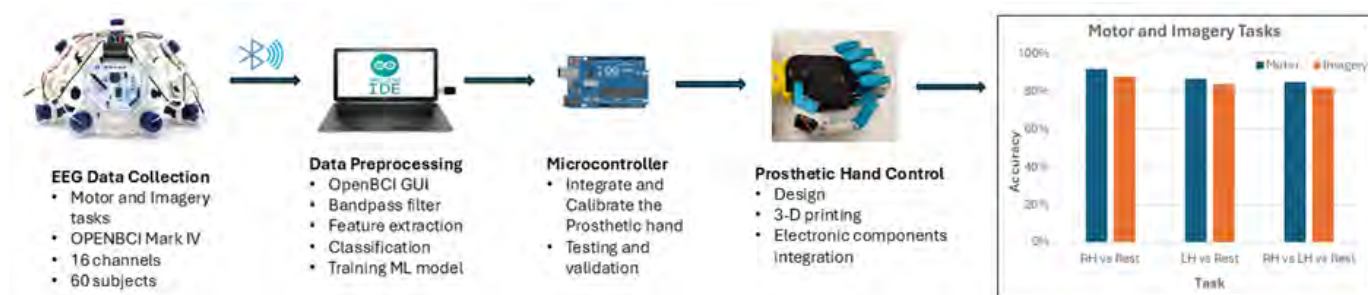


Figure. Experimental setup and result



DISCUSSION AND CONCLUSION

The findings reveal the effectiveness of the proposed EEG-based algorithm for controlling prosthetic hands with high accuracy in motor and imagery tasks. This aligns with recent trends toward semi-autonomous prosthetic technology, demonstrating significant potential in enhancing adaptive handling capabilities. The consistent accuracy, especially in right-hand control, highlights the feasibility of brain-controlled prosthetics, offering an essential step forward in improving the functionality and quality of life for individuals with upper limb disabilities.

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ACKNOWLEDGEMENTS

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Posters | Prosthetics and Orthotics: in less resourced settings

6.069 The Walking Free Program: A Sustainable Approach to Prosthetic and Orthotic Production, Fitting, and Training in Less Resourced Regions

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BACKGROUND

Healthcare providers in less resourced countries have identified a lack of sustainable partnerships to improve healthcare in their regions, with short term programming representing a particular weakness ⁽¹⁾. The Walking Free system represents a departure from traditional approaches by prioritizing sustainability and community empowerment in prosthetic and orthotic fabrication and training. Rooted in the ethos of "teach one, heal many," this system integrates production and training with physical rehabilitation education.

AIM

Describe structural, philosophical, and operational aspects of a sustainable strategy to introduce the capacity for prosthetic and orthotic fabrication and training to a healthcare system, tailored for less resourced regions.

METHOD

The Walking Free system begins with establishing Memorandums of Understanding with government entities and local non-governmental organizations to ensure accountability and sustainability. Capacity for prosthetic and orthotic care is then introduced, with updated methods now consisting of the prosthetic & orthotic lab built inside a 12-meter shipping container for immediate productivity upon delivery. Finally, short follow-up trips are formatted as educational opportunities for rehabilitation professionals across disciplines. These are supported by free educational materials on the fully accessible [youtube.com/missiongait](https://www.youtube.com/missiongait) platform, as well as meetings and training sessions completed via Zoom or WhatsApp.

RESULTS

The Walking Free Program has demonstrated significant success in fostering independence and long-term productivity in less resourced regions. The educational approach, focusing on training rehabilitation professionals rather than isolated treatments, has extended the program's impact. The system has a long-term presence in 7 countries, from the Caribbean and Central America, to the Middle East, and South Pacific - most recently in the Solomon Islands.

DISCUSSION AND CONCLUSION

The results confirm the effectiveness of sustainable and educational approaches in prosthetic and orthotic care. By nurturing local expertise and ownership, the Walking Free Program fosters continuous care beyond short-term interventions. The initiative's success in diverse, less resourced regions highlights its potential for broader application and impact, and is consistent with the World Health Organization's recommendation to improve access to assistive technology through "international cooperation to support national efforts" ⁽²⁾.

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6.070 LIMBKIT: A Portable 3D Printing Kit for Prosthetic Sockets

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BACKGROUND

3D printing technology holds the promise of transforming prosthetic care by making it more accessible and affordable, particularly in rural/remote areas and conflict zones where conventional prosthetic services are challenged. The LIMBKIT, a portable unit designed for producing prosthetic sockets, has the potential to mitigate service gaps. A scoping review on prosthetics technologies suggested that increased collaboration among academia and clinical teams could help address the gaps in evidence in bringing technologies to practice ^[1].

AIM

To determine whether the LIMBKIT's 3D printed prosthetic sockets were comparable to traditional definitive prosthetic sockets in terms of walking and balance performance outcomes.

METHOD

The participants were unilateral and bilateral transtibial amputees recruited for an AB single-subject design study. Participants used their definitive sockets (Phase A) and then switched to LIMBKIT's 3D printed sockets (Phase B) for three weeks each, whereupon we took 3 measurements a week (total of 9 each phase). We evaluated them remotely using Zoom. Performance measures included the Timed Up and Go (TUG), Four Square Step Test (FSST), Figure-of-8 Walk Test (F8WT), and Short Physical Performance Battery (SPPB). Self-reported measures included the Socket Comfort Score (SCS), Activities Specific Balance Confidence Scale (ABC), and Prosthetic Evaluation Questionnaire (PEQ-Mobility).

RESULTS

A total of six participants were recruited from Metro Vancouver, British Columbia, Canada. The participants included five men and one woman, aged 47 to 69 years, consisting of four unilateral and two bilateral transtibial amputees (one printed socket only). Analyses using 2 standard deviation band method indicated no statistically significant difference for the TUG and F8WT (N=6/6 participants). There was variation in the SPPB and PEQ-Mobility (N=2/6), (N=3/6) respectively, the ABC (N=1/6), FSST (N=4/6), and SCS (5/6). However, none of these differences were statistically significant as the observed changes fell below the minimum detectable change (MDC) thresholds.

DISCUSSION AND CONCLUSION

3D-printed sockets did not alter mobility performance, self-reported balance confidence or self-reported mobility but there was variability in balance performance and self-reported socket comfort. The observed changes, however, did not represent reliable or true changes beyond measurement error, as they fell below the MDC threshold, suggesting similar outcomes between the printed and traditional sockets. The findings are encouraging regarding the feasibility of the Limbkit for use in areas challenged for prosthetic care.

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ACKNOWLEDGEMENTS

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6.071 Exploring the Experiences of Trans-Tibial Users of Rural Region of Nepal in Karnali Province: A cross-sectional survey

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BACKGROUND

Nepal has a history of more than 50 years in establishing prosthetic and orthotic services. Though there are fewer prosthetic clinics and registered professionals, only 12 are working in the capital and urban areas, whereas no prosthetic clinics and professionals are working in Karnali. The unmet need for AT in Karnali is higher among 7 provinces, the prevalence of AP is just 8.9 % where the use of AP in Urban areas is 28.9%.

AIM

To explore the challenges experienced by transtibial prosthesis users and analyze the gap in accessing prostheses.

METHOD

Purposive sampling was used for this survey. The participants were recruited from the registered data of Limb Care Nepal and contacting volunteers from the local community. The twenty users were interviewed with semistructured questions for qualitative study. An in-depth one-on-one interview was conducted to explore their experience and Thematic analysis was applied.

RESULTS

The thematic analysis was produced by using repeated words from the participants. Five themes were identified; Financial Difficulty, Service Provision, Lack of Knowledge, Social Participation, and Satisfaction.

User X: " I had to wait for 2 years to get my leg since I could not afford myself"

User Z: " My prosthesis falls when I walk for long distances, I use clothes around my stump to tighten."

The participant hardly repaired their prosthesis once they got it and they were compelled to use broken prostheses for 2 to 4 years to replace new prostheses in the absence of provision in the system. However, the participants were satisfied with the prosthesis despite everyone saying that they want good quality prosthesis though they do not have any knowledge about the poor and good quality of the service.

DISCUSSION AND CONCLUSION

This survey looked into different aspects of trans-tibial users' experiences. Even though users had difficulties in financing and service provision they had a positive attitude toward life and enjoyed social participation. Their frustration with the bad system in service provisions could be a guidance to bring changes in the service provision.

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6.072 Integrating evidence-based medicine in the humanitarian intervention: managing complications associated with blast injury amputation for improved rehabilitation outcomes

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BACKGROUND

The application of evidence-based rehabilitation medicine in war-zone humanitarian rehabilitation efforts can be challenging due to the displacements, poly-trauma, distress and lack of precise data. We developed a system for assessing blast injury related amputations to enhance better prosthetic care through: screening of comorbidities, utilizing a syndromic approach for blast injury rehabilitation protocols, minimizing poor compliance, enhancing adherence to care, and providing adapted prostheses for better outcomes.

AIM

Developing a remote assessment form incorporating complications and veiled comorbidities associated with blast amputations, such as bTBI¹, behavioural health problems², or phantom pain; leading to holistic personalised treatment plan.

METHOD

We developed a simple assessment form for patients suffering from blast amputations with hidden comorbidities to be filled by paramedical staff in war-zone or evacuation areas with limited professional medical care. The form included information on additional trauma like burns, spinal cord injuries, blast Traumatic Brain Injury (bTBI); and information on veiled comorbidities affecting prosthetic care, Post-Traumatic Stress Disorder (PTSD), heterotopic ossification³, etc. Our medical team remotely monitored the filling of the form by paramedical team on displaced Gazan amputated patients within Egypt. The form was later updated utilizing the feedback and compliance of the paramedical team.

RESULTS

The initial patient assessment form was filled by physiotherapists of NGO's in Egypt; we asked them to stress on the underlying factors leading to dissatisfaction of prosthetic care or, to non-compliance of patients. As an example, we monitored the prosthetic care of an adult female patient with complications like, symptoms post bTBI (persistent headache, nausea, dizziness etc.), shrapnel in her face, breast cancer (not taking medications), undetected PTSD, reduced body image. Her top priorities did not include prosthetic care, but rather funding her cancer medications and removing the shrapnel visible in her face. Our plan included referring her to an oncologist and a surgical team to perform shrapnel removal and revision surgery of her amputation, along with psychological treatment. With such plan she agreed on receiving a trans-humeral prosthesis.

DISCUSSION AND CONCLUSION

Through our remote assessment form we facilitate a feasible systematic approach for patient data acquisition, considering the frailty of war-displaced patients and the negative confounding factors on the success of a fitting, inherent to blast injury. In addition, collecting data could help enhance humanitarian evidence-based medicine, by the development of predictive syndromic models for new standardised procedure in the prevention/treatment of secondary complications and comorbidities.

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6.073 Scaling Access to 'World Health Organization (WHO) Standard Prosthetics' in Humanitarian and Development Settings

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BACKGROUND

An estimated 1.3 billion people globally experience significant disability, or 16% of the population. However, only 1 in 10 people in need have access to assistive products like prostheses, due to factors such as high cost, lack of awareness, trained personnel, and limited policy and financing. The number of people requiring assistive products is projected to exceed 2 billion by 2050. WHO has included lower-limb prostheses on its Priority Assistive Products List.

AIM

Our goal is to increase access to WHO-standard prosthetics in humanitarian and development settings through sustainable, community-driven solutions.

METHOD

Since 2009, we have directly distributed nearly 35,000 prostheses in various humanitarian and development settings across Africa and South East Asia. By combining advanced manufacturing techniques with low-cost materials, we produce WHO-standard prosthetics that are both affordable and durable, tailored to the needs of individuals in low-resource settings.

Our approach to prosthetic distribution is rooted in a community-centered model, with a focus on sustainability and long-term impact.

Localized Outreach Camps in areas with high unmet needs and limited healthcare access. These camps serve as hubs for prosthetic distribution and rehabilitation services, ensuring efficient and cost-effective delivery by mobilizing local resources. This approach ensures timely, accessible care for individuals in underserved regions.

Engagement of Local Communities in the planning and execution of outreach activities, creating a supportive environment that reduces hesitation and stigma, and encourages acceptance of prosthetics.

Collaboration with Local Healthcare Providers to ensure our prosthetics meet community needs, integrating them into the local healthcare system for sustainable care and long-term support.

Ongoing Support and Follow-up care, adjustments, and physical therapy to help recipients adapt, and establish local support networks for ongoing rehabilitation.

Data Collection and Feedback.

RESULTS

Key results for successful Community-centered model include:

1. *Improved Access*: Overcoming barriers like cost and lack of professionals, providing life-changing mobility.
2. *Sustainability*: Engaging local communities and healthcare providers for long-term support and integration into local systems.
3. *Increased Acceptance*: Community engagement has reduced stigma and fostered greater acceptance.
4. *Better Rehabilitation*: Follow-up and local support networks have improved adaptation and mobility for recipients.
5. *Improvement*: Data collection and feedback help refine our methods for maximized impact.

DISCUSSION AND CONCLUSION

Our model has successfully provided life-changing mobility to thousands, improving the quality of life for individuals with disabilities. By focusing on community engagement, sustainability, and ongoing support, we're creating lasting impact and paving the way for broader access to prosthetic care worldwide.

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6.074 Visualisation of Temperature Regulation Effect During Exercise of Outlast Treated SmartTemp Silicone Liners Compared to Standard Silicone Liners

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BACKGROUND

Increased residuum heat and perspiration are known issues amongst amputees.¹ This is common in K2 and K3 activity levels and in different climate environments. The Alpha SmartTemp liner by WillowWood® features a phase change material (PCM) to regulate residuum temperature. Residuum heat is absorbed into the liner and returned when the residuum has cooled down, maintaining the conditions of the surrounding environment for longer periods². Many amputees would benefit from this technology.

AIM

Investigate whether the reported effects of PCM in the SmartTemp liner could be visualised using an infra-red video camera to help show a different perspective of the mechanism of residual limb heat regulation.

METHOD

A 61-year-old above-knee unilateral amputee performed successive 5-minute sessions of vigorous treadmill walking in a temperature-controlled room, first with a SmartTemp Silicone liner, then a standard Alpha Silicone liner without a PCM. The speed of walking was set identically in each session. Prior to each exercise session, the subject was asked to rest for 10 minutes without a liner to stabilise limb temperature. Pulse was also measured to ensure equal starting points. Post exercise, the subject stood still for 5 minutes, removed the liner and stood stationary to show the heat signature of both limb and liner under Infra-Red (FLIR) video observation.

RESULTS

Upon donning of each liner and socket prior to exercise, no obvious temperature differences were detected by the thermal camera. During the first 2 minutes of exercise, the socket was seen to heat to an identical temperature in both cases. The sound side limb also showed the same heat signature during both sessions. After exercise, when the liners were removed and turned inside out, the SmartTemp liner showed a highly uniform heat signature, compared to a heat spot in the non PCM liner and displayed a lower temperature of between 1.0 and 3.5 degrees Celsius compared to the non PCM liner.

DISCUSSION AND CONCLUSION

It was thought that heat regulation during walking would support previous findings during cycling.

The temperature difference between SmartTemp and the control liner for walking was greater than measured during previous cycling studies. This suggests walking to be a more vigorous steady state activity and therefore more crucial for prosthetic technology to regulate residuum temperature.

Further studies varying the walking cadence and activity time should be carried out, to establish optimum conditions for PCM liner use.

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6.075 Algorithms, High Flow Printing, Sprint Education, Leveraging Technology to create Prosthetic Solutions for the Untreated 30 million

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BACKGROUND

Global prosthetic care varies accross the globe, multiple factors define the quality and the outcomes in each individual situation and country. Health policy, reimbursement, educational standards, cultural considerations, supply chain, and political factors are all contributors. Given the breadth and scope of these challenges is it not surprising that virtually all countries in the world struggle to meet the full demand of its citizens. With improved technology solutions that gap can be reduced and more than 30 million people globally that have historically lacked access to prosthetic care can be gift the gift of mobility. IN most cases the Socket or interface provides the foundation of a functional prosthesis and is often created in a labor intensive and highly specialized field.

AIM

Share findings related to ongoing research and development of a first of kind combination of hardware, software, and education platform , in both pilot and production phases in post war Ukraine and beyond. The innovative first of its kind system has global implications and deployability in less served areas globally. The system leverages a new scanning technology, novel materials, a unique training and education structure, and a simplified global supply chain to bring scale and access to quality prosthetic care in areas that would not otherwise have access or opportunity.

METHOD

An ongoing multiphase multi-country program including the following stages:

- Needs assessment
- Policy Development
- Resourcing/Solutioning
- Development, Testing and Refinement,
- Education and Training
- Pilot Launch
- Research and Outcome Measurment
- Refinement
- Scale

Research is done in all countries of operation, development has been global with US, Czech, Ukrainian, Polish, partnerships.

RESULTS

The results show that it is possible and feasible to provide custom prosthetic care including the creation of prosthetic sockets at scale. Repeatability is key, and retrainign algorithms speeds development, and leads to more cohesive sound solutions. Materials science and innovation has led to the creation of a one of a kind socket that is preferred over traditional laminated sockets common in many global markets. with most patients transitioning selecting the new proted socket over well fitting traditional designs.

DISCUSSION AND CONCLUSION

Results are coming and increasing daily as scale is increased. Success in this areas proves viability, and shows that production of custom made products at scale is not only possible but actually may supercede in quality the traditional methods used in most markets.

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6.076 Bone-Anchored Prostheses (BAP) through Osseointegration (OI), Deal or No Deal; A multicenter study to assess the willingness-to-undergo OI-treatment

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BACKGROUND

Patients with socket-related complaints can opt for BAP through OI. BAP is an effective treatment¹. Although the goal of the treatment is to improve multiple dimensions of life, complications can unfortunately be part of the process. The willingness for OI treatment (WOI) scenarios and the impact of complications need to be quantified²

AIM

To determine the uptake in percentages of different WOI through scenarios based on changes in quality-of-life (QOL), implant lifespan (YIF) and short-term and long-term complications (STC and LTC).

METHOD

Patients with BAP had to choose between multiple treatment scenarios with randomized elements per option and the possibility of opting out. Using maximum utility theory (i.e., the most value for investment) and a corresponding Bayesian model, WOI was calculated for different scenarios. Additionally, the relative severity of complications was calculated using the model. Consequently, the severity was expressed in terms of STC and LTC.

RESULTS

A total of 7,687,134 scenarios were created across 10,374 choices through 247 participants. Scenarios were summarized into groups of 1- and 3-year quality of life (QOL) and 10- and 20-year implant lifespan (YIF). An increase in QOL and YIF positively impacts the WOI (Figure1). With more complications, WOI decreases in each group. Severity of changes are the strongest in more complications and relatively smaller compared to less QOL or YIF. With similar complication profiles, the relative increase in WOI is stronger for QOL than for YIL. The impact of STC is 3.8 times smaller than that of LTC.

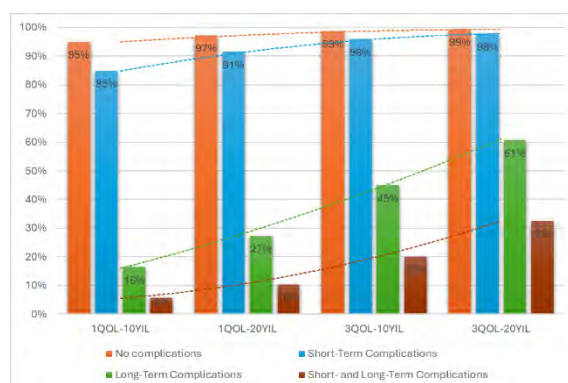


Figure 1. Willingness of opting for BAP by QOL-changes and YIL given outcomes of treatments.

DISCUSSION AND CONCLUSION

Understanding the impact and severity of complications helps in offering the most suitable treatment for each individual or group. These results can be combined with predictive models to align suitability with WOI for potential BAP candidacy. Additionally, potential increases in willingness can be achieved by adjusting factors during treatment to improve outcomes.

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Posters | Orthotics: spinal

6.077 A Methodological Study for Monitoring Geometry Changes and Applied Forces Resulting From a Scoliosis Brace

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BACKGROUND

Scoliosis braces are the standard conservative treatment for adolescent patients with idiopathic scoliosis, aiming to halt or reduce the progression of the spinal curve. X-ray imaging is the current method of evaluating the scoliosis brace performance measuring the decrease of the Cobb angle before and while wearing the brace. Using experimental techniques, a plethora of information can be collected for a more comprehensive understanding of what happens to the body.

AIM

The present work investigates the geometrical changes of the body inside and out of the brace as well as the forces exerted by the brace on the body which are related to the Cobb angle reduction and the general performance of the brace. The goal is to propose a methodology for the collection of additional data that could enhance decisions involved in creating a brace.

METHOD

For the study, a case involving a patient with thoracolumbar scoliosis was selected. A custom-made, 3D-corrective brace was fabricated. 3D scanning technology was used to capture the patients' body and the plaster model before and after corrective adjustments. The scanned 3D model provided data on the translation and rotation of key anatomical points in space. Flexible force sensors were then placed at the interface of the brace and the body, at the apex of the scoliosis curve and other critical correction areas, to measure the corrective forces that are being applied to the patient.

RESULTS

By tracking the geometry changes, a better understanding can be achieved on how the plaster rectifications ultimately impact the body and how the intended posture encouraged by the brace translates to Cobb angle reduction. Additionally, the flexible force sensors effectively measure the exerted forces by the brace. At the apex of the curve the forces reach maximum values. The findings are then correlated to the two-dimensional X-rays, which are currently the standard method for evaluating brace effectiveness.

DISCUSSION AND CONCLUSION

This study demonstrates the potential of using 3D scanning and sensors to gain a more detailed insight on the effect of a scoliosis brace. The experimentally obtained data can enhance the understanding of how the body reacts to corrective adjustments. By expanding the undertaken work to include more patient case studies, significant relationships of forces, rectifications, elasticity of the thoracic cage and Cobb angle could be identified and documented. Eventually, such information could improve design decisions related to the development of more effective, patient-specific braces.

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ACKNOWLEDGEMENTS

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6.078 The Effects of Open and Closed Pelvic Trimlines of TLSO in Adolescent Idiopathic Scoliosis Patients: Pilot Study

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BACKGROUND

Scoliosis is a three-dimensional deformity of the spine defined as a lateral curvature of the spine in the coronal plane of more than 10 degrees. Adolescent idiopathic scoliosis (AIS) is the most common. Braces are designed to provide external forces on the spine to prevent the progression of deformity during the growth phase of patients and the Cobb angle is between 25-45 degrees. There are many designs of scoliosis brace to stabilize and control spinal curvature such as the Boston brace, Cheneau brace, etc. Those designs have different principles of controlling the coronal alignment and spinal curvature. The difference between these two designs is the pelvic alignment. the pelvic trim lines cut above the iliac crest on the opposite side of the pelvic obliquity to provide force to realign the pelvis and spinal curve. The approach to the correction of spinal curvature in different brace designs is questionable. Some clinicians have been curious about whether the biomechanical approach has better effects in controlling coronal alignment.

AIM

To investigate the effect of two different pelvic trim lines of TLSO in terms of Cobb angle, coronal trunk decompensation, and pelvic alignment in AIS patients who have pelvic obliquity to the same side of coronal trunk decompensation.

METHOD

This study was approved by the Siriraj Hospital, Faculty of Medicine Siriraj Medicinen institutional Review Board. 4 participants were recruited and took an X-ray while wearing custom-made TLSO with two different pelvic trim lines. Cobb angle, coronal trunk decompensation, and pelvic obliquity were measured by three professional prosthetist and orthotist using the computer program provided by Siriraj hospital.

RESULTS

4 females participated to the study. The mean age was 12 ± 0.8 years. All of them were diagnosed as the idiopathic scoliosis with different curve pattern, 1 double curve (major lumbar), 2 single thoracolumbar curves and 1 single lumbar curve. Mean Risser sign was 1.3 ± 1.3 degrees with the average Cobb angle 39.5 ± 2.4 degrees. Mean pelvic displacement was 0.754 ± 0.413 cm and the mean trunk decompensation 1.984 ± 1.153 cm. The In- brace cobb angle reduction in percentage in Design 2 was greater than Design1 compared to out-brace radiograph

DISCUSSION AND CONCLUSION

Custom-made TLSO with the pelvic trimline cutting above the iliac crest (design 2) provides the better curve reduction in all participants but the coronal trunk decompensation and pelvic obliquity was still controversial. However, the lesser trimline would reflect the better appearance which would improve the patient's compliance and quality of life.

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ACKNOWLEDGEMENTS

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Figure 1 – X-ray without brace, X-ray with design 1 and X-ray with design 2, respectively



Figure 2 – Patient without brace, Patient with design 1 and patient with design 2, respectively



6.079 Comparative Outcomes of Chêneau and Custom-Made Boston Braces in Adolescent Idiopathic Scoliosis Management at Sirindhorn School of Prosthetics and Orthotics

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BACKGROUND

Adolescent idiopathic scoliosis (AIS) is a three-dimensional spinal deformity that can lead to significant physical and psychological consequences if left untreated ^[1,2]. Orthotic intervention is a primary non-surgical treatment aimed at halting curve progression and correcting spinal alignment. The Sobernheim Chêneau and custom-made TLSO based on Boston bracing principles are widely used, each with distinct biomechanical principles. Previous studies have explored their biomechanical differences ^[3,4], but comparative clinical outcomes in real-world settings remain limited.

AIM

To compare the outcomes of Sobernheim Chêneau and custom-made TLSO based on Boston principles in reducing spinal curvature and improving trunk alignment.

METHOD

This retrospective review examines medical records of AIS patients aged 10-18 years treated between 2021 and 2023 at the Prosthetics and Orthotic Clinic, Sirindhorn School of Prosthetics and Orthotics. Patients who received either the Sobernheim Chêneau brace or the custom-made TLSO based on Boston bracing principles are included. Patients are categorized based on the brace type documented in their medical records. Data to be collected includes demographics and radiographic measurements. Statistical analysis is used to compare mean differences in curve reduction measured from Cobb angle and trunk alignment improvement between the two brace groups. Adjustments for potential confounders are discussed. A p-value < 0.05 is considered statistically significant.

RESULTS

As this is an ongoing project, it is expected that both brace types will result in significant reductions in spinal curvature and improvements in trunk alignment based on previous studies. The Sobernheim Chêneau brace may demonstrate greater curve reduction measured from Cobb angle compared to the custom-made TLSO based on Boston bracing principles, attributable to its three-dimensional corrective design ^[5]. Anticipated findings include a higher percentage of curve correction and better trunk alignment outcomes in the Sobernheim Chêneau group.

DISCUSSION AND CONCLUSION

Expected results may suggest that the Sobernheim Chêneau brace offers certain advantages over the custom-made TLSO based on Boston bracing principles for correcting spinal curvature and improving trunk alignment in AIS patients. Studies have highlighted the biomechanical benefits of the Chêneau brace's three-dimensional corrective design, which may provide more effective curve control in some cases ^[6,7]. However, patient compliance, brace fit, and individual anatomical differences remain crucial factors that can influence the outcomes of both braces ^[8]. While these findings may guide clinical decisions regarding optimal brace selection, further research with larger samples and extended follow-up is recommended to validate these preliminary results and to better assess long-term effectiveness.

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6.080 Stress level and quality of life of adolescents with idiopathic scoliosis during brace treatment

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BACKGROUND

Scoliosis is a serious risk factor in creating psychosocial issues that may lead to alcohol consumption and suicidal thoughts. The self-image of scoliosis patients can affect their cognition, thinking, and behavior. The quality of life (QoL) in adolescent idiopathic scoliosis (AIS) patients is mainly associated with psychological coping mechanisms rather than radiological parameters. Brace treatment may increase the patients' level of anxiety, stress, depression, and decrease self-esteem, and QoL.

AIM

This study aimed to assess the effect of brace type on stress levels and quality of life of adolescents with idiopathic scoliosis compared to healthy adolescents.

METHOD

We studied 194 adolescents in two groups: 1) 97 adolescents with idiopathic scoliosis (AIS group) and 2) 97 age- and sex-matched adolescents with no spinal deformity (control group). The AIS group wore the Milwaukee brace or thoracolumbosacral orthosis (TLSO) based on the location of the apical vertebra. All participants of AIS group filled the Persian versions of the revised 22-item Scoliosis Research Society (SRS-22r) questionnaire, the eight-item Bad Sobernheim Stress Questionnaire (BSSQ)-Deformity and BSSQ-Brace. The control group only answered the first 20 items of the SRS-22r. The brace-related QoL and stress level were assessed based on sex, brace, and deformity types.

RESULTS

The sub-total score of the SRS-22r in AIS group was significantly lower than the control group ($p < 0.001$). There was a significant difference between deformity-related stress and brace-related stress ($p < 0.001$). Regarding type of treatment, there were no significant differences in QoL and stress level between the Milwaukee brace and TLSO groups ($P > 0.05$). Moreover, there was a small correlation between the BSSQ-Brace and the self-image, mental-health scores, and the total scores of the SRS-22r questionnaire ($r = 0.39$ to 0.42 , $p < 0.001$); low level of perceived stress was associated with a high level of perceived quality of life.

DISCUSSION AND CONCLUSION

The stress due to brace treatment can decrease function/activity and self-image of adolescents with idiopathic scoliosis compared to age- and sex-matched adolescents with no spinal deformity.



6.081 The Effectiveness of Correction of In- Braces Patients in Treatment of Adolescent Idiopathic Scoliosis

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BACKGROUND

Scoliosis is a three-dimensional deformity of the spine and trunk. The most common form is Adolescent Idiopathic Scoliosis (AIS). The prevalence of AIS is 0,47%-5,2% and is more common in girls. The use of custom Braces as conservative treatment could be considered to control the scoliotic curves. In-brace correction is the most important predictive factor for successful brace treatment with right pressures to control curve 3-dimensional to provide a combined deflection-derotation effect.

AIM

In our study we pretend to show the effectiveness of correction when patients are use the custom braces to correct the Scoliosis.

METHOD

This study included 13 patients with Adolescent Idiopathic Scoliosis (AIS) who were either currently receiving treatment or had completed treatment at the MGOrtopedia Clinic. All braces were custom-made at MGOrtopedia using advanced 3D technology. The process involved obtaining a precise 3D body scan, which was then processed and adjusted using CAD modeling to optimize fit and corrective effectiveness.

Patients were instructed to wear the brace for a minimum of 18 hours daily. To assess in-brace effectiveness, evaluations included clinical follow-ups every six weeks and radiographic imaging (X-rays) every six months with and without the brace. Our analysis focused on the initial Cobb angle and the degree of curve correction achieved while the patient was in-brace

RESULTS

All patients refer that use the brace at least 18 hours and are using brace at least 6 months. Three patients have been using the brace for almost 2 years.

In table 1 we present the characteristics of the subjects included in this study. The mean values of Risser were 3,78. The mean values of the primary curve during the initial visit were 38,12 degrees independently of brace type. After 6 months of use brace, patients carried out other X-Ray, one incidence without brace and other with brace. In figure one and two we present the results of two patients from our sample.

Table 1 The characteristics of the subjects recruited in this study

Parameters	Brace Type		
	Boston	Cheneau	Providence
Number of patients (Girl/Boy)	8,00	2,00	3,00
Age	11,25	13,5	13,33
Primary curve type (thoracic/lumbar) angle	34,71	36,66	43
Risser	3,00	4,33	4,00



Figure 1. Patient with a dorsolumbar curve without brace A and with brace B



Figure 2. Patient with a dorsolumbar curve without brace A and with brace B

DISCUSSION AND CONCLUSION

Scoliotic deformity should be controlled to improve the quality of life and avoid surgery. Different types of brace designs are considered, and independently of this it is very important build effectiveness braces, with right pressures to control the scoliosis. Our results present shows this effectiveness. We can see the improvements and the reduction of the curve when in-brace patient.

This study lacks from a bigger patient pool

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6.082 Immediate and short-term effects of a dynamic trunk orthosis in the treatment of adolescent idiopathic scoliosis

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BACKGROUND

Conservative treatment of scoliosis is often criticized for its lack of evolution and aestheticism. If efficiency of brace treatment has been proven [1], fact remains that this type of care takes place in a complex socio-psychological environment which can impact results. Changes in society also affect the evolution of care management: in the last decades, more importance has been given to design and ergonomics of devices to increase acceptance and compliance.

In 2017, a survey of patients treated with back brace was initiated to better detect their needs and wants. Following this study, we worked on different subjects aiming at enhancing treatment and follow-up tools solutions. The 3D Brace using carbon and silicone is one of these subjects.

AIM

The aim of this retrospective study is to evaluate the immediate and short-term efficiency of the 3D Brace in the treatment of adolescent idiopathic scoliosis (AIS).

METHOD

Retrospective multicentric study on AIS patients fitted with a 3D Brace made of carbon and silicone between 01/01/2022 and 31/12/2024.

Data is collected from patient's medical files.

Outcomes studied: number of patients treated on the period and anthropometric data (gender, age, size, weight at initiation of treatment), evolution of Cobb and kyphosis angles, first device status VS renewal, curve topography, auto-declared compliance, duration of adaptation period.

RESULTS

To date, 28 patient files are included for initial VS under brace comparison: population is 85.7%F, mean age is 11,9 ± 1,8 years old, mean height 155,1 ± 12,2cm and mean weight is 42,1 ± 8,9kg. preliminary results show an in brace mean correction of 42% of thoracic curves and 36% of the lumbar curves while kyphosis increase by a mean 4.6°. Adaptation period in those sites is usually 7.0±1.6 days, but it is 3,1± 3,3 days with the 3D Brace.

Population studied will be described and efficiency of the brace will be evaluated by comparing initial evaluation to immediate correction (under brace) and short-term correction (6 month follow up).



DISCUSSION AND CONCLUSION

Feedback from certified orthotist-prosthetists, physicians and patient about this brace are really positives. Advantages and drawbacks of this type of treatment will be discussed.

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COI

All the authors are employees of Proteor



Posters | Orthotics: lower limb and footwear

6.083 Computer-aided design methods for digitising the orthoses manufacturing workflow: A scoping review

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BACKGROUND

Traditionally produced using artisanal methods, the design and manufacture of ankle-foot and foot orthoses has increasingly utilised computer aided design (CAD) technologies. Both general use and CAD software developed specifically for prosthetics and orthotics have been used for creating digital 3D orthotic shapes. However, the CAD workflows can vary considerably depending on the software used, making generalisation of research findings difficult.

AIM

The aim of this scoping review is to identify the CAD methods reported for digital ankle-foot orthosis (AFO) and foot orthosis (FO) production.

METHOD

Six electronic databases (AMED, CINAHL, Embase, Medline, Scopus and Web of Science) and the Google search engine were searched. Research studies of any design that reported using some form of CAD to produce designs for AFOs or FOs were eligible for inclusion. There were no restrictions on population. Studies were excluded if they investigated prostheses or any other orthoses such as spinal orthoses and hand splints. Studies were also excluded if no information was provided for CAD and the focus was 3D printing. Publications in a non-English language and non-full text were excluded.

RESULTS

Sixty-seven articles met the inclusion criteria for this review. Across the studies, a wide range of CAD programs were used to produce orthotic devices, however the procedures and reproducibility of the design processes were poor or not described in 48% of articles. A mix of general purpose and orthoses-specific CAD software were used to design the devices, with Solidworks being the most reported general-purpose software for both AFOs and FOs. Shapeshift3D and Rodin4D were the most reported currently available orthoses-specific CAD software for FOs and AFOs respectively. In addition, time taken to produce the orthotic designs varied widely and were only reported in 10% of articles, where the CAD operation time for general-purpose software (maximum 8 hours) were generally longer than orthoses-specific ones (maximum 30 minutes).

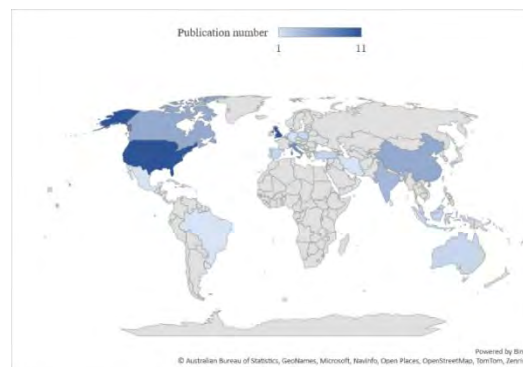


Figure 1. Choropleth map of publication numbers across different countries.

DISCUSSION AND CONCLUSION

We recommend orthoses-specific CAD software for busy clinics, and general-purpose CAD packages for small number of special or innovative cases unless the process can be highly automated. We have also developed a checklist to assist in standardising and ensuring reproducibility of FOs and AFOs studies. Moreover, knowledge exchange amongst researchers, clinicians and industries should be encouraged to help address real-world need, improve CAD functionalities, and support CAD programs in clinical studies.

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6.084 Individual Responder Analysis of the International Randomized C-Brace Crossover Study

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BACKGROUND

An international, randomized cross-over study with the C-Brace found significant improvements in balance, falls, mobility, and quality of life compared to traditional knee-ankle-foot orthoses (KAFOs) and stance control orthoses (SCOs) ⁽¹⁾. However, it remains unclear whether certain subgroups of KAFO/SCO users, such as polio survivors or patients with non-polio neurologic conditions, or users of locked or free-swing KAFOs are more likely to benefit from using a C-Brace than others.

AIM

The aim of this secondary data analysis was to evaluate whether certain subgroups of the study sample were more likely to benefit from using the C-Brace than other patient groups.

METHOD

The individual results of the 69 per-protocol participants of the original study were analyzed for individual clinically meaningful benefits from using the C-Brace in the Berg Balance Scale (BBS), ABC scale, Dynamic Gait Index (DGI), or self-reported falls. Thresholds for clinical meaningfulness were defined as follows: BBS: improvement by ≥ 5 pts ⁽²⁾; ABC scale: improvement by ≥ 11 pts ⁽³⁾; DGI: improvement by ≥ 1.9 pts ⁽⁴⁾; falls: reduction by $\geq 25\%$. Responder rates were calculated for polio survivors (n=35) vs. participants with non-polio conditions (n=34) and users of locked (n=23) vs. free-swing KAFO/SCO (n=46) and analyzed statistically using the Chi Square test.

RESULTS

Participants with non-polio conditions were more likely to benefit from the C-Brace than polio survivors in the BBS, ABC scale, and falls with responder rates of 79%, 62%, and 59% as compared to 51%, 35%, and 17%, respectively. The differences in responder rates were statistically significant for the BBS ($p=0.015$) and falls ($p<0.001$). In addition, participants with non-polio conditions were more likely to improve in one or more and not deteriorate in any of the analyzed outcomes than polio survivors (70% vs. 46%, $p=0.035$).

Users of free-swing KAFO/SCOs were more likely to benefit from the C-Brace than users of locked KAFOs in the BBS, ABC scale, and falls with responder rates of 70%, 57%, and 41% as compared to 57%, 48%, and 30%, respectively. However, the differences were not statistically significant.

DISCUSSION AND CONCLUSION

Participants with non-polio conditions and users of free-swing KAFO/SCOs were more likely to experience individual clinically meaningful improvements in balance, risk of falling, and falls

with the C-Brace than polio survivors and users of locked KAFOs. Therefore, patients with non-polio conditions and users of free-swing KAFOs are promising C-Brace candidates. Polio survivors and locked KAFO users require more clinical scrutiny to identify C-Brace candidates.

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6.085 The perception of ankle-foot orthosis use among youth with cerebral palsy and their parents

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BACKGROUND

Ankle-foot orthosis (AFO) is the most used orthotic device for children with cerebral palsy (CP). Evidence suggests that AFOs can improve stride length, walking speed, and stability. The largest group of AFO-users is children between 6-12 years-of-age, however as the children grow older the use decreases. Importantly, little is known how children experience AFO use in their daily life.

AIM

This study explored the perceptions and experiences of AFO use in daily life of children and adolescents with CP and their parents, with focus on activity and participation.

METHOD

This qualitative interview study included nine AFO-users with CP, 8-15 years old, and their parents. The data were analysed using a phenomenological approach.

RESULTS

Four closely related themes emerged during analysis. The first two themes “AFO use evokes emotions and feelings” and “AFO use requires adaptation” consists of perceptions of the usage in the moment. The theme “Learning by experience brings confidence and insight of what works or not” concerns AFO use over time and how children and parents gain a more focused knowledge of what is helpful to function in everyday life. Finally, “Participation in the process” concerns the experiences in the meeting between the professionals and the families.

DISCUSSION AND CONCLUSION

The study highlights the complex, multifaceted experiences of AFO use among children with CP and their parents. The emotional impact, practical adaptations, perceived benefits, and the need for active participation in the fitting and adjustment process are important factors that influence the overall effectiveness and acceptance of AFOs. These insights can guide healthcare providers to enhance support systems and to develop more family-centered approaches in the management of AFOs. This could optimize the benefits of AFOs, ensuring they support not just physical function but also emotional well-being and active participation in daily life.



6.086 Users' Satisfaction with Diabetic Foot Offloading Devices and Service in Gaza Strip

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BACKGROUND

In Palestine, 11.8% people have diabetes. Of them, 15% develop diabetic foot (DF). In Artificial Limb and Polio center (ALPC); main provider in Gaza, 34.8% of amputations is due to diabetes. Therefore, since 2017, International Committee of Red Cross (ICRC) has supported diabetic foot offloading services at ALPC. There is information-gap, as almost nothing is available to measure device and service satisfaction. Therefore, need for this evaluation is particularly acute.

AIM

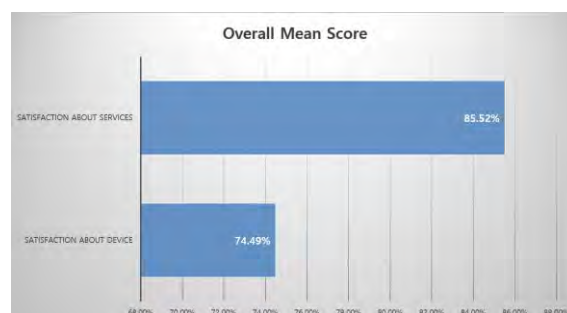
To evaluate patient satisfaction with Diabetic foot (DF) offloading devices and services to provide preliminary data and clients perspectives for improvement and developing the clinical care

METHOD

A cross-sectional study was conducted by phone interviews with 206 clients who had DF offloading services from ALPC from Jan 2019 to Sep 2021, using Orthotics and Prosthetics Users Survey (OPUS) instrument that evaluate satisfaction with device and services, it has 21 question (11 related to device and 10 to services). Data collection took place in November through December 2021 with a response rate 81.1%. Data was analysed by using SPSS version 26.

RESULTS

Of clients, 167 responded: 67.1% males and 32.9% females, 77.8% have other health conditions and 58.7% using assistive device. Mean age since diagnosed with diabetic is 17.4 years and started to suffer from foot problem since mean years of 5.28, almost half of them unilaterally affected. Devices received are 68.9% diabetic shoes, 23.4% air cast, 16.2% sandals, 3% slippers, 1.8% PTWB AFO, 0.6% insole and 1.2% others. Highest score of satisfaction was for 'free of wear and tear from device' (4.25/5) while lowest score was for 'affordability' (2.67/5). For satisfaction of service, highest score was 'level of courtesy and respect by staff' (4.65/5) and lowest was "information about equipment choices" (3.58/5). Mean score of service satisfaction was significantly higher than device satisfaction (figure 1).



DISCUSSION AND CONCLUSION

The results provide opinions and experiences from 167 DF patients, considered as foundational information to build on further future studies. In summary, it indicates general satisfaction and identifies areas that need improvement at the same time to increase the level of satisfaction. The results aid in exhibiting the effect and implications of ICRC and ALPC services. This work will serve to provide a vision for policy, service providers and donors.

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6.087 Comparative Analysis of Pre-Fabricated Walking Boot and Custom Charcot Restraint Orthotic Walker (CROW) in a Single Patient

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BACKGROUND

Foot and ankle conditions like Charcot arthropathy often require orthotic intervention to provide stability, reduce pressure, and facilitate healing. In Thai clinical practice, two main devices are used: pre-fabricated walking boots and custom Charcot Restraint Orthotic Walkers (CROWs). Pre-fabricated boots are widely accessible, they lack individualized molding, potentially leading to inadequate pressure relief and stability. In contrast, the CROW orthosis is a custom, bi-valve device offering precise immobilization and better pressure redistribution. The effectiveness of these devices for patients with Charcot arthropathy remains a topic of ongoing debate. This study aims to assist clinicians in selecting the most suitable orthotic device for such patients and support decision-making within an interdisciplinary team.

AIM

This study compares the efficacy of pre-fabricated walking boots and CROWs in a single patient, focusing on pressure distribution and mobility

METHOD

A single patient with a complex foot condition was sequentially fitted with a pre-fabricated walking boot and a custom Charcot Restraint Orthotic Walker (CROW), with a 15-minute washout period between devices. Plantar pressure distribution, stability, and mobility were assessed at regular intervals using standardized scales. The Tekscan pressure system was used to evaluate peak plantar pressure, while the 3-meter Timed Up and Go test with the G-Sensor BTS G-WALK assessed the patient's mobility. Comparative data from both devices were analyzed to evaluate each orthotic's effectiveness in immobilization, pressure distribution, gait balance, and overall comfort.

RESULTS

The results showed that the custom Charcot Restraint Orthotic Walker (CROW) provided better pressure distribution and lower peak pressure, reducing risk of skin breakdown compared to the pre-fabricated walking boot. In terms of mobility, the patient demonstrated improved gait balance and stability with the CROW as shown by faster completion times in Timed Up and Go test. In contrast, the pre-fabricated walking boot offer basic support but resulted in less stability and higher-pressure points on the lateral midfoot and forefoot, leading to minor discomfort. Overall, the CROW showed greater effectiveness in pressure relief, immobilization making it a more suitable option for this particular patient.

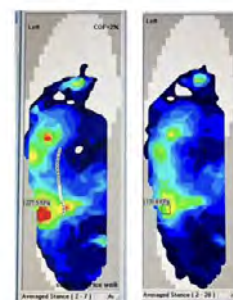


Figure 1. a. Peak pressure distribution with a pre-fabricated walking boot
b. Peak pressure distribution with CROW

DISCUSSION AND CONCLUSION

The results align with previous studies showing that custom orthoses, particularly CROW. Studies by Armstrong et al. (2001) and Lavery et al. (2005) showed custom devices reduce plantar pressure and improve stability in Charcot arthropathy compared to pre-fabricated boots, supporting our findings. These results highlight the importance of individualized treatment for high-risk patients and suggest further research with larger cohorts to strengthen clinical recommendations.

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ACKNOWLEDGEMENTS

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6.088 Non-removable offloading of diabetic foot ulcer without restricting patients' daily activities

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BACKGROUND

Evidence-based guidelines recommend using non-removable knee-high devices (total contact cast and non-removable knee-high walker) to offload and heal plantar diabetic forefoot ulcers ^[1]. However, these devices are infrequently used in clinic, partly because they immobilize foot and ankle joints and thereby interfere with walking and daily activities.

AIM

This study describes our initial clinical experiences of using non-removable, non-restrictive offloading devices in terms of healing outcomes, adverse events, and patient acceptance/adherence.

METHOD

We used two types of non-removable and non-restrictive offloading devices: the football dressing ^[2] and a non-removable insole (Fig.1), inspired by Hochlenert's Fifi-mobil® sole ^[3] and Jarl and Tranberg's "sealed shoe" ^[4]. The case series included 7 persons (1 woman) with diabetes, median age was 63 years (range 44-72). All had sensory neuropathy, a non-infected plantar forefoot ulcer (1st toe, n=4; MTH3-5, n=3) and prescribed shoes and insoles. Median ulcer diameter was 1.2 cm (range 0.4-2.0), toe pressure 87 mmHg (70-149) and toe-brachial index 0.68 (0.35-0.97).

RESULTS

Three ulcers were treated with football dressing, and healed in 21-27 days without complications. Three ulcers were treated with non-removable insole and healed in 8-22 days, but skin maceration developed on the plantar foot in two cases. One ulcer was first treated with football dressing for 10 weeks, but as ulcer healing did not progress, treatment was changed to non-removable insole, which is the ongoing treatment. All patients adhered to always wearing the devices, and were able to walk with the devices.



Figure 1. Left: Football dressing (photos from ^[2]), Right: Non-removable insole, covered with a sock and attached with Fixomull Stretch.

DISCUSSION AND CONCLUSION

Six of seven ulcers healed in approximately 1-4 weeks, which is similar to previous studies on non-removable, non-restrictive devices (football dressing or non-removable therapeutic shoe) ^[2,4]. Two participants developed skin maceration when wearing non-removable insole, which highlights the importance of using a sock between the skin and insole, and instruct patients to always keep the foot dry. A study limitation was that the study had no control group which should be used in future studies.

In conclusion, non-removable, non-restrictive offloading devices may effectively heal plantar forefoot ulcers. The devices are well accepted by patients and may fill the clinical need of effective offloading that do not interfere with walking and daily activities.

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6.089 A Preliminary Evaluation of the Momentum Brace for Limb Salvage Following Complex Foot and Ankle Injuries

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BACKGROUND

Patients with severe foot and ankle injuries often present with significant mobility issues. When surgery is no longer an option up to 15% seek amputation (Bedigrew et al 2014). The Momentum brace has previously been used for high-energy lower extremity trauma for limb salvage and is not routinely available on the NHS. It has never been examined in the elective amputation population. We undertook a collaborative project between prosthetics and orthotics to explore the effectiveness of the Momentum as a limb salvage and cost saving orthotic device for patients who have exhausted other medical options.

AIM

To explore the effectiveness of the Momentum brace for limb salvage in elective amputation patients referred to our orthotics clinic

METHOD

Patients were referred via pre amputation clinic or trauma consultants and were assessed in the MDT clinic. Those who met the inclusion criteria were casted, and the brace was trialled at a delivery appointment. If it reduced pain, it was issued alongside a course of physiotherapy. Given that this was an exploratory study, individualised outcome measures were used including NRS pain on walking, 2MWT, 10MWT and TUG. These were recorded at delivery and review appointments (at 3-6 months, and 1 year). Data was analysed using descriptive methods.

RESULTS



Figure 1.
Momentum Brace

14 patients with complex foot and ankle injuries considering amputation were assessed and 7 patients met the clinical criteria

Of the 7 patients who were fitted with the Momentum, at the delivery appointment, NRS pain scores improved for 4 patients and these patients were issued with the brace. For the remaining 3 patients, there was no improvement in pain and alternative orthoses were considered.

Clinically significant Improvements were seen in the NRS pain and 2MWT and all patients have thus far avoided amputation.

DISCUSSION AND CONCLUSION

In patients who were not issued with a Momentum, this was mainly because they did not meet the inclusion criteria of having previously trialled alternative orthoses.

The results show promise that the Momentum may be a beneficial and cost saving brace for patients with severe ankle and foot injuries considering an amputation, where medical options have been exhausted. Improved awareness of potential benefits amongst orthopaedic surgeons and pre-amputation clinicians may result in earlier Momentum provision. This may prevent the need for complex surgeries and avoid further mobility deterioration and weakness before amputation is even considered. Further research is required to determine optimum patient selection and whether earlier referral can result in further improved outcomes.

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6.090 A database for evidence-based plantar foot orthoses: linking foot orthotic designs to risks, symptoms and diagnoses

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BACKGROUND

Plantar foot orthoses (FO) are commonly prescribed for a wide range of foot and lower limb pathologies. Evidence-based design relies on current literature to ensure effectiveness. However, the variety of FO designs and outcome parameters measured in studies creates challenges in selecting the most appropriate treatment.

Additionally, it is difficult to compare designs effectively and understand which one offers the best solution for a patient's specific needs.

AIM

The aim is to develop a workflow and database that summarises and structures the current literature on FO designs, to improve understanding and facilitate evidence-based decision-making for both the scientific community and clinical practice.

METHOD

A new graph database structure was created (in neo4j) containing *elements* and their relationships. The *elements* include diagnoses, patient features, and FO designs. Patient features represent lists of risk factors and symptoms associated with diagnoses. These features are predefined to manage varying descriptions in literature. Relationships include causal or correlational links between features or diagnoses, and the links between FO and the features they treat, and the corrective elements they used. Clear guidelines were written to standardise source selection (research questions about pathogenesis and FO effectiveness), and to define the specific information of the source that should be included, to minimise researcher interpretation and preserving detail.

RESULTS

The complete graph database structure (Figure 1a, simplified structure) was created, along with a step-by-step workflow guiding researchers in consistent literature integration. A level of evidence was assigned to each relationship to indicate statistical relevance. The structure of the database was filled with content, including 328 predefined patient features categorised into 10 types (e.g., pain, pressure, mobility) and 34 predefined FO corrective elements.

For four research questions about hallux valgus and metatarsalgia (pathogenesis and insole designs), sources were selected and the relationships mentioned in them were incorporated into the database. For hallux valgus this results in 11 research papers that are translated in 240 causal/correlation relationships and 46 FO designs linked to 137 features (Figure 1b, example). A tool to explore and visualize the graph for the scientific community was developed and tested.

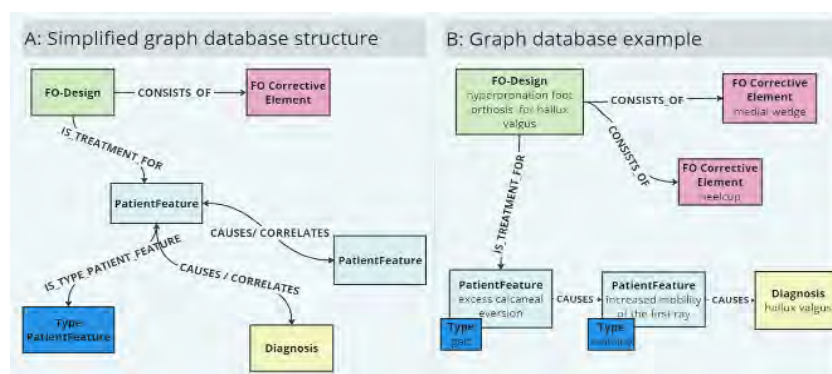


Figure 1: graph database



DISCUSSION AND CONCLUSION

The detailed workflow and database structure resulted in good repeatability between different researchers and positive first feedback from the scientific community (user-friendly and trustworthy in providing insights based on neutral information). Currently, additional sources are being implemented, and an in-depth analysis of FO designs is being conducted, allowing for more practical use in clinical settings.

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6.091 Bracing for Change in the UK: The Need for Sustainable Orthotist Inclusion in Research

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BACKGROUND

Research is critically important for prosthetics, orthotics, and all small allied health professions. It drives innovation, ensures treatment efficacy, and underpins good clinical practice. By developing a solid evidence base, we can improve patient outcomes, justify funding and resource allocation, and elevate our standing within the broader healthcare system. Despite this clear importance, the evidence base for orthotics is notably weak, and our research capacity in the UK to improve this is extremely limited.

AIM

This poster aims to highlight the challenges facing orthotics research in the UK, and to identify opportunities to sustainably build research capacity and capability.

METHOD

Prosthetists and orthotists have minimal involvement in high-level research, routinely being excluded from large, well-funded, multi-centre trials that affect our practice. For example:

BIG TOE Study: Investigating carbon fibre inserts for first metatarsophalangeal joint osteoarthritis. No orthotist on the study team.

OSTRICH Study: Investigating the efficacy of foot orthoses for children with flat feet. No orthotist on the study team.

BASIS Study: Investigating night-time bracing for adolescent idiopathic scoliosis. One orthotist on the study team.

We can sustainably improve this problem by fostering research careers among our clinicians, enhancing collaborations with the National Institute for Health and Care Research (NIHR), and ensuring orthotist involvement in orthotics trials. Additionally, supporting orthotist-led research amongst the profession, including student projects, is crucial.

DISCUSSION AND CONCLUSION

Significant gaps exist in the evidence base for prosthetics and orthotics. A timely example is the removal of knee bracing from NICE guidelines for osteoarthritis due to insufficient evidence of its effectiveness. To address these gaps, we need to set our own research priorities based on pressing questions in our practice. This focus will help direct our efforts towards meaningful projects. Furthermore, building research skills, confidence, and capacity among clinicians will ensure that significant trials are not solely conducted by external research teams without prosthetist and orthotist input.



6.092 The Effectiveness of Customized Orthopedic Shoes for Club Foot Patients: A One-Year Follow-up Study

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BACKGROUND

Clubfoot, whether typical or complex, presents significant challenges in foot and ankle management. Customized orthopedic shoes have emerged as a potential intervention to provide enhanced foot control while maintaining user comfort. However, limited research exists on the effectiveness of customized orthopedic shoes.

AIM

This study aimed to evaluate the effectiveness of customized orthopedic shoes by: (1) assessing the initial presentation, (2) analyzing client expectations and outcomes, and (3) examining the impact of specific modifications addressing leg length discrepancy, compensatory mechanisms, and heel-to-ground contact.

METHOD

A prospective interventional study was conducted with 48 clubfoot clients over a one-year period. The intervention followed a systematic process including initial assessment, casting, modification, rectification, manufacturing, and fitting. Custom modifications incorporated heel additions, strategic padding at pressure points, and specialized material selection. Follow-up evaluations were conducted throughout the one-year period to assess outcomes.

RESULTS

The implementation of customized orthopedic shoes demonstrated positive outcomes in three key areas: (1) successful management of heel-to-ground contact through targeted gap filling, (2) improved foot alignment through bilateral heel additions compensating for abnormal segmental positioning, and (3) enhanced comfort achieved through strategic padding placement and soft-layer material selection at pressure points.

DISCUSSION AND CONCLUSION

Customized orthopedic shoes showed promising results in managing complex clubfoot cases, which matched with several studies done in developing countries. However, extended wear time is recommended to effectively prevent progressive ankle valgus deformity. Further research with larger cohorts and longer follow-up periods is warranted to validate these findings.



6.093 Preliminary evaluation of KAFO with a Sensor Lock II knee joint on gait and PCI of subjects with quadriceps weakness

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BACKGROUND

Subjects with quadriceps weakness compared to able-bodied subjects have weight bearing on the non-paretic limb and therefore high energy consumption. A reduced stance phase percentage time and reduced step length on the affected side, in addition decreased walking speed have been demonstrated in walking of subjects with quadriceps weakness. Since improvement of spatiotemporal parameters and energy consumption are important for increasing independent mobility in subjects with quadriceps weakness, evaluation of these parameters, are important in these subjects.

AIM

The purpose of the present study was to compare speed of walking , endurance and energy efficiency in a knee ankle foot orthosis (KAFO) associated with “sensor lock II “stance control (SC) knee joint in automatic mode and locked mode in patients with quadriceps weakness and evaluate patient satisfaction through a usability evaluation questionnaire for both walking modes.

METHOD

Eight subjects with quadriceps weakness were participated in this study. A custom-made stance-control knee–ankle–foot orthosis (SCKAFO) with the same set of components was constructed for each participant. 10 Minute Walk Test (10MWT) and 6 Minute Walk Test (6MWT) were used for speed and walking endurance. To analysis of the Physiological Cost Index (PCI), The Polar Heart Rate Monitor, with a chest electrode attached to the participants chest was used to get data .This was obtained by using the related formula. Orthotics and prosthetics users survey (OPUS) answered through phone interviews was used to assess the users' satisfaction with the O&P devices and services.

RESULTS

Walking speed and endurance increased in the SC mode compared to the knee joint locked mode. There was a significant difference between two test conditions with regard to PCI. High rate of satisfaction announced in the using KAFO with SC mode compared to the knee joint locked mode.

DISCUSSION AND CONCLUSION

Compared to locked knee mode, SC mode demonstrated a higher speed of walking and increased endurance. Regarding energy consumption, this parameter decreased when the KAFO with SC mode was used compared to KAFO with knee joint locked mode.



6.094 Which factors influenced walking ability in subjects with spinal cord injury? A literature review

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BACKGROUND

Improving walking and standing in patients with spinal cord injury (SCI) depends on several factors. Walking ability is dependent on many variables such as spasticity, balance, drugs, motivation, participation, manual ability, pain, body mass index, biomechanical factors (weakness, decreasing range of motion), associated disorders, medical factors, socioeconomic factors, environmental factors and quality of life. Environmental and personal factors influence the performance, what a SCI subject actually does do in a daily life situation.

AIM

Since there was no comprehensive review on the factors affecting the movement and walking of patients with SCI, the aim of this study was to determine the effective factors and to identify the factors affecting walking in patients with SCI.

METHOD

A review of intervention studies including the following words in the title/abstract: Syndrome, reflex, gender, level of injury, etiology of the lesion, age, time since injury, severity of injury, level of sensation, spasticity, contracture, orthotics intervention, assistive devices, robot-assisted gait training in SCI subjects. Databases searched included PubMed, ISI Web of Knowledge, Scopus, and Google Scholar. The procedure was followed using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses method.

RESULTS

82 studies, investigating a total of 28684 SCI subjects, met the inclusion criteria.

DISCUSSION AND CONCLUSION

Base of demographic data and clinical evaluation of the SCI subjects, the chance of the gait rehabilitation can be accurately predicted. Early recovery of quadriceps strength, lower extremity motor scores, pinprick scores and age announced as an excellent prognostic factors for ambulation in SCI subjects. Interventions, therapies, and devices which have been introduced to improve functional outcomes after SCI are great; Research in this field is few. Some of these proposals need to evaluate in the clinical trials in the future.



6.095 Gait Effectiveness of Triple Action AFO for Bilateral Drop-Foot Patient

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BACKGROUND

Charcot-Marie-Tooth (CMT) is a common inherited neuropathy leading to ankle muscle weakness, impairing joint function and causing foot deformities. This results in gait abnormalities like drop foot, impacting foot clearance and gait velocity. Early rehabilitation with orthosis is crucial to prevent deformities, enhance function, and avoid surgery or wheelchair reliance. Various AFO designs influence gait differently, emphasizing the need for personalized orthotic selection for optimal gait function.

AIM

To evaluate the effectiveness of triple-action ankle joint AFO compared to Tamarack AFO and barefoot walking on ankle, knee, and hip joints, and investigate endurance and temporospatial parameters.

METHOD

A 44-year-old male with Charcot-Marie-Tooth disease, using bilateral AFOs with Tamarack dorsiflexion assist, underwent physical assessment and gait analysis. Bilateral AFOs with triple-action ankle joints (lateral side) and CAMBER axis joints (medial side) were fabricated using 5mm polypropylene. The 6-Minute Walk Test (6MWT) measured walking distance and symmetry index. A 3D motion capture system analyzed hip, knee, and ankle kinematics, along with temporospatial parameters. The Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST 2.0) was used to assess patient satisfaction. Results were compared with barefoot walking and the patient's previous AFO device.

RESULTS

The triple-action AFO significantly reduced foot drop compared to barefoot walking. On the right lower limb, the triple-action AFO notably improved gait at the ankle, knee, and hip joints. However, the effect was less pronounced on the left side, where the Tamarack AFO provided more benefit. Regarding temporospatial parameters, the Tamarack AFO outperformed both the triple-action AFO and barefoot walking, except for step length and gait symmetry index. The triple-action AFO showed better performance in these two measures, indicating its potential benefits in improving gait symmetry and step length.



DISCUSSION AND CONCLUSION

An AFO is a better option for Charcot-Marie-Tooth patients than barefoot or just shoes. While the triple-action ankle joint AFO significantly improved gait, the results were not as expected. The patient had been using the Tamarack AFO for a long time, making it challenging to compare the new device after a single trial. Further exercise programs and gait training may be needed to optimize the efficiency of the new AFO.

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6.096 How does ankle joint restriction affect gait function and plantar forefoot pressure in people with diabetes?

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BACKGROUND

This study investigated how functional level and plantar pressure under the forefoot change for people with diabetes depending on whether the ankle joint is locked or not. Offloading diabetic foot ulcers (DFUs) are a central aspect of healing. Gold standard for treating DFUs according to the International Working Group on the Diabetic Foot is knee-high non-removable devices which locks the ankle joint. This in turn leads to unintended negative consequences such as decreased balance and gait function.

AIM

How does locking the ankle joint affect function level and pressure under the forefoot in people with diabetes?

METHOD

The study is a cross-sectional cross-over study where participants undergo various tests. All measurements are made for four conditions, starting with shoe as the first measurement and then the others in randomized order: Locked ankle, locked dorsiflexion/open plantar flexion, free ankle motion.

1. Functional test, Timed Up and Go (TUG).
2. 10 Meter Walk test (10MWT).
3. Pressure measurement under the sole of the foot when standing and walking using a FScan system with video recording and sensors under the sole.
4. Self-rated walking comfort based on a ten-point VAS scale.

RESULTS

Preliminary data suggest improved results in both TUG and 10MWT with less restriction of range of motion in the ankle joint. The results was in falling order Shoe, Free ankle motion, Locked dorsiflexion/open plantar flexion and last Locked ankle.

Regarding forefoot pressure there was an increased pressure under the forefoot for the locked dorsiflexion/open plantar flexion and the free ankle motion setting compared to the locked setting. The shoe only condition had the highest pressure under the forefoot.

In the self-assessed comfort level, preliminary data shows the greatest comfort in the shoe only condition and then in falling order: Free ankle motion, locked dorsiflexion/open plantar flexion and last Locked ankle joint.

DISCUSSION AND CONCLUSION

The increased pressure under the forefoot in the locked dorsiflexion/open plantar flexion condition compared with the locked ankle joint was not expected since both conditions are functionally the same after midstance in the gait cycle. We did however see an improved result in both TUG and 10MWT. Following an increased gait speed we also get increased ground reaction forces in gait, and this dynamic component to the measured max force might explain the difference. The remaining question is then if increased function outweighs the increased plantar pressure?



6.097 Is Knee Varus Thrust a Useful Indicator of Responders and Non-responders to Offloading Knee Bracing in Individuals with Knee Osteoarthritis?

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BACKGROUND

Many studies have shown that knee bracing can be effective in treatment of Osteoarthritis (OA), but approximately 33% ^[1] of patients do not respond, and there has been limited investigation of why this is. This paper hypothesises the link between the presence of varus thrust and effective offloading knee bracing. Varus thrust is defined as "the dynamic worsening or abrupt onset of varus (bow-leg) alignment as the limb accepts weight" ^[2]. There is currently a lack of information on why certain populations respond better than others to this intervention, the benefit of this insight would be to improve clinical efficiency in having a defined clinical treatment pathway based on sound evidence-based practice.

AIM

This study aims to identify those participants who are unlikely to respond to knee bracing using a series of standard physical examinations within clinic as well as clinical questionnaires to gauge the efficacy of the intervention.

METHOD

A cohort study with a convenience sample of 50 people with diagnosed medial compartment OA referred to the hospital for the provision of a medial knee offloading brace was conducted. Before brace provision, participants completed the Knee Osteoarthritis Outcome Score (KOOS) questionnaire and a Numeric Pain Rating Score (NPRS). Gait was observed to assess the presence of varus thrust. Directly following brace fitting a follow-up NPRS, Global Rate of Change (GROC) and Numerical Comfort Rating Score (NCRS) were recorded. Following this appointment participants recorded their brace usage in a wear diary, over a 6-week period and were reviewed after this time, where another KOOS and NPRS were recorded.

RESULTS

The preliminary data thus far shows an average reduction in pain of 3.6 points (NPRS) in those participants with a presence of varus thrust, compared to a 1.4 point reduction in pain in those without varus thrust identified. This is also supported by an average GROC score of -3.2 in responders, compared to -1.5 in non-responders, further showing a greater reduction in pain in participants with varus thrust present. Follow-up KOOS scores have not yet been collected as review appointments are yet to be carried out.

DISCUSSION AND CONCLUSION

Research shows that anatomical features can contribute to worsening of symptoms of OA. This research addresses the critical gap in real world clinics compared to laboratory-based experiments. Preliminary results show this to be the case and develop further questions for the development of this field.

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6.098 Effect of Different Orthotic Applications on Walking in Multiple Sclerosis; case report

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BACKGROUND

Multiple sclerosis (MS) is a progressive and degenerative autoimmune condition that affects the central nervous system, often leading to a decline in walking ability. The patients experience motor, sensory and cognitive impairments; the impairment of proprioception is more frequent than other sensory inputs (1,2).

AIM

The objective of this study was to assess the immediate impact of using an Ankle Foot Orthosis, proprioceptive insole, and elastic extension strap on physical performance in an MS patient.

METHOD

This study was designed to assess the immediate effects of three different orthotic interventions (Solid Ankle Foot Orthosis (AFO), proprioceptive insole, and elastic extension strap with long anterior tibial shell) on the physical performance of a patient with MS. The participant in this study was a 59-year-old woman with a prolonged history of progressive MS. She had a score of 6.5 on the Expanded Disability Status Scale (EDSS). Two standardized tests were used to evaluate the participant's walking performance: 2-Minute Walk Test and Timed Up and Go Test. Each application was applied to the patient at one day intervals.

RESULTS

The results of the 2-minute walk test (2MWT) showed that the walking distance increased with each orthotic intervention. With the Ankle Foot Orthosis (AFO), the distance was 52.5 meters, with the proprioceptive insole it was 71.5 meters, and with the elastic extension strap it was 67.6 meters. Without any aid, the distance was 45 meters. The proprioceptive insole resulted in the longest walking distance, while the AFO resulted in the shortest. In the Timed Up and Go (TUG) test, the results were as follows: without any aid, the time was 37 seconds; with the proprioceptive insole, it was 28 seconds; with the AFO, it was 40 seconds and result for the elastic extension strap was 39 seconds.

DISCUSSION AND CONCLUSION

The study's findings provide valuable insights into the immediate effects of different orthotic interventions on physical performance in a patient with multiple sclerosis (MS). As demonstrated, the proprioceptive insole resulted in the greatest improvement in walking distance, followed by the elastic extension strap and finally the Ankle Foot Orthosis (AFO). This improved sensory input may lead to better muscle coordination and balance during walking. The insole's flexibility allows for a more natural gait pattern.

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6.099 Goal Attainment and Reduced Dependence on Walking Aids One Year after C-Brace Fitting: Results from the C-Brace Registry

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BACKGROUND

Goal achievement is an important treatment outcome for patients treated with a KAFO¹. Previous studies have shown that C-Brace microprocessor-controlled Stance and Swing Controlled Orthosis (MP-SSCO®) improves perceived ease and safety of Activities of Daily Living (ADLs) and quality of life ^{2,3}. However, the ability of C-Brace users to achieve their personal goals and the reduction of walking aids has yet to be disseminated.

AIM

A prospective, multicenter registry was designed to gather real-world safety and effectiveness data from patients that have been fitted with a C-Brace. The purposes of this analysis was to assess (1) goal achievement and (2) dependence on walking aids after 12 months of wear.

METHOD

IRB approval was obtained, and all subjects signed informed consent prior to participation.

Outcome measures included the Patient-Specific Functional Scale (PSFS) and use of assistive devices at baseline and during performance measures (PM), Timed Up and Go and 10-meter Walk Test. The PSFS is a goal-attainment scale in which subjects identify 3-5 activities and rate them on a scale of 0-10, 0 being unable to perform and 10 being able to perform at the same level as before injury.

Questionnaires were completed by the subjects and PMs performed by the investigators at baseline with the existing orthosis and at 6 and 12 months with the C-Brace.

Changes of 2 points on the PSFS were considered clinically meaningful. The Wilcoxon signed rank test was used to test the difference in the PSFS scores between baseline and follow up.

RESULTS

46 subjects from 29 sites had both baseline and follow-up data available for analysis; 17 female/29 male, mean age of 51.8 yrs. and mean weight of 174.8 (58-270) lbs. 9 subjects were bilateral users. Most common diagnoses were incomplete spinal cord injury (13), trauma (9), polio (7), iatrogenic (3), and multiple sclerosis (2).

The mean and standard deviations for PSFS score were 2.13 ± 1.24 at baseline and 5.72 ± 2.36 at follow-up ($p < 0.00001$). The scores for the top activity categories are shown in Table 1. 87% reported using walking aids at baseline, and 70% used them during baseline PMs. After the C-Brace fitting, only 48% still needed them.

Table 1. Top activity categories, PSFS scores at BL and after C-Brace fitting

Activity Category	Goals/ Subjects	Avg PSFS	
		BL	C-Brace
Sports/exercise	59/27	1.5	4.0
Slope/stairs/uneven ground	31/19	2.0	6.2
Shopping/concerts/crowds	13/10	2.5	5.6
Household chores/repairs	10/10	3	7.8
Walking better/faster/farther	7/7	3.3	7.6

DISCUSSION AND CONCLUSION

Subjects significantly increased PSFS scores after C-Brace fitting with clinically meaningful changes in the top categories. This improvement in PSFS along with the reduction on the dependence of walking aids suggested the C-Brace contributed to patients achieving their own personal goals.

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6.100 Using in-shoe plantar pressure measuring technology to assess the efficacy of orthotic intervention in the management of preventing foot re-ulceration

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BACKGROUND

Diabetic peripheral neuropathy impacts nearly 50% of individuals with diabetes within 10-15 years, increasing risk of foot ulceration¹ The International Working Group on the Diabetic Foot (IWGDF) emphasizes elevated plantar pressures are a significant risk factor. For patients with healed plantar ulcers, therapeutic footwear should alleviate pressure at vulnerable areas. IWGDF guidelines suggest offloading devices should reduce peak pressure during gait by at least 30% or <200Kpa.²

AIM

To investigate the use of in-shoe plantar pressure technology to assess the efficacy of total contact insoles (TCIs) and therapeutic footwear in preventing foot re-ulceration to meeting the IWGDF recommendations.

METHOD

Data was collected from February to October 2024, involving 48 participants.

Inclusion criteria: Age 18+, with history of plantar foot ulceration or Charcot neuroarthropathy in remission, or identifiable at-risk ulceration sites.

Exclusion criteria: Active foot disease.

Baseline mean peak plantar pressures (MPPP) were assessed in patients current shoes using an in-shoe pressure system. Footwear was checked for suitability by Orthotist and TCIs supplied. MPPPs were repeated to compare against IWGDF guidelines. If interventions didn't meet IWGDF guidelines, orthoses were modified and retested. Outcomes measured included adherence to guidelines and occurrences of ulceration in relation to MPPP.

RESULTS

48 patients assessed; 39 male, 9 female.

45 neuropathic patients; 39 patients with diabetes. 7 T1DM, 32 T2DM.

6 patients with a history of Charcot neuroarthropathy.

17 patients with a history of amputation; 7 hallux, 8 lesser toes, 2 transmetatarsal amputations.

51 ROIs were assessed; 12 @ PIPJ1, 2 @ PIPJ3, 1 @ PIPJ5, 15 @ MTPJ1, 5 @ MTPJ2, 1 @ MTPJ3, 3 @ MTPJ4, 10 @ MTPJ5, 2 @ midfoot/Charcot deformity.

- Outcome 1: Did the TCI intervention meet IWGDF guidelines?
- Outcome 2: Has ulceration or re-ulceration occurred since assessment?
- Outcome 3: Was the ulceration or re-ulceration in the same ROI as MPPP?

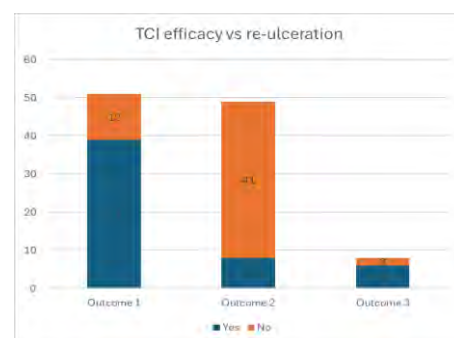


Figure 1. TCI efficacy vs re-ulceration

DISCUSSION AND CONCLUSION

This study shows that in-shoe plantar pressure technology is an effective tool for evaluating the efficacy of therapeutic footwear and TCIs in aligning with IWGDF guidelines to reduce the risk of re-ulceration. Limitations include the inability to measure shear stress, tethered equipment, and a data collection period of <1 year. Findings will inform future service design and foster collaboration between podiatry and orthotic departments to improve foot ulceration management and prevention.

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ACKNOWLEDGEMENTS

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6.101 The role of orthoses in the rehabilitation of specific animals (Canines)

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BACKGROUND

The use of orthoses in animal rehabilitation, especially for dogs, is a growing field with custom designs aiding recovery by promoting controlled movement and minimizing disability. Given dogs' unique needs, a personalized approach is essential, as a one-size-fits-all solution may cause harm. This study evaluates commonly used dog orthoses, such as custom braces, neoprene supports, splints, and specialized bandages.

AIM

This research aims to review studies on orthoses, splinting, and bracing methods in dog rehabilitation, focusing on improving the quality of life for both pets and their owners.

METHOD

In order to carry out this study, we searched Google Scholar, PubMed, Scopus, and ScienceDirect databases using the keywords Canine, orthotics, splint, brace, cranial cruciate deficiency, spica splint, ehmer sling, velpeau sling, hobbles, Coaptation devices in the period from 2005 to 2024. After searching, 15 articles and one book were found. One article in German was excluded from our review, and the remaining 14 articles were reviewed.

RESULTS

Veterinary sports and animal rehabilitation utilize advanced tools, including bandages, Coaptation orthoses, and dynamic supportive orthoses, to improve recovery and functionality, particularly for dogs. Bandages, a soft orthotic type, support healing structures or stabilize limbs. Coaptation orthoses, as soft splints and braces, offer additional support, while dynamic supportive orthoses enhance locomotion and mobility. Unlike traditional splints that immobilize, specialized orthoses provide custom support, align injured limbs, prevent further injuries, and correct deformities, thus promoting effective functional recovery. Figure [1] illustrates an example of one of these orthoses.



Figure 1- An image of a static-progressive orthosis for reducing soft tissue contracture in a dog

DISCUSSION AND CONCLUSION

The combined efforts of veterinarians, rehabilitation specialists, orthotists, and prosthetists have enhanced pet care quality. Specialists face challenges in evaluating and selecting appropriate orthoses for each unique case, requiring creativity and in-depth knowledge of available devices. Advancements in orthotic devices and rehabilitation methods improve pets' quality of life and provide psychological comfort to their owners.

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6.102 A Content Analysis of Canadian Public Facing Educational Information on Charcot Foot

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BACKGROUND

Despite the ease and accessibility of online healthcare educational information, the number of individuals with diabetes in Canada has continued to rise, along with related complications. As of 2022, 8.9% of the Canadian population have a confirmed diagnosis of diabetes, with this number increasing by 3.3% each year.¹ A serious complication of diabetes is Charcot foot (CF), which has been found to be present in 7.5% of the diabetic population.² Nearly half of patients with CF are misdiagnosed, and often experience delayed treatment as a result.^{3,4,5} A prolonged diagnosis can worsen the already destructive nature of the pathology, resulting in further deformation of the foot and ankle or amputation in severe cases. As Diabetes is the most common cause of CF, it is imperative that the awareness and education of CF is improved for people with diabetes.^{6,7}

AIM

This study aims to assess the current CF messaging to individuals with diabetes across Canada, to help bridge this critical gap in knowledge and improve understanding of the messaging limitations.

METHOD

A content search identified Canadian public health related webpages/online documents for each province/territory (n=62) with public facing information on CF (n=104). Each resource will be analyzed using descriptive codes, grouped into three key categories - CF definition/description, signs & symptoms and treatment opportunities. Language availability was examined by documenting the resources' primary language, in addition to language options offered. Resource readability will be assessed to evaluate the complexity and determine the number of formal years of education required to understand the material. Six validated readability scales will be used.

RESULTS

While we identified that organizations across Canada are providing CF content, our currently ongoing study aims to yield insights on any inconsistencies and considerable gaps in the availability of material and the strategies presented to educate the Canadian public on CF. Results are expected to be finalized by March 2025.

DISCUSSION AND CONCLUSION

This research will be part of a broader scope analysis of the current information on education (public), diagnosis (physicians) and treatment (healthcare professionals) of CF in Canada. This initial study intends to bring light to the current state of public CF education, and therefore guide the likely need for increased public resources. Later studies will assess the information available to physicians, to highlight the gap in knowledge which has led to the misdiagnosis and delayed treatment of Charcot Foot.

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Posters | Gait and balance

6.103 Development and Application of a New Evaluation Index, the Gait Degree Index, for Gait Analysis in Stroke Patients with Hemiplegia

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BACKGROUND

Many stroke survivors with hemiplegia experience gait disturbances, which makes gait improvement a high priority. Gait analysis based on clinical observations often relies on qualitative descriptions that may lead to conflicting evaluations. Although the Rancho Los Amigos gait cycle¹ provides joint angle ranges, there is a lack of studies reporting on joint angles at specific time points^{2,3}. This reliance on qualitative assessments can lead to varying interpretations.

AIM

The objective of this study is to develop a new quantitative method to comprehensively evaluate hip, knee, ankle, and shank angles across the gait cycle in individuals with stroke-induced hemiplegia.

METHOD

A novel gait evaluation index, the Gait Degree Index (GDI), was developed using data from 298 healthy subjects in the AIST Gait Database 2019. Joint angles of the hip, knee, ankle, and shank at eight key time points in a gait cycle were calculated and standardized by height and walking speed. The GDI was calculated using the mean (μ) and standard deviation (σ) of the healthy population: $GDI = (x - \mu) / \sigma$. Angles with a Z-score exceeding ± 3 were considered abnormal. Validity was confirmed in healthy subjects and then applied to 17 stroke patients using 3D motion analysis.

RESULTS

Figure 1 illustrates the GDI results for individuals with hemiplegia. The vertical axis represents the Gait Degree Index (GDI), while the horizontal axis displays the characteristic time points of the gait cycle. The GDI values for the hip, knee, ankle, and shank are plotted for each subject. For most subjects, the GDI values exceeded ± 3 at multiple time points, indicating abnormal joint angles compared to healthy controls. A GDI value greater than 3 suggests excessive joint motion, while a value less than -3 indicates reduced joint motion.

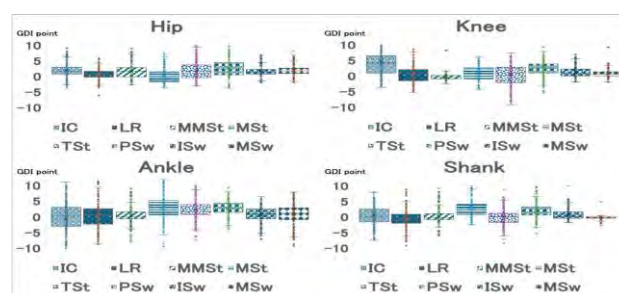


Figure 1. GDI results for hemiplegic patients

DISCUSSION AND CONCLUSION

The GDI effectively identified abnormal gait patterns in hemiplegic patients by detecting joint angles exceeding ± 3 standard deviations from the norm. Additionally, the use of ankle-foot orthoses was associated with a reduction in abnormal GDI values, suggesting its potential role in orthotic prescription. The GDI provides an objective, easy-to-understand clinical gait assessment and identifies problems. This may facilitate effective rehabilitation and improve the patient's ability to gait.

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6.104 Energy consumption to stabilize walking may be increased in individuals with transtibial amputation due to reliance on reactive stepping responses

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BACKGROUND

Energy consumption during walking is higher in individuals with compared to without transtibial amputation [1]. The ability of powered prostheses to reduce energy consumption is limited suggesting that loss of power is not the sole reason for the increased energy consumption [2]. We hypothesize that altered balance control strategies may contribute to increases in energy consumption. Healthy individuals rely on the modulation of ankle torque to control sagittal plane walking balance [3], a strategy that is impaired after amputation. Increased reliance on anticipatory adjustments in step length and reactive foot placement in individuals with transtibial amputation might contribute to increased energy consumption during walking.

AIM

Investigate whether the energetic cost of stabilizing walking is higher in individuals with than without transtibial amputation and whether this can be explained by alterations in balance control strategies.

METHOD

Participants walked on a treadmill with and without quasi-random belt-speed perturbations at three walking speeds between 0.8, and 1.6 m/s. We measured metabolic energy consumption using indirect calorimetry and spatiotemporal gait characteristics using reflective markers. We evaluated changes between perturbed and unperturbed walking in energy rate, mean step length as a measure of anticipatory alterations to gait, and step length variability as a measure of reactive foot placement. So far, we collected data in 22 out of 22, and 1 out of 20 individuals without and with transtibial amputation.

RESULTS

In individuals without amputation, metabolic rate increased, and mean step length decreased due to perturbations. The effect of perturbations was higher at lower speeds, suggesting that walking at higher speeds is intrinsically more robust against perturbations.

In the individual with transtibial amputation, metabolic rate increased more due to perturbations than in the individuals without amputation at the lowest but not at higher gait speeds (Fig.1A). Compared to individuals without amputation, this individual also increased step length variability at the lowest but not at the higher speeds (Fig.1B), while the decrease in mean step length was similar. This may explain why energy consumption was higher in the individual with transtibial amputation.

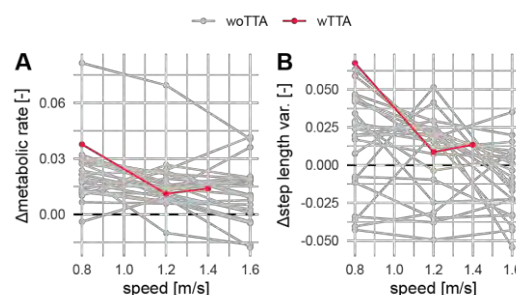


Fig.1 Panel A displays the change in metabolic rate (normalized to body weight and leg length) and panel B shows the change in step length variability (normalized to leg length) due to perturbations for individuals with and without transtibial amputation, wTTA and woTTA respectively.

DISCUSSION AND CONCLUSION

The larger effect of perturbations on the energy rate at low walking speeds in individuals without transtibial amputation is in line with previous observations on larger balance corrections at lower than higher speeds. Our pilot data is in line with our hypothesis that individuals with transtibial amputation require more energy to stabilize walking because they rely more on an energy costly foot-placement strategy.

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6.105 Does Free Walking Effect Sagittal Spinal Posture in Young Adults?

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BACKGROUND

Spinal kinematics frequently change in response to daily activities, which underscores the importance of evaluating spinal posture in relation to musculoskeletal health, ergonomic adaptations, and postural training. Free walking, as one of the most fundamental daily activities, plays a significant role in influencing spinal alignment and movement. Understanding the impact of walking on spinal kinematics can guide its therapeutic use in rehabilitation and support treatment approaches to improve spinal health

AIM

The aim of this study was to investigate whether natural walking, an activity performed almost daily by every healthy individual, has an important impact on sagittal plane spinal kinematics.

METHOD

Healthy individuals aged 18-30 years were included in the study. Sagittal spinal posture was assessed by photographing participants before and after a 3-minute walking session ^[1]. Angle measurements were obtained from these photographs using Kinovea software. For head angle, the lateral line between the eye and the tragus was used as the reference, while cervical angle was measured between the tragus and the C7 spinous process. Thoracic angle measurements used reference points at T1, T5, and T10, and lumbar angle measurements used pivot points at T10, L3, and S2. The Wilcoxon signed-rank test was used to compare pre- and post-walking measurements.

RESULTS

The study comprised 42 participants (mean age 22.9 ± 2.5 years), including 20 females and 22 males. The mean values of spinal kinematics before and after 3 minutes of free walking were as follows: prior to walking, the head angle was $72.5^\circ \pm 7.5$, the neck angle $41.1^\circ \pm 7$, the thoracic angle $24.4^\circ \pm 5$, and the lumbar angle $21.5 \pm 9^\circ$. After walking, these values were $71.5^\circ \pm 7.8$ for the head, $40.3^\circ \pm 8.6$ for the neck, $24.2^\circ \pm 4.7$ for the thoracic region, and $20.6^\circ \pm 8.3$ for the lumbar region. In the analysis of spinal kinematics before and after walking, no statistically significant differences were observed in the angles of the head, neck, thoracic, and lumbar regions ($p > 0.01$).

DISCUSSION AND CONCLUSION

The findings from this study indicate that 3 minutes of free walking does not lead to significant changes in spinal kinematics. Therefore, for therapeutic effects in spinal issues or ergonomic interventions related to spinal health, brisk and speed-dependent walking may be more effective. We also recommend that future studies investigate spinal kinematic changes over durations longer than 3 minutes to better understand potential impacts.

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6.106 Reliability of a mobile phone enabled system to analyse gait

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BACKGROUND

Quantifying the characteristics of walking is useful in clinical practice. There are simple (stopwatch) and complex (3D motion capture) methods, but often these are insufficiently reliable or expensive and time consuming to operate. Harnessing the technology in a mobile phone has potential to fill the gap between these technologies. MovementAlly is a system which uses a free app (SensorLog) to access accelerometer data from the phone and a custom-built Python algorithm to analyse the data.

AIM

To determine the ability of MovementAlly to present reliable tempo-spatial, variability and asymmetry walking data.

METHOD

Five people without a disability performed a number of walking trails under different conditions. The procedure for the 10m walk test was used. A mobile phone was placed on the lower back and secured by a tight-fitting belt. Condition 1 compared the data for 'In/Out'. This involved collecting 4 trials with the phone held securely by a belt and it was not removed between trials (In) and 4 trials when it was removed between each trial (Out). Condition 2 compared the inter-session reliability. This involved collecting 4 trials with the phone held securely by a belt on two occasions, between 5-8 days apart.

The algorithm (i) identified start and end times (calculate velocity), (ii) smoothed the data and autocorrelated (calculate symmetry index and variability) and (iii) counted steps (average step length and cadence). CV determined inter-trial variability. Given the small sample size, paired t-test determined the agreement between samples and Pearson correlation between condition 1 and condition 2.

One person with a transtibial amputation (TTA) walked over flat and uneven ground.

RESULTS

Analysis indicates the MovementAlly is a reliable system. CV was below 10%, no statistical differences. It worked for the TTA.

Table 1. Reliability data for Condition 1 (In/Out) and Condition 2 (Inter-session)

	In	Out	Correlation	Day 1	Day 2	Correlation
Velocity	1.34 (0.08)	1.34 (0.08)	R=0.97	1.30 (0.09)	1.36 (0.08)	R=0.70
Step Length	0.71 (0.04)	0.71 (0.05)	R=0.92	0.72 (0.07)	0.70 (0.04)	R=0.70
Cadence	112 (4)	112 (4)	R=0.96	109 (6)	112 (4)	R=0.86
Symmetry	0.90 (0.03)	0.88 (0.02)	R=0.70	0.90 (0.04)	0.88 (0.02)	R=0.60
Variability	0.80 (0.02)	0.01 (0.03)	R=0.93	0.81 (0.02)	0.81 (0.03)	R=0.61

DISCUSSION AND CONCLUSION

MovementAlly, a custom-designed gait analysis tool which harnesses a mobile phone's technology and combines it with a custom software produces relevant and reliable data. Further research is required to assess its efficacy on more people using more robust statistical models.



6.107 Postural control imbalance in individuals with a minor lower extremity amputation: a scoping review

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BACKGROUND

The rising prevalence of minor lower extremity amputations (LEA) highlights an emerging gap in the current healthcare landscape. While major LEA dominate the research focus, minor LEA also have a significant impact on mobility and physical function. Postural deficits, primarily resulting from sensory loss and musculoskeletal changes, increase the risk of falls. However, the biomechanical consequences of minor LEA, especially on postural control, remain underexplored in the current literature.

AIM

To synthesize the current research literature that has described postural control deficits following a minor LEA, focusing on any resection through or distal to the ankle joint, and to evaluate the efficacy of orthotic and therapeutic interventions to improve these deficits.

METHOD

A comprehensive search strategy will be applied to multiple databases, including MEDLINE, SPORTDiscus, CINAHL, Cochrane, and grey literature. Quantitative studies on balance sensation and postural control following minor LEA in children and adults will be included in the scoping review. The focus will be on evaluating biomechanical alterations, including kinematic, kinetic, and electromyographic changes, to assess the impact of minor LEA on postural control. In addition, changes in balance sensation, and risk of falling, using various balance assessments and dynamic tests, will be considered to assess the balance confidence and functional abilities of these individuals. Screening, data extraction, and quality assessment will be performed by two independent reviewers.

RESULTS

The findings of this scoping review will map the postural control deficits documented in the scientific literature in individuals with minor LEA. The results will be used to compile data on biomechanical changes, functional assessments of fall risk, and self-reported questionnaires on the sensation of balance in this population. Subsequently, this scoping review will examine the interventions assessed in the included studies, identifying the orthotic, therapeutic, and rehabilitative approaches that have been tested in individuals with minor LEA to restore impaired postural function.

DISCUSSION AND CONCLUSION

This scoping review will examine postural deficits in individuals with minor LEA and highlights key areas for therapeutic interventions. The effectiveness of external aids, such as prostheses, foot orthoses, and ankle-foot orthoses, will be emphasized. By identifying the current gaps in the literature, this scoping review will provide a foundation for the development of robust research protocols designed to address these gaps. Such research will facilitate the advancement of more targeted and effective rehabilitation strategies to enhance postural control, balance confidence, and quality of life in this population.



6.108 Does Coronal Plane Prosthetic Foot Adaptation Improve Asymmetry for Level and Uneven Ground in Trans-tibial and Trans-femoral Amputees?

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BACKGROUND

Over 50% of amputees report falling at least once a year¹. Risk factors include muscle weakness, comorbidities and environmental terrain. Self-aligning ankles have been shown to reduce the prevalence of falls by increasing toe clearance during swing², however side-ways falling also contributes to injuries³. There are limited prosthetic foot options available which provide medio-lateral (ML) articulation. It is likely ML articulation will provide a stability benefit to amputees on both level and uneven ground.

AIM

Compare Prosthesis Evaluation Questionnaire (PEQ) and asymmetry scores for two amputees walking on level and uneven ground, using a fixed energy storage and return (fESR) foot and an energy storage and return foot with ML articulation (mESR).

METHOD

Two established amputees (one trans-tibial (TT) and one trans-femoral (TF)) were asked to evaluate their fESR foot using the Seattle PEQ. Acceleration data was collected using a mobile phone movement app (MovementAlly). Following a period of four weeks, the mESR foot was fitted and trialled for a further four-week period. A second PEQ was filled in and repeat data collected for level and uneven ground.

RESULTS

For all answered PEQ responses, scores for the mESR were higher than the fESR. The TT was more symmetrical on level ground for both foot conditions compared to uneven ground and more symmetrical when using the mESR foot compared to the fESR. Velocity was similar across all conditions. The TF was more symmetrical using the mESR foot on level ground compared to the fESR foot, however less symmetrical on uneven ground. The velocity was greater on level ground compared to uneven ground for both foot conditions and greater using the mESR foot than the fESR foot for both terrains.

DISCUSSION AND CONCLUSION

That the TT amputee was more symmetrical using the mESR compared to the fESR, suggests ML adaptation to be important regardless of terrain. While both amputees favoured the mESR foot, it was surprising that the symmetry data didn't reflect this for both terrain conditions for the TF. It is possible that having greater ML compliance gave more confidence to walk faster, however this may have in turn contributed to the mESR being less symmetrical on the uneven ground. Further research is being collected to increase the data pool and to further compare TT to TF amputees.

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6.109 Evaluation of the aid ALFESS for patients with neurological conditions

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BACKGROUND

A person with a neurological condition often has a functional limitation e.g walking. Impaired dorsiflexion is a factor that contributes to walking disability.

Functional electrical stimulation (FES) device employs sensors to measure acceleration, leg angle, and step frequency, enabling precise activation of the foot-lifting muscles during the correct phase of the gait cycle. Muscle activation is optimized and gait pattern is improved in individuals with neurological or musculoskeletal impairments.

AIM

The aim of the evaluation was to assess the effect of the ALFESS device on function and quality of life for patients with impaired dorsiflexion in one foot due to neurological condition.

METHOD

Two patients with diagnosed neurological condition and impaired dorsiflexion in one foot were included in the study. Their functional and activity levels were assessed using various tests before starting ALFESS and after one, three and six months of use. Tests were performed both with active and inactive ALFESS. The tests included the 6-minute walk test, active range of motion in the foot, stair climbing (8 steps), and a dual-task walking test (70 meters of walking while performing a counting task). A self-assessment of quality of life using the EQ-5D questionnaire was also conducted to evaluate changes over time.

RESULTS

Both patients demonstrated a gradual increase in walking speed during the 6-minute walk test, with a total improvement of 41% for patient 1 and 8% for patient 2 from the first test to the final test with ALFESS. Both patients improved their time in the stair climbing test. Patient 1 reduced the time from 20 to 10 seconds (50%). Patient 2 reduced the time from 12 to 8 seconds (33%). In the dual-task walking test, both participants increased their walking speed, for patient 1, 26 % and for patient 2, 30 %. Active range of dorsiflexion increased with 40 degrees for patient 1 and 17 degrees for patient 2. Patient 1's EQ-5D self-reported quality of life improved from 59 to 87, while patient 2's score remained unchanged at 70.

DISCUSSION AND CONCLUSION

This case study includes two patients, and the results should be interpreted with caution. However, a trend can be observed where interventions with FES have a positive effect for patients with neurological conditions. After six months using ALFESS, both patients have improved functional ability. The tests show increased function in the affected foot as well as improved specific and functional mobility.



6.110 Benefits of two types of microprocessor-controlled stance and swing phase knee-ankle-foot orthoses compared with a stance-controlled orthoses, a case study

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BACKGROUND

Stance-controlled knee-ankle-foot orthoses (SCKAFOs) are often prescribed to people with proximal leg muscle weakness to improve walking ability ⁽¹⁾. SCKAFOs allow free knee flexion during swing while walking, reducing compensatory movements like hip hiking and circumduction. However, these benefits are mostly limited to walking on level surfaces, and not to walking on uneven terrain, stairs, and/or ramps ⁽¹⁾. Microprocessor-controlled stance and swing phase controlled KAFOs (SSCKAFOs) with hydraulic knee-joints, such as the C-Brace, have shown to improve mobility especially on these uneven surfaces ⁽²⁾. Recently a new SSCKAFO, the NEURO HiTRONIC, has been introduced, which has not yet been evaluated in daily life use, but may also show these benefits.

AIM

To compare walking ability, balance and daily activity performance between the NEURO HiTRONIC SSCKAFO and NEURO TRONIC SCKAFO and between the NEURO HiTRONIC SSCKAFO and C-Brace.

METHOD

This was a case study of a 68-year-old male with polio who used a NEURO TRONIC SCKAFO in daily life, and who was consecutively provided with a NEURO HiTRONIC SSCKAFO and C-Brace. Both devices were used for three months in daily life, after which measurements were taken and compared with baseline measurements of the NEURO TRONIC SCKAFO. The measurements included: energy cost of walking, walking speed (both assessed with 6-minute walk test), timed-up-and-go test (TUG), balance performance (Berg Balance scale), balance confidence (activities specific balance confidence scale (ABC)), stair and hill assessment index and daily life functioning (OPUS lower extremity functioning scale (OPUS-LEFS)).

RESULTS

Compared to the NEURO TRONIC SCKAFO, walking with the NEURO HiTRONIC resulted in improvements in walking speed (+13%), energy cost of walking (-11%), balance confidence (+11 ABC points) and daily life functioning (+10 OPUS-LEFS points), Table 1. The results for energy cost of walking and balance performance with the NEURO HiTRONIC and C-Brace were similar. Walking speed, TUG outcome, balance confidence and stair and hill descend improved more with the C-Brace than with the NEURO HiTRONIC SSCKAFO, compared to the NEURO TRONIC SCKAFO.

Table 1

	NEURO TRONIC	NEURO HiTRONIC	C-BRACE
Walking ability			
Walking speed (6MWT)	0.84 m/s	0.95 m/s (+13.1%)	1.03 m/s (+22.6%)
Energy cost (6MWT)	4.92 J/kg/m	4.36 J/kg/m (-11.4%)	4.31 J/kg/m (12.4%)
Stair Assessment Index (0-13)	3	3 (+0)	6 (+3)
Hill Assessment Index (0-11)	5	5 (+0)	7 (+2)
Balance			
Timed-up-and-Go test	15.63 sec	15.20 sec (-2.8%)	10.6 sec (-32.1%)
Berg Balance Scale (0-56)	54	53 (-1)	53 (-1)
ABC Scale (0-100)	59	70 (+11)	86 (+27)
Daily functioning			
OPUS-LEFS (0-80)	37	47 (+10)	51 (+14)

6MWT: 6 minute walking test, m/s: meter/second, J/kg/m: Joule/ kilogram/meter, ABC: Activities Specific Balance Confidence, OPUS-LEFS: Orthotics and Prosthetics User Survey - Lower Extremity Functional Status

DISCUSSION AND CONCLUSION

This was the first study to evaluate and compare SSCKAFOs, including the NEURO HiTRONIC and the C-Brace. Both SSCKAFOs were beneficial in improving energy cost of walking, balance confidence and daily life functioning compared to the NEURO TRONIC SCKAFO. The C-Brace showed additional benefits for walking speed, balance confidence and stair and hill descent, when compared to the NEURO HiTRONIC SSCKAFO, which is likely due to the controlled knee flexion resistance functionality of the C-Brace knee-joint.

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6.111 Current Challenges and Future Directions of Osseointegration Lower Limb Reconstruction for Amputees

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BACKGROUND

Direct transcutaneous attachment of a bone refers to Osseointegration. Achieving advancements has increased the acceptance frequency over the last decade by improving functional outcomes like quality of life, better walking and gait postures, and good range of motion. By completely debarring the socket-based prosthesis which causes difficulties in suspension, tissue/bone pain, skin irritation, etc, and decreased quality of life.

AIM

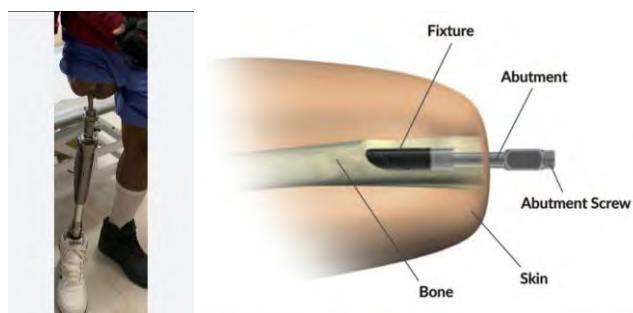
This study aims to review the complications following osseointegration for lower limb amputation, with attention to mechanical abutment failure.

METHOD

A scoping literature search was conducted on Google Scholar, Journals, peer research papers PubMed for studies published from 2019 to 2023, using terms like "osseointegration," "amputee," "infection," "production," "sustainability," "design," "feedback," and "advances." Articles addressing advances in infection prevention, production and biomaterials, and prosthesis design were included, while unrelated articles were excluded. In total, 90 papers were reviewed, and 31 were selected by consensus with senior authors, organized under [i] advances in infection prevention and control, [ii] production and biomaterials, and [iii] prosthesis design and feedback.

RESULTS

This study review has a well-articulated focus on addressing key limitations of current osseointegration limb reconstruction, with an emphasis on future innovation driven by systematic research, Investigating implant design and manufacturing, including 3D printing for cost-effective, sustainable production, laid a foundation for exploring advanced biomaterials. Moreover, the attention to enhancing functionality through smart implants, biofeedback, and myoelectric pattern recognition aligns with the goal of creating a sensate limb for users, which is an exciting direction in the field. Systematic approach could indeed be pivotal in shaping the next generation of osseointegration technology.



DISCUSSION AND CONCLUSION

The use of osseointegration in limb reconstruction for amputees is progressing along a similar path to that of total joint arthroplasty, which has achieved global acceptance and widespread adoption over the past 30 years. With emerging technological advancements addressing current challenges in osseointegration such as infection control, precision manufacturing, and implant feedback-we see a promising future for amputee rehabilitation.

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6.112 The effect of different heel heights on the risk of falls in patients with a lower leg prosthesis

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BACKGROUND

People with a Transtibial amputation (TTA) have an increased risk of falling. Risk factors for falling in TTA are increased age, co-morbidity, medication and bilateral amputation. Changes in alignment of the prosthesis are also linked to fall risk. The alignment of the prosthesis is influenced by the heel height. However until this day there has not been any research that has investigated the influence of changing the heel height on balance in people with a lower leg prosthesis.

AIM

To identify if change of heel height in both shoes in patients with unilateral lower leg prosthesis influences balance and therefore fall risk.

METHOD

An experimental study was conducted on 26 people with an unilateral TTA in possession of an adequate prosthesis with an activity level 2-4. The heel height was changed in each participant. T0 was their normal heel height, T1 a heel height of + 0.5 cm, T2 a heel height of + 1 cm and T3 a heel height of – 0.5 cm compared to the normal heel height of the participant. At each measurement moment the Berg balance score (BBS) was taken and if this score was higher than 51, a functional gait assessment (FGA) was also taken.

RESULTS

The Friedman's test was performed to investigate whether the BBS and the FGA changed with different heel heights. Both the BBS ($\chi^2_{23}=65.6$, $p < 0.0005$, $W=0.84$) and FGA ($\chi^2_{23}=45.2$, $p < 0.0005$, $w=0.58$) changed significantly with different heel height. In both the effect was large. For both scores, the higher the heel height the worse the score, but with a heel height reduction the median score is the lowest.

Table 1. Median Berg Balance Score (BBS) and Functional Gait assessment (FGA) and their interquartile range (IQR) at different heel height.

	BBS	FGA
Patients normal heel height	55 (52-56)	26 (24-28)
0,5 cm increase	54 (51-55)	24 (24-26)
1,0 cm increase	53 (49-53)	23 (21-24)
0,5 cm decrease	51 (48-53)	20 (18-23)

DISCUSSION AND CONCLUSION

In participants with unilateral lower leg prosthesis the heel height of the shoes influences balance, both higher and lower heel height, and their fall risk. People with a TTA should be aware of this risk and contact their prosthetist for adjustments in the alignment of the prosthesis when they change their shoes. This study confirms the advice given by doctors, prosthetist and physical therapist in daily practice when patients wear shoes with a different heel height.



6.113 Clinical and gait analysis on prosthetic use in lower limb amputees

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BACKGROUND

The alignment and selection of prosthesis for individuals with lower limb amputation (iLLA) rely on professional expertise and clinical observations. No standardized measure exists for objectively assessing prosthetic use. An inadequate prosthetic choice may influence activities of daily living.

AIM

To assess the key biomechanical parameters in walking based on type of prosthesis.

METHOD

Eleven iLLA (six transfemoral [iATF] and five transtibial [iATT]) and 16 healthy individuals (iSI) performed a walking task (comfortable speed). A motion capture system and four force platforms were used to record spatiotemporal, kinematic, and kinetic data. iLLA were assessed with their current prosthesis (P1) and then with a component modification (P2) six to ten days later. In addition to evaluating pain and comfort levels during the walking test, several biomechanical variables (e.g., range of motion, symmetry of ground reaction forces, and joint powers of the lower limbs) were measured. All variables were selected based on previous studies. The effect of the prosthesis on walking was compared between iLLA (P1) and healthy individuals using Cohen's d. Parameters with an effect ≥ 0.80 were compared between P1 and P2 using a Wilcoxon test. Effect sizes were calculated between P2 and healthy individuals.

RESULTS

The average pain level experienced across the two visits decreased by 46%, while comfort level improved by 24%. The amputation had an influence on 33 biomechanical variables of interest. For 17 variables, the effect was reduced with the new prosthesis (P2), with six under 0.80. For iATT, speed, propulsion force, the hip extension moment, and knee flexion (beginning of stance phase) decreased significantly at P2. For iATF, step length on the amputated side and pelvic range of motion (frontal plane) on the non-amputated side were reduced, and plantar flexion moment on the amputated side increased. The symmetry index for the first peak of vertical ground reaction forces between the healthy and amputated limbs improved by 10% between P1 and P2 (0.88 vs 0.98).

DISCUSSION AND CONCLUSION

iLLA showed a preference for their new prosthesis (P2); however, its impact on several biomechanical parameters remains modest, potentially due to inter-subject variability.

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Posters | Education

6.114 Utilizing Online Education to Combat Global Health Disparities: Trends in Mission Gait Foundation's YouTube Channel

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BACKGROUND

High quality medical education videos on Youtube have the potential to reduce healthcare spending, improve patients' quality of life, and reduce health disparities ^(1,2). Mission Gait Foundation's YouTube channel provides educational resources on gait rehabilitation, with a focus on prosthetic and orthotic interfaces. Engagement has increased from viewers aged 65+ and from low- and middle-income nations, indicating the platform's potential to disseminate advanced rehabilitation knowledge globally and combat health disparities.

AIM

Demonstrate the efficacy of free online education in spreading high-income nation rehabilitation information to low- and middle-income nations while promoting empowerment among older adults.

METHOD

YouTube analytics were utilized to assess trends in viewer demographics over time. The data focused on the percentage of viewers aged 65+ and the percentage of views from low- and middle-income nations. Content on the channel includes detailed videos on gait rehabilitation techniques, prosthetic and orthotic management, and educational material for caregivers and professionals. Trends were analyzed to determine the reach and impact of the educational content on targeted demographics.

RESULTS

Analytics indicated a significant increase in the percentage of viewers aged 65+ and those from low- and middle-income nations between 2017 and 2023. Specifically, the watch time of viewers aged 65+ increased 11.5% (from 9.2% to 20.7%), while views from low- and middle-income nations increased 20.4% (from 4% to 24.4%). This trend suggests a growing global audience benefiting from the content, indicating that the channel is effectively reaching and engaging these critical demographics.

Youtube Video Watch Time Percentage by Age Group

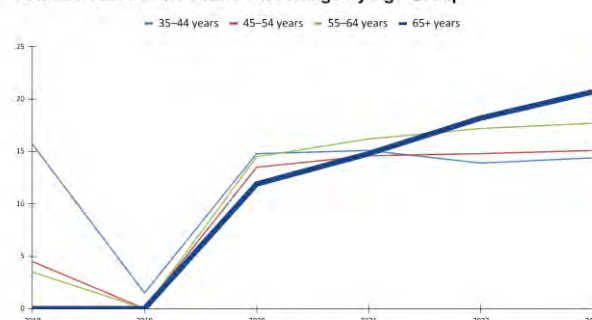


Figure 1. YouTube watch time percentage by age group.

DISCUSSION AND CONCLUSION

The increasing engagement from older adults and viewers in low- and middle-income nations underscores the potential of this replicable method using online education platforms in addressing global health disparities. Mission Gait Foundation's YouTube channel demonstrates that providing accessible, high-quality educational content can empower individuals and healthcare providers worldwide, promoting better health outcomes and reducing inequalities in gait rehabilitation knowledge and practice.

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6.115 BARS and BEAMS: Evaluating Instruction of Mechanical Concepts for Prosthetics and Orthotics

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BACKGROUND

Skills to ensure the operational safety and durability of prosthetic and orthotic (P&O) devices are essential for P&O professionals¹. Accurate device quality control requires an understanding of fundamental mechanical concepts, such as stress and behavior of materials, to make appropriate decisions about the patient-centered design and fabrication of P&O devices. Therefore, these concepts should be reinforced during the training process. An assessment modality with evidence of content validity² has been developed to objectively evaluate student learning in this area.

AIM

To assess instruction of fundamental mechanical engineering concepts using an assessment modality developed with evidence of content validity (i.e., pre-test and post-test exams).

METHOD

Fourteen graduate students (n=14), including thirteen P&O and one Bioengineering Master's students, consented and participated in the University of Washington RHB PO 541: Engineering Concepts course. An online pre-test and a paper-based post-test were conducted before the start of the term and at midterm, respectively. The question formats included multiple-choice, true/false, free-body-diagram, and short-answer. The structure of the pre-test questions matched closely but was not identical to that of the post-test.

RESULTS

Most students (12/14) improved their scores between pre-test and post-test exams (Fig. 1A). On average, the increase in score change was about 47% (Fig. 1B). Further, four students improved their scores close to and above 100%, while one student showed no improvement in their scores (Fig. 1A and 1C).

DISCUSSION AND CONCLUSION

This assessment indicates a positive impact of the instructional intervention on student learning of mechanical engineering concepts. Notable improvements in post-test scores suggest that students gained a strong grasp of key concepts during the learning period. Furthermore, score improvements close to or above 100% further support the effectiveness of this instructional intervention. Future work could explore strategies to support students who showed little or no improvement. Additionally, the instructional intervention could be further refined through implementation at other P&O institutions nationally and worldwide.

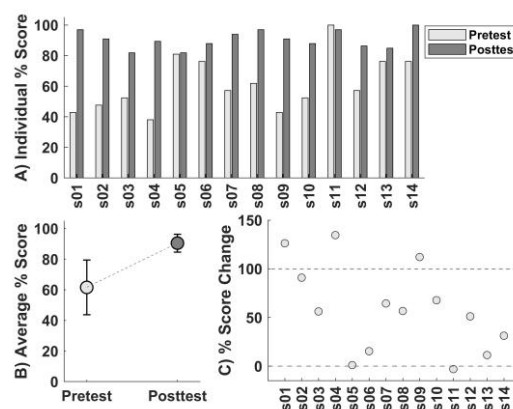


Figure 1. Student Pre- and Post-test Scores

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6.116 A process to improve the application of hands skills post short-term training in less resourced countries

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BACKGROUND

Prosthetists/orthotists attend short-term trainings to develop their hands skills. However, they often do not apply acquired skills effectively post training. If a trainee fails to apply the acquired skills, the resources and efforts are wasted for trainers, employees (trainees) and employers. An innovative approach is needed to improve the effect of training.

AIM

To identify factors that influence the effectiveness of short-term trainings for trainers, employees (trainees) and employers.

METHOD

The research employed Grounded Theory to identify the influencing factors in application of hand skills. 12 professionals who received short-term training from the International Committee of Red Cross were interviewed in Rwanda, Somalia, and Tanzania. The qualitative data obtained was coded, grouped, and categorized to identify these influencing factors.

RESULTS

The characteristics of the service users, service providers, human-resources, and leadership are factors identified as related to people. Whereas facilities, process, financing, and outcome are factors identified as related to systems influencing the effect of short term trainings.

DISCUSSION AND CONCLUSION

Implementing recommendations on the training process will enhance the effectiveness of short-term training.

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6.117 Survey of Employment Status of Graduates in Prosthetics and Orthotics, Faculty of Medicine Siriraj Hospital, Thailand, During Year 2018-2022

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BACKGROUND

Economic and social changes at the ASEAN and global levels directly impact Thailand, affecting various sectors, including government, healthcare, and education¹. Reforms in public administration and global university rankings have led to policy changes to enhance university management². Mahidol University's Faculty of Medicine, in line with its 2023-2028 strategic plan, focuses on producing skilled prosthetists. This study assesses the employment status and distribution of prosthetics graduates, providing insights for curriculum development and workforce planning.

AIM

The purpose of this exploratory study is to examine the employment status of graduates from the Prosthetics and Orthotics program at the Faculty of Medicine, Siriraj Hospital, Mahidol University.

METHOD

This study employs a retrospective design, covering graduates from the P&O program in Thailand from the academic years 2018-2022. The questionnaire was conducted through an electronic survey and was designed in accordance with guidelines from the Office of Higher Education Commission (OHEC) and tailored for the field of prosthetics to capture context-specific information relevant to the graduates' work experience.

The questionnaire consists of three main sections: 1) general information about the graduates 2) current employment status; and 3) job-related information, including job type, position, workplace, and start date.

After data collection, the research team reviewed the completeness and accuracy of the responses. Incomplete or erroneous data were followed up or screened to ensure completeness and achieve the desired response rate.

RESULTS

The data were analyzed using SPSS version 28.0. The study identified key trends in response rates, employment rates, and career paths of P&O graduates from 2018 to 2022. Response rates ranged from 68.75% to 95.45%. Employment rates varied, peaking at 100% in 2020, with an average of 90.03% over the five-year period. Prosthetics-related roles remained the primary career choice, with 17 graduates employed as P&O professionals in both 2018 and 2021, followed by positions as lecturers and researchers. Overall, P&O professional roles were the most prevalent career choice among graduates.

DISCUSSION AND CONCLUSION

This study offers valuable insights into the employment status, career paths, and job distribution of P&O graduates. It reveals high employment rates, especially in P&O roles, though a decline in 2022 may reflect factors like reduced medical staffing or changing work values. P&O positions remain the most sought-after career choice. To better support graduates, educational institutions should consider adapting curricula to meet evolving labor market needs and equip the skills for diverse roles in management, research, and communication.

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6.118 Clinical Internship Experience Enhances Comprehensive Practical Examination Performance in Undergraduate Prosthetics and Orthotics Students

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BACKGROUND

Comprehensive Practical Examination (CPE) is a key graduation requirement for undergraduate P&O students at Sirindhorn School of Prosthetics and Orthotics, Thailand. This examination is associated with significant stress and anxiety [1]. Clinical internships, considered as a critical component of P&O education, contribute significantly to the development of students' knowledge, skills, and attitudes [2]. Internships offer students opportunities for self-assessment and obtain feedback to improve performance on the CPE.

AIM

To evaluate relationship between students' performance during clinical internships and their outcomes on the Comprehensive Practical Examination in final-year P&O students at Sirindhorn School of Prosthetics and Orthotics, Thailand.

METHOD

Data was collected from all final-year students across two consecutive cohorts. Students' performance in device production during each of the three internship periods was analyzed and compared with their comprehensive practical examination results. The correlation between clinical internship performance and CPE outcomes was examined. Additionally, students' self-evaluations of their knowledge and skills were assessed before and after each internship session. Descriptive statistics were used for data analysis, and qualitative open-ended feedback was reviewed to identify areas for improvement in the internship, examination, and curriculum.

RESULTS

Data was collected from 51 students across two consecutive cohorts retrospectively. The analysis revealed a consistent improvement in student performance across the three internship periods in both cohorts. A positive correlation was found between internship performance and CPE outcomes. Self-evaluations on knowledge and skills indicated an increase in students' confidence and perceived competence before each internship session; however, no significant differences were observed in their self-evaluations following the internship periods.

Table 1. Students' performance on internships 1, 2, 3, average of all internships, and outcome of the comprehensive practical examination

Cohort A (N=29)	Internship 1 (%)	Internship 2 (%)	Internship 3 (%)	Average (%)	CPE (%)
Max	91.5	90.5	91.4	86.6	81.1
Min	57.8	64.2	66.7	69.6	57.8
Ave	76.6	79.0	78.9	78.2	72.0
Cohort B (N=22)	Internship 1 (%)	Internship 2 (%)	Internship 3 (%)	Average (%)	CPE (%)
Max	86.9	90.0	88.9	83.5	83.2
Min	59.4	61.0	61.4	60.5	52.4
Ave	71.3	77.3	78.1	75.4	69.5

DISCUSSION AND CONCLUSION

The findings of this study align with previous research by Kim (2014), which suggests that clinical internship experience positively correlates with clinical examination performance [3]. This study confirms that students' performance and experience during clinical internships positively affect the outcome of the comprehensive practical examination, enhancing both practical skills and confidence. Further research should be conducted to investigate the relationship between students' cumulative grades (GPA) and CPE results.

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6.119 Shared Decision-Making Tools for Individuals Living with Diabetes and Foot complication: Protocol for a Rapid Review

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BACKGROUND

Diabetes can lead to minor and major lower extremity amputations (LEA)s. Post-LEA care are complex, and need an integrated interdisciplinary approach where individuals are actively involved in their health decisions. To address their specific needs and enhance value-based care and their engagement, shared decision-making tools have demonstrated significant positive outcomes. These tools help align care with patients' preferences while incorporating evidence-based practices to support informed choices. However, tools tailored for this population remain unclear.

AIM

To identify shared decision-making tools for individuals with diabetes, assess their relevance and highlight the gap for individual with minor LEA. Minor LEAs are defined as those occurring through or below the ankle.

METHOD

A rapid systematic review was conducted in Cochrane, MEDLINE, and CINAHL databases, focusing initially on decision-making tools and their effects in individuals with diabetes, in knowledge synthesis. Subsequently, primary studies of decision-making tools related to diabetes were searched. Grey literature was also explored through decision tool databases, open searches on Google Scholar, and bibliographies of selected tools.

RESULTS

Various decision-making tools are available for individuals with diabetes and mainly cover general diabetes management, medication or surgical treatment choices, and weight management. Individuals with a LEA have specific decision-making needs regarding lower limb prosthetic and orthotic devices. However, no currently developed or underway tools to inform patients on prosthetic and orthotic options, especially in individuals with a minor LEA. This review is still in progress, but the final results will be presented at the conference.

DISCUSSION AND CONCLUSION

Despite recent advancements in decision-making tools in the population with diabetes, none are specifically tailored to deal with the unique needs of individuals presenting minor LEAs. This gap underscores the importance of developing targeted solutions, particularly regarding the adequate selection of therapeutic shoes, foot orthoses, and above-ankle prostheses to inform shared decision-making and ultimately improve care quality.



6.120 Evaluation of the design of disability cultural safety curriculum and the impact on student learning and perceptions of disability

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BACKGROUND

Although disability culture is well described in the literature, there is little documentation on the effectiveness of Prosthetic and Orthotic curriculum in challenging, deepening and transforming students' perceptions of disability cultural safety. The introduction of Australia's National Disability Insurance Scheme provided the impetus for a critical review and redesign of a User Centred P&O curriculum which prioritises the rights and voices of people with disability.¹

AIM

To explore the impact and effectiveness of curriculum design on Prosthetic and Orthotic students' perspectives of disability culture and cultural safety.

METHOD

This project applied a qualitative approach to align with the studies aim to explore participants experiences and perceptions. Following institutional ethics approval and student consent, previously submitted student work was transcribed and analysed using a qualitative thematic analysis. Data was selected across a three-year period from the subject 'Assistive technology and User Centred Design'. Data analysis was managed using NVivo software and followed a thematic approach including familiarisation, coding and the generation and development of themes.

RESULTS

Analysis of the data is ongoing, initial developing themes include concepts of transformative perceptual change in students' awareness of disability and an awareness of the importance of applying a collaborative, user centred approaches to professional practice. Detailed reporting of final themes will be presented.

DISCUSSION AND CONCLUSION

This study demonstrates how a critical approach to the development of a rights based and user centred design curriculum can positively influence the perceptions and attitudes of undergraduate P&O students. The results of this study will contribute to the improvement of graduate disability cultural safety skills and provides a model for broader adoption in P&O education.

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ACKNOWLEDGEMENTS

This work was undertaken on the lands of the Wurundjeri people of the Kulin Nation.



6.121 Shared Decision Making: Understanding and Significance for Prosthetics and Orthotics

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BACKGROUND

After amputation, multiple prosthetic designs are available for amputees, but prosthetist often fail to fully align with the individual's needs and preferences as lack of decision-making process. Shared decision-making is crucial in providing the best prosthetic solution, as it ensures the patient receives the most suitable prescription while allowing them to make informed choices about their prosthetic or orthotic needs.

AIM

This study highlights the significance of the shared decision-making process in prosthetics and orthotics particularly for lower limb amputees. It aims to educate prosthetists, orthotist and healthcare professionals on the benefits of a multidisciplinary approach to decision-making.

METHOD

The study is based on Evidence-Based Practice (EBP) to examine the role of shared decision-making in prosthetics, incorporating both literature reviews and subjective feedback from personal experience working in multidisciplinary teams. Literature was gathered from academic databases, including CINAHL, ProQuest, P&O Journals, and other reputable sources. Key search terms included "shared decision making," "multidisciplinary approach," "patient-centered care," "prosthetics and orthotics decision making," "healthcare and decision-making," "patient engagement," "health and disability policies," and "post-amputation rehabilitation."

RESULTS

Findings from studies and personal feedback emphasize the importance of involving patients in the decision-making process to ensure the prosthetic /orthotic solution meets their needs. Evidence supports the need for more clinician training in shared decision-making and a shift toward patient-centered clinical practices. Additionally, evidence suggests that this process is essential for improving the quality of life after limb loss or other disabilities.

DISCUSSION AND CONCLUSION

The literature highlights the significance of shared decision-making process in prosthetics and orthotics, outlining key practices for prosthetists, orthotist and healthcare providers. To fully realize the benefits of shared decision-making, further training for healthcare professionals is vital, alongside the restructuring of clinical practices to focus on patient-centered care. Continued research is essential to identify the most effective strategies for implementation of this process around the world.



Posters | Health care, policy, sustainability

6.122 Innovative Foot Orthotic Clinic: The model development in Thailand

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BACKGROUND

"Innovative Foot Orthotic Clinic (IFOC)" is an innovative service to increase access to foot healthcare service and is the first one-stop service in Thailand. It provides footcare and responds to individual foot problems at professional care standard. Technology is applied to improve diagnostic precision and reduce production time and process to enable fast services. The innovation creates cooperation among multidisciplinary teams. The clinic environment has been renovated for client's convenience. Patient's opinion is welcomed for the continual development process and to enable the rights to access to care for all.

AIM

To share experience of developing the IFOC as an innovation of specialized services, intended to increase access to government services at affordable cost.

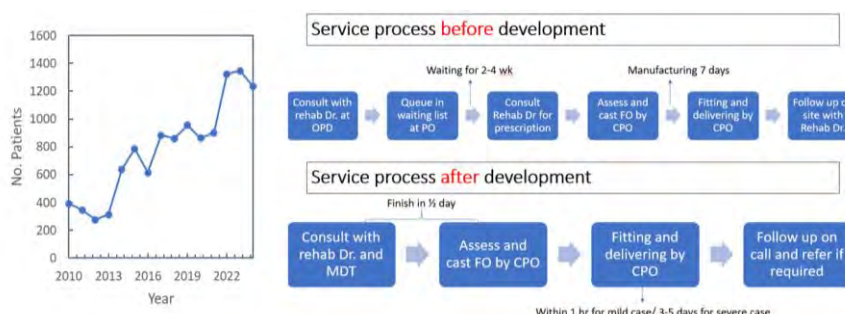
METHOD

The development approach is as followed:

1. Develop capable personnel: this includes planning, allocating, and increasing the number of specialized personnel by attending training in Thailand and other countries. Knowledge is shared among orthotists within the organization to promote Community of Practice.
2. System Service Improvements: by readjusting the procedures, simplifying workflows, and increasing service effectiveness with cooperation of a multidisciplinary team. The clinic reduces the whole process into 1 day instead of 5-7 days. Moreover, the clinic establishes the follow-up system in every patient to ensure quality of use.
3. Advanced technology is introduced into the assessment and manufacturing of insoles, for example, assess foot pressure with Presscam, designing insoles by CAD-CAM, and using Podiatech to enhance better quality in shorter time.
4. The clinic environment is renovated in order to serve more clients at the same time.

RESULTS

Since 2010, there has been a steady increase in patients attending the clinic from around 350/yr to over 1200/yr. The Figure above illustrates how our processes were modified to accommodate this increased population in need of care.



DISCUSSION AND CONCLUSION

The development of the IFOC is an innovation of specialized services that increases access to government services. It serves people with all foot diseases. The cornerstone in developing the clinic is patient-centered care. New technology has been implemented to assist in the patient assessment process to analyze the problems, make an accurate diagnosis, and enhance the production of insoles within shorter time with the standard quality. Therefore, IFOC is outstanding and different in terms of uncomplicated service systems with customized insoles. The fast and easy system makes it convenient for all patients to receive a premier service and devices without extra-cost and reducing unnecessary waiting and traveling time and expenses.

ACKNOWLEDGEMENTS

IFOC is operated under the "Sirindhorn National Medical Rehabilitation Institute (SNMRI), Department of Medical Services, Ministry of Public Health.



6.123 Road Surface Classification for a Fall Prevention System in Snowy Regions

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BACKGROUND

Prosthetic and orthotic users should walk cautiously on snowy/icy roads, observing the slipperiness of the road surface and taking care not to fall. However, they tend to be more focused on walking forward; thus, they are less able to notice changes in slipperiness and are at greater risk of falling. Therefore, we have begun to develop a fall prevention system that uses AI to determine the degree of slipperiness several steps ahead based on road images and encourage users to walk cautiously in advance.

AIM

The purpose of this report is to investigate the accuracy of classifying slipperiness from images of winter road surfaces.

METHOD

The training was conducted using 96,775 image datasets, which are image regions cropped from 1,801 winter road surface images labeled from level 0 (dry/wet) to 3 (extremely slippery) according to their slipperiness, several steps ahead. Training was performed in three trials by randomly changing the combination of training and validation data in the dataset, and the performance of road surface classification after training was evaluated using the confusion matrix, accuracy, and F-measure.

RESULTS

An example of the confusion matrix obtained as a result of the classification is shown in Figure 1. The mean accuracy was 0.729, and the mean F-measure was 0.638. On the other hand, the classification between dry/wet road surfaces (level 0) and snowy/icy road surfaces (level 1 to 3) resulted in an accuracy of 0.976 and an F-measure of 0.930. Similar results were obtained for all three trials, with a mean accuracy of 0.729 and a mean accuracy of 0.984 for classifying dry/wet and snowy/icy road surfaces.

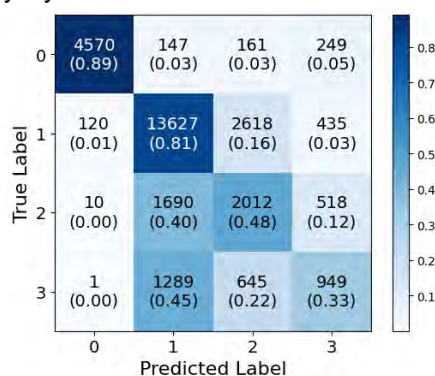


Figure 1. An example of confusion matrix.

DISCUSSION AND CONCLUSION

As shown above, high accuracy was obtained for classifying dry/wet and snowy/icy road surfaces. However, the accuracy between each snowy/icy road surface level (level 1-3) was low, and practical accuracy was not achieved. In particular, the accuracy of level 3 was low, likely due to the infrequent occurrence of this road surface and the small number of datasets compared to other road surface levels; therefore, it is necessary to collect more diverse road surface images.

ACKNOWLEDGEMENTS

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6.124 Machine learning approach to the prescription support algorithm for the transtibial prosthesis

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BACKGROUND

The goal of lower limb prosthetic prescription is to select prosthetic components suited to the amputee's physical condition and activity level. However, decisions often rely on the prosthetist's clinical experience and patient feedback, which are subjective. To improve objectivity, efforts are being made to apply machine learning models based on Electronic Medical Record (EMR) data, establishing a stronger foundation for selecting suitable prosthetic components in clinical decision-making¹.

AIM

To develop and evaluate a machine learning algorithm to determine the appropriate prosthetic components for a lower limb amputee using data on transtibial prosthesis prescription information accumulated in EMR.

METHOD

We used data from 898 lower limb amputees who visited the Veterans Health Service Medical Center from January 2014 to December 2023. The dataset included 10 independent variables, including activity level (k-level), cause of amputation, and length of stump, and two dependent variables, including socket type and prosthetic foot type, reflecting the physical information of the patients recorded in EMR and the prosthetic prescription information finally supplied. To develop the prediction model, we compared algorithms such as CatBoost, Gradient Boost, and Random Forest. Each model was evaluated using Area Under the Curve(AUC), Accuracy, Recall, Sensitivity, Precision, and F1 score based on a confusion matrix².

RESULTS

This study included 898(100%) male. The mean age was 68.8 ± 9.9 years, with the majority of patients aged 60 years and older. Among the prescription information, the socket type included 430(47.9%) Patella Tendon Bearing(PTB) and 468(52.1%) Total Surface Bearing(TSB), and the prosthetic foot type included 276(30.7%) Single Axis Foot(SAF) and 622(69.3%) Energy Storing Foot(ESF).

After evaluating the algorithms, The CatBoost Classifier was selected as the optimal algorithm for predicting prosthetic components. The selected algorithm was developed into the final model through hyperparameter tuning. The performance of the final prediction model was achieved for socket type AUC = 0.922, Precision = 0.919, and prosthetic foot type AUC = 0.858, Precision = 0.945.

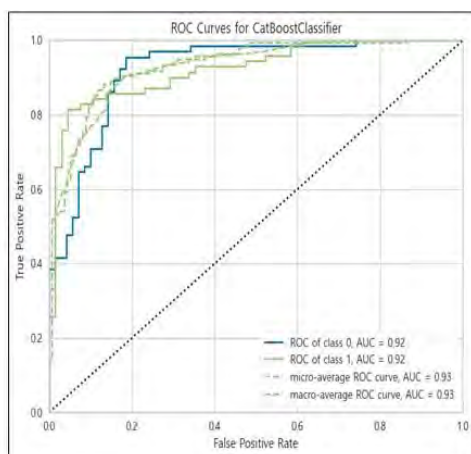


Figure 1. AUC for the socket type prediction model

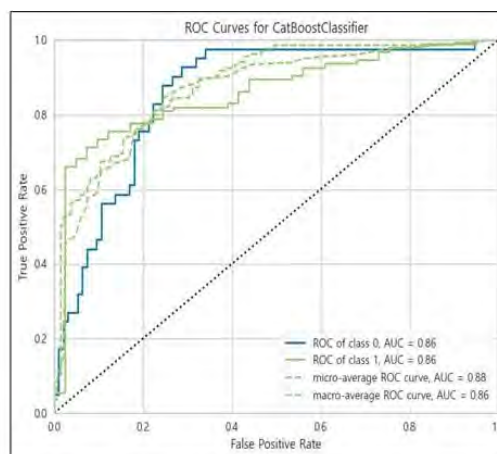


Figure 2. AUC for prosthetic foot type prediction model



DISCUSSION AND CONCLUSION

The prosthetic component prediction model developed in this study is not meant to replace systems like the K-levels of the Medical Functional Classification Level (MFCL). However, if an automated system allows prosthetists to enter accessible patient data into the EMR and instantly predict suitable prosthetic components during consultations, it would support prosthetists in offering the most appropriate lower limb for patients based on objective clinical decision-making.

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ACKNOWLEDGEMENTS

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6.125 Development of a Global Prosthetics Registry: what data should we collect?

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BACKGROUND

Collecting and analysing real-world-data provides a powerful tool for assessing prosthetic rehabilitation outcomes and creating an improved evidence base in an area where randomised trials are difficult. Currently only a handful of countries hold national prosthetic rehabilitation data with limitations including non-representative populations, incomplete data on the patient journey and differences in definitions. A global registry would allow for more direct comparison and improve the evidence base of prosthetic practice.

AIM

To establish consensus among academics, clinicians, service providers and those living with amputation or limb loss, on essential data fields necessary for the standardisation of prosthetic data and outcome reporting.

METHOD

A modified Delphi study will be performed drawing on previous consensus studies and Delphi guidelines for use in Prosthetics and Orthotics to try and maintain participation and ensure a rigorous consensus is achieved¹. Data fields that are included were identified from other registries (SwedeAmp, SPARG, ICRC, LLPR), LEAD Data Dictionary and from studies identified in a systematic review^{2,3}.

Two parallel Delphi studies are proposed: One for clinicians, service providers and academics; One for those living with amputation and service users. The aim is to recruit 15-20 participants for each group which is currently ongoing.

RESULTS

A focus group will be run first to discuss data use and barriers to implementation of standardisation, check question wordings and any missing data fields. An initial round will gather participant information and views on big data research. Two rounds will comprise participants ranking each data field for inclusion on a 9 point Likert scale with a 70% consensus rate threshold. A third round will only be run if required for data fields that haven't met the consensus cut off. Personalised summaries between rounds allow participants to reconsider their scoring.

Final analysis and overall ranking of each data field will be performed. Scoring will be grouped with those achieving consensus within 1-5 to be categorised for non-inclusion. Scores 6-9 will be averaged and ranked in importance for inclusion.

DISCUSSION AND CONCLUSION

A final summary feedback session will present the findings of the consensus and allow for further discussion. The report will lay the groundwork for a standardised dataset for global collection and reporting while allowing viewpoints from a full range of stakeholders to be considered. This promises to improve prosthetic rehabilitation by enhancing data comparability across regions and elevating clinical practice and outcomes for individuals with limb loss, facilitating evidence-based prosthetic care.

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ACKNOWLEDGEMENTS

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6.126 Prosthetists' perspective on surgical intervention, postoperative treatment, and prosthetic assessment following transtibial amputation

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BACKGROUND

The care of individuals undergoing transtibial amputation (TTA) involves a multidisciplinary approach, with numerous healthcare professionals playing pivotal roles in their clinical care and rehabilitation journey. The early stages of rehabilitation are critical to the patient's long-term functional outcomes and quality of life. Among the involved professionals, Prosthetists hold a central, ongoing role in the patient's care and adaptation to life with a prosthesis, whereas surgeons typically engage in limited follow-up care, often within the first 1-2 weeks post-surgery. This imbalance in follow-up care emphasizes the need for Prosthetist input and consideration in treatment decisions made early in the rehabilitation process.

AIM

This paper seeks to offer insights from two Prosthetists on various aspects of TTA care and rehabilitation, focusing on the importance of their perspective. It explores the influence of residual limb length on outcomes, the benefits and drawbacks of different surgical incision techniques, the emergence of new alternatives in postoperative treatment, and their collective impact on early prosthetic fitting within the Swedish healthcare setting.

METHOD

To address this aim, we will discuss each section individually, summarizing relevant evidence and perspectives, from a professional perspective. To achieve these aims, key aspects of TTA care were individually analyzed, with a focus on summarizing relevant evidence from professional practice. This evidence included peer-reviewed studies, data from national patient registries, and firsthand professional experiences.

RESULTS

The authors observe that, with the use of contemporary postoperative treatment strategies and advancements in prosthetic technology, the Sagittal incision (SF) approach may offer advantages over the traditional posterior flap (PF) technique for TTA. Specifically, the SF approach has the potential to expedite the timeframe to prosthetic fitting. While the adoption of novel postoperative treatments is not yet universal and may face limitations in some regions, their increasing accessibility and recognition contribute to a broader evidence base that supports better decision-making in TTA care.

DISCUSSION AND CONCLUSION

From a Prosthetist's perspective, significant opportunities remain to optimize the pathway from amputation to prosthetic fitting and enhance functional outcomes for patients. The paper reflects on traditional methodologies dating back to the 1950s, contrasting these approaches with emerging alternatives to highlight the potential for improved care pathways and more personalized rehabilitation plans for individuals undergoing TTA.

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6.127 Communication between Prosthetic / Orthotic Clinicians and Technicians: Impact on Prosthetic / Orthotic Devices and Positive Relationships in the Workplace

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BACKGROUND

Communication between Prosthetic & Orthotic (P&O) clinicians and technicians plays a vital role in Prosthetics and Orthotics. Both parties have to exchange clinical and technical information which needs to be accurately understood to ensure the unique needs of patients are integrated into the design and fabrication process. As no previously published literature which has investigated the relationship between P&O clinicians and technicians and its impact on quality of P&O devices exists, a qualitative exploratory study is needed to investigate this topic.

AIM

The aim of this qualitative investigation was to understand experiences of communication between clinicians and technicians and impact on P&O device quality. A secondary aim was to explore how communication effects relationships in the P&O workplace.

METHOD

Semi-structured interviews were conducted with UK-registered prosthetists, orthotists, and technicians from four Opcare centers in England. Each interview lasted around 30 minutes and was held via Zoom or face-to-face, depending on participant preference and distance from the researcher. The transcribed interviews were then input into Nvivo software (v20.3.2) for analysis. Data was analysed using Braun and Clarke's (2006) six-phase method for thematic analysis to identify, analyse, and report patterns or themes within the data, providing insights into communication practices and their impact on prosthetic and orthotic work.

RESULTS

Ten respondents, including seven clinicians and three technicians, participated in this study. While participants used various communication methods, verbal communication was generally preferred. The main barrier to effective written communication was long, ambiguous specifications. Offsite manufacturing of P&O devices also posed communication challenges. Six key themes regarding the impact on P&O devices emerged: device quality, patient safety, fabrication assurance, clear specifications, problem-solving, and meeting patient expectations with timely delivery. Nine participants highlighted device quality as a primary benefit of effective communication. Additional themes related to workplace relationships included collaboration and teamwork, workplace environment, job satisfaction, familiarity among colleagues, professional development, trust, and mutual respect. Effective communication was found to be essential for maintaining both high-quality device production and positive interpersonal relationships in the workplace.

DISCUSSION AND CONCLUSION

This qualitative study explored the impact of communication on P&O devices and relationships in the workplace and provided comprehensive and rich data, highlighting the importance of the clinician- technician relationship and its impact on quality of devices. Effective communication is a fundamental element of a positive workplace environment and fostering a positive work environment will contribute to enhanced patient care.

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ACKNOWLEDGEMENTS

We thank all the participants for their time and valuable insights which enriched the research data.



6.128 A Systematic Review of Global CTEV Treatment Challenges and Adjustments during COVID-19 Pandemic

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BACKGROUND

Congenital Talipes Equino Varus (CTEV) is a common congenital condition that can lead to lifelong mobility issues if untreated. Early intervention using the Ponseti method, a low-cost, highly effective treatment, is essential. However, the COVID-19 pandemic disrupted access to CTEV care worldwide, delaying treatments and limiting healthcare availability. This review explores the pandemic's impact on CTEV treatment, and the adaptations developed to ensure continued patient care.

AIM

The study aims to understand the impact of COVID-19 on global CTEV treatment, identifying barriers faced by patients and healthcare providers and evaluating innovative approaches developed during this period.

METHOD

A systematic review was conducted according to PRISMA guidelines, focusing on peer-reviewed articles in English. Database searches on PubMed, MEDLINE, Scopus, and others were carried out, screening articles from 2019 to 2023. Studies were included if they discussed CTEV treatment amid the pandemic, specifically identifying patient and provider challenges. Data were extracted and analyzed to evaluate strategies such as telemedicine, local treatment adaptations, and protective measures implemented to sustain care access during the pandemic.

RESULTS

Out of 23 initial studies, 12 met the inclusion criteria, encompassing data from developed and developing nations. COVID-19 caused delays in CTEV treatment globally, reducing access to surgeries, consultations, and essential procedures like tenotomies, particularly in countries with limited resources. Patients faced challenges such as travel restrictions, lack of public transportation, financial strain, and increased travel distances to reach healthcare facilities, especially in rural areas. Healthcare providers dealt with limited resources, clinic closures, and redirected efforts toward COVID-19 care, impacting the availability and frequency of CTEV treatment. To overcome these barriers, providers implemented telemedicine, "barrier casting" for safe procedures, and clinic-based tenotomies under local anaesthesia, maintaining treatment continuity during the pandemic.

DISCUSSION AND CONCLUSION

The COVID-19 pandemic emphasized the need for robust contingency plans in healthcare, especially for conditions requiring timely interventions like CTEV. The adaptive approaches developed, such as telemedicine and localized procedures, offer valuable insights for future healthcare crises, underscoring the importance of preparedness and flexibility in managing CTEV and similar conditions globally. Future healthcare planning should incorporate such adaptive practices to strengthen care resilience in crisis scenarios.



6.129 Suitability and Feasibility of the Consumer Assessment of Healthcare Providers and Services for Custom AFO Users

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BACKGROUND

Patient experience of care measures are not used widely to evaluate the quality of lower-limb orthotic services, reflecting the lack of consensus on what to measure. This study builds on our efforts to assess patient and clinician perspectives on quality-of-care topics that are important to measure for custom ankle-foot orthosis (AFOs) users [1]; assess orthotists' and physiotherapists' perspectives on quality-of-care topics [2]; and identify instruments that can be used to develop quality measures [3].

AIM

Evaluate the suitability and feasibility of selected questions from the Consumer Assessment of Healthcare Providers and Services (CAHPS) Outpatient and Ambulatory Surgery survey for custom AFO Users.

METHOD

We recruited a convenience sample of adults receiving a new or a major new component of a custom AFO from 2 VAs and a rehabilitation hospital. We selected 13 items from the CAHPS Outpatient and Ambulatory Surgery because it is used widely in outpatient settings in the US. We modified items to reflect personnel in orthotic clinics. Staff recruited participants and administered the CAHPS about one month after device delivery. We calculated top-box scores using established criteria.

RESULTS

The sample of 31 adults had a mean age of 57±14 years. Conditions necessitating an AFO resulted from strokes (35%), traumatic injuries (13%), other neurological conditions (26%), and other conditions (26%). Twenty-eight participants completed the modified CAHPS survey. The questions that obtained the highest percentage of the most favorable (top-box) scores focused on facility cleanliness (96.4%), staff making them feel comfortable (92.6%), staff explaining the visit in a way that was easy to understand (92.6%), and a helpful receptionist (92.0%). Pre-visit information and instructions had the lowest top-box scores, 62.5% and 58.3%, respectively. Top-box percent for facility ratings (9 or 10 on a 10-point scale) was 82.1%, and 74.2% would definitely recommend the facility. Half of the sample described their overall health as poor, and mental health was evenly distributed across the response options of excellent, very good, good, and fair; 82.1% reported they received help completing the survey.

DISCUSSION AND CONCLUSION

Responses to the modified CAHPS revealed the greatest opportunity for improvement in communication, particularly regarding pre-visit information, discharge instructions, and preparation for procedures. Ratings about the facility and staff were highly positive, leaving fewer opportunities for improvement. Most participants required assistance from a helper to complete the items. Some items appear promising for measuring patient experience for patients using custom AFOs.

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ACKNOWLEDGEMENTS

The United States Department of Defense, Orthotics and Prosthetics Outcomes Research Program funded this project (W81XWH-16-1-0788).



6.130 Prosthetic parts selection based on the user's perspective: The need for SDM (Shared-Decision- Making) by amputees and medical professionals related

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BACKGROUND

In Japan, prosthetics and orthotics are provided for medical purposes through various health insurances including Industrial Injury Insurance, while for welfare purposes, the same Industrial Injury Insurance or the Services and Supports for Persons with Disabilities Act are used. Among these, prostheses used for medical and rehabilitation purposes in hospitals are called temporary training prostheses, and it is no exaggeration to say that the amputee's future walking pattern is created during primary gait training with these temporary prostheses.

However, to what extent are the prosthesis user's wishes reflected in the socket, components, and other aspects during the training stage of a prosthesis that will be worn for the rest of their life? Based on the SDM (Shared-Decision-Making) concept, which has been attracting attention in Japan in recent years, we would like to consider the selection of prosthetic parts that incorporate the user's perspective.

AIM

This study aims to build a system for selecting prosthetic parts from the user's perspective using the SDM concept, a process in which user opinions have not been reflected much until now in Japan. There was a literature review regarding SDM performed as well.

METHOD

To create the SDM aid which to be used during SDM process, the study subjects will be a total of about 30 people from active groups in the prosthetic user community.

At the same time, interviews will be conducted with professionals involved in the prescription, manufacture, and fitting of prostheses, as well as rehabilitation (physicians, prosthetists, and physical therapists). Since it is expected that participants will not be able to gather enough participants even if they are publicly recruited, the study content will be explained in advance to facilities and companies that are likely to cooperate, and documents will be distributed to the subjects once consent has been obtained. A total of about 10 people will be included (hereafter referred to as the expert group).

RESULTS

The SDM aid including information about amputation, life-style, physical condition, mobility in the society, was created, insurance, etc. was created with a volume of 20 pages. The next step is that to ask whether the proposed SDM aid is physibile to use in the existing rehabilitation settings by the amputees and professionals related by using the method mentioned previously.



6.131 Prevalence of Limb Loss and Limb Difference in the United States: Implications for Public Policy

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BACKGROUND

The Amputee Coalition's newly commissioned study titled, *Prevalence of Limb Loss and Limb Difference in the United States: Implications for Public Policy*, which was published on February 14, 2024, shows that there are 5.6 million individuals living with limb loss or limb difference in the United States. This presentation will provide an overview of this first-of-its-kind study with discussion on the public policy implications of its results.

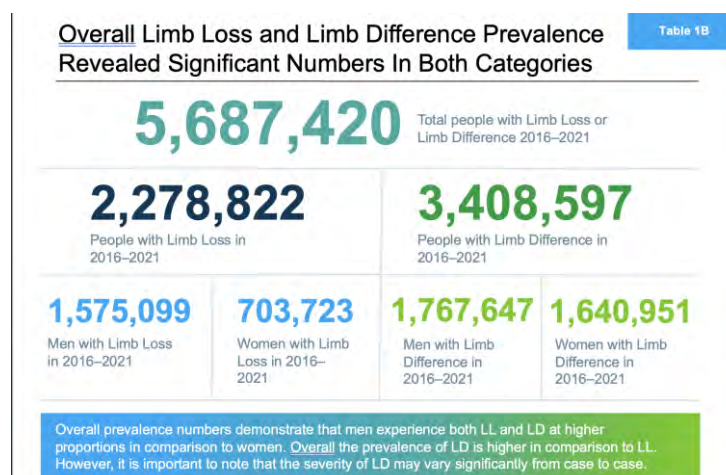
AIM

Information about those born with limb differences or those who undergo amputations is not data that is collectively tracked in a systematic way in the US. With this new information and evidence of increased prevalence we know there is a tremendous need for increased support and education, ensuring those living with limb loss and limb difference can thrive in their lives as they choose. We are now able to ground our work to improve quality of life outcomes and health policies for our community and those at risk of amputation with this prevalence data

METHOD

Avalere Health conducted a retrospective analysis of 2016–2021 Medicare, Medicaid, and commercial insurance claims to identify the incidence and estimate the prevalence of LL and LD.

RESULTS



DISCUSSION AND CONCLUSION

Upon completion, participants will be able to describe the recently published prevalence data for the limb loss and limb difference population.

Upon completion, participants will identify the limitations of the retrospective claims review data, including populations not captured in the data set.

Upon completion, participants will be able to discuss trends in the data specific to immediately preceding diagnoses prior to amputation.

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Posters | Outcome measurements

6.132 A Literature Review of Pain Assessment Tools Following Amputation

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BACKGROUND

Amputation results in various types of pain, including residual limb pain, phantom limb pain, and pain associated with prosthesis use. Effective pain management requires comprehensive assessment using appropriate tools. However, a wide range of pain assessment tools are currently employed, and there is a lack of consensus regarding best practices. This variability can hinder effective treatment and research comparisons.

AIM

This literature-review aims to critically evaluate the validity, reliability, and applicability of commonly used pain assessment tools for individuals with amputations, identifying trends and highlighting the need for standardized approaches.

METHOD

A systematic literature search was conducted across four databases (EMBase, JSTOR, PubMed, Web of Science) in May 2022. Keywords included "pain," "assessment," "tool," "scale," "measure," "amput*," "prosth*," "socket," and "residual limb." Articles were screened using predefined inclusion/exclusion criteria. The quality of included studies was assessed using SIGN and JBI checklists.

RESULTS

Twenty-one studies met the inclusion criteria, identifying 30 different pain assessment tools. These tools were categorized as either unidimensional, including the Numerical Rating Scale (NRS) and Visual Analogue Scale (VAS), or multidimensional, including the Brief Pain Inventory (BPI), McGill Pain Questionnaire (MPQ), Trinity Amputation and Prosthesis Experience Scales (TAPES), and Disabilities of the Arm, Shoulder, and Hand (DASH). Notably, only these six tools were reported in multiple studies. Unidimensional tools focus on pain intensity, while multidimensional tools evaluate additional factors like quality, location, duration, and functional impact.

DISCUSSION AND CONCLUSION

The variety of pain assessment tools used suggests a need for standardization. While generic tools offer simplicity, amputation-specific and limb-specific tools provide more comprehensive assessments, capturing the multifaceted nature of amputation pain. This comprehensive approach is crucial for targeted interventions and improved patient outcomes. Future research should investigate the relationship between phantom limb pain and other post-amputation pain types.



6.133 Data Collection Methods for Measuring Prevalence of Prosthetic Limb Use; A Scoping Review

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BACKGROUND

The number of those living with amputation in the USA is expected to reach 3.6 million by 2050, double the estimated population of amputees from 2008¹. Prosthetic limb prescription and use is key to rehabilitation and social participation, with prosthetic limb use linked to reduced mortality². A range of studies investigate factors affecting prosthetic receipt but understanding how this is captured is required to ensure all populations are accounted for³.

AIM

To review data collection methods used to measure the prevalence of those with amputation or limb loss who use a prosthetic device, to increase understanding of the sample populations captured.

METHOD

A scoping review was performed searching databases Medline, CINAHL and Web of Science using key concepts “data collection”, “prevalence”, “major amputation and limb loss” and “prosthetic devices” for papers published from 2012-2023, focusing on the USA population⁴. 40 studies were identified that investigated limb use for specific populations with 14 studies investigating factors affecting use, and the remainder reporting rate of use as an outcome measure. These were analysed to investigate any differences or biases introduced by the data collection method.

RESULTS

94% of the study participants were from the veteran populations with 96% of the total participants male and the majority white (67% of veterans, 58% of adults and 74% paediatrics). 85% of veteran data, 79% of adult data and 100% for paediatric studies were collected using database or electronic medical records. 87% of upper limb participants used self-reported measures for prosthetic limb use, compared to 10% of those for lower limb studies. All but one veterans’ study covered the whole USA by using a comprehensive database system for data collection and patient identification with the adult population tending to cover more localised or specific populations. Adult and paediatric studies tended to be of a lower quality due to sample size, analysis and depth of statistical analysis.

DISCUSSION AND CONCLUSION

Current studies into the prevalence of prosthetic limb use are performed more on the veteran population with larger participant groups, compared to the general population. Due to the large veteran population, more of the total number study participants were male and white compared to the US general population. The comprehensive database infrastructure appears to allow for improved data collection. This would indicate the need for more inclusive and nationwide methods covering the whole population.

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6.134 Student-led outcome measure collection service for community-based individuals with lower limb amputation

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BACKGROUND

Lifelong management post lower limb amputation (LLA) responds to changes in physical function, balance confidence, functional capabilities and prosthetic use. Outcome measures play an important role in evaluating and monitoring individuals' status. A novel student-led outcome measure collection service was established at Royal Melbourne Hospital to address a service gap in outcome measure collection for independently mobile community-based adults with LLA. To our knowledge there are no previous reports of student-led clinics for amputee cohorts.

AIM

The aim of this study was to describe the measures collected and report any adverse events from the pilot student-led outcome measure collection service during 2023.

METHOD

Prosthetic & Orthotic and Physiotherapy students undertaking clinical placements completed reliability training in administering the Amputee Mobility Predictor, Timed up and go (TUG), 6 Metre Walk Test, 6 Minute Walk Test, Activities-Specific Balance Confidence Scale (ABC), Locomotor Capabilities Index-5 (LCI-5), Socket Comfort Scale and the Trinity Amputation and Prosthesis Experience Scales (revised) (TAPES-R). The measures collected by students were recommended by prosthetists and reflected each client's individual needs. Clients consented to students collecting the measures. Tests completed each session were documented in a non-identifying spreadsheet; age, sex and level of amputation were also recorded. Students documented individual test data in the medical record.

RESULTS

Outcome measures were collected from 41 clients in 2023. The majority of clients had a transtibial amputation (88%), were male (88%) and their mean age was 57.9 years [range 18-88]. Table 1 summarises the 120 outcome measures collected. No adverse events were reported.

Table 1. Outcome measures collected

Level of Amputation	Amputee Mobility Predictor	TUG	6 Metre Walk Test	6 Minute Walk Test	ABC	LCI-5	TAPES-R	Prosthetic Socket Comfort Score
Transtibial (n=36)	12	25	15	1	13	24	0	11
Transfemoral (n=2)	1	2	1	1	2	1	0	1
Bilateral Transtibial (n=1)	0	1	0	1	0	1	0	0
Van Nes Rotationplasty (n=1)	0	1	0	1	1	1	0	0
Symes + Transmetatarsal (n=1)	0	0	0	0	1	1	0	1
Total occasions outcome measure collected	13	29	16	4	17	28	0	13

DISCUSSION AND CONCLUSION

Students safely collected outcome measures with no adverse events. All measures were collected except for TAPES-R, due to time constraints. The student service was successfully integrated into an existing clinic without additional staff. The service allowed clients to have measures collected during existing appointments, saving them time and travel costs. Clinicians can access the data to aid in treatment planning, individualised intervention and funding requests. The program's model was feasible and sustainable leading to the continuation of the service. Future directions will focus on reviewing data collected over time.



6.135 Measuring change in functioning in humanitarian settings: responsiveness of the Activity Independence Measure-Trauma (AIM-T) in patients after injury

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BACKGROUND

“Functioning change” is a core indicator of the WHO Rehabilitation Indicator Menu. Within functioning, independence in activities is often limited after injury. The Activity Independence Measure-Trauma (AIM-T) was developed to address shortcomings of existing measures of independence in humanitarian settings. It has since been used in daily practice and its validity and reliability were supported in such settings^[1]. However, its ability to reflect changes in independence over time has not been assessed yet, limiting its interpretation in research and clinical practice.

AIM

This study aimed to test the AIM-T responsiveness among patients after acute injury in humanitarian settings.

METHOD

This study used data from a longitudinal cohort study performed in four health facilities ran or supported by Médecins Sans Frontières located in Cameroon, Central African Republic, Burundi and Haiti. This study included patients >5y, admitted for acute orthopedic, visceral and/or skin injury. The AIM-T was collected in the inpatient departments (IPD) (i.e.at hospital admission and discharge), and in the outpatient departments (OPD) (i.e.at three and six months after injury). Pre-defined hypotheses regarding differences in change in independence between subgroups of patients during a given time period, as well as hypotheses between time periods within a given subgroup, were tested using the independent t-test and the paired t-test, respectively. Responsiveness was assessed through the confirmation of at least 75% of the eight pre-defined hypotheses.

RESULTS

Overall, 75% the pre-defined hypotheses were confirmed ($p<0.001, d\geq 0.5$). More specifically, a greater change in AIM-T was identified for patients with trunk injury compared to those with only upper or lower limb injuries, as well as for patients with lower limb fractures without external fixation compared to those with external fixation, in both IPD and OPD. Patients with upper limb injury demonstrated a greater change in AIM-T in the first three months after injury compared to after three months. In contrary, for patients with trunk injuries, the change in AIM-T was not significantly larger in IPD than between discharge and three months, as initially hypothesized ($p=0.466$).

DISCUSSION AND CONCLUSION

The AIM-T responsiveness is supported over the first six months after acute orthopedic, visceral, and/or skin injury. The use of the AIM-T to measure change over time with these patients seems relevant, and these findings are encouraging for its potential use in effectiveness studies. However, further testing of responsiveness, as well as the calculation of the minimum important change will ease the interpretation of change in AIM-T scores.

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6.136 Investigation of the reliability of a gait measurement device (StepLab) using inertial sensors in a 6-minute walk test

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BACKGROUND

The 6-minute walk test is also used to assess the walking ability of lower limb amputees and is highly reliable and valid in relation to physical activity and quality of life¹.

Wearable measurement devices using inertial sensors have been developed to evaluate walking function, but their accuracy needs to be verified.

AIM

This study aims to compare StepLab's use of inertial sensors and actual measurements of walking distance in the 6-minutes walk test and to learn the reliability of StepLab's measurement accuracy.

METHOD

The subject sample included 11 healthy males (mean age 21.4 ± 0.9 years, height 171.4 ± 5.0 cm, weight 61.1 ± 7.7 kg). This study was conducted in accordance with the Declaration of Helsinki. The measurements for the 6-minutes walk test were taken in accordance with the protocols given in the guidelines of the American Thoracic Society (ATS)². StepLab (HELTEC Co., Ltd., Japan) use the Movella DOT wearable sensor (60 Hz). Inertial sensor measurements were taken simultaneously with actual measurements using the StepLab sensor attached to the shoe. Statistical analysis was performed using EZR (Easy R, ver 1.68) to obtain the intraclass correlation coefficient (ICC) (2.1) for the reliability between StepLab and the actual measured data. For absolute reliability, the Brand-Altman method was used to check for systematic errors. The statistical significance level was set at 5%.

RESULTS

The average distance for the 6-minutes walk test was 619.8 ± 65.2 m for StepLab and 623.3 ± 70.6 m for the actual measurement, with a median difference of 3.5 m between the two measured distances.

The intraclass correlation coefficient for ICC (2.1) was 0.97 (95% confidence interval: 0.78–0.99), which was judged to be "almost perfect" based on the Landis index. The 95% limits of agreement between StepLab and measured values ranged from -22.69 to 16.09 m, based on the plot using the Brand-Altman method to statistically determine the presence of systematic errors. No addition or proportional errors were observed. The absolute reliability of the measurements was also examined, with a standard error of 18.1m for StepLabs.

DISCUSSION AND CONCLUSION

In the present study, StepLab's measurement values using inertial sensors during the 6-minutes walk test were found to have relative and absolute reliability in the accuracy of walking distance. StepLab is a simple, wearable device that has distinctive analytical functions, such as (1) distance measurement events can be set at will, (2) distance / time factors other than the 6-minutes walking distance, and foot angle measurement are possible.

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6.137 The reliability and validity of clinical ultrasound to assess muscle in post-stroke patients: a systematic review

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BACKGROUND

Stroke is a profoundly debilitating condition, responsible for approximately 113 million disability-adjusted life years and 6.5 million deaths annually ^[1,2]. Skeletal muscle abnormalities, such as dystonia and atrophy, are common post-stroke complications, significantly impacting motor function. While electromyography is typically used to assess muscle activity, understanding muscle architecture is equally vital for effective rehabilitation. Although clinical ultrasound has shown promise in evaluating muscle architecture, yet its reliability and validity in post-stroke patients have not been thoroughly investigated.

AIM

To analyze and synthesize existing data on the reliability and validity of clinical ultrasound for muscle assessment in post-stroke patients.

METHOD

A comprehensive literature search was conducted across PubMed, Medline, Embase, Web of Science, and CNKI from April 10th to 13th, 2024, using the keywords "ultrasound" and "stroke." Studies were included if they involved post-stroke patients, providing valid reliability and/or validity data on muscle assessment via ultrasound, and available in full text in English. Data extraction encompassed study characteristics, muscle parameters, and reliability/validity metrics. Study quality was assessed using the COSMIN checklist. Two assessors independently performed these procedures. Data were analysed and synthesized qualitatively using level of evidence method ^[3].

RESULTS

A total of 10 studies were included, involving 290 post-stroke patients aged 48-80. All studies focused on reliability, with none providing validity data. Of these, 9 studies examined inter-rater reliability, and 6 assessed intra-rater reliability. Two/Three-dimensional ultrasound, DP-MBMW, and P-US system, in conjunction with a linear probe, were utilized. The gastrocnemius and tibialis anterior muscles were the most frequently studied. All studies were of good quality. The ultrasound demonstrated moderate to excellent reliability in evaluating muscle thickness (intra-class correlation coefficient [ICC] = 0.76-0.99) and pennation angle (ICC = 0.77-0.97), supported by strong evidence. It also showed good to excellent reliability in assessing cross-sectional area (ICC = 0.75-0.98), muscle volume (ICC = 0.75-0.95), and muscle length (ICC = 0.76-0.96), although supported by limited evidence.

DISCUSSION AND CONCLUSION

This systematic review highlighted the moderate to excellent reliability of clinical ultrasound in assessing various muscle parameters among post-stroke patients, with strong evidence supporting its use for muscle thickness and pennation angle, while its validity remained further studied. Nevertheless, ultrasound demonstrated its potential in post-stroke rehabilitation.

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6.138 The probability of losing the anatomical knee is influenced by gender, age and underlying diagnosis - national data from Sweden

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BACKGROUND

It is well known that in people undergoing a lower limb amputation the loss of the anatomical knee means severe difficulties to regain prosthetic mobility as compared to lower levels. Moreover, the loss of the knee is more common in amputations due to vascular disease as compared to diabetes and in older age groups. The influence of sex is less clear. The SwedeAmp registry has collected these data since 2011¹.

AIM

To analyze the probability of losing the anatomical knee with regard to age, sex and underlying diagnosis at amputation, based on Swedish national registry data.

METHOD

SwedeAmp collects individual based patient-level data for amputations, prostheses and outcome in a web-based platform. Data registration is voluntary and made by clinicians. In this study data on amputations performed between 2015 and 2020 in the 6 regions contributing a data coverage >80% to SwedeAmp were included. Data was further restricted to a primary amputation or re-amputation on patients ≥50 years, to the highest amputation level per patient and to amputations with underlying cause due to diabetes and vascular disease. In total 1959 amputations were included. A logistic regression model was used.

RESULTS

Data showed that 32.8% (n=642) had lost the anatomical knee and 67.2% (n=1317) had not. Among women (n=705), 43.3% had lost the knee as compared to 26.9% of men (n=1254). Vascular disease accounted for 50.9%, and diabetes for 24.5% of those who lost the knee. The regression model showed a higher probability for a woman to lose an anatomical knee as compared to a man, regardless of underlying diagnosis or age ($\beta=0.539$, $p<0.001$). Furthermore, the probability of losing the knee increased with age for the group with amputation due to diabetes, while the probability remained unchanged with increasing age when the cause of amputation was vascular disease without diabetes.

DISCUSSION AND CONCLUSION

SwedeAmp aims for equal care of patients undergoing amputations and provide yearly reports¹. National registry data might contain missing, which we tried to control for by only including regions in Sweden with high coverage of registrations in SwedeAmp.

In this study we demonstrate un-equal care in Sweden by showing that the probability for a woman to lose the anatomical knee is higher than for a man, regardless of underlying diagnosis or age at amputation. Further research is needed in this topic.

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6.139 The PROsthetic Mobility Performance Test (PROMPT): a new performance-based test for measuring mobility in lower limb prosthesis users

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BACKGROUND

Performance-based tests of prosthetic mobility can help to guide and justify the care provided to people with lower limb amputation. These tests can be used to assess patients' functional capabilities, direct selection of interventions, and measure changes in function over time. Existing tests are often limited by a structure that requires administration of numerous tasks, many of which provide little clinical value. Methods that have been used recently to develop robust self-report surveys¹ can be applied to improve the efficiency of performance tests.

AIM

The goal of this study was to develop and calibrate a performance-based task bank for measuring prosthetic mobility in people with lower limb amputation.

METHOD

A cross-sectional survey was developed based on feedback from rehabilitation clinicians¹ and administered to a national sample of prosthetists³ and physical therapists⁴ to determine the time, space, and equipment available for performance testing. Novel administration and scoring instructions were developed based on review of existing tests and input from content experts. Tasks were pilot tested lower limb prosthesis users to assess feasibility. Candidate tasks that spanned a range of mobility were selected for large-scale testing and administered to prosthesis users across the United States. Results were used to simplify scoring and calibrate the bank.

RESULTS

A total of 374 prosthetists and 524 physical therapists completed surveys. Results indicated that performance tests should be 10-20 minutes in length and utilize available spaces like clinic rooms and hallways. Forty-three tasks were developed and pilot-tested with 28 prosthesis users. Thirty-three tasks were selected for large-scale testing and administered to 364 participants (mean age 52.7±15.8 years, 68% male, 65% transtibial amputation, 49% traumatic etiology, 47% K-level 3). Time was selected as the best performance attribute and 3 cutpoints were identified for each task. A bank of 22 tasks, termed the PROsthetic Mobility Performance Test (PROMPT), was calibrated using item response theory. Both general and targeted task sets were created for patients with low, moderate, and high mobility. Targeted task sets were linked to Prosthetic Limb Users Survey of Mobility (PLUS-M)⁵ T-scores to guide selection (Figure 1).

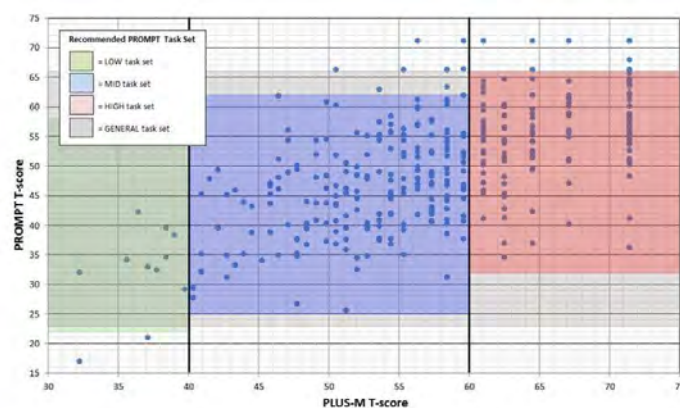


Figure 1. Prosthetic Limb Users Survey of Mobility (PLUS-M) T-scores can be used to select a PROsthetic Mobility Performance Test (PROMPT) task set (e.g., the PROMPT "mid" task set is best for people who score 40-60 on PLUS-M)



DISCUSSION AND CONCLUSION

In this study, we developed a novel performance-based test of prosthetic mobility to address limitations inherent to existing measures. PROMPT was designed to span a broad range of mobility and be administered in the spaces and time available to clinicians. The resulting instrument achieved the stated objectives, but additional psychometric testing is needed to assess its validity, reliability, and efficiency.

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6.140 Comparison of Five-year Survival-data Post Major Lower Extremity Amputation between 2000-2009 and 2010-2019 in a Tertiary Referral Hospital, Ireland

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BACKGROUND

Major lower extremity amputation (LEA) in the context of peripheral vascular disease (PVD) and diabetes is associated with significantly increased mortality rates. Despite advances in care, the impact on survival over consecutive decades within one medical institution has not been examined since 1992¹. Understanding changes in post-surgical survival rates is crucial for guiding patient care and improving outcomes.

AIM

To examine demographic data and survival rates post major LEA in St. Vincent's University Hospital (SVUH) Dublin from 2010-2019 and to compare the findings to those from 2000-2009².

METHOD

A retrospective review of non-traumatic major LEAs in SVUH was conducted for years 2010-2019. Details collected included gender, age, diabetic status, level of amputation, length of stay (LOS), and duration of post-operative survival. Demographic data was collated, and five-year survival rates were calculated and stratified by these factors to identify differences in outcomes.

RESULTS

Initial analysis shows:

Table 1

	1 st decade (2000-2009)	2 nd decade (2010-2019)
No of amputations performed	192	243
Male: Female	2:1	2.9:1
Median age (yrs) at op;	73 (65-82)	70 (18-94)
No of diabetics	76/192(39.5%)	114/243(47%)
Median LOS (days)	28	38
Overall 5-year survival	21%	44.4%
5-year survival for BKA	28%	57.5%
5-year survival for AKA	19%	37.2%

Other 2010-2019 five-year survival analyses showed those <65-years had a rate of 59.6% (53/89) compared to 37.7% (55/154) for those ≥65-years.

For BKA patients it was 57.5% (50/87); higher than 37.2% (58/156) for AKA (n=155) +HQ (n=1) patients. Males had a rate of 44.2% (80/181), similar to 45.2% (28/62) for females.

Diabetics exhibited a rate of 50.1% (58/114) compared to non-diabetics at 38.2% (49/128). A single case with unknown diabetic status survived five years.

DISCUSSION AND CONCLUSION

About 26% more LEAs were performed in SVUH in the second decade. Differences observed were based on age, amputation level, diabetic status and LOS. Those under 65 and BKAs had better survival outcomes. Most notably, there was a better five-year survival for diabetics than for non-diabetics and the overall LEA-cohort five -year survival more than doubled. Results likely reflect advances in overall management and education of patients.

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6.141 Delving into the Importance of Outcome Measures and Remote Monitoring in Lower-Limb Prosthetic Rehabilitation: Insights from an Online Survey

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BACKGROUND

Outcome Measures (OMs) are standardized tools that assess a patient's current condition in clinical settings ^[1]. OMs accurately assess patient mobility and reduce reliance on subjective data. To facilitate standardization, the rehabilitation team can use validated OMs that integrate performance-based metrics, patient self-reports, and remote monitoring.

AIM

Our goal is to explore the significance of OMs and remote monitoring in the lower limb prosthetic rehabilitation. An online survey was designed to gauge OMs usage and gather views on real-world data integration.

METHOD

Data was collected through an online questionnaire written in English and administered via JotForm, accessible from May 18 to September 8, 2023. It was designed for professionals extensively engaged in lower-limb prosthetic clinical care worldwide.

The survey was structured to reveal specific questions based on individual responses. Comprising a total of 12 questions, it featured only multiple-choice questions in which participants could provide context in their answers. The questions were related to demographics, utilization of OMs in a clinical context, as well as the importance of remote monitoring and key metrics to assess functional levels and clinical care.

RESULTS

A participation of 33 respondents, with 70% being CPOs (Certified Prosthetist Orthotist).

The majority (58%) believe it is very important to assess and understand the potential of each patient, regarding their physical abilities and limitations (Figure 2). Over 20% of participants use OMs to track patient progress and adjust treatment plans (Figure 3). Most respondents also spend up to 25% of the appointment gathering OMs (Figure 4).

Of the 23 OMs (Table 3) presented in the survey, the most used (>50%) were self-reported ADLs, TWT, DWT, TUG, Self-reported falls, and AMP (Figure 6). The use of SAM was only reported by 23% of the respondents. However, everyone believed the use of real-world activity data is relevant to assess functional level (Figure 7).

Table 1 – Population demographics (n=33)

Occupation	%	Region	%	Age Group	%
CPO	70	America	42	18-24	3
OT	9	Europe	21	25-34	42
Physician	6	Oceania	18	35-44	33
Physiotherapist	6	Asia	12	45-54	12
Other	9	Africa	6	55-64	6
				>65	3
Years working in clinical practice		Number of lower limb prosthetic patients worked with/treated per year			
	%		%		%
0-1	3	<30			25
1-3	9	31-50			15
3-5	15	51-100			30
5-10	33	>100			30
10-15	9				
15-20	9				
>21	21				

Table 2 – Frequency of Outcome Measures collected in respondent's practice.

How often do you collect outcome measures in your practice?	%
Never	6
Less than once a week	18
About once a week	24
More than once a week	21
In every appointment	30

Table 3 – OMs considered in the survey.

Outcome Measures
Activities Specific Balance Confidence Scale (ABC)
Activities of Daily Living (ADLs)
Amputee Mobility Predictor (AMP)
Berg Balance Scale (BBS)
Distance Walk Test (DWT)
Functional Mobility of the Amputee (FMA)
Houghton Questionnaire
Locomotor Capabilities Index (LCI)
Lower Extremity Functional Scale (LEFS)
Nottingham Health Profile (NHP)
Orthotic and Prosthetic Users Survey (OPUS)
Patient Assessment Validation Evaluation Test (PAVET)
Prosthesis Evaluation Questionnaire (PEQ)
Prosthetic Limb Users Survey of Mobility (PLUS-M)
Prosthetic Profile of the Amputee (PPA)
Rivermead Mobility Index (RMI)
Borg Rating of Perceived Exertion (RPE)
State of Comorbidities
Self-Reported Falls
Step Activity Monitor (SAM)
Trinity Amputation and Prostheses Experience Scales (TAPES)
Timed Up and Go (TUG)
Timed Walk Test



DISCUSSION AND CONCLUSION

The results suggest that several factors affect the assignment of functional levels and are vital to improving patient care, even if they are not all explicitly defined in the functional level descriptors. One example is the use of activity monitoring, which seems to be relevant to all respondents. However, the low use of SAM raises the question of low access to or low relevancy of this type of technology.

From our perspective, this approach could not only empower the rehabilitation team with continuous insights into patients' functional performance

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6.142 The Importance of Contextual Understanding in Daily Activities of Prosthetic Users

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BACKGROUND

Prosthetic rehabilitation relies on patient feedback [1]. Choosing the right prosthesis is complex due to individual needs. Workday and holiday schedules affect activity levels. To assess a patient's potential, monitor their activity, and accomplishments, and consider these differences.

AIM

This study examines how a prosthetic user's daily routine differs between workdays and vacation days.

METHOD

A paralympic athlete, wore an ankle pedometer on their prosthesis for 29 days to monitor their daily activity. During the data collection, they spent 17 days on holiday and worked for the remaining 12 days. The data was subsequently processed and analyzed based on three key metrics:

1. *Daily Steps*: total number of steps/day,
2. *Total Active Time*: Cumulative daily time in motion,
3. *Percentage of time spent in different activity levels*: low (1-30 steps/min), medium (31-80 steps/min), and high (>81 steps/min) [3].

RESULTS

Table 1 shows that workdays have more steps and longer activity than holidays.

Figure 1 and Figure 2 illustrate these findings. Workdays show tighter data clustering around mean values, signifying greater consistency and routine. In contrast, holidays display more variable step counts and activity durations, with a broader data spread and higher standard deviation.

When assessing activity intensity (Figure 3), workdays have longer active time but at lower intensities (87% in a low-medium intensity level). Holidays, with shorter active time, have a higher step cadence, spending around 2.4x more time in high intensity in an average holiday than during days of work (31% vs 12%).

Figure 4 shows that workdays and holidays have different activity patterns. Workdays focus on low-intensity activities, while holidays emphasize high-intensity ones.

Table 1: Descriptive statistic (mean $\pm$ standard deviation) of the metrics evaluated: Daily Steps, Total Active Time, Activity Intensity Levels.

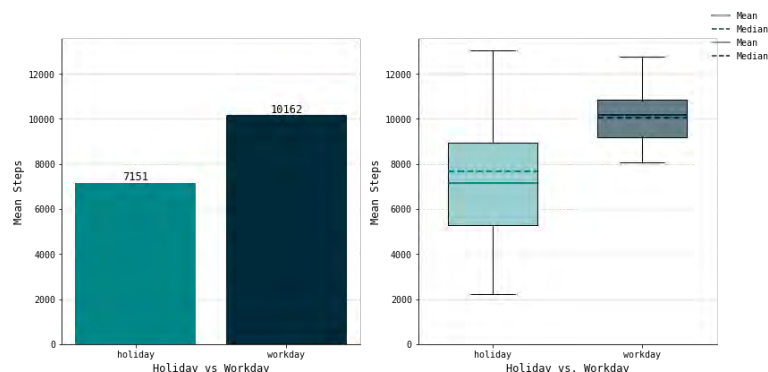


Figure 1: Daily Steps Distribution for workdays and holidays: (a) Mean daily steps; (b) Daily steps data distribution.

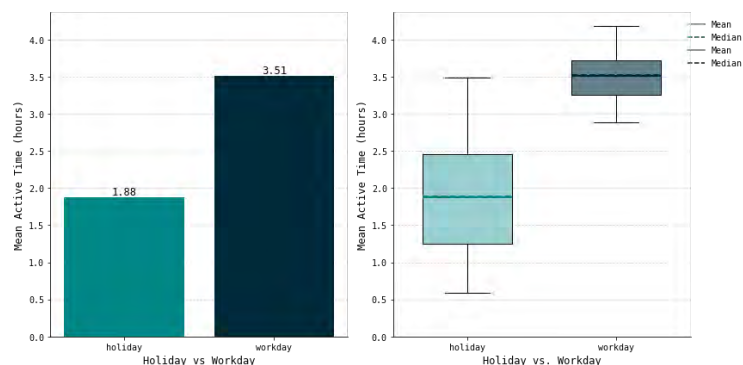


Figure 2: Total Active Time Distribution for workdays and holidays: (a) Mean daily active time; (b) Total active time data

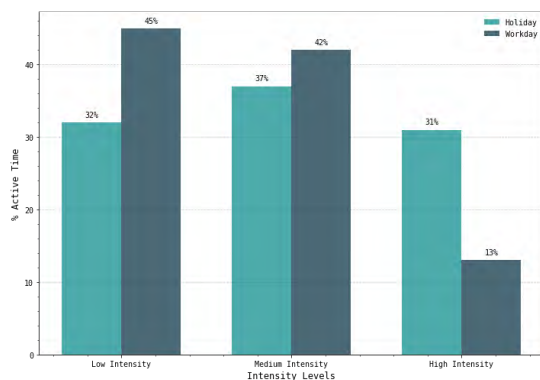


Figure 3: Activity Intensity Levels: Average percentage of time spent in each intensity level, daily.

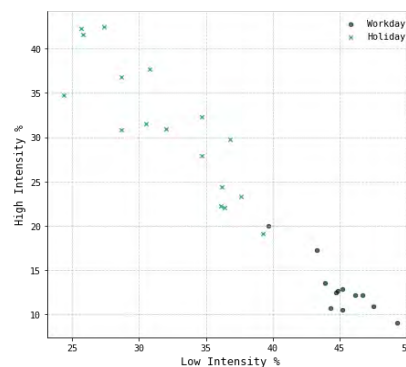


Figure 4: Scatter plot: holiday and workday data distribution between low- and high-intensity activities.

DISCUSSION AND CONCLUSION

Workdays and holidays have different activity patterns. Workdays have higher, more consistent activity levels, while holidays show more variation. Workdays focus on low-intensity activities, while holidays emphasize high-intensity ones. Clinical assessments should consider these differences to avoid misinterpretations.

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6.143 Examination of a 6-minute walk test under different gait measurement conditions

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BACKGROUND

In 2002, the American Thoracic Society (ATS) established comprehensive guidelines on the measurement method used in the 6MWT, which incorporated unclear methods¹. The method recommended by the ATS involves walking a 30-m along flat, straight course to "walk as far as possible". It has been pointed out that the instruction "walk as far as possible" is difficult for subjects to judge.

AIM

The purpose of this study is to compare the differences in the distance and physiological cost index and the Borg Scale in the 6MWT under measurement speed and course method.

METHOD

The subject sample included 19 healthy males (mean age, 21.3 ± 1.0 years; height, 170.6 ± 4.6 cm; weight, 61.6 ± 7.6 kg) with no medical or orthopedic history. This study was conducted in accordance with the Declaration of Helsinki. The three types of verbal walking speed instructions were (1) "normal walking speed," (2) "as far as possible," and (3) "as fast as possible". Three different pathways around the traffic cones at each end of the course were set: (1) lap around a 0.5-m radius, (2) lap around a 1.0-m radius, and (3) lap around a 1.0-m radius and intersecting in a figure 8 at the center of the course. Statistical processing was performed using EZR (Easy R, ver, 1.68) with one-way analysis of variance, Tukey's multiple comparison method, and a Krauskal–Wallis test. The significance level was set at 5%.

RESULTS

The farthest walking distance among the combinations of different walking speeds and walking circuits was the pathway that lapped around a 0.5-m radius of the traffic cone. The average walking distance was 498.2 ± 71.3 m for "walking at normal walking speed," 638.3 ± 77.0 m for "walking as far as possible," and 671.5 ± 58.1 m for "walking as fast as possible". Of the walking speed with the maximum walking distance was "walk as fast as possible". Based on the differences in each condition according to walking speed and circuit, there were significant differences in walking distance between "walking at normal walking speed" and "walking as far as possible" and between "walking at normal walking speed" and "walking as fast as possible".

DISCUSSION AND CONCLUSION

Instructing subjects to "walk as fast as possible" rather than "walk as far as possible" appeared to facilitate better understanding and encouraged them to exert maximum effort while walking. Verbal instructions for the walking speed were found to affect the 6MWT measurement.

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6.144 Literature Review: Significance of Outcome Measures for Transfemoral Amputees in Evaluating the Best Prescription to Improve Quality of Life

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BACKGROUND

Transfemoral amputees often experience gait deviations due to knee joint prescriptions, increasing fall risk and impacting their physical and mental well-being. Effective outcome measures are vital for determining the correct prescription, improving quality of life, and supporting mental health. These measures help prevent complications and risks associated with the use of prosthesis. This literature review examines best practices for prescribing knee joints to above-knee amputees post-amputation.

AIM

This study reviews the impact of outcome measures (6MWT, Patient-Specific Functional Scale, Activities-Specific Confidence Scale, and Timed Up and Go) for transfemoral amputees, based on literature from 1951 to 2023. It explores how these measures guide the prescription of microprocessor knee joints post-amputation.

METHOD

This study based on Evidence-Based Practice (EBP) to explore post-above-knee amputation rehabilitation and prosthetic fitting. Literature was gathered from electronic academic and professional databases, including CINAHL, ProQuest, Cochrane Library, and other full-text internet sources. Key search terms included "above knee amputation," "transfemoral amputee," "prosthesis fitting," "post-operative rehabilitation," "microprocessor knee," "outcome measure," "gait management," and "amputation rehabilitation." Results were studied both individually and in combination. To deepen understanding, additional terms like "microprocessor knees and above knee amputation" and "falls prevention after amputation" were also used. The review covered literature from 1951 to 2023 to ensure a comprehensive analysis.

RESULTS

The results are drawn out from 23 studies assessing outcome measures for transfemoral amputees. All studies found that MPKs are more effective than mechanical knee joints, providing greater safety, stability, and improved quality of life, including mental well-being. However, some studies suggested that mechanical knee joints can be effective during the interim prosthesis fitting phase. Only two studies specifically assessed the use of MPKs immediately after amputation, highlighting their role in enhancing safety and reducing fall risk.

DISCUSSION AND CONCLUSION

The literature evidence reviews examined studies on outcome measures for transfemoral amputees to determine the best prescription for preventing falls, improving quality of life, and supporting mental health. Compression of all the studies, used to provide best prescription to the patients and evaluated the literature to find best evidence practice for above knee amputees after the amputation. Recommendations for the best prescription regarding the use of microprocessor knees vs mechanical knees are drawn from literature review.

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Posters | Psychosocial issues

6.145 Anxiety and Depression in People after Lower Limb Amputation in Slovenia – Preliminary Results

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BACKGROUND

According to the International Classification of Functioning, Disability and Health, lower limb amputation is a change in body structure that affects all areas of a person's functioning ⁽¹⁾. A growing number of authors have found that people who have had a lower limb amputation experience symptoms of anxiety and depression ⁽²⁻⁴⁾.

AIM

The aim of our study was to describe the frequency of anxiety and depression among people after major lower limb amputation in Slovenia.

METHOD

All patients visiting the outpatient clinic for lower limb prosthetics at our institute between March 1, 2024, and June 30, 2024, amputated at least one year before, who filled in the Hospital Anxiety and Depression Scale (HADS) and gave written consent to use their clinical data (including answers to questionnaires for research purposes) were included into the study.

RESULTS

We included 65 patients (52 men), 61 years old on average (from 19 to 89), amputated mainly due to peripheral vascular disease. The majority had trans-tibial amputation, followed by trans-femoral amputation. Their mean Anxiety and Depression scores were low (3.8 and 4.2, respectively). Only five had anxiety and ten depression scores higher than the respective cut-off. We did not find a differences in average anxiety and depression level between people with different cause or level of amputation, nor between men and women.

DISCUSSION AND CONCLUSION

We do not know how many of our patients had anxiety and/or depression before surgery and upon admission for rehabilitation, which is the major limitation of our study. More than one year after amputation, the symptoms of anxiety and depression were not frequent; for anxiety, they were similarly ⁽³⁾ or less frequent than previously reported ⁽⁴⁾. Hence, one year after major LLA, very few people in Slovenia experienced anxiety and depression that requires treatment.

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ACKNOWLEDGEMENTS

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Posters | Paediatrics

6.147 Examination of posture, balance and gait in children with upper limb deficiency – a series of case reports

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BACKGROUND

Children born with limb deficiency face specific physical challenges that can affect their daily living, development. They have weaker individual motor skills compared to their peers (Gettys, 2020; Postema, 2012). Establishing correct movement patterns and posture in the early period can prevent serious health problems (Somhegyi, 2022). There are only few article in the literature regarding the posture, balance abilities and gait patterns of children with upper limb deficiencies.

AIM

The aim of our study is to examine the children's posture, gait and balance ability to determine the characteristics of certain deformities and functional deviations caused by the upper limb involvement.

METHOD

The participants of the study were two girls (3 and 7 years old) and two boys (7 and 11 years old) with below-elbow deficiency, who didn't use prosthesis and they didn't have congenital spinal diseases. The shape of the spine was determined using an ultrasound-based Zebris CMS-10 system and WinSpine software based on the spatial position of the spinous processes in natural upright position. The position of scapula and pelvis was measured with marked anatomical points. The static balancing during standing and walking were tested using Zebris FDM-T system with a built-in ground-reaction force-sensing Cosmos type treadmill.

RESULTS

The shape of the children's spine in all three planes of space showed one or more deviations from the physiological one. Angulus inferior on the affected side was detected closer to the spine (5-23mm) and the shoulder line turned forward in relation to the pelvis on the affected side in all children (0,5-11,5°). Weight loading on the affected side was greater (8-16%) than the intact side with the exception of a boy (7ys). The direction of the body sway was not affected by the deficiency. Measuring step length and time during gait showed no tendentious differences, but the stance phase was shorter on the affected side (0.9-14.2%) than on the intact side with the exception of one boy (11ys).

DISCUSSION AND CONCLUSION

Our results show that limb deficiency affects posture similar to other previous researches and also indicate that it has an effect on the distribution of body weight and on the phases of gait. The sample was small, therefore the measurements should be continued on a larger sample in order to help planning of a targeted musculoskeletal prevention and rehabilitation program.

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6.148 The CELLOS Study: The Development of a Core Outcome Set for Children's Elective Lower Limb Orthopaedic Surgery

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BACKGROUND

In the financial year 2018/2019, over 70,000 children's lower limb orthopaedic surgeries were performed in England. This incorporates surgeries for a range of conditions including cerebral palsy, metabolic bone disease and congenital deformities, all of which can cause long term disability. There are often different surgical options, therefore having access to high-quality research to inform this choice is critical. However, the evidence base for children's elective lower limb orthopaedic surgeries suffers from inconsistent outcome selection, making comparison and meta-analysis of studies challenging.

Improving the consistency of outcome selection can be achieved through the development of a core outcome set, a standardised collection of key outcomes to be measured and reported in all clinical trials.

AIM

This study aims to develop a core outcome set for children's elective lower limb orthopaedic surgery.

METHOD

This project will follow recommended methods for developing a core outcome set from the Core Outcome Measures in Effectiveness Trials (COMET) group.

- *Workpackage 1:* A scoping review will be conducted to identify outcomes measured in recent clinical trials.
- *Workpackage 2:* Qualitative interviews will be conducted to identify further outcomes of importance. Interviews will be conducted with children, parents, allied health professionals and surgeons.
- *Workpackage 3:* An international Delphi survey will be conducted. Participants will be asked to vote on which outcomes (from Workpackages 1 and 2) are most important.
- *Workpackage 4:* Consensus meetings will be held to establish the final core outcome set, and recommend outcome measurement tools for each outcome domain. This will be informed by Workpackage 3.

DISCUSSION AND CONCLUSION

Anticipated Impact:

- The development of a core outcome set for children's elective lower limb orthopaedic surgery will improve the evidence base for this patient group by:
- Ensuring stakeholder involvement in the selection of outcomes and outcome measurement tools. This will ensure trial results are relevant and useful to patients, parents and healthcare professionals.
- Improve the strength of evidence from meta-analysis, as outcomes will be measured more consistently between studies.
- Reduce research and clinical resource waste through an improved evidence base.

ACKNOWLEDGEMENTS

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6.149 Effectiveness of Helmet therapy for infants positional plagiocephaly or brachycephaly: a retrospective study

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BACKGROUND

Through the last few decades, there has been a tremendous increase in the incidence of deformational plagiocephaly in children throughout the world. Therapeutic options include observation, active counter-positioning, external orthotics, and surgery. Proteor's Orthotists have been treating patient using helmet therapy for more than 30years, yet we have never formally investigated the results of this type of orthosis.

AIM

This study aims to investigate the efficiency of helmet therapy within Proteor's clinics in the treatment of deformational plagiocephaly or brachycephaly.

METHOD

We retrospectively and systematically reviewed the case file of 366 patients who were fitted with a helmet between 2011 and 2022. To assess effectiveness of the helmets, we compared Cranial Vault Asymmetry Index (CVAI) for plagiocephaly and Cranial Index (IC) for brachycephaly at the beginning and the end of treatment. Mean initial age and severity, duration of treatment and number of helmets were also investigated.

Infants will be divided into subgroups according to severity and age at initiation to evaluate the impact of these parameters on treatment success.

RESULTS

To date, measurements obtained during care demonstrate improvement of cranial deformities when treated with helmet therapy. The cranial vault asymmetry in plagiocephaly was reduced by $6,6 \pm 4,67\%$ over a period of $5,07 \pm 1,86$ months. The cranial index in brachycephaly decreased by $7,62 \pm 4,72$ over a treatment period of $4,88 \pm 1,70$ months.

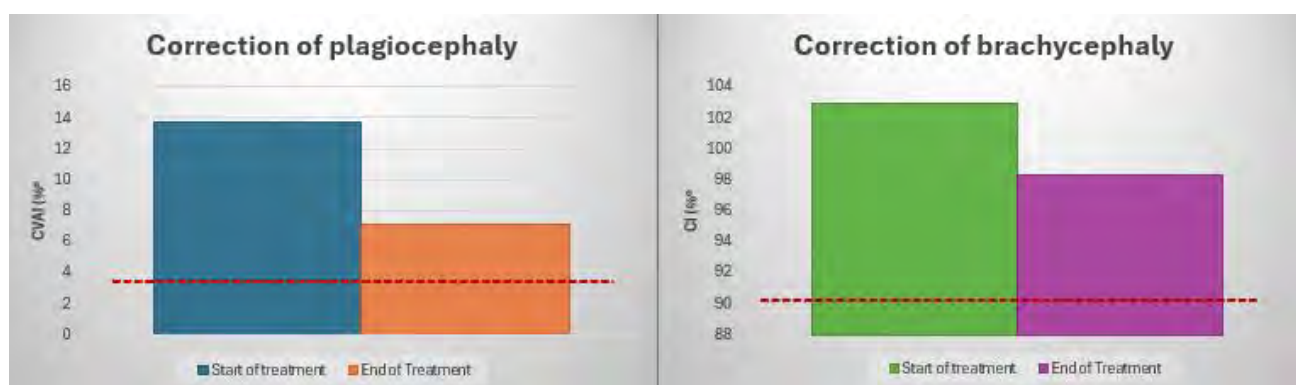


Figure 1. Correction of cranial deformities using helmet therapy

DISCUSSION AND CONCLUSION

Even so helmet therapy is still controversial, national guidelines indicates that it is an effective second intention way of care. With a mean "severe" initial status for both plagiocephaly and brachycephaly decreasing to "moderate" by the end of the therapy, the results observed in this serie confirms that Proteor's helmet therapy bring satisfying results.

COI

All the authors are employees of the R&D department of Proteor.



6.150 Effectiveness of Cranial Orthoses in Recovery of Plagio and Brachycephaly

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BACKGROUND

The number of babies with some sort of cranial pathology as increased, due to gestational or positional reasons (Headlines, 2002), these pathologies can be classified as plagiocephaly, brachycephaly, scaphocephaly, and trigonocephaly (dP, 2005). In such cases it's usual to prescribe cranial orthoses, however the efficiency of these is still widely discussed between physicians who require studies to confirm it.

AIM

Demonstrate the efficiency of cranial orthoses in aiding the recovery of plagio and brachycephaly, a Case Study. The objective is to bring the values of CI and CVAI as close as possible to their recommended values of 85 and 3.5 respectively, with the CI value being used mostly in cases of brachycephaly and the CVAI value in cases of plagiocephaly (Mark A Holowka, 2017).

METHOD

The size of the anteroposterior (AP), mediolateral (ML), diagonals and perimeter of the cranium of 36 babies who use cranial orthoses were registered. These measurements were obtained by using Rhino 7 CAD CAM software after a 3D scan with the EinScan H scanner.

Through these measurements, the values of Cranial Index (CI), Cranial Vault Asymmetry Index (CVAI) and asymmetry were calculated using the following equations:

$$CI = (ML * 100) / AP, \quad CVAI = (Diagonal_{major} - Diagonal_{minor}) / Diagonal_{major} * 100$$

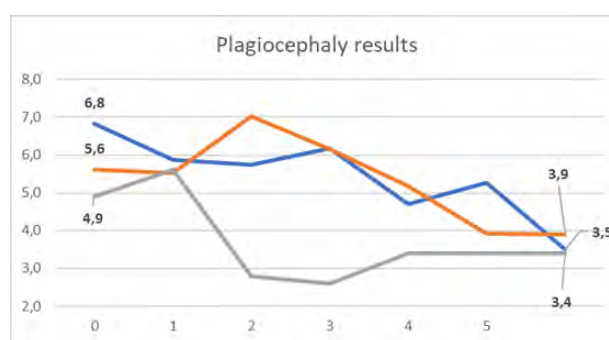
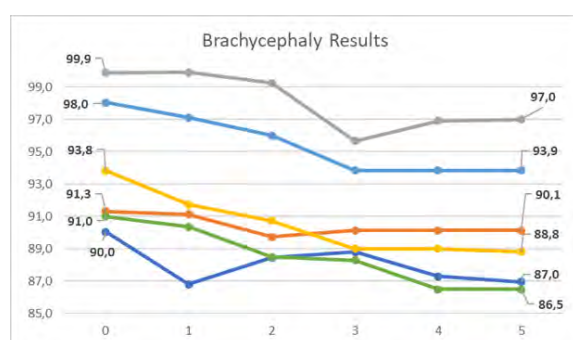
$$Asymmetry = Diagonal_{major} - Diagonal_{minor}$$

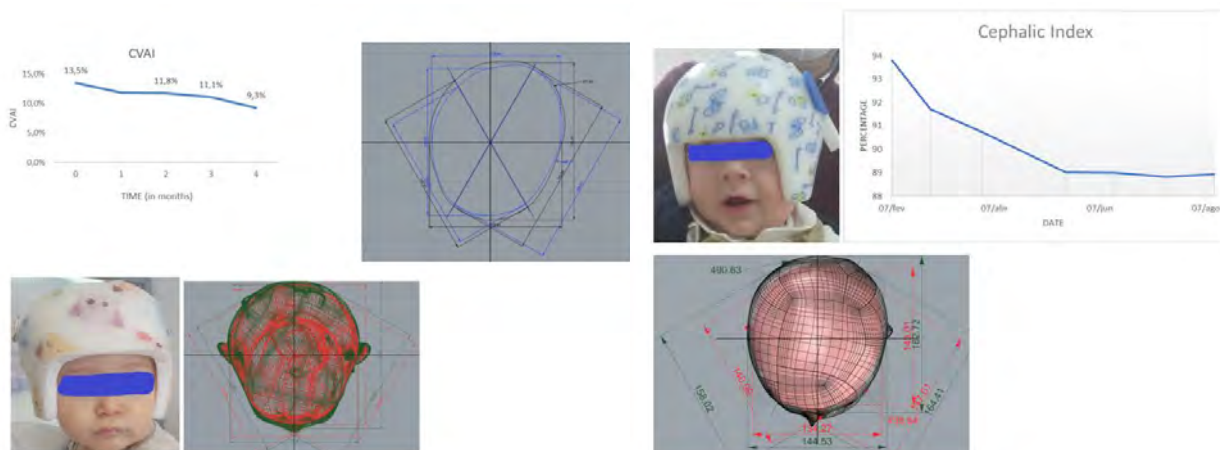
These measurements were gathered over multiple months to better compare the evolution of the patient cranium; for this study there were only considered patients who use the orthoses for at least 5 months.

RESULTS

Of the 36 patients from which the measurements were taken, 16 of them suffered from plagiocephaly and 20 from brachycephaly.

The patients showed an Average improvement of 2,9 % in the Brachycephaly and 2,2 % in Plagiocephaly on its CVAI percentage (main measure of plagiocephaly improvement). These improvements are visible in the charts, graphs, and images below.





DISCUSSION AND CONCLUSION

Through these results we can conclude that there were improvements in all patients' conditions, even though the rate of development being completely different from patient to patient. These differences can be explained by such factors as parents' compliance to the orthosis, individual growth and the CI/CVAI percentage at the beginning.

The differences in results can be explained by factors as: parents' compliance to the orthosis; the individual patient growth; the starting age of helmet use; the CI/CVAI percentage at the beginning (level of severity).

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Posters | Rehabilitation medicine and surgery

6.151 Assessing Functioning and Quality of Life: Questionnaire Findings from Individuals with Brachial Plexus Injury and Amputation

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BACKGROUND

Brachial plexus injury (BPI) can result in a flail limb, a non-functional arm, and/or severe glenohumeral traction pain. These conditions may significantly impair quality of life (QoL) and functioning. Amputation is considered a treatment option for individuals with flail limb or severe traction pain who do not respond to conservative management.

AIM

This study aims to explore the impact of amputation on arm function, pain, and QoL in individuals with BPI.

METHOD

This retrospective study included 12 preoperative and 14 postoperative questionnaires from 20 individuals (Males: Females = 17:3, aged 25-81 years, mean 55 years) with BPI who were eligible for amputation. Of these individuals, 6 have filled in both pre- and postoperative questionnaires. The following validated questionnaires were used: the RAND-36, the Pain Disability Index (PDI), Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, the Body Image Scale (BIS) and the EQ-5D-5L. Pre- and post-operative descriptive statistics were compared to assess trends in outcomes and statistical significance was assessed with use of Mann-Whitney U Test.

RESULTS

The RAND-36 pain domain showed a statistical significant difference post-amputation ($p=0.036$), indicating a reduction in pain. Similarly, the post-amputation DASH scores were also improved ($p=0.023$) as was the post-amputation EQ5D5L VAS score ($p=0.008$). No statistical significant differences were observed in the other questionnaires between pre- and post-amputation groups, though post-amputation results showed a trend of improvements in most questionnaires when compared to pre-amputation results, such as the RAND-36, PDI scores and EQ5D5L scores. The body image scale (BIS) showed a small, non-significant, deterioration of body self-image, with an increase in score from 3.0 (pre-amputation) to 5.5 (post-amputation).

DISCUSSION AND CONCLUSION

Despite limited statistical evidence due to our small sample size, some positive trends favoring amputation were visible. Amputation can have a positive effect on functioning, QoL and general health in select individuals as a final treatment option for flail arm and/or traction pain. Furthermore, minor negative effects on body image were found. Our results can help physicians in informing patients who are contemplating amputation for their BPI.



6.152 Outcomes of Children's Elective Lower Limb Orthopaedic Surgery: A Qualitative Study of Allied Health Professional Perspectives

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BACKGROUND

A common methodological limitation of research that guides surgical procedure selection for children's elective lower limb orthopaedic surgeries is inconsistent outcome selection. Improving outcome consistency can be achieved through the development of a core outcome set (COS).

AIM

The aim of this study is to identify which outcomes are considered important for children's elective lower limb orthopaedic surgeries by allied health professionals (AHPs) and explore why they select these outcomes, to inform a COS development project.

METHOD

Online semi-structured interviews were conducted with relevant AHPs. Participants were selected using maximum variation purposive sampling; selection was based on profession and inpatient/outpatient role. The data set was analysed using an inductive and deductive approach to thematic analysis.

RESULTS

Four physiotherapists, three orthotists, three prosthetists, and two occupational therapists were interviewed. Most identified outcomes of importance related to "activities and participation". From the data, we conceptualised that AHPs with effective multidisciplinary communication focused on child-centred outcomes, while clinicians with limited multidisciplinary teamwork focused on role-based outcomes.

DISCUSSION AND CONCLUSION

Allied health professionals (AHPs) prioritise activity and participation outcomes after children's elective lower limb orthopaedic surgery. It is important to the rehabilitation of children after elective lower limb orthopaedic surgery that all involved AHPs collaborate with the wider multidisciplinary team. Multidisciplinary team communication encourages collaborative outcome identification, and discourages role defined outcome focus.



6.153 Establishment of the Norwegian Amputation Registry – NorAmp-Rehab

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BACKGROUND

There is no existing database describing demographics, function and life-quality of patients undergoing rehabilitation after major lower-limb amputation (MLLA) in Norway. Neither are there existing national guidelines for rehabilitation after MLLA in Norway. This results in geographical differences in rehabilitation programs. Research is needed on this topic, but a lack of a systematic registration of data about MLLA patients makes research difficult.

AIM

We aimed to develop a national registry for patients undergoing specialized rehabilitation for MLLA.

METHOD

A professional council was established in order to decide what data would be relevant in the registry. We reviewed existing literature and registries from other countries. A group consisting of multidisciplinary professionals from all of Norway was used as a reference group. Several meetings were held to arrive at a consensus for choice of included variables. The council arrived at a number of variables to be included (patient characteristics, outcome measures, descriptors of surgical and rehabilitation treatment pathways). Practical support for IT-solutions was provided by local and regional registry-support.

RESULTS

A “long lasting research registry with broad consent” was established, called NorAmp-Rehab. The registry was built in a database (Medinsight) at Sørlandet Hospital HF (SSHF). Data is either directly registered in the database, or collected digitally (Nettskjema). The variables included at each timepoint are shown in Table 1 (below).

Registration started 01.01.2022 in the rehabilitation unit at SSHF. Current inclusion rate is 97%. One year later a process was started to implement the rehabilitation unit in Oslo University Hospital (OUS). In February 2024 OUS started sending data to the database. The technical solutions are functioning satisfactorily. Challenges of implementation in a new center included capacity to complete follow-ups in the pathway, finding dedicated personnel and close cooperation with registry owner. Further new departments will be included, with a goal of national coverage.

Table 1. Variables collected at each timepoint

	baseline	discharge	4 months	1 year	2 years
Demographics					
Age, sex ,comorbidity (CCI), side and level of MLLA, type of amputation, cause	X				
Function and quality of life					
K-level	X	X	X	X	X
Q-TFA		X	X	X	X
TUG (Timed-up-and-Go)		X	X	X	X
PROMS (EQSD and PLUS-M)		X	X	X	X
pain (stump and phantom) (NRS 0-10)		X	X	X	X
Descriptors of surgical and rehabilitation treatment pathways					
Direct transfer from surgery unit to rehab unit (Yes/no)	X				
Days from amputation to prosthesis-fit		X			
Days of stay in rehab unit		X			
Interrupted rehabilitation because of complications (days)		X			
Re-admission in followup period (days)					X

DISCUSSION AND CONCLUSION

The NorAmp-Reg has been successfully established in a local version at Sørlandet Hospital and inclusion of new departments has begun. The model is functioning successfully with a high inclusion rate of potential patients. Successful implementation in new departments requires close cooperation between registry owner and included rehab units.

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6.154 Post-Traumatic Above-Knee Amputation Associated with Brachial Plexus Injury: Case Review

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BACKGROUND

Lower limb amputations resulting from high-energy trauma are often associated with fractures, soft tissue injuries, internal organ damage, head trauma, and peripheral nerve injuries. Later complications may include heterotopic ossification and mental health issues. Although less common, the association of brachial plexus injury (BPI) with lower limb amputation significantly exacerbates disability and difficult prosthetic use.

AIM

To describe the clinical course and rehabilitation process of patients with post-traumatic above-knee amputation (PT-AKA) and concomitant BPI during intensive rehabilitation treatment (IRT).

METHOD

A descriptive study was conducted analyzing the clinical records of two patients diagnosed with PT-AKA and BPI who underwent IRT at the Amputee Rehabilitation Unit at Sant Joan de Déu Hospital (Palma de Mallorca-Spain).

RESULTS

CASE 1: A 63-year-old male sustained a PT-AKA in 1978, along with left BPI. Subsequent physical deconditioning due to recurrent falls, a right scaphoid fracture, and pacemaker surgery hindered prosthetic use. Initial m-Barthel Index score was 69.

IRT improved right upper limb grip strength, lower limb function, trunk control, transfers, and overall autonomy. At discharge, the patient could independently don and doff the prosthesis and ambulate indoors with assistive devices, achieving an m-Barthel score of 80.

The patient uses an endoskeletal prosthesis with a total contact socket, valve suspension system, polycentric knee, and energy-storing foot.

CASE 2: A 55-year-old male suffered polytrauma in a traffic accident, including a left shoulder fracture, complex pelvic fracture, open fractures of the distal left femur and tibia, and complete left BPI, leading to PT-AKA, calcifying polymyositis, and generalized deconditioning. Initial m-Barthel score was 31.

IRT improved upper limb function, transfers, prosthetic donning and doffing, standing balance, gait with assistive devices, and fall management. A suspension harness and an upper limb exoskeleton were used during rehabilitation. At discharge, the m-Barthel score was 90, AMP PRO score was 32, and TUG time was 32 seconds. The prescribed prosthesis was an endoskeletal design with a full contact socket, vacuum valve suspension system, microprocessor-controlled knee, and energy-storing foot.

DISCUSSION AND CONCLUSION

BPI in conjunction with PT-AKA presents significant challenges, impacting rehabilitation and long-term functional outcomes. A comprehensive, multidisciplinary approach tailored to individual needs is essential to maximize functional recovery and quality of life. Further research is necessary to develop more effective treatment protocols to minimize long-term functional sequelae.



6.155 Additional nursing efforts and costs in the rehabilitation of lower limb amputees - transfemoral amputation and transtibial amputation

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BACKGROUND

The retrospective patient-controlled study (PCT) made by the Baumrainklinik, Bad Berleburg analyzes the nursing effort and wound dressing times for patients with transfemoral and transtibial amputations based on medical records from 2007, 2009, and 2011. The study reveals significant additional costs, with 685.17 minutes for nursing care and 176.74 minutes for wound dressing changes per patient, which are not covered by standard reimbursements.

AIM

The PCT study investigates the nursing needs, additional care efforts, and material costs for wound dressing in patients with transfemoral and transtibial amputations during rehabilitation. No comparable, detailed surveys exist at the national or international literature.

METHOD

This retrospective PCT analyzes the medical records of 229 patients with transfemoral and transtibial amputations and documents the time spent on nursing care and wound dressing changes. The study is based on the nursing time guidelines from the Medical Service (MD) and the Social Code (SGB).

RESULTS

The Baumrainklinik rehabilitated 302 patients with lower extremity amputations – 229 with tf- and tt-amputation, with significant nursing and material costs identified. The average age of the patients was 68-70 years, majority being retired. The average length of stay for tf-amputees was about 21 to 26 days, while for tt-amputees, it was approximately 20 to 25 days. The main diagnoses: peripheral arterial disease (PAD), diabetes mellitus (T2DM), often accompanied by other diseases. MRSA infections were present in all years and often led to amputation. For tf-amputees we found additional nursing effort of 786.58 minutes per patient (2007), 932.73 minutes (2009), and 1,299.37 minutes (2011), both wound dressing and nursing time showing continuous increase. Material costs for tf patients also rose from €77.96 (2007) to €108.60 (2011). For tt-amputees, the additional nursing time was 685.33 minutes in 2007, 889.05 minutes in 2009, and 1,465.15 minutes in 2011, with material costs rising from €84.94 (2007) to €118.64 (2011). These findings highlight the nursing needs and additional financial burdens on the rehab clinic, as these costs not covered by reimbursements.

DISCUSSION AND CONCLUSION

This study does not consider the physical and psychological demands on both nursing staff and amputees. Compared to admission and discharge assessments, amputees show a clear improvement in mobility and independence (measured by mobility class and the Barthel Index). In the long term, this reduces nursing needs and alleviates the financial burden on the healthcare system. The current reimbursement framework for amputee rehabilitation is inadequate, and clinical structures must be adapted to meet the specific needs of these patients.

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6.156 Who takes part in prosthetic rehabilitation research?

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BACKGROUND

Accurate reporting of demographic data in research is crucial to demonstrate the characteristics of patients who participated in the studies and thus, how generalisable the findings are to other clinical populations. Anecdotally, participants in lower limb prosthetic rehabilitation studies differ from prosthetic users attending clinical services, and exploring the reporting of demographic characteristics in research will identify any underrepresented groups for future studies, and highlight best practice in research reports.

AIM

This study aims to map the demographic data for reported participants in lower limb prosthetic rehabilitation studies, identifying groups that are underrepresented in current research.

METHOD

A scoping review was conducted following Joanna Briggs Institute guidelines to extract demographic data reported in studies on lower limb prosthetic rehabilitation in adults. Searches across five databases (PubMed, CINAHL, ProQuest, Google Scholar and Google) identified 1651 sources. After eligibility screening, 625 sources were selected for full review. The demographic characteristics of participants in lower limb prosthetic rehabilitation were reviewed and collated.

RESULTS

Preliminary findings indicate that most studies include young, fit and healthy participants. Women are underrepresented except in studies with self-selected participants, such as online surveys, and studies focussed on complications arising secondary to prosthetic rehabilitation, such as osseointegration or falls. Race, despite its known impact on biomechanics, is rarely reported. Psychosocial factors are also underreported, with most studies focussing on physical function. Coping styles and motivation are seldom mentioned, despite being a key factor in rehabilitation. Depression, which is recognised as the most influential modifiable factor on rehabilitation outcomes [1], is rarely reported.

DISCUSSION AND CONCLUSION

Favouring participants with certain characteristics or omitting demographic data limits the generalisability of studies and their applicability to the wider population, resulting in devices suited only for users aligning with the sample's criteria. This approach potentially hinders successful prosthetic rehabilitation for diverse users and fails to address the psychosocial factors, thereby limiting the reach and impact of the research.

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6.157 Evaluation of rehabilitation of sarcoma patients and their supply with assistive devices in Germany

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BACKGROUND

Sarcomas are rare malignant tumors, classified into soft tissue and bone sarcomas. They can develop almost anywhere in the body, often affecting the torso and extremities. Treatment is complex, involving surgery, chemotherapy, and radiation, making rehabilitation challenging. Effective rehabilitation and supply with assistive devices are essential for patient quality of life, yet the rehabilitative needs of sarcoma patients in Germany have not been analyzed.

AIM

We aim to assess the current rehabilitation modalities of sarcoma patients in Germany and their supply with assistive devices to build a better understanding of their long life rehabilitation needs.

METHOD

A web-based online survey assesses different parameters regarding the rehabilitation as well as the supply and use of assistive devices in different sarcoma centers and rehabilitation facilities in Germany over a period of 12 months from February 2024 to February 2025. Participants had to be at least 18 years old and their diagnosis of sarcoma had to be at least 1 year ago. The online survey could be accessed via the website of the German Sarcoma Foundation or QR codes displayed in the participating clinics/rehabilitation facilities.

RESULTS

Data collection is still ongoing. Collected data includes demographic data (e.g. sex, age at diagnosis, type and localization of sarcoma, type of treatment, malignancy grading and tumor size), socioeconomic data (education and type of occupation before and after sarcoma diagnosis), permanent (neurological) impairments due to sarcoma treatment (mobility before and after therapy (K-Level), Patient Specific Functional Scale (PSFS), impairments of upper/lower limb, amputation, prostheses, implants, other impairments). Furthermore, we assess the current and past use of assistive devices and therapies and satisfaction with the assistive devices. Lastly, we collect data regarding the rehabilitation after sarcoma therapy (length of rehabilitation, in- or out-patient, prescription and cost coverage of rehabilitation, psychological support, support by certified prosthetist and orthotist, satisfaction, expectations, rehabilitation goals) as well as the health-related quality of life (WHO-5 Well-Being-Index).

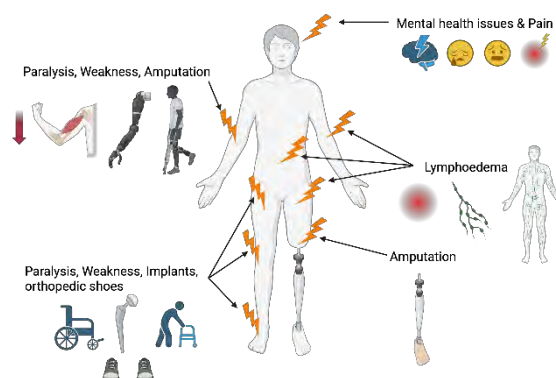


Figure 1: Typical issues and functional limitations of sarcoma survivors.

DISCUSSION AND CONCLUSION

This study aims to address the gaps in multi-professional rehabilitative care for sarcoma patients especially with sensorimotor deficits. By analyzing existing limitations and optimizing care pathways, we seek to develop a needs-based rehabilitation model that enhances social participation, physical function and quality of life. Leveraging current methodologies, technology, and innovative assistive devices, we seek to establish a comprehensive rehabilitation framework that addresses the complex needs of this patient population.



6.158 Patient characteristics, rehabilitation and functional outcome after Major Lower Limb amputation: a retrospective cohort study from southern Norway

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BACKGROUND

There is a lack of standardized national clinical guidelines for treatment and rehabilitation of individuals with major lower limb amputation (MLLA) in Norway. There is a significant gap in the existing body of knowledge regarding the characteristics of this patient population, their clinical management, and real-world functional outcomes within the country

AIM

1. Describe characteristics, functional outcomes and rehabilitation pathways following MLLA in county Agder in Norway;
2. Evaluate predictors of outcomes for function at 1 year for patients with MLLA, and
3. Identify predictors for successful treatment/prosthesis use at one-year post amputation.

METHOD

A retrospective cohort study of register data from a local amputation register which collected data for all MLLA patients admitted for specialized rehabilitation at Sørlandet Hospital between 2012-2022. We analyzed patient characteristics, complications, timing and characteristics of the rehabilitation process, function (TUG, LCI), and health-related life quality (EQ-VAS) at discharge, 3 and 12 months. Predictors for function and life quality were analyzed by multivariable linear regression models

RESULTS

194 admissions to rehabilitation, for 180 individual patients. Average age at amputation was 68 years (± 14.5 SD), 68% were male. The primary causes of amputation were diabetes mellitus (49%) and ischemic disorders (32%). Mean Charlson Comorbidity Index (CCI) of 6.3 ± 2.8 (high pre-amputation comorbidity). 69% of participants experienced complications during rehabilitation. A short summary of outcomes is presented in Table 1. Low CCI was a significant predictor of successful prosthesis use. Among prosthesis users, higher function was associated with lower age, male gender and lower level of amputation.

Rehabilitation, outcome measures ^a	Admissions n-194
Days from amputation until first test prosthesis, Median (IQR)	29 (25-58)
Rehabilitation length, days, Median (IQR)	43 (37-53)
Surgical wound complications	24 (12%)
Re-amputations	42 (22%)
Medical complications	107 (55%)
Prosthesis user at 12 month	95 (49%)
Locomotor capability index at 2 month follow up, Mean $\pm$ (SD) ^b	43 $\pm$ 11
TUG/Timed up and go, sec., Median (IQR)	13 (9-21)
EQ5D5L, Median (IQR)	0,85 (0,7-0,94)
EQ VAS score 0-100 (100 highest score) Mean $\pm$ (SD)	67 $\pm$ 22
^a Categorical data presented as n (%), mean and Standard Deviation for normally distributed data, median and Interquartile Range for skewed data. ^b 0-56, higher level- better function	

DISCUSSION AND CONCLUSION

MLLA patients were characterized by advanced age, high comorbidity burden pre-amputation, high incidence of complications during the rehabilitation, and half became prosthesis users. The findings are consistent with similar studies conducted in Western countries. The study has provided further insights of MLLA patients in Norway

ACKNOWLEDGEMENTS

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6.159 Fatty Degeneration Following Knee Disarticulation – A Case Study

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BACKGROUND

A case study of 3 patients with knee disarticulation, along with incidentally investigations of fatty degeneration of the thigh muscle prior to a secondary amputation, has highlighted several important considerations for both clinical practice and future research in prosthetics. Fatty degeneration is a well-known phenomenon in amputees, yet the specific patterns of this degeneration at different amputation levels in the lower extremity remain underexplored.

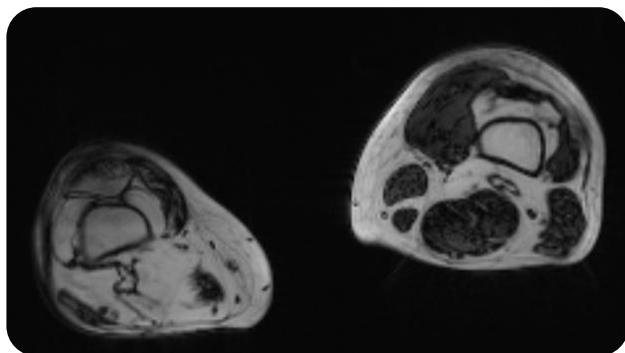
AIM

An internet search identified the Goutallier classification (1989) and its modified version by Yoon et al. (2023) for assessing fatty degeneration, though both are primarily used for the shoulder. The only relevant study, by Kumar (2014), compared intramuscular fat content and cross-sectional area of thigh muscles in knee osteoarthritis, but no specific classification for lower limb fatty degeneration exists.

METHOD

MRI scans performed on these patients revealed advanced stages of fatty degeneration in some individuals, particularly those with extended periods post-amputation (e.g., patients HM and BH – stage 5), while others, like patient JM, showed less pronounced degeneration (stage 1). These findings are consistent with previous research on the degeneration of muscle tissue following amputation but also underscore the need for more systematic studies examining the specific factors contributing to this process, including time post-amputation, the level of amputation, and the underlying causes of the amputation.

RESULTS



The findings in this study suggest that knee disarticulation may lead to extensive fatty degeneration in the thigh muscles, particularly in the knee-joint-adjacent regions.

- Patient HM, with multiple amputations since 1980 - knee disarticulation in 2020, now at age 63, highlighting the significant time elapsed since the initial procedure.
- Patient BH, with lower leg comminuted fracture underwent knee disarticulation in 2010, now at 64 years.
- Finally, patient JM, who underwent knee disarticulation by Ewing sarcoma at the age of 16, now at 56 years.

This raises critical questions about the extent and consequences of fatty degeneration in amputated limbs and whether this phenomenon plays a role in decision-making for secondary amputations, such as thigh amputation.

DISCUSSION AND CONCLUSION

Furthermore, the lack of a standardized classification system for assessing fatty degeneration in amputees points to a significant gap in the literature. Existing systems, such as the Goutallier classification, which was designed for rotator cuff pathology, do not directly apply to the unique context of lower extremity amputation. A classification system tailored to the anatomical changes observed after knee disarticulation could help in better understanding the degeneration of muscle.

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6.160 Effects of a full body neuromodulation garment in subjects with spastic movement disorder and chronic pain

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BACKGROUND

Full-body neuromodulation represents an innovative, non-invasive and non-pharmacological approach to the treatment of spastic motor disorders, spasticity-induced pain as found in diseases with an upper motor neuron lesion such as Infantile Cerebral Paresis (ICP) or Multiple Sclerosis (MS). Early research confirmed the potential of the first version of the treatment, presented in Sweden in 2012 [1]. Recent research also showed effectiveness in the treatment of fibromyalgia [2].

AIM

We provide a comprehensive overview over the state of research in this relevant and most rapidly developing field.

METHOD

We provide a retrospective analysis of data from 72 subjects observed during trial fittings and derive information relevant for study design [3]. We present the results of randomized sham-controlled trials, addressing the effects on spastic motor disorders in subjects with multiple sclerosis and the reduction of symptoms in subjects suffering fibromyalgia [4,5].

RESULTS

Mattar et al. [5] show significant and clinically relevant improvements of full body neuromodulation in subjects with fibromyalgia. Results improve with duration of application (Figure 1).

Hahn et al. [3] show that full body neuromodulation exhibits strongest effects in subjects suffering Multiple Sclerosis. Specifically, an increase in balance, a decrease in risk of falling, an increase in mobility and in health related quality of life can be observed: We report Cohen's d for Berg Balance Scale 1.83***, Timed-Up and Go 0.83***, Functional Gait Assessment 1.28**, 10mWT 0.93*, EQ-5D-5L 1.11**, Pain (VAS) 0.78** where significance levels are indicated by *: $p < 0.05$, **: $p < 0.01$, *** $p < 0.001$, (t): $p < 0.1$. T



Figure 1. Progress of study outcomes (selection) within the active condition.

* = significant ($p < 0.05$) improvement over baseline; green checkmark: above minimal clinically important difference threshold (MCID)

DISCUSSION AND CONCLUSION

Conclusive first data in fibromyalgia are in agreement with most recent data presented by Rubio et al. [6]. Here, the increase of effect size with longer application is also confirmed. First data in MS suggest a significant and relevant effect already after 60 minutes of stimulation which is either maintained or increased after 4 weeks of use [3]. We shall compare these data to those from currently conducted RCTs [4].

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6.161 Changes in Functional and Clinical Outcomes Following Transfemoral Amputation: An Observational Follow-Up Study

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BACKGROUND

During a transfemoral amputation (TFA), surgeons use different surgical techniques to secure the transected muscles in the residual limb. The two main methods are myodesis, where muscles are sutured to the bone, and myoplasty, where muscles are sutured to the antagonistic muscle group. The choice of technique can potentially affect clinical and functional outcomes like limb functionality, wound healing, and femur deviations. However, the literature is inconclusive about the effects of each technique, and there are no evidence-based guidelines for determining which technique to use. Our recent interview study found that this lack of evidence and patient follow-ups greatly influences technique selection [1]. Surgeons often do not follow up on clinical or functional outcomes of their patients, and when they do, they have varying opinions on the outcomes. Also, the literature lacks comprehensive follow-up data on TFA outcomes from the time since amputation, and often does not consider the surgical technique used.

AIM

This study aims to obtain more information about the current surgical techniques used and the functional and clinical outcomes following TFA.

METHOD

A prospective observational cohort study with a follow-up period of 1 year is being conducted. Patients who need to undergo a TFA are approached within 5 days before or after their TFA surgery. Participant inclusion takes place at hospitals in the Northern Netherlands. Individuals are eligible if they are 18 years or older, have undergone a unilateral TFA, and have enough Dutch knowledge to read the information letter and complete the questionnaires. Collected outcomes include participants' functional mobility (AMP(no)PRO), physical activity (Adapted SQUASH), Quality of Life (RAND-36), residual limb pain (PEQ subscale), stump quality (Chakrabarty score), hip flexion and abduction angles (degrees), residual limb length (cm), and hip strength (Nm). Furthermore, information is gathered about participant characteristics, amputation details and the surgical technique used.

RESULTS

Currently, five participants are included in the study and recruitment is ongoing. Targeted inclusion number is 30. Preliminary results in June 2025, focusing on the first two measurement points (baseline and 1-month follow-up), will be presented based on all included participants up and until May 2025.

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We would like to thank the participating hospitals and healthcare facilities for assisting in recruiting patients and facilitating our measurements.



6.162 Incidence, Challenges and Rehabilitation Outcomes for Individuals with Multiple Limb Amputations: A Qualitative Study

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BACKGROUND

Individuals with three or four limb amputations, typically due to severe infections or trauma, face unique rehabilitation challenges as they cannot rely on unaffected limbs to compensate. Data on the incidence and prevalence of these amputations is limited. Clinical observation in Dutch rehabilitation centers suggest a possible increase, posing a growing demand on specialized multidisciplinary rehabilitation approaches that are essential to meet the complex needs of this group.

AIM

This study aims to explore the experience with rehabilitation care of patients with multiple limb amputations in the Netherlands, focusing on independence in daily activities and participation.

METHOD

First, we conducted an exploratory literature search, whereafter we will conduct a qualitative case series. Participants with three or four limb amputations, who began rehabilitation post-2022, will be recruited nationwide. Semi-structured interviews will explore patient experiences and challenges, with data analyzed thematically to identify patterns in rehabilitation outcomes. Interviews with rehabilitation physicians will provide insights into current treatment approaches focusing on independent living.

RESULTS

The literature search yielded knowledge from various case studies. Research shows that it is possible for patients with multiple limb amputations to function almost completely independent with the use of assistive technology and adaptive equipment. However, there is a wide variation in the content of the rehabilitation process and what is considered independent functioning. In our search we did not find any studies with a patient perspective on experiences and challenges of rehabilitation care or the outcome on independence in different domains.

Patient recruitment from multiple centers is ongoing. (Preliminary) Findings will be presented at the conference and will highlight specific rehabilitation needs.

DISCUSSION AND CONCLUSION

The outcome of our literature search shows that there is a lot unknown for this specific group of patients. There is a lack of information regarding standard care for this group. With the results of both the literature search and the outcomes of the qualitative study we can improve our current care for people with multiple limb amputations.

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6.163 Timing of Ankle-Foot-Orthotic Management in Post-Stroke Rehabilitation and its Influence on Gait and Mobility: A Literature Review

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BACKGROUND

Walking impairment affects approximately two-thirds of patients in the acute and subacute phases of stroke recovery, making the restoration of walking ability a primary focus in rehabilitation¹. Ankle-Foot Orthoses (AFOs) are frequently used to address walking impairment gait abnormalities by providing mediolateral stability in stance, facilitating toe clearance in swing, and promoting proper heel strike during ambulation¹. While widely utilized, the literature lacks definitive evidence regarding the ideal timing for AFO provision and its subsequent influence on recovery trajectories.

AIM

This research will examine whether the specific timing of AFO intervention post-stroke impacts gait mechanics, balance, and functional independence.

METHOD

A literature review of articles published within the past ten years was conducted to assess the current knowledge on early versus delayed AFO treatment for individuals who have suffered unilateral ischemic or hemorrhagic stroke leading to hemiparesis. A search was conducted using the following databases: Google Scholar, George Brown Library Learning Commons, and EBSCO Host databases (including Academic Search Complete, CINAHL, and Medline). Based on specific article selection criteria, a total of five (n=5) articles were chosen to examine the timing of AFO intervention post-stroke and its biomechanical impacts on stroke survivors.

RESULTS

Functional outcome measures demonstrated that post-stroke AFO use positively impacted balance and gait, thereby enhancing an individual's capacity to perform activities of daily living. Outcome measures indicating these effects that were included in this study include the 10-meter-walk test, the Berg balance scale, the L-test, the TUG-test, GaitRite data, and a stairs test. These trends indicate that AFO use post-stroke has many benefits concerning gait mechanics, balance, and functional independence.

DISCUSSION AND CONCLUSION

Additionally, positive transient effects were observed when AFO provision occurred early post-stroke. As for this literature review, there are important study limitations such that four of the five articles chosen from the methods were written by the same authors¹. This may cause bias towards the results, indicating that further studies should be conducted to test the inter-rater reliability of their results. Nonetheless, the ultimate timing for AFO provision post-stroke did not influence the results in the long term.

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Posters | Therapy, physical activity, sports

6.164 Controlled randomized open label study to assess the efficacy of UniReliever™ Brace in the management of knee osteoarthritis UNIBRACE STUDY

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BACKGROUND

Knee osteoarthritis (OA) is one of the most common joint disorders. The prevalence of knee OA was 22.9% in individuals aged 40 and over, corresponding to around 654.1 million OA individuals in 2020 worldwide ⁽¹⁾. Guidelines recommend a treatment based on a combined pharmacological and non-pharmacological approach. The use of an offloading knee brace has proven to be a safe, cost-efficient treatment option for reducing pain and improving function ⁽²⁾.

AIM

The study aim was to compare the efficacy of UniReliever (Thuasne), and Unloader One X (Ossür) knee braces in combination with usual care to usual care alone, after a 6-week treatment period.

METHOD

60 patients (age: 69.6 ± 9.6 years, 34 male and 26 female) with symptomatic medial knee OA (Kellgren-Lawrence grade II-IV) were randomized into 3 groups: UniReliever group (semi-rigid knee OA brace), Unloader One X group, and Control group (absence of brace). Patients followed recommendations on analgesic management with lifestyle advice / physical exercise. Primary endpoint was the pain-free walking distance. Pain (VAS), function (Lequesne index), analgesic consumption, compliance and safety were assessed after 6 weeks of treatment.

RESULTS

After 6 weeks, a significant increase in the pain-free walking distance was observed for patients of both bracing groups compared to the brace absence ($p < .0001$). Compared to patients from control group, patients having worn an offloading knee brace for 6 weeks also presented significant decreases in exerting pain ($p < .0001$) and in Lequesne index score ($p < 0.01$ for UniReliever and $p < 0.05$ for Unloader One X). Most patients taking analgesics reduced or stopped medication in both groups of patients wearing a knee brace in contrast to patients from control group. According to the PGIC questionnaire, 80 to 85% of patients from the bracing groups reported an improvement in their condition after 6 weeks. In contrast, the patients from control group reported no change or almost the same condition. There was no statistically significant difference between UniReliever and Unloader One X regarding all clinical outcomes. But compliance to the brace was higher in the UniReliever group (4.36 vs 3.14 hours a day for UniReliever and Unloader One X respectively), and no skin issue was reported with UniReliever in contrast to Unloader One X (2 irritated skin and 2 rubbing)

DISCUSSION AND CONCLUSION

Combining UniReliever knee brace with usual care is a powerful nonpharmacological therapeutic strategy to handle medial knee osteoarthritis. Both offloading knee braces significantly improved pain-free walking distance, algofunctional Lequesne index score, exertional pain and global patient condition.

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6.165 Outcome Measures for Patients with Limb Loss Undergoing Out-Patient Prosthetic Rehabilitation –Consideration of Clinically Meaningful Change

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BACKGROUND

The 'BACPAR Evidence based clinical guidelines for the physiotherapy management of adults with lower limb prostheses' highlights that outcome measures should be used in evaluating prosthetic rehabilitation. Patients attend for specialised out-patient physiotherapy and prosthetic rehabilitation 3 times a week, with a prosthetic service on site. The amputee rehabilitation physiotherapy team aims to complete outcome measures at the start of patients' prosthetic rehabilitation and when they are discharged from physiotherapy.

AIM

The aim of this service evaluation is to review the changes in 2021-2024 patients' outcome measures and establish if they are clinically meaningful based and examine the completion rate.

METHOD

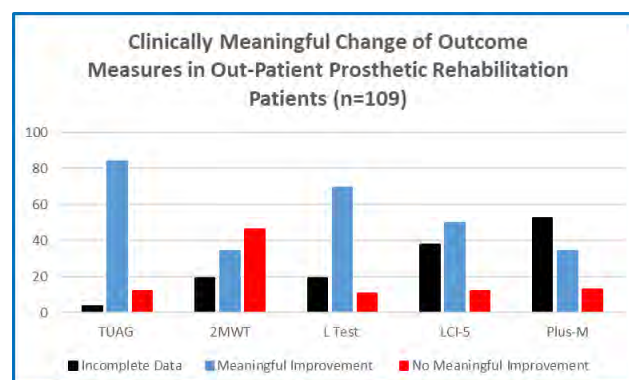
The literature was reviewed highlighting what was the meaningful change for each outcome measure. Outcome measures used are: Timed Up and Go (TUAG), 2 Minute Walk Test (2MWT), L Test and Special Interest Group in Amputee Medicine (SIGAM) mobility scale. Patient self-reported outcome measures used include: Locomotor Capabilities Index-5 (LCI-5) and Prosthetic Limb Users Survey of Mobility (PLUS-M). A database of outcome measures is kept and from our database we were then able to analyse the outcome measure data for patients discharged from rehab from January 2021 to September 2024 to look into trends.

RESULTS

109 patients' results from 2021-2024 were reviewed and are reported as a percentage of all patients. Cause of amputation was 69.5% dysvascularity/diabetes and 20.4% trauma. For our objective measures, the TUAG (84.3) and L Test (69.4%) had a clinically meaningful improvement. With the 2MWT while there was an improvement in time, it was only clinically meaningful in 34.3% of patients. Patient self-reported measures LCI-5 and Plus-M showed positive improvements in scores shown in the graph.

Full completion of outcome measures was best observed for TUAG. Patients with complete measures were: L-Test 80.6%; LCI-5 62% and Plus-M 47.2%.

SIGAM scores were improved in 71.3% of patients and remained static in 10.2%. 23% achieved SIGAM E or F and 31.5% achieved D (ability to walk over 50 metres with or without aids).



DISCUSSION AND CONCLUSION

Work needs to continue improving completion of measures both at initial assessment/discharge and further analyse effect of amputation level/cause. Prosthetic physiotherapy outcome measures were analysed reviewing clinically meaningful change. All outcome measures used apart from 2MWT had a higher percentage of patients with a clinically meaningful change than with no clinically meaningful change, indicating a positive effect from prosthetic rehabilitation. This information helps to create some normative data for the population of this service.

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ACKNOWLEDGEMENTS

Amputee rehabilitation physiotherapy team for ongoing completion/recording of data.



6.166 Walking bike as an effective tool to reduce plantar peak pressure in diabetes mellitus

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BACKGROUND

Foot ulcers and infections are a major and costly problem in Diabetic patients and a major cause for amputations. Plantar peak pressure (PPP) plays an essential role in plantar ulceration. Offloading is a common tool to reduce PPP and the risk of ulceration. A walking bike is a bike without pedals.

AIM

The goal of this study is to find out if reduction of plantar peak pressure can be achieved using a walking bike compared to walking.

METHOD

The study starts with a literature review in pubmed.com. In a blinded prospective protocol 14 healthy subjects, 7 male, 7 female, average age (39.5 ± 11.3 y) are included. In-shoe-pedobragraphy-sensors (Medilogic®) were attached between the skin and the standardized shoes then all subjects walked three times over 10m and then moved over the same distance using a walking bike without removal of the sensor (3 times) in a gait lab (measurements, n=84).

RESULTS

In a single-blinded prospective study the complete data of 14 subjects are included. Plantar peak pressure is highly significant reduced from (49.4 ± 12.9 N/cm²) walking to (35.2 ± 14.6 N/cm²) using a walking bike ($p=0.003$). Average step length increased very highly significant from (0.68 ± 0.13 m to 0.91 ± 0.19 m; $p<0.001$) due to a very high significantly reduced number of steps (7.7 ± 1.4 steps/10m walking to 5.7 ± 1.1 steps/10m walking bike, $p<0.001$).

DISCUSSION AND CONCLUSION

Plantar peak pressure is a risk factor for ulceration in Diabetic patients. In this study a significant reduction of plantar peak pressure can be shown using a walking bike compared to walking ($p=0.003$). Walking bikes could therefore be a tool for offloading for diabetic patients especially if both feet are ulcerated. Limitations are the number of subjects. Following studies to validate these findings in patient care are already planned.

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ACKNOWLEDGEMENTS

We thank Dr. Gunnar Riepe, who was involved in a pre-study.



6.167 The hidden burden of cast treatment in charcot neuro-arthropathy: A call for enhanced patient support and rehabilitation

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BACKGROUND

Charcot neuro-osteoarthropathy (CNA) is a severe condition characterized by non-infectious bone resorption in the foot. The pathophysiology of CNA remains unclear, with both neurovascular and neurotraumatic theories being supported ⁽¹⁾. Clinical guidelines recommend prolonged offloading through a non-removable total contact cast (TCC) to prevent further damage. However, this treatment can severely affect patients' quality of life, self-sufficiency, and social participation, an impact frequently reported but possibly insufficiently addressed in treatment planning ⁽²⁾.

AIM

This study aims to explore the experiences of patients with CNA during cast treatment and improve quality of care to enhance quality of life and participation.

METHOD

A structured qualitative evaluation was conducted through a focus group, gathering experiences from five participants who had undergone cast treatment within the past two years. The discussion was moderated by a trained facilitator, with healthcare providers attending as listeners without active participation.

RESULTS

Participants expressed concerns about the acute, severe and impactful diagnosis, poor communication, and the sudden initiation of cast treatment. Patients found the provided information overwhelming, highlighting a need for improved, ongoing communication, a consistent point of contact, and accessible informational brochures outlining the treatment process and expected duration.

Rehabilitation was also emphasized as essential for maintaining mobility and participation throughout the long immobilization period. Specific advice about compensatory mobility aids and adjustments at home, training to walk with crutches and mental support are important to enhance quality of life and participation during this impactful long-lasting immobilisation. Once the CNA had resolved, post-treatment with orthopaedic footwear was found to be beneficial and comfortable.

DISCUSSION AND CONCLUSION

The findings underscore the need for enhanced communication and information provision during CNA treatment. Integrating rehabilitation at the beginning of the treatment could mitigate the impact on the patient's mobility and quality of life. Additionally, an improvement plan will be developed to ensure continuity and clarity in care, with a key role designated for the rehabilitation specialist.

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6.168 What are the experiences and perceptions of social support for patients who are undergoing prosthetic rehabilitation following traumatic amputation?

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BACKGROUND

Following amputation, recognising and understanding a patient's level of social support is integral to providing effective rehabilitation. It contributes to the overall well-being of the individual and enhances the likelihood of successful outcomes in terms of both physical recovery and emotional resilience. This is reflected in a study by Anderson et al (2017) who found that people with limb difference who presented with reduced activities of daily living function and reduced levels of social support had higher prevalence of depressive symptoms. This suggests that patients with reduced functional status may value social support more than those with greater levels of independence

There is currently little evidence to guide our practice in engaging families in rehabilitation of people who have experienced a traumatic lower limb amputation. Whilst there is literature that advises that family social support is beneficial, little is known of the experience of this from both the individual and the families providing social support.

AIM

- To understand patient's views and experiences of social support they received during the rehabilitation process.
- To understand family members' views and experiences of the social support they provided during the rehabilitation process.
- To explore views of what support or advice may have been helpful to both groups in retrospect.

METHOD

Research Design: This will be an empirical, qualitative study using a semi-structured interview approach for both patients and a chosen member within their support network. The interviews will be conducted online using Microsoft Teams. This design has been chosen as the aim of the study is to understand lived experiences through gaining insight into their experiences and views of both positive and negative aspects of the social support they received and reflect on what they feel may have been helpful.

Sampling and Participants: A convenience sampling method will be used.

The target sample size for this project is 6-8 patients and 4-6 family members which should be enough to provide adequate data and themes to answer the research questions whilst also being a realistic number to recruit within the time constraints.

Data Collection: Semi-structured interviews will serve as a rigorous approach for gathering primary data, specifically addressing inquiries regarding participant experiences. This semi-structured format guarantees a degree of organization in discussions, facilitating responses to research questions whilst also remaining receptive to participants' perspectives.

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6.169 Evidence Based Treatment Recommendation for Physical Medicine and Rehabilitation Interventions in the Management of Phantom Limb Pain

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BACKGROUND

The use of non-invasive and non-pharmacological treatments in the field of physical medicine and rehabilitation for phantom limb pain (PLP) is an essential part of pain management. Their primary position in the therapeutic setting results from their high level of acceptance, low side effects and the ability to implement self-effective active pain relief strategies. Evidence is limited in terms of pain reduction compared with a control treatment.

AIM

To evaluate the therapeutic non-invasive and non-drug treatment options in the field of physical medicine and rehabilitation and to provide an evidence-based treatment recommendation.

METHOD

The treatment recommendation is based on a systematic literature review according to the PICO scheme in the databases 'pub Med' and 'PEDro', which determines the level of evidence (1-3) of the treatment options in a multi-stage process. After reviewing the guidelines, systematic reviews were assessed. Randomized controlled trials were then identified. Search terms were determined by clinical experience in a peer group process using an expert consensus Delphi study¹. After checking for relevance, timeliness and duplication, the review was conducted by two experienced clinicians to produce a treatment recommendation.

RESULTS

Mirror therapy can be recommended as a proven pain-relieving therapy, either alone or as part of a combination therapy. Virtual/augmented reality techniques and graded motor imagery can be used in patients with complex injuries, reduced imagery abilities and multiple amputations. Compared with control interventions, mental exercises are sufficient to alleviate PLP. Sensory discrimination training, intensive use of a prosthesis and biofeedback training can help to reduce PLP. Relaxation techniques provide analgesic benefits in a multimodal treatment approach. There is a lack of randomized controlled trials on action observation, massage techniques, residual limb bandaging, intermanual transfer and TENS to be able to make a recommendation.

DISCUSSION AND CONCLUSION

In summary, there is a need for methodologically high-quality RCTs. Barriers such as a lack of suitable control interventions, insufficiently comparable study participants and the wide methodological diversity of innovative approaches lead to this deficit. The controlled testing of physiotherapy and occupational therapy for the reduction of PLP with the aim of increasing function and participation is ethically difficult in a control group design, which is why innovative methods are crucial.

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6.170 An Amputee's Perspective: Achievement of life goals with innovative assistive devices

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BACKGROUND

This Free Paper will focus on the achievement an amputee's life goals with the aid of prosthetic devices. The journey from the beginning to the desired destination encompasses an array of obstacles and opportunities. Science in practice acknowledges that science is multifaceted, which reflects the multidisciplinary health care model. With the end users input and consent, within a collaborative approach, innovative solutions present which creates a new dimension of performance. Whether it be within the rehabilitation setting or the pursuit of life goals.

AIM

The objective of these case studies is to explore the importance of the amputee's leadership and collaboration with the multidisciplinary team to achieve the desired outcome with innovative assistive devices.

METHOD

The activities in these case studies were all initiated by the individual amputees. The applied methodology followed the treatment pathway of clinical assessment by the team, evaluation, application of technology and ongoing review. Pivotal to the ongoing review was the input from the amputee and their belief that the desired outcome was to be achieved.

RESULTS

Case Study 1: Trans-femoral, Trans-tibial and Trans-humeral TRAUMA amputee trekking Mt Fuji. This ambitious goal of trekking to the summit of Mt Fuji, was initiated by the individual. Follow the path of the individual and the multidiscipline team to achieve this goal

Case Study 2: Bi-lateral Congenital partial digits and partial foot amputee, and a Right Trans-tibial amputee from Chronic infection. Embracing life, studying Allied Health, and now running, snowboarding and participating in life. Individual motivation combined with innovative solutions has enabled the pursuit of life goals.

Case Study 3: Unilateral Trans-radial Congenital amputee achieving sporting excellence in both Para and Able body sports. The lack of Myoelectric protocol delayed the fitting; however, life events motivated the change.

DISCUSSION AND CONCLUSION

The life goals achieved as described in these case studies were all initiated by the individual amputees. Working in collaboration with health team members applying their knowledge and skills, innovative assistive devices were fitted. A treatment pathway was defined allowing timely planning and review.



6.171 RehAmp^{TT}: Development of an open-source teaching tool for rehabilitation after amputation in Ukraine

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BACKGROUND

The war against Ukraine has dramatically increased the number of amputees. There is a lack of trained specialists, prostheses, aids and instructions for self-help and training for amputees and their relatives. The Federal Ministry of Health has funded the creation of a digital learning module to provide this knowledge.

AIM

Aim was to increase rehabilitation for amputees during the ongoing war in Ukraine by developing an intuitive teaching module on post-amputation rehabilitation for professionals, amputees and their families in Ukraine.

METHOD

An interdisciplinary team of medical specialists, scientists, physiotherapists, occupational therapists, orthopedic technicians, medical informatics specialists and an interpreter, developed the holistic teaching and learning module for amputation rehabilitation.

RESULTS

The bilingual teaching was created in Ukraine and German language. The e-learning module teaches about rehabilitation after arm and/or leg amputation (RehAmp^{TT}) and is available free of charge at <https://digitale-lehre-mhh.de>. It includes content on activities of daily living, training of strength and mobility, body management, assistive devices, prostheses, pain, swelling, wound as well as residual limb management. For some topics, there are further sub-pages. The specific content usually consists of a pathway, short texts, images and videos on treatment, self-exercises and practical tips. Color and easy-to-understand icons distinguish the different rehabilitation phases and topics. It is easy to use, clear and intuitive to convey information on different end devices.

DISCUSSION AND CONCLUSION

The huge amount of knowledge, the prioritization of topics and the digital processing of the material were barriers. A team of experts provided support in terms of content, didactics and management to ensure that all topics were given adequate space. In about 9 months, an effective bilingual and free learning tool for the rehabilitation of amputees was created with a lot of commitment and intensive, enthusiastic teamwork.



6.172 Layered Telerehabilitation Frame for Patients with Wearable Sensors

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BACKGROUND

There are some studies referring that practices achieved at home via telerehabilitation system have no apparent disadvantage over face-to-face physical therapy [1,2]. In practice, health specialists will be able to observe patients practising wide variety of rehabilitation exercises over dedicated website. Monitoring of the patient only by visual observation is challenging [3], thus the telerehabilitation system should cover measurements through wearable sensors for more information that can be used for consistent analysis and personalized treatment [4].

AIM

The aim is to design multilayered telerehabilitation system transferring all the movement details and muscle activations obtained from wearable sensors during exercises. The system should use a central server and associated network that is accessible by patients and therapists in order to connect and assist.

METHOD

In the device end, a wireless transmission was preferred for user convenience and suitability for physical therapy. Muscle activity, force and position information are collected by “STM32” and transferred to the card “ESP32” via UART communication channel. ESP32, from the local network, establishes connection with the server via IP, then transfers the block information embedded in JASON (JavaScript Object Notation) format packages into the database. The data transmitted using Wi-Fi can be monitored instantly via the dedicated interface and is used to guide patients for exercises during the treatment process.

RESULTS

This study is part of a (telerehabilitation) project covering remote monitoring, care, and treatment, as the layers are given in Figure 1. The project includes designing layered telerehabilitation system utilizing the information gathered from wearable devices such as Duchenne Muscular Dystrophy (DMD), Multiple Sclerosis (MS) and posture disorder patients and creating an infrastructure for home rehabilitation practices under expert supervision through servers within the network. Online and recorded data can be accessed by patients and therapists via the web-based interface communicating with the server. The rehabilitation process is improved by measuring and reporting the similarity of the collected data to movement patterns defined by physiotherapists for patients' conditions.

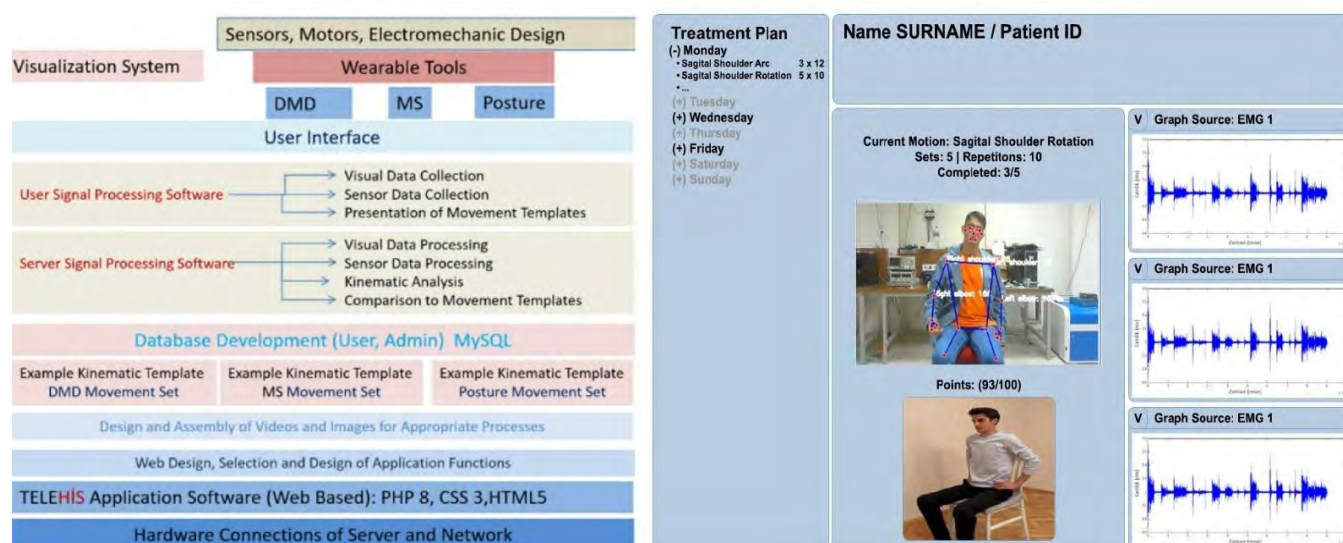


Fig. 1 Telerehabilitation Layers and Web-based Interface



DISCUSSION AND CONCLUSION

In this paper, the important infrastructure units of a telerehabilitation system organized for home care and treatment purposes in the daily lives of physical therapy patients were examined. Information from wearable sensors is collected, processed and transferred to the server where it can be accessed via a web-based interface. Evaluation, presentation and patient guidance of data are carried out through an internet-based interface called Tele-Motion Inspection System (TELEHiS).

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6.173 Experiences with Introducing Aquatic Therapy for Lower Limb Amputees

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BACKGROUND

People with amputations are not participating in physical activity conducive to health benefits (1). An amputation and use of a prosthesis makes it difficult to meet such guidelines. Swimming and aquatic therapy provide low impact work out and can be accomplished both with and without a prosthesis. Our experience is that many amputees avoid aquatic therapy due to barriers such as insecurities of physical abilities and reluctance to appear undressed.

AIM

The aim was to increase the patient's confidence in their abilities and the likelihood of visiting a community pool after the intervention and to gain experience in introducing aquatic therapy.

METHOD

From 2019-2024 we offered people with lower limb amputation aquatic therapy 4 times 60 minutes.

The sessions were led by physiotherapists with long experience in amputee rehabilitation.

The sessions included getting dressed/shower/getting in and out of the pool, floating, swimming with or without a prosthesis and doing exercises in the pool for strength, balance and endurance.

Inclusion criteria: not having been in a pool after the amputation.

Exclusion criteria: wounds, incontinence and unable to understand instructions. The first 15 patients were included in a pilot project and answered questionnaires before and after the intervention. These experiences guided the further intervention.

RESULTS

50 patients, 34 men 16 women, age 12-79, (mean 54), participated. Reasons for amputation were diabetes (7), atherosclerosis without diabetes (6), trauma (17), sarcoma (6), other (14). Amputation levels were transtibial (24), knee disarticulation (6), transfemoral (13), bilateral (5) and hemipelvectomy (2).

The pilot project resulted in a significantly increased confidence ($p < 0,001$) in patients' abilities to get in and out of a pool, and their likelihood to go to a pool in the community. Experiences gained are for example; a hygiene prosthesis is beneficial for showering and getting in/out of the pool but most patients did not prefer it for swimming. To float is a good exercise for experiencing security and the criteria for being able to swim in Sweden is a good base when conducting the sessions.

DISCUSSION AND CONCLUSION

Offering pool therapy is a valuable input in the rehabilitation after a lower limb amputation.

Our experiences are concluded in a checklist with evaluation measures to ensure that relevant parts are included and identify potential progress with the intervention. We have also conducted a training protocol and a document with advice when introducing aquatic therapy to share with other physiotherapists interested in introducing aquatic therapy for lower limb amputees.

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6.174 Intensive Visual Stimulation for Treatment of Chronic Phantom Limb Pain. A Randomized Controlled Trial

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BACKGROUND

Phantom limb pain (PLP) is the feeling of pain in a body part that no longer exist. In mirror-therapy (MT) a mirror creates an illusion (visual feedback) of an "intact" body-part in place of the missing limb, tricking the brain into thinking movement may occur without pain. Research show that MT may reduce PLP. However, persons with bilateral amputation cannot use MT, and with other limitations, widespread implementation is reduced.

AIM

The current project will implement a novel and digital version of visual feedback therapy, i.e. Intensive Visual Stimulation Therapy (IVS-Therapy) in persons with PLP and uni-or bilateral lower limb amputation.

METHOD

For treatment of PLP, The IVS4 system from Dessintey, France, will be used. Patients will be randomized to either IVS-T or Usual Care (UC). IVS-Therapy participants will receive two sessions week⁻¹ for 8 weeks based on patient's individual pain history. One IVS-Therapy session lasts about 20 minutes. The UC group receive only standard care for 8 weeks. PLP will be monitored by a pain-diary for 14 days prior to start of IVS-T or UC, during the first 14 days post IVS-Therapy/UC intervention and after a two-month follow-up period. During IVS-Therapy sessions, pain will be monitored pre- and post each session.

RESULTS

Pilot studies show promising results of IVS-Therapy for treatment of PLP, but to date no large-scale RCT using IVS-Therapy has been conducted. The present RCT will provide much needed evidence for the effectiveness of IVS-Therapy in the treatment of PLP. The study is ongoing and per November 2024, 10 persons are enrolled in the study. Some early patient experiences following one session of IVS-T therapy are exemplified below:

Patient 1: "Coming into the treatment I felt like having a stone in my shoe, but now the stone is gone"

Patient 2: "It normally feels like I am wearing a wet sock, but I don't feel this now"

DISCUSSION AND CONCLUSION

If effective, IVS-Therapy may be a valuable, non-invasive alternative to e.g. pharmacological treatment of PLP. Conclusion: IVT-Therapy sessions are rapid compared to other methods and has a patient-centric approach to PLP treatment.



6.175 A Clinical Method for Adjusting AFOs in the Clinical Setting to Reduce Pathologic Gait Abnormalities with Supporting Evidence

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BACKGROUND

Ankle-foot orthoses (AFOs) are often prescribed to improve function for patients with gait abnormalities. Biomechanics research demonstrates that AFOs can reduce tripping and improve gait efficiency by improving ankle and knee kinetics and kinematics. Clinicians have traditionally fit and adjusted hinged AFOs to treat gait deficits using intuitive approaches without an evidence-based methodology.

AIM

The aim of this study was to propose a clinical method for the adjustment of multi-function articulated AFOs in the clinical setting. A secondary aim was to outline the evidence supporting this method.

METHOD

Literature review and mechanical testing were used to determine the biomechanical influence of isolated features of multi-function AFOs. The AFO features that systematically influenced pathologic gait deviations were identified and associated with specific observable gait events to create a method.

RESULTS

This study revealed that multi-function articulated AFOs demonstrate complex, sigmoid-shaped mechanical characteristics including resistance threshold and independent adjustment of ankle alignment. Specific mechanical characteristics of multi-function AFOs demonstrated isolated influence over gait deviations. Literature review also suggested that observational gait analysis (OGA) was prone to errors but can be enhanced through repeated observation of specific gait events using slow-motion video.

DISCUSSION AND CONCLUSION

Evidence from peer-reviewed research demonstrates that multi-function AFOs systematically influence pathologic gait through all phases of the gait cycle. Furthermore, that influence can be associated with specific, independently adjustable features of multi-function AFOs. By defining a set of explicit gait deviations and associating those with multi-function adjustments it was possible to create an adjustment method. Observational gait analysis (OGA) was used for adjustment. However, observational gait analysis can be prone to errors. Through repeated observation of specific gait events using slow motion video, it is possible to enhance the reliability of OGA to provide a clinical assessment for the adjustment and optimization of articulated, multi-function AFOs in the clinical setting.

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Posters | Device fabrication and design

6.176 Reverse Omega Shoe Insert (ROSI) Enhances Power Generation and Efficiency in Hemiparetic Gait

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BACKGROUND

We developed an energy storing carbon shoe insert, the Reverse Omega Shoe Insert (ROSI), to assist forefoot rocker function during the gait of post stroke individuals. Previous studies have shown that use of an AFO with dorsiflexion resistance and the ROSI induced forefoot rocker function and increased the propulsive force during gait. However, the effect of the ROSI on the energy storage and release during gait of post stroke individuals has not been clarified.

AIM

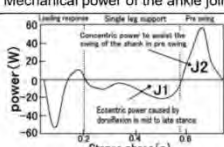
The purpose of this study was to show the effect of the use of the ROSI with an AFO on power efficiency as it assists the initial swing of the shank during the gait of post stroke individuals.

METHOD

Sixteen post stroke individuals (Brunnstrom stage III and IV) participated in this study. Their gaits were measured in two conditions, (1) with an AFO with dorsiflexion resistance only and (2) the same AFO with the ROSI. Gait at comfortable speed was measured using a 3D motion capture system (VICON). The shank and the foot segments were defined using 3D coordinate values, and the ankle joint moment, force between the segments, and angular velocity of the segments were calculated using Visual3D (HAS-motion). Next, the storage and release power caused by the viscoelasticity of the foot and the ROSI and power efficiency were calculated based on Ehara's method¹⁾.

RESULTS

Compared to the AFO only condition the power efficiency increased in the AFO with the ROSI condition. In the AFO with the ROSI condition, J1 decreased and J2 increased compared to the AFO only condition.

	J1 area(eccentric power)		J2 area(concentric power)		power efficiency		Mechanical power of the ankle joint	Appearance of ROSI
	(1) AFO with dorsiflexion resistance	(2) AFO with dorsiflexion resistance and ROSI	(1) AFO with dorsiflexion resistance	(2) AFO with dorsiflexion resistance and ROSI	(1) AFO with dorsiflexion resistance	(2) AFO with dorsiflexion resistance and ROSI		
Median(J)	4.0	2.7	3.4	3.8	43.0%	80.0%		
SE	0.4	0.3	0.2	0.2	10.8	7.1		

DISCUSSION AND CONCLUSION

The power efficiency indicates how the stored energy in the late stance contributes forward and upward lift of the shank to assist the initial swing of the trailing limb in preswing. Results showed that the gait with an AFO and the ROSI enabled the greater generation of concentric power and less eccentric power expended.

As the AFO with dorsiflexion resistance restricted the forward rotation of the shank in the late stance, it was difficult for subjects to utilize the eccentric power for concentric power generation. However, the ROSI assisted the forefoot rocker function by raising the heel upward in the single stance phase. This movement facilitated the forward rotation of the shank and increased the power efficiency.

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ACKNOWLEDGEMENTS

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6.177 Plastic Shrinkage: how to avoid disappointment. A Quality Improvement Initiative

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BACKGROUND

Individually, experienced technicians report a variety of reasons they consider to be responsible for plastic shrinkage with no consensus. This study tests 3 variables with 3 commonly used plastics, aiming to suggest an ideal set of conditions to decrease the likelihood of plastic shrinkage/springing.

AIM

The aim of this study was to determine the possible causes of Plastic Shrinkage/springing, the event in orthotic manufacture when an Ankle Foot Orthosis (AFO) is cut from the cast and the plastic opens up or curls in, and bears only a passing resemblance to the cast from which it was formed.

METHOD

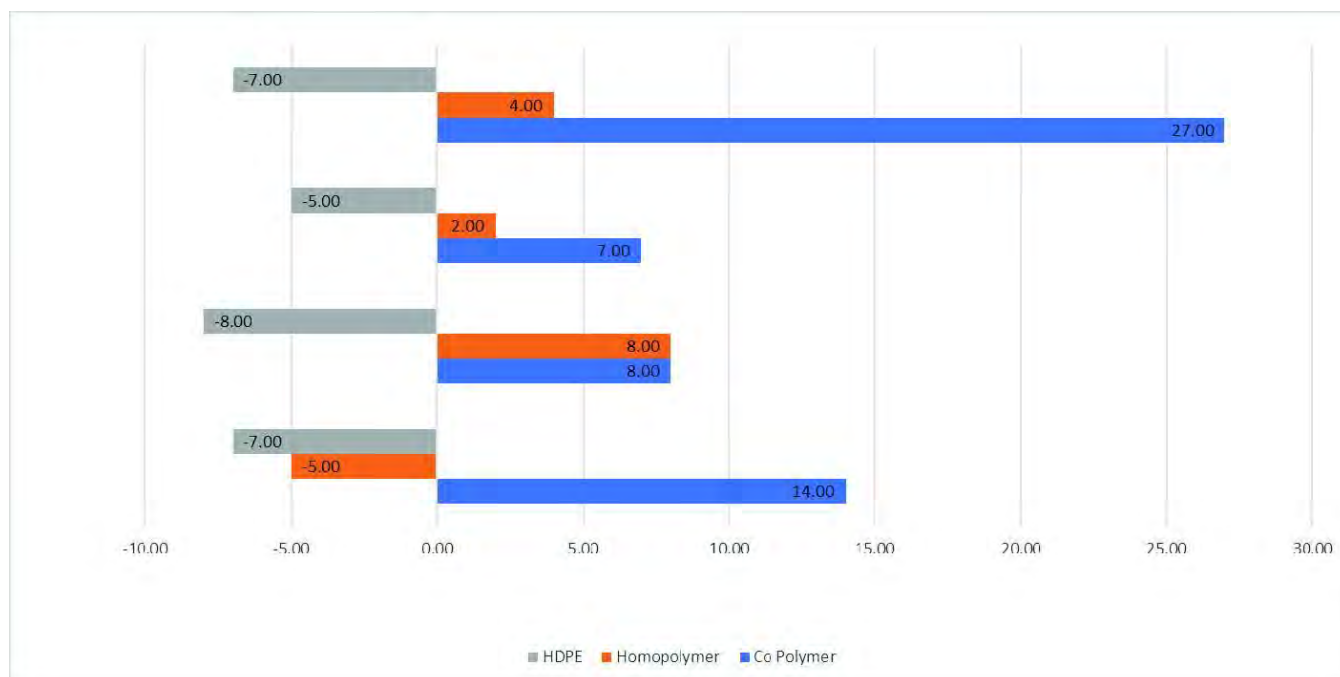
12 plastic AFO drapes were consistently performed, using 4mm Thermoplastic, in 3 types/grades, High Density Polyethylene HDPE, Co-polymer and Homopolymer polypropylene.

The same plaster cast was marked with a trimline for, repeatable shape consistency of the AFO manufacture; the position where the width measurement is to be recorded, this was at the calf strap height.

4 Drapes of each plastic were performed with 3 variables tested, 1. applying a stretch or no stretch; 2. Cut off timing, less than 1 hour cool to touch or over 24 hours; 3. the temperature of the dry cast prior to drape, unheated room temp-24° or heated at 80° for ½ hour;

An excel sheet was designed to record the study conditions and variables tested, with the resulting width measurements analysed to indicate the condition for the least plastic shrinkage.

RESULTS





DISCUSSION AND CONCLUSION

The least amount of shrinkage would suggest that the best condition for these plastics is an oven temp of 165°, a heated cast, cutting off after 24 hours, a stretch. Homopolymer plastic shrinkage had the least amount of movement.

The main explanation for shrinkage is the introduction of stress during the moulding the process, it is essential that the plastic is evenly heated to allow the material to flow into the desired shape, uneven heating introduce tension between the material that flows and the material that stretches at a molecular level. The inner surface can cool against a cold cast and not flow vs the outer surface flowing, introducing the stress/tension. Its offered that allowing the plastic the time to heat evenly and moulding over a warm dry cast is an optimal condition.

Technicians all agree 'once the springing has sprung in the moulding process, it cannot be unsprung. Don't waste time trying to fix it, consider the variables and remould.'

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ACKNOWLEDGEMENTS

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6.178 Effects of Reverse Omega Shoe Inserts (ROSI) combined with Ankle Foot Orthoses in gait of post-stroke individuals

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BACKGROUND

While ankle-foot orthoses (AFOs) provide support the heel and ankle rocker functions, forefoot rocker, crucial for terminal stance, remains unsupported in many stroke survivors. To address this gap, we developed a Reverse Omega Shoe Insert (ROSI), a novel shoe insert designed to restore forefoot rocker function. Our previous research¹ has shown that combining ROSI with AFOs significantly increases the percentage of terminal stance in individuals with stroke.

AIM

The objective of this research was to determine the impact of ROSI on the kinematic and kinetic characteristics of gait of post-stroke individuals.

METHOD

Sixteen patients (Brunnstrom stages III-VI, age: 56±9 years) participated. Gait analysis was conducted using a VICON system to compare gait with and without ROSI while wearing AFOs with dorsiflexion and plantarflexion control. Parameters showing the change of gait, such as terminal stance percentage, gait speed, toe clearance at initial swing, and heel velocity (anterior and vertical) at pre-swing onset and mid-swing were analyzed. Paired t-tests were used to compare gait characteristics between conditions at a significance level of 10%.

RESULTS

The results of gait analysis with and without ROSI are presented in Table 1. When ROSI was combined with AFOs with dorsiflexion and plantarflexion control, the percentage of terminal stance significantly increased by 3.6%, gait speed significantly increased by 9.5%, and the maximum propulsive ground reaction force significantly increased by 15%.

Diagram of ROSI's image	Analysis Parameters	unit	With or without ROSI		test result	probability
			without	with		
	terminal stance percentage	%	4.3 (6.6)	7.9 (7.3)	**	P=0.003
	gait speed	m/s	0.67 (0.3)	0.74 (0.3)	*	P=0.015
	Maximum propulsive ground reaction force	N/kg	0.066 (0.04)	0.078 (0.04)	**	P=0.001
	Toe clearance at initial swing	mm	34.1 (14)	35.6 (14)		P=0.143
	Anterior heel velocity during pre-swing	m/s	0.85 (0.5)	0.91 (0.5)	♀	P=0.074
	Vertical heel velocity during pre-swing	m/s	0.74 (0.5)	0.77 (0.6)		P=0.181
	Maximum anterior heel velocity during mid-swing	m/s	1.98 (0.9)	2.11 (0.9)	*	P=0.011
	Maximum vertical heel velocity during mid-swing	m/s	0.81 (0.5)	0.81 (0.5)		P=0.441

mean(SD), ♀:P<0.1, *:P<0.05, **:P<0.01

DISCUSSION AND CONCLUSION

Our study demonstrated that the additional use of ROSI to AFOs significantly increased terminal stance phase percentage. This increased weight-bearing on the forefoot, shifted the ground reaction force vector tilts forward, and enhanced propulsive forces, leading to faster gait and swing speeds. These findings suggest that ROSI could be beneficial for improving gait function in post-stroke individuals by assisting forefoot rocker and enhancing propulsion.

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ACKNOWLEDGEMENTS

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6.179 Exploring the Emotional Response [Kansei] of Consumers Toward Lower Limb Cosmetic Cover Design Alternatives

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BACKGROUND

Products that are perceived as high quality are typically those which elicit positive emotions and feelings within consumers. In product development, the emotional response a person experiences from a product is referred to by the Japanese word 'Kansei'. Kansei engineering is a methodology that aims to facilitate the translation of consumers' feelings and emotions into specific design parameters^[1]. While the method is used extensively to support the design of automotive and home products, examples from the medical technology industry are rare^[2].

AIM

We aimed to quantify the relationship between users' emotional response to different cosmetic cover designs and specific product attributes as well as explore if characteristics of the individual affect the way different designs are perceived.

METHOD

Semantic words representing prosthesis users' emotional response (Kansei) to prostheses with different cosmetic designs were identified using interviews and mood boards. A group of experts consolidated the words into thematic groups, each represented by a single, high-level 'Kansei' word. 53 lower limb prosthesis users completed a questionnaire using the Kansei words to rate their perception of 13 different prostheses. Repeated measures ANOVA and Quantification Theory Type 1 were applied to explore the relationship between words and specific product attributes (i.e. colour, form, surface finish and material). Sub-analyses were performed to assess for differences based on sex, age and personality type (introvert/extrovert).

RESULTS

5 Kansei words were identified as representing the range of cosmetic cover designs available to prosthesis users ('Natural', 'Technological', Cool', 'Unique' and 'Functional'). Figure 1 presents average ratings for each word. For the Kansei word 'Natural', prostheses with a more realistic appearance scored significantly higher than prostheses with no cosmetic cover or those incorporating more expressive designs ($p < 0.001$). For the Kansei words 'Technical', 'Cool' and 'Unique', prostheses with more expressive designs and particularly those that were 3d printed, scored significantly higher than all other designs ($p \leq 0.001$). Few differences were observed when comparing ratings of Kansei words between sub-groups (e.g. male/female; introvert/extrovert).

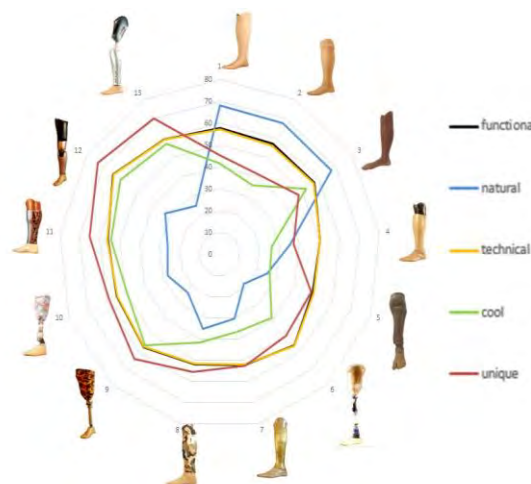


Figure 1: Rating of Kansei words

DISCUSSION AND CONCLUSION

Using Kansei Engineering we demonstrated clear links between four Kansei words and specific design elements of lower limb cosmetic covers. Designers of prosthetic components may find these results useful when deciding which product attributes they should incorporate into a new cosmetic cover to achieve the desired emotional response from consumers. The words may also be useful to help guide clients in their prosthetic design choices.

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ACKNOWLEDGEMENTS

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6.180 The Design of Upper-limb Rowing Prostheses

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BACKGROUND

Currently limited upper-limb prostheses are available for people with limb difference. These largely do not meet users' needs or expectations for either everyday living or, critically, their hobbies. Subsequently, there is a high rate of abandonment (up to 50%) [1], which demonstrates the need for prostheses improvement. By taking a user centred design approach, prostheses for sporting activities, including rowing, can provide maximum impact and support adoption of the technology.

AIM

The aim is to design, construct and test a set of bespoke rowing prostheses for a quadruple amputee to complete a multi-day row, implementing a user centred design approach.

METHOD

A single oar approach is taken, with the development of two rowing prostheses. The prostheses were designed to attach to existing sport sockets, where the right arm has a transradial limb difference and the left a transhumeral. The prostheses need to attach rigidly to allow power to be transferred from the body through the oar, however, safety mechanisms are also needed for independent detachment and release of the oar under high load conditions. A design specification was created, and a user centred design approach implemented to ensure the design would be accepted by the user, enabling the necessary rowing motions.

RESULTS

The solution for the prosthesis design is shown in Figure 1. For both the right and left arm, a shaft collar is used to attach the prosthesis to the oar. For the right arm, a wrist unit is created with a quick release mechanism such that the rower can detach independently. For the left arm, in addition to an elbow joint, a safety mechanism was incorporated. A design was chosen as shown in Figure 1, where a 3D printed part would be included below the elbow joint, such that it would intentionally break under high torsional forces. This would protect their shoulder from experiencing detrimentally high loads that the water may impose through the oar. To ensure longevity of the prostheses, anodisation was completed.



Figure 1. Quad-amputee with unilateral oar prosthesis fitted to the left arm (transhumeral).

DISCUSSION AND CONCLUSION

Through a user centred design approach, a set of rowing prostheses was created, which were used (with minor modifications) in a 14-day rowing event around the south coast of England; the first time a quadruple amputee has undertaken an ocean-going row. This work demonstrates that creating flexible and affordable options which satisfy users' needs and expectations, will provide people with limb difference the freedom and independence to participate in their activity of choice.

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ACKNOWLEDGEMENTS

This project was supported by the University of Bath Alumni Fund.



6.181 Patient-Centered Approaches in Treating Plagiocephaly: Advances in Eacs and Customized Cro Solutions

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BACKGROUND

Deformational plagiocephaly, a condition characterized by asymmetrical skull development in infants, has become more prevalent with updated infant sleep positioning guidelines. Cranial remodelling helmets are crucial in guiding symmetrical skull growth during early development through non-invasive means. However, traditional helmet designs often face limitations relating to comfort, weight, fit, and customization, impacting compliance and treatment success. Recent helmet technology advancements address these limitations, enhancing patient comfort and improving treatment outcomes.

AIM

This presentation examines recent innovations in cranial remodelling helmet design, emphasizing advancements in materials, digital fabrication methods, and patient-centred design. The key goals are to assess how these advancements enhance comfort, customization, and treatment outcomes for infants with plagiocephaly post Endoscopic-Assisted Craniosynostosis Surgery (EACS).

METHOD

This presentation reviews recent research on incorporating advanced technologies, including 3D scanning and printing, alongside hypoallergenic and thermoregulating materials in helmet design. A comparative analysis examines traditional versus modern helmets, focusing on enhancements in fit precision, weight reduction, breathability, and caregiver convenience. The content draws from studies published in the past five years. Additionally, it highlights the role and significance of Endoscopic-Assisted Craniosynostosis Surgery (EACS) within Cranial Remodelling Orthoses (CRO), discussing its impact on clinical outcomes and the importance of technological advancements in improving both patient comfort and procedural efficiency.

RESULTS

Initial findings from the literature review indicate that improvements in helmet materials significantly enhance comfort and reduce skin irritation. CAD and 3D printing enable precise, fully customizable helmet designs, reducing production time and allowing adjustments tailored to individual growth patterns. The results indicate significant improvements in patient outcomes, including enhanced cranial symmetry and patient comfort, through the integration of Endoscopic-Assisted Craniosynostosis Surgery (EACS). Additionally, patient-centred features, including softer edges, adjustable liners, and aesthetic customization, are associated with greater patient and parent satisfaction, which in turn promotes higher compliance and more successful treatment outcomes.

DISCUSSION AND CONCLUSION

The advancements in cranial remodelling helmet design have significantly enhanced the treatment of plagiocephaly, providing safer, more comfortable, and effective options. By leveraging digital fabrication and innovative materials, orthotists are better equipped to offer tailored, patient-focused care that meets the unique needs of infants and their families. Future research should continue to assess the long-term impact of these design innovations, with a focus on developing standardized guidelines that optimize helmet efficacy and the patient experience.



6.182 Design and Evaluation of Assistive Device to aid Transhumeral Amputee with Fishing

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BACKGROUND

The subject has a unilateral right side transhumeral amputation following a work accident in 2019. He lives by the coast of Largs in Scotland and enjoys fishing most days. Following the amputation, he uses only his left arm to support the fishing rod under the axilla. Thus, causing tiredness and breakage of the reel. Thus, he would like a device that could help with his hobby.

AIM

Design, manufacture, fit and evaluate an assistive device that meets the participant needs and involve the use of the amputated side differently. Furthermore, reducing the risk of developing overuse syndrome.

METHOD

A customized frame was manufactured following a traditional casting method. Suspension included a shoulder and a waist strap. Lastly, the controlling mechanism, which was placed on the left side of the torso, uses the residuum body movement to operate the semi- automatic lock.

RESULTS

Pugh matrix results showed satisfaction of the device when compared to 8 other alternatives in term of stability, position, and movement. In addition to the light weight of 1.2 kg. The diary illustrated increase time spent fishing without feeling fatigued. However, the cost of the device is considerably high compared to the alternatives in the market.

DISCUSSION AND CONCLUSION

Addressing amputee recreational activities enhance well-being, reduce the risk of overuse syndrome and fatigue.

Although the requirements of: independent donning, stability, movements, and adjustability were met, the cost of manufacturing the device was high. Future development could involve means to reduce the cost of the device by using local and affordable materials. Moreover, evaluation methods including digital diary and stress testing could enhance the quality of the results.

ACKNOWLEDGEMENTS

I would like to express my gratitude to University of Strathclyde prosthetics technicians, for their contribution in the manufacturing process

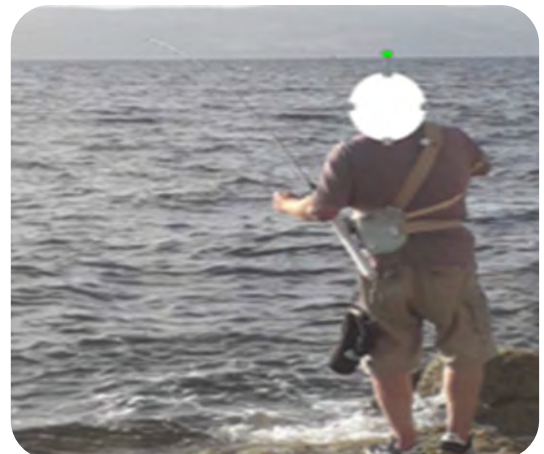


Figure 1. the participant using the device in the coastal environment. It can be noted that the left hand is now free to reel without the added weight of the device.



6.183 Taking the next step in 3D printing of prostheses and orthoses: combining materials of different hardnesses

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BACKGROUND

3D printing (additive manufacturing) is increasingly used in the prosthetic and orthotic field to produce prosthetic sockets, shoe insoles, ankle-foot orthoses (AFOs), etc. However, current 3D printing technologies are limited to print one material at a time, which is not compatible with device designs where materials of different hardnesses are combined. For example, it is common to use a flexible material in the forefoot of AFOs and stiffer materials in the shank portion.

AIM

To communicate our studies on 3D printed AFOs, created with multi-material 3D printing technology, combining two TPE materials (one hard and one soft) and with seamless material transitions.

METHOD

A first prototype of AFO was put on a lower limb prosthesis and repeatedly loaded in a test machine according to the ISO 10328:2016 standard for testing of ankle-foot devices. Two AFOs were 3D printed for one woman and one man who currently used AFO due to ankle-foot disability. They used the 3D printed AFOs for two weeks and compared them to their ordinary AFOs by answering the Trinity Amputation and Prosthesis Experiences Scales (TAPES) and a study-specific questionnaire. Finally, a life cycle assessment (*from cradle to grave*) was conducted.

RESULTS

The developed Dryflex[®]-material solution consisted of one hard (hardness: 70 shore D) and one soft (hardness: 45 shore A) thermoplastic elastomer (TPE-S and TPE-O), and an innovative extruder system which allowed 3D printing of devices with seamless transitions between the hard and soft material zones. The first AFO prototype survived 2 million loading cycles in the test machine (Fig.1). The life cycle assessment found that the carbon footprint of a conventional AFO is approximately five times higher than that of a 3D printed AFO. The clinical testing of the AFOs on patients is ongoing, and the results will be presented at the conference.

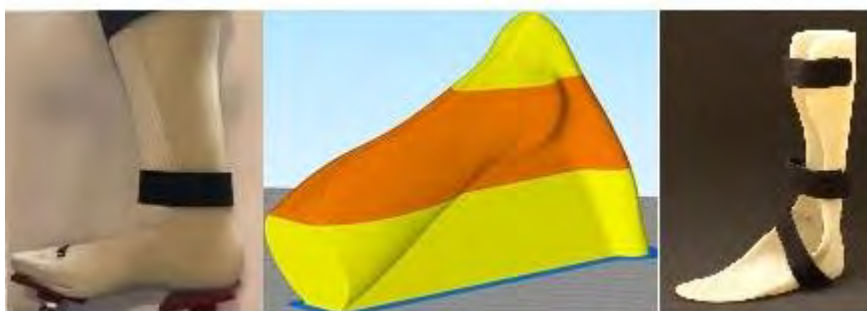


Figure 1. Orthosis in test machine (left), zones of materials of different hardnesses (middle) (yellow=soft, orange=hard) and one of the final orthoses (right).

DISCUSSION AND CONCLUSION

We found that new extruder technology and material solutions allow for 3D printing of AFOs with seamless transitions between materials of different hardnesses. The orthosis fulfils the mechanical durability requirements and result in 80% less carbon footprint in the production compared to an orthosis produced with conventional techniques and materials. The clinical testing is ongoing.

ACKNOWLEDGEMENTS

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6.184 Dimensional Accuracy Assessment of 3D-Printed Medical Hand Models Produced by Hospital-based Fused Deposition Modelling 3D-printer: An Experimental Study

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BACKGROUND

3D Printing (3DP) technologies expand rapidly in the medical field, especially for manufacturing prostheses and orthoses.¹ Indeed, many orthotists and prosthetists include 3DP within their workflow as it allows the manufacturing of custom-made devices.² As 3DP paves its way into clinical routine, evaluation of accuracy of 3D-printed medical models and devices is required.¹ However, no established guidelines exist to assess dimensional error of models and devices manufactured using 3D printing for medical applications.

AIM

This study aims to evaluate the dimensional accuracy of 3D-printed medical models and parts using a hospital-based Fused Filament Fabrication (FFF) 3D-printer.

METHOD

Two dissected cadaveric right hands were marked with Titanium Kirshner wires to identify landmarks on the heads and bases of all metacarpals, and proximal and middle phalanges. The two hands were then scanned using a Cone Beam Computed Tomography Scanner. Radiological images were postprocessed and segmented using 3D Slicer Software. Hand models were 3D-printed using a professional hospital-based FFF 3D-printer. Manual measurements of all landmarks on both pairs of cadaveric and 3D-printed hands were performed by two independent investigators using a digital Caliper. Mean Absolute Difference (MAD) and Mean Dimensional Error (MDE) were calculated. A Paired samples T-test was also performed. Inter-observer and Intra-observer agreements were assessed by calculating the Intraclass Correlation Coefficient (ICC).

RESULTS

Our results showed acceptable level of dimensional accuracy. The overall study MAD was 0.32mm (+/- 0.34) and MDE was 1.03% (+/- 0.83). These values fall within recommended range of errors. Moreover, a high degree of reproducibility, reliability and consistency was achieved by observers as ICC values ranged between 0.98 and 1.00 for both inter-observer and intra-observer agreements.

DISCUSSION AND CONCLUSION

A high level of dimensional accuracy of 3D-printed anatomical models was achieved suggesting their reliability and suitability for medical applications. Although, 3D printing technology can seem appealing, clinicians should investigate and confirm the accuracy for their 3DP equipment to ensure the quality and precision of 3D-printed parts and devices that they produce. Our methodology can be easily replicated and adjusted in different settings to test 3DP processes accuracy.

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6.185 A Novel Casting Device for Hip Disarticulation Casting

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BACKGROUND

From clinical perspective, the process of casting for patients with hemi-pelvic amputation or hip disarticulation requires at least two professional prosthetists to accomplish it. The whole casting process is conducted manually and time-consuming. Thus, the research team has developed a hip disarticulation casting equipment which could decrease the time of casting process and make prosthetists measure the size of stump more rapidly. There are no similar H-D casting equipment have been developed nationwide, while most casting equipments are for the Trans-femoral amputees.

AIM

To develop a new casting device enabling prosthetists to perform accurate, efficient casting for amputees.

METHOD

The novel device developed can be prepared in advance to position the height required for taking impressions of each case. The front and rear of the pelvis are pressed against the triangular pressure part. The angle of the pressure part can be adjusted, and the sides can also be adjusted horizontally. After adjusting the position in advance, place a layer of soft cushion (silicone) on the mold-taking frame to improve the comfort during mold-taking for each case. Before taking the impression, let each case sit on the impression-taking device and observe the gap between the device and the case.

Use a hexagonal wrench to adjust the gap so that the skin and the device are more floating. Then directly lay a plaster bandage on the mold-taking frame and wet it before taking the mold. Then wrap the plaster on the side. After wrapping, the center of gravity sits on the mold-taking frame. On the device, there are triangular PP plates on the device for pressure at the front and rear, and there are outer supports for pressure on the sides.

There are two straps on the device that can compress the iliac ridge, eliminating the need for additional belt compression and shaping in the traditional way. The fitter only needs to confirm whether the patient is standing firmly and can complete the mold taking action.

RESULTS

The casting process successfully produced an accurate negative mold with reduced effort and time compared to traditional methods. The adjustable casting seat streamlined height and position adjustments, while the device enabled consistent outcomes. With practice, further reductions in casting time are achievable.



DISCUSSION AND CONCLUSION

The device expedites the casting process for hemipelvectomy/hip disarticulation amputees, reducing dependency on multiple prosthetists and enhancing precision. Wider adoption may optimize clinical workflows and improve patient outcomes.

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ACKNOWLEDGEMENTS

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6.186 AI-Enhanced 3D Reconstruction for Prosthetics: NeRF and Monocular Camera Solution as an Affordable Alternative to High-Cost Depth Scanners

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BACKGROUND

Traditional prosthetic fabrication has relied on physical molds, but digital methods using high-cost 3D scanners are gradually replacing this approach [1]. Smartphone-based scanning offers a more affordable alternative but typically requires depth sensors [2]. This research explores the use of AI-powered 3D reconstruction with the Neural Radiance Fields (NeRF) algorithm, utilizing monocular cameras to enable accurate prosthetic modeling on standard smartphones. This approach reduces costs and allows for remote monitoring of limb conditions, making prosthetic care more accessible [3].

AIM

This study aims to develop and evaluate an AI-powered 3D reconstruction method using NeRF with monocular cameras, comparing its accuracy to conventional depth-based 3D scanners to assess suitability for prosthetic applications.

METHOD

This study scanned the residual limbs of 12 below-knee prosthetic users and a dummy limb model using two methods: a depth-based scanner (Einscan) and an AI-powered Neural Radiance Fields (NeRF) system on smartphones. To enhance NeRF accuracy, a best-frame selection strategy was implemented, choosing images based on limb center alignment, blur, brightness, and contrast scores instead of using static intervals. Accuracy was evaluated by comparing circumferential differences and calculating mean absolute error (MAE) relative to the depth-based scanner. Surface detail clarity was also assessed to ensure quality for marking positions, validating smartphone-based NeRF as a practical alternative to traditional scanning.

RESULTS

Scanning tests on the dummy limb model and 12 patient limbs showed high accuracy for both methods. The depth-based scanner, with 0.04mm precision, achieved 0.3% accuracy as the benchmark. The smartphone-based NeRF scan reached a mean absolute error (MAE) of 3.88mm (0.9%) on the dummy model and 2.07mm (0.7%) on patient scans. The traditional static interval method, which extracts frames at fixed intervals without quality checks, resulted in 60% of scans with errors >10mm, 20% between 5mm and 10mm, and 20% below 5mm. The best-frame selection strategy, optimized for limb alignment, blur, brightness, and contrast, improved accuracy: only 20% of scans had errors >10mm, 20% between 5mm and 10mm, and 60% below 5mm. These findings support the smartphone-based NeRF's practicality for prosthetic applications.



Figure. Comparative scanning results: two perspectives



DISCUSSION AND CONCLUSION

The smartphone-based NeRF scan achieved accuracy within 0.7% of the depth-based scanner, manageable with thin prosthetic interfaces like stump socks. This validates the NeRF approach with monocular cameras as a practical, cost-effective alternative to costly depth sensors, suitable for accurate prosthetic modeling. The best-frame selection strategy further narrowed the accuracy gap, supporting the NeRF system's potential for real-world prosthetic applications.

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6.187 Remote Deployment of Reusable Weighted Cast Device

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BACKGROUND

Complete prosthetic service delivery is a continuous challenge faced in regions that lack support and proximity to fabrication units, especially in an archipelago like the Philippines. Current 3D technologies reduce waste while allowing remote measurement, but without the impressions needed for ensuring stability, functionality and comfort. This novel device is developed to provide a remote service delivery model that utilizes the benefits of 3D technologies and weight bearing during measurement.

AIM

The study aims to develop a reusable prosthetic casting device that incorporates weight bearing of the residuum, which enables deployment to remote areas using 3D technologies.

METHOD

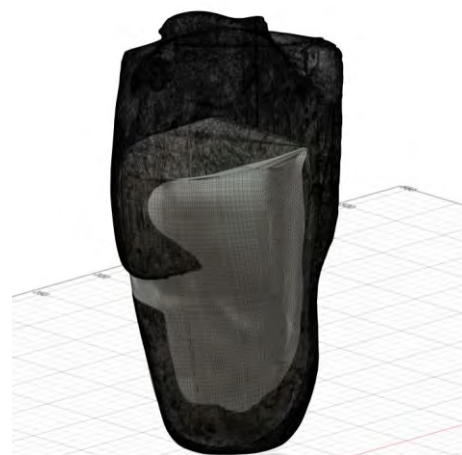
A modified CIR casting system enhanced with 3D scanning technologies is developed. This device of 2 opposing negative molds are individually scanned after the cast hardens by vacuum. The generated 3D model is stitched together by using 3D scanner native software and a publicly available 3D modelling software. For comparison, a trial transtibial cast is used as control. The 3D scan of the cast is compared with the scan of the negative molds produced by the modified casting system. A volume comparison and analysis of impressions is made by superimposing the 3D models.

RESULTS

The majority of the difference in the volumes lies in the subpatellar area and posterior knee. Deviations in the volume are seen between the two models. The dark gray area is the control. The impressions created below the patellar tendon are still intact after the modified casting and subsequent rectifications in the 3D modeling software.

DISCUSSION AND CONCLUSION

The CIR casting system has benefits that must be utilized while innovating with current technologies. Creating a remote service delivery model is most appropriate in areas that are difficult to reach by the prosthetist to complete service delivery. Given the minimal deviation in the results, this fabrication method is yet to be tested for socket pressure and socket comfort score and deployed for validation of results.





6.188 Effect of using Ankle-Foot orthoses with adjustable ankle joints on walking an inclined surface

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BACKGROUND

Walking on inclined surfaces presents unique challenges, especially for individuals using rigid AFOs. The rigidity of these devices restricts ankle movement, necessitating greater reliance on hip and knee muscles to compensate for the lack of ankle flexibility. The surface type and slope steepness further influence these dynamics, potentially necessitating additional assistive devices for support.

AIM

This study aimed to evaluate the mechanical performance and the effects on gait kinematics of an ankle-foot orthosis with an adjustable ankle joint compared to a traditional rigid AFO during walking on inclined surfaces.

METHOD

The clinical evaluation compared the joint kinematics of subjects walking on 0%, 4%, and 8% inclines while wearing the adjustable AFO versus a rigid AFO. The mechanical testing demonstrated the adjustable AFO's ability to withstand the increased forces experienced during inclined ambulation, maintaining structural integrity under cyclic loading

RESULTS

The mechanical testing demonstrated the adjustable AFO's capacity to effectively support the weight of an 80-kilogram user, accommodating the increased forces generated during inclined ambulation. Specifically, the AFO was able to withstand the higher vertical loads experienced at the heel and forefoot when walking on 15-degree and 20-degree inclined surfaces, respectively. Additionally, the AFO maintained its structural integrity and alignment under the cyclic loading tests, which simulated approximately daily walking over an extended period. These results suggest the adjustable AFO's durability and reliability for long-term use by patients, providing confidence in its ability to function as intended for frequent daily use and ambulation on inclined surfaces.

The clinical evaluation of the adjustable ankle-foot orthosis compared to a traditional rigid AFO during walking on inclined surfaces demonstrated significant differences in joint kinematics. The results showed that the adjustable ankle-foot orthosis provided several benefits compared to the traditional rigid AFO during walking on inclined surfaces. The adjustable AFO can increase foot clearance and reduce compensatory movements at the knee and hip joints when walking on an inclined surface, especially during walking uphill.

DISCUSSION AND CONCLUSION

The investigated the effects of an AFO with an adjustable ankle joint on the walking of individuals on inclined surfaces. The mechanical testing confirmed the structural integrity and durability of the adjustable AFO design, the clinical evaluation provided compelling evidence for the benefits of the adjustable AFO compared to a traditional rigid AFO to improved joint kinematics, with increased ankle range of motion and reduced compensatory movements at the knee and hip joints, as well as enhanced ground clearance during both uphill and downhill.

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6.189 Advances in 3d-Printed Orthotics for Windlass Mechanism Optimization

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BACKGROUND

The windlass mechanism is critical for maintaining arch stability and ensuring efficient gait, with dysfunctions contributing to conditions such as flat feet and plantar fasciitis. Although traditional orthotics provide support for the windlass mechanism, they often lack the necessary customization and adaptability. Recent advancements in 3D printing technology allow for the development of highly personalized orthotics with precise adjustments. Understanding the impact of various 3D-printed materials on the windlass mechanism is essential for creating more effective, individualized orthotic solutions.

AIM

This study aims to evaluate the impact of different 3D-printed materials used in orthotic insoles on the activation and efficiency of the windlass mechanism, specifically assessing improvements in foot arch stability, load distribution, and gait dynamics.

METHOD

Several studies have explored the use of 3D-printed orthotics to optimize the windlass mechanism, utilizing materials such as thermoplastic polyurethane (TPU), flexible photopolymer resin, and carbon fiber-reinforced nylon, selected for their unique mechanical properties, including flexibility and durability. Custom insoles, designed through 3D scanning, ensure an optimal fit and enhanced arch support. Common assessment methods include gait analysis and plantar pressure testing to evaluate changes in arch height, pressure distribution, and load transfer efficiency following orthotic intervention. The literature reviewed for this process includes studies published in the past five years, sourced from databases such as PubMed, Google Scholar, Springer, and Science Direct.

RESULTS

Preliminary results indicate that TPU-based insoles provide optimal flexibility, promoting effective arch compression and release, which enhances the windlass mechanism during gait. These insoles facilitate smooth energy transfer, improving overall foot function. Flexible photopolymer resin insoles offer moderate support but are less adaptable to varying loads, reducing their effectiveness in dynamic conditions. In contrast, carbon fiber-reinforced nylon insoles deliver superior rigidity and arch support, significantly activating the windlass mechanism in static postures, but are less responsive during dynamic movements. These findings underscore the distinct advantages of each material in optimizing the windlass mechanism based on individual needs and activity demands.

DISCUSSION AND CONCLUSION

The results indicate that 3D-printed TPU orthotics offer an optimal balance of flexibility and support, effectively enhancing the windlass mechanism during dynamic activities. Carbon fiber-reinforced nylon provides superior static support, making it particularly suitable for individuals with significantly compromised arches. Flexible photopolymer resin demonstrated moderate efficacy but was less adaptable to varying loads. These findings emphasize the potential of TPU-based orthotics for personalized windlass optimization, suggesting that further research into multi-material insoles and long-term biomechanical adaptation could advance foot rehabilitation strategies.



Posters | Robotics, soft robotics, exoskeletons

6.190 Gait analysis of Transtibial amputees with Korean Micro-Processor prosthetic ankle

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BACKGROUND

Lower limb amputation restricts mobility and independence, reducing quality of life¹. Microprocessor-controlled ankles (MPAs) can improve daily function and gait stability for amputees. This study compares the gait outcomes of two transtibial amputees using a Korean-developed MPA versus a commercially available MPA on flat and inclined surfaces. Findings highlight design improvement areas for the Korean MPA and suggest future research directions to enhance performance and adaptability.

AIM

This study aims to guide research and development for the Korean micro-processor prosthetic ankle by analyzing energy expenditure and 3D gait data of transtibial amputees on flat and inclined surfaces.

METHOD

Two healthy adult males (mean age: 60 years; height: 166.7 cm; weight: 65.2 kg) participated. The prosthetic ankles tested were RoFT (Hugo Dynamics, South Korea) and Proprio (Ossur, Iceland). To eliminate carryover effects, a two-week wash-out period was applied between trials, and a 30-minute acclimation was provided for data reliability². Testing consisted of three stages: first, walking on a 10% incline treadmill at 1 m/s for 10 minutes to measure energy expenditure; second and third stages involved walking on a 10% incline and flat ground at 1 m/s for 6 minutes each, collecting kinetic and kinematic gait data.

RESULTS

At a 10% incline and 1 m/s speed, oxygen consumption increased by 2.4 ml/kg/min, and heart rate rose by 8.8 bpm when wearing the RoFT. The RoFT ankle absorbed 0.284 W/kg more energy in terminal stance and released 0.216 W/kg more at push-off, which occurred 1% earlier. Ankle joint moment was consistently higher across the gait cycle, showing the largest difference at 45.5%, with 0.248 Nm/kg. Knee joint moment also varied significantly, with notable differences from 5% post-heel strike to 60% post-push-off, reaching a maximum difference of 0.346 Nm/kg at 45.5% in terminal stance. Both the step length and stance time ratios for the intact and prosthetic limbs were close to 1 with the RoFT, indicating enhanced stability and balanced gait.

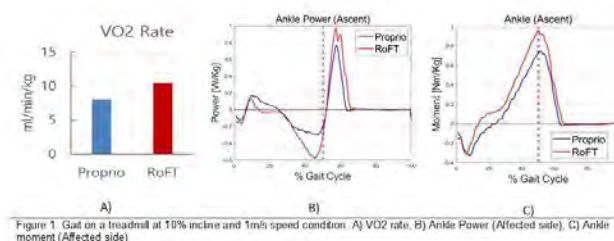


Figure 1. Gait on a treadmill at 10% incline and 1m/s speed condition. A) VO2 rate, B) Ankle Power (Affected side), C) Ankle moment (Affected side)

DISCUSSION AND CONCLUSION

The Korean micro-processor prosthetic ankle (RoFT) enhances gait stability and balance, increasing users' confidence and psychological comfort. RoFT effectively supports forward propulsion during push-off, aided by motorized assistance. However, oxygen consumption and physical load were higher than the Proprio feet, with users experiencing increased fatigue. The consistently high joint moments suggest a need for improved energy efficiency through optimized timing control, moment adjustment, and motor output distribution in push-off phases.

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6.191 Biomechanical Characteristics of Micro-processor Knee on Gait Analysis in Two Transfemoral Amputees

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BACKGROUND

Previous studies indicate that transfemoral amputees may experience decreased quality of life due to increased pain and reduced activity levels caused by asymmetric gait¹. To address these challenges, microprocessor knees (MPKs) offer potential benefits. This study compares various gait parameters of a Korean-developed MPK with conventional models, aiming to guide future development of the Korean MPK by identifying its biomechanical advantages and areas for improvement.

AIM

The aim of this study is to compare biomechanical and functional outcomes of a Korean-developed microprocessor knee with commercial models in flat and inclined walking for transfemoral amputees.

METHOD

Two healthy adult males (mean age: 47, height: 178 cm, weight: 82.5 kg) participated in this study. The prosthetic knees tested were the KIMM (Korea Institute of Machinery & Materials) and the 3C60 (Ottobock, Germany). A 30-minute adaptation period preceded testing. The protocol involved a 6-minute uphill walk at a 12% incline and a 6-minute level walk, conducted on a treadmill with pressure sensors at each participant's preferred speed. After each stage, participants rested, switched knees, and repeated both stages. Infrared markers enabled 3D motion analysis, and kinetic data were collected to assess gait performance.

RESULTS

Balance was assessed by comparing the ratios between the intact and amputated limbs, using step length and stance time ratios, where values closer to 1 indicate balanced gait². On flat ground, step length ratios were 0.93 for the 3C60 knee and 0.89 for the KIMM knee, and 0.98 and 1.05 on the incline. Stance time ratios were 1.14 and 1.16 on flat ground, and 1.13 and 1.11 on the incline. No significant differences in lower limb joint moments appeared between knees. For inclined walking, knee joint power was 0.35 W/kg at 67% and 0.37 W/kg at 91% of the gait cycle with the 3C60 knee, and 0.13 W/kg at 62% and 0.38 W/kg at 94% with the KIMM knee, indicating less power variation and more restricted movement with the KIMM.

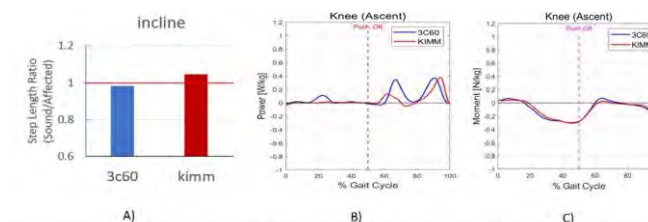


Figure 1 Gait on a treadmill at 12% incline and Preferred speed condition. A) Step length Ratio, B) Knee Power (Affected side), C) Knee moment (Affected side)

DISCUSSION AND CONCLUSION

The KIMM knee demonstrated a generally smooth and low power output across joints, prioritizing stability over dynamic assistance in hip extension, providing balanced gait but less propulsion. Its knee and ankle power curves were steady, supporting stability but limiting responsiveness. Compared to the 3C60, KIMM had lower power peaks, especially on inclines, requiring greater user effort. Adding power assist for hip and ankle could enhance incline support and propulsion.

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6.192 A Comprehensive Framework For transfemoral Prosthetic Socket Design Using Machine Learning MRI Images Segmentation and Simulation Analysis

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BACKGROUND

Developing an effective framework for transfemoral prosthetic socket design is crucial for ensuring user comfort and functionality. This involves utilizing image processing techniques, such as Deep Learning, to automatically segment MRI images, thereby streamlining the acquisition of internal tissue information. Accurate pressure distribution assessment within the prosthetic socket is vital for optimal load distribution and successful fitting, highlighting the need for comprehensive simulation methods and validation against actual measurements.

AIM

This study aims to develop a comprehensive framework for transfemoral prosthetic socket design, integrating deep and surface information through machine learning-based MRI segmentation and evaluating the accuracy of the simulation results against actual measurements.

METHOD

MRI images of four patients with above-knee amputations were acquired both with and without a socket. The MRI images were automatically segmented using machine learning into fat, femoral, and ischial tissues, and muscle was modeled as tissue between the bone and fat. Finite element analysis (FEA) was then performed on these 3D models to evaluate pressure distribution with the socket in place. Analysis conditions included bipedal and single-legged static standing. Simulation results were validated against actual pressure measurements taken from patients under similar conditions to ensure reliability and accuracy of the FEA results.

RESULTS

Each tissue of the thigh estimated by machine learning was evaluated by F-measure, and the estimation accuracy of each tissue was 0.917 for fat, 0.934 for femur, and 0.851 for ischium. A point cloud with 3D spatial information was obtained from the machine learning estimation results, and a 3D model of the thigh was created using the point cloud. The 3D model of the thigh was evaluated by FEA, and the correlation between the measured values and the simulated values was 0.6325 ($p < 0.05$), indicating a correlation. In the pressure distribution, pressure concentration was confirmed in the distal lateral region and just below the ischium, but pressure concentration near the greater trochanter, which was seen in the measured values, could not be confirmed.

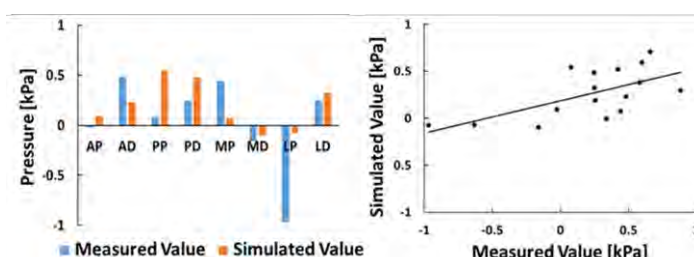


Figure 1. Comparison of measured value and simulation values

DISCUSSION AND CONCLUSION

This study established a novel framework for integrating deep and surface information in prosthesis design using machine learning-based MRI segmentation. The framework accurately predicted pressure distribution, showing a significant correlation with actual measurements. Discrepancies, such as the absence of pressure near the greater trochanter in simulations, may be improved by refining model accuracy. This framework holds promises for enhancing the design and fitting of transfemoral prostheses, potentially improving outcomes for amputees.



6.193 Surgical protocol for Targeted Muscle Reinnervation for a Randomized Controlled Trial in Postamputation Pain

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BACKGROUND

In the past decade, human-prosthetic integration has advanced significantly, particularly in surgical techniques that improve prosthetic limb functionality. Notably, novel interventions have also alleviated neuropathic pain in individuals with amputation. One such advancement is Targeted Muscle Reinnervation (TMR), a surgical procedure that reroutes severed nerves to motor nerves in nearby muscles. Initially developed to enhance myoelectric signals for better prosthetic control, TMR has also been shown to prevent painful neuromas and reduce postamputation neuropathic pain. Numerous studies confirm TMR's effectiveness in reducing pain and improving prosthetic function, although technical variations exist as the procedure gains global adoption.

AIM

This work outlines a detailed protocol for the TMR technique, established as the standard procedure for the international randomized controlled trial (RCT; ClinicalTrials.gov, NCT05009394)¹, and is intended to facilitate for those who is interested to integrate TMR surgery into their amputation management.

METHOD

A cadaveric anatomical study was undertaken to precisely define each surgical step, followed by in-depth discussions with all surgeons participating in the RCT to ensure procedural consistency. Additionally, surgeons with extensive expertise in the TMR technique were consulted to provide critical feedback on the protocol.

RESULTS

A consortium of surgeons specializing in TMR developed and validated this step-by-step surgical protocol. TMR is a surgical technique that reroutes nerves via a structured nerve transfer to connect with motor nerves in nearby denervated muscles (Figure 1). The protocol is organized into four key steps: 1) Presurgical Preparations, 2) Preparation of the donor nerve, 3) Motor point identification, and 4) Nerve-to-nerve coaptation. The written protocol provides an in-depth description of each step, accompanied by an instructional video for additional guidance. Furthermore, successful outcomes of the technique depend on proper mobilization of the donor nerve stump to achieve tension-free sutures, complete denervation of the target muscle, and the use of known proximal innervation points.

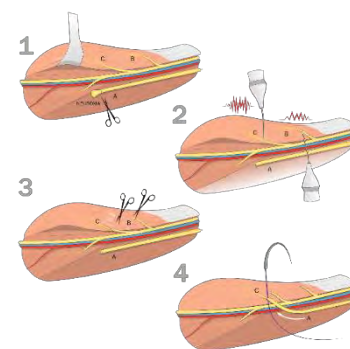


Figure 1. Flowchart following the Targeted Muscle Reinnervation procedure.

DISCUSSION AND CONCLUSION

TMR is a modern approach in amputation care designed to enhance myoelectric control of prostheses and has been shown to effectively reduce and prevent postamputation neuropathic pain. Although studies demonstrate the efficacy of TMR, no comparative research has yet assessed TMR against other nerve reconstruction techniques, such as Regenerative Peripheral Nerve Interface (RPNI), or standard treatments without reconstruction, highlighting the need for this RCT. This work consolidates expert insights to develop a standardized TMR surgical protocol for the RCT, providing guidance for professionals looking to adopt the technique in amputation care.

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ACKNOWLEDGEMENTS

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6.194 Use of Robot-Assisted exoskeleton for overground ambulation in a patient with Guillain barre syndrome. A Case Report and literature review

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BACKGROUND

Guillain barre syndrome (GBS) is a form of acute inflammatory demyelinating polyneuropathy (AIDP) an autoimmune condition affecting the peripheral nerves. Depending on the severity of the condition, this may lead to debilitating impairments, requiring a prolonged course of rehabilitation. Robotic rehabilitation has been well established in neurological conditions such as stroke and spinal cord injury. However, there is limited literature on the role of robotic rehabilitation in AIDP.

AIM

We report a case of a Madam L, 61 year old lady, with GBS in inpatient rehabilitation, whom received Hybrid assistive Limb (HAL) robotic rehabilitation as an adjunct to conventional rehabilitation.

METHOD

We tracked our patients progress during inpatient rehabilitation, In addition to conventional therapy of 180 mins a day (Physiotherapy, Occupational therapy and Speech therapy), patient underwent 10 sessions of HAL. Based on her Modified Erasmus GBS Outcome Score (EGOS) score, she had a 95% probability of being unable to walk unaided at 4 weeks, and 79% probability of being unable to walk at 3 months. The outcome measures that were used were the Functional independence measure (FIM) Scores, 6 min walk test, and level of assistance required for ambulation.

We also did a literature review on robotic therapy for ambulation in patients with AIDP.

RESULTS

Madam L exceeded expectations for ambulation based on the mEGOS score. Madam L was taken over by the inpatient rehabilitation team on Day 23 of admission, at that point, Madam L was unable to walk due to Lower limb weakness. We commenced HAL therapy on Day 36 of admission to Day 51 of admission (10 consecutive sessions, not including weekends), By Day 61 of admission, patient was able to ambulate independently without the use of a walking aid.

In our literature review using PubMed, using the key terms “Robotic rehabilitation” and “Acute inflammatory demyelinating disease”. There were only 2 cases reports reporting the use of robotic therapy in ambulation in GBS, both reported positive results in improvement in ambulation.

DISCUSSION AND CONCLUSION

Based on this case report, and the literature review, there is a role for robotic rehabilitation therapy for ambulation in patients with AIDP. We postulate that HAL allows opportunity of early rehabilitation and gait training even before patient has regained the ability and strength to stand. However, as literature remains limited at this current juncture, more research is required to establish a clearer role for robotic rehabilitation in AIDP.

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6.195 A Cross-Sectional Survey Investigating Allied Health Professionals' Perspectives of Actuated Assistive Upper Limb Devices and Validation Methods

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BACKGROUND

The ageing population is increasing, and the globe must prepare for old age dependency. Hand impairment is a pathology noticed in this patient population and could be supported with assistive devices.

Actuated devices can provide additional strength and prehension, these motorised and powered assistive technologies can aid in activities of daily living, therefore enhancing the independence and quality of life of the user. Yet, they are rarely prescribed.

AIM

This study explores the barriers and limitations of current actuated assistive devices, focusing on trends in design and outcome measurement tools.

This may suggest improvements to future devices, decision-making tools, and validation of these devices.

METHOD

The cross-sectional survey was conducted from 2023 to 2024 and included 26 items grouped into:

1. Demographic features: occupation, work experience, and place of work
2. Trends in recognised assistive devices from a literature-curated list ^[1].
3. Importance level of design features in actuated devices
4. Opinions on validation methods for persons requiring assistive devices.

The study was ethically approved, and the survey was disseminated to affiliated associations via mailing lists, e-posters and newsletters.

The quantitative results were statistically analysed using Microsoft Excel, and open-ended questions were subjected to thematic analysis using Braun and Clarke's method ^[2].

RESULTS

A total of 87 survey responses were collected, achieving a 69% completion rate. Most participants (70%, 42/ 60) had experience using electrical stimulation devices but showed limited knowledge of other actuated devices. Additionally, 66% of respondents (40/60) reported insufficient access to assistive devices. Common themes of barriers to prescribing these devices included limited awareness, lack of experience, and inadequate prescription methods. While respondents expressed a preference for multifunctional devices, they placed less importance on features like weight, portability, and mechanical power.

Outcome measures were found useful by 72% of participants, though 58% agreed there was room for improvement. Key limitations to using outcome measures included a lack of time and necessary equipment.

DISCUSSION AND CONCLUSION

Prescribers and assessors of assistive devices lack the access, knowledge, and clinical methods needed to effectively assess and prescribe actuated devices. This may be due to the mechanical requirements for developing actuated devices not aligning with prescribers' priorities for user needs, such as comfort, satisfaction, and ease of use. In addition, outcome measures could be improved with the use of objective functional activities of daily living tasks to track patient progress. User needs in the design and validation of actuated devices should be the focus of the future.

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6.196 Identification of Gait Cadence and Phase from a Single Upper Arm Mounted Accelerometer

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BACKGROUND

A person's step cadence is a function of walking speed and stride length, which can vary throughout the day during ambulation. Real-time cadence can be tracked to monitor the amount and intensity of daily activity ^[1] and may also provide feedback to control robotic assistive devices, such as prostheses ^[2]. Algorithms for cadence detection at the shank have been previously validated ^[3], but methods using arm movements are less researched.

AIM

This study developed an algorithm for estimating gait cadence and phase using upper arm accelerations and compared estimations to an established shank-based data algorithm.

METHOD

Seventeen able-bodied participants (7M/10F, 27 ± 9 years, 1.73 ± 0.13 m, 73 ± 15 kg) provided informed consent and completed the protocol involving walking on a treadmill for 30 seconds at 0.5, 0.7, 0.9, 1.1, 1.3, 1.5 m/s, and their self-selected speed. Accelerations were recorded from sensors mounted proximal to the left elbow and distal to the right knee. The algorithm utilized medial-lateral arm accelerations to detect initial contact of the contralateral leg. Cadence was calculated using the contact timing and compared for each participant and walking speed condition to estimates from shank-based detection algorithm to estimate overall error.

RESULTS

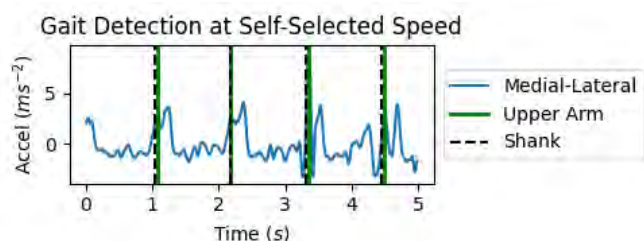


Figure 1. Medial-lateral arm acceleration for one participant during walking at a self-selected speed (1.1 m/s). The plotted line is medial-lateral arm acceleration, while the dashed vertical lines show initial contact detected via shank IMU and the solid vertical lines show initial contact detected by upper-arm IMU.

Figure 1 displays example medial-lateral arm acceleration for one participant during walking at a self-selected speed (1.1 m/s), with identified initial contact from the shank-based and our novel upper-arm algorithms. Cadence measured by the elbow mounted sensor had an average error of 0.05 steps/second (standard deviation: 0.17; range: 0.02 to 0.13) compared to the shank-based estimated cadence across all participants and speeds. There was an average phase offset of 11% gait cycle (standard deviation: 11%; range: 7.35% to 13.71%) between the two algorithms across all participants and speeds.

DISCUSSION AND CONCLUSION

Our results suggest a single arm-mounted sensor is as accurate as a shank-based sensor for estimating gait cadence and phase for a large range of walking speeds. The low variation in phase offset suggests this can be accounted for with a simple time offset. In the future, this algorithm could track cadence from arm-based assistive devices such as upper-limb orthoses and prostheses for activity monitoring and feedback for microprocessor controllers.

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3MT only | Psychosocial issues

6.200 Resources Available to Support Psychosocial Adaptation for People with Lower Extremity Amputations in Canada

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BACKGROUND

When someone experiences a lower limb amputation (LLA), their physical, emotional and social context is disrupted, requiring physical and psychosocial adaptation.¹ While rehabilitation programs address physical rehabilitation^{2,3}, there is less focus on psychosocial adaptation, defined as being the process of integrating the effects of LLA into one's self-image and lifestyle. In Canada, less than 50% of rehabilitation programs for people with LLA have professionals that address psychosocial adaptation and coping with limb loss.³ The lack of psychosocial resources limits the ability of people to cope with the psychosocial effects of LLA and may reduce their ability to participate in things that are meaningful to them.

AIM

This project seeks to examine the resources available for facilitating psychosocial adaptation to amputation, and to identify opportunities to fill the gaps through developing new resources to promote the participation of people with LLA in meaningful activities.

METHOD

I seek to further understand the current landscape in Canada regarding the psychosocial adaptation of people over the age of 18 with LLA due to any cause through the following mixed methods approach:

1. Conduct a systematic review of the literature to understand how individuals with LLA cope
2. Complete a secondary qualitative analysis of 59 interviews from a previous project, that explores the barriers and facilitators to participation, to gain insight into psychosocial factors influencing participation and resources people with LLA use
3. Survey health care providers and people with LLA across Canada to understand the current resources available for supporting psychosocial adjustment to LLA and where the most significant gaps are.

RESULTS

I will integrate the results of the systematic review, secondary analysis of interview data, and survey of resources available in order to map what is currently available to support the psychosocial adaptation of people with LLA. The analysis will be broken down based on geographical location and rehabilitation context (inpatient vs outpatient vs community), type of resource and method of coping support (e.g. education, peer support, etc.). I will also identify where the largest gaps and opportunities are for future development.

DISCUSSION AND CONCLUSION

This study will provide valuable insight into the resources available to support psychosocial adaptation, challenges with current resources that require refinement, and opportunities where additional resources need to be developed. This will provide rehabilitation professionals and community organizations direction to develop or refine resources to support the psychosocial adaptation of people with LLA in order to promote full participation in meaningful activities.

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ACKNOWLEDGEMENTS

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3MT only | Gait and balance

6.201 Exploring the Associations between the Biomechanical and Psychological Mechanistic Pathways of Lower Back Pain Development amongst Persons with Lower-Limb Amputation

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BACKGROUND

Amputations cause serious physical and psycho-social disabilities, compromising quality of life. Biopsychosocial factors (e.g., altered gait, fear-avoidance behaviours) increase the risk of lower back pain (LBP) in lower-limb amputees [1]. Exploring the potential mechanistic pathways of LBP development is novel and important to inform timely patient-centred care.

AIM

To understand the relationships between different forms of pain, gait, and psycho-social variables in adults with lower-limb amputation, and how these change over time.

METHOD

The gait of 20 unilateral amputees (60±15 years old) was assessed as soon as they were fitted with the prosthesis, ~3-months post-amputation (time 0), and then every 3-months over a period of 12-months (time 1, 2, 3, and 4). Kinesiophobia [2], LBP [3], and gait kinematic and kinetic measurements were captured with eight Miquis M5 Qualisys cameras (Qualisys, Sweden) and one portable Kistler force plate (Kistler, Switzerland). Twelve walking trials were recorded for each participant. Since this is an ongoing study, results will be reported only for eight participants (n= 6 transtibial; n = 2 transfemoral) at time 0, 1, and 2.

RESULTS

Between time 0 and time 1, mean gait velocity increased by 16%, and by 27% by time 2. Sound limb stance phase increased by 13% at time 1 and 12% at time 2, while it decreased for the prosthetic limb by 12% and 3%, respectively. A two-way repeated measures ANOVA showed: 1) a significant interaction between time and limb for peak positive anterior-posterior GRF (apGRF) and the net impulse, with the sound limb showing a significantly higher positive peak apGRF than the prosthetic limb; 2) a significant interaction between time and limb for peak knee flexion. Kinesiophobia decreased over time, while LBP severity increased significantly (Table 1). Pearson's correlation showed weak correlations between LBP severity and Kinesiophobia ($r = 0.07$ and -0.04 , respectively).

Table 1 . Peak joint angles and anterior-posterior net impulse over time. * denotes a significant difference between limbs across all time points ($p < 0.05$), # denotes a significant difference between time points ($p < 0.05$)

	Time 0		Time 1		Time 2	
	Prosthetic	Sound	Prosthetic	Sound	Prosthetic	Sound
Hip extension (°)	-18.5 ± 8.4	-19.1 ± 8.9	-20.1 ± 8.6	-23.2 ± 11.1	-24.6 ± 18.9	-24.1 ± 14.0
Knee flexion (°)	-49.9 ± 7.6	-62.7 ± 4.9*	-52.8 ± 11.1	-66.8 ± 7.1*	-53.8 ± 16.2	-64.1 ± 7.1*
Ankle plantarflexion (°)	-5.8 ± 4.9	-4.3 ± 7.8	-8.7 ± 7.8	-5.8 ± 6.0	-6.9 ± 4.2	-8.8 ± 6.8
Ant-post net impulse (Ns)	-0.3 ± 1.0*	0.5 ± 0.6	-0.2 ± 0.6*	0.3 ± 0.6	-0.3 ± 0.6*	0.4 ± 0.8
Peak +ve apGRF (N/bw)	0.04 ± 0.04	0.09 ± 0.03*	0.06 ± 0.04	0.10 ± 0.04*	0.07 ± 0.04	0.11 ± 0.06*
Kinesiophobia	39 ± 9		35 ± 9		37 ± 9	
LBP	3 ± 4		7 ± 5#		5 ± 6	

apGRF = anterior-posterior GRF; bw = body weight; LBP = lower back pain



DISCUSSION AND CONCLUSION

At 6-months post-amputation, the temporal-spatial gait parameters improved, suggesting enhanced mobility and confidence with prosthetic use. Stance phase asymmetry, with greater sound limb reliance, suggests a stability shift as users adjust to the prosthesis. Gait adjustments were associated with increased lower-limbs joint angles. The significant time-limb interaction effect on the anterior-posterior net impulse may suggest improved cumulative loading over time for both limbs. Despite gait improvements and reduced Kinesiophobia, LBP severity increased significantly over time, suggesting that musculoskeletal discomfort may worsen, possibly due to compensatory pelvis movements.

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Technical track | P&O Material science

7.01 Applications of industrial thermoplastic felt in orthotic solutions

Rickard Bergman

Jönköping University, Jönköping, Sweden

Abstract

For many years, orthopedic technology in Scandinavia has utilized moldable felt in the manufacture of orthoses, with numerous clinics and companies in this field providing aids crafted from the material. This lecture will explore both the advantages as well as limitations of moldable felt, examining its strengths and weaknesses while showcasing several commonly used orthotic solutions that have proven effective with this material. Additionally, the presentation will illustrate manufacturing techniques and demonstrate how moldable felt can be effectively combined with other materials.

As part of the lecture, physical examples of orthoses made from moldable felt will also be presented.



Statement of the objective / learning objectives

To build awareness and knowledge of the industrial thermoplastic felt and present potential solutions related to material combinations in orthotics.



Technical track | P&O Material science

7.02 The use of thermoplastic in prosthetics: materials and fabrications technics

Eddy Fuentes

Diabetic Solutions Corporation, Manati, Puerto Rico. US ISPO, OHIO, USA. American Academy of Orthotists and Prosthetists - AAOP, Virginia, USA. Centro Bionico, Guatemala, Guatemala

Abstract

Thermoplastics and prosthetics have been used for decades, however, is not widely used for socket fabrication. A variety of thermoplastics options will be presented and discussed, fabrication technics will be demonstrated as well as suspension systems available, advantages and disadvantages of using thermoplastics and acrylic laminations will be discussed and final prostheses will be presented with different sockets designs and materials used.

In addition, examples of hybrid prostheses using thermoplastics and acrylic laminated will be shown demonstrating the traditional fabrication technics so a comparison of both systems can be evaluated and discussed by the audience.

Also, a list of minimum equipment, tools and machinery will be described.

Statement of the objective / learning objectives

The main objective is to demonstrate the fabrication process of prosthetics using thermoplastics

The other objective is to describe the different materials options available

Finally, to demonstrate the finishing options



Technical track | P&O Equipment & tools

7.03 Revolutionizing Prosthetic Comfort: A Live Demonstration of User Adjustable Systems in a Fabrication Process

Mike Marten

Click Medical, Steamboat Springs, USA

Abstract

This demonstration showcases custom application of user adjustable technologies. The session includes practical demonstrations focused on integrating user adjustability into prosthetic devices, with an emphasis on techniques that aid in design rule compliance for ideal function and outcomes. Layup and lamination options will be discussed along with useful ideas for adding adjustability in diagnostic and retrofit applications.

Statement of the objective / learning objectives

Attendees will learn best practices for fabrication of user adjustable O&P devices. Tech tips will be provided throughout the demonstration to inform attendees about optimizing their layup and finishing process.



Technical track | P&O Fabrication techniques

7.04 Partial foot orthosis manufacturing method for young persons in an easy and fast way

Sten-Åk Wallin

TeamOlmed, Växjö, Sweden

Abstract

We see in different warzones today a record number of amputated children. Sweden has a tradition of receiving children who flee from war-torn countries. Through this, we in O&P industry have been able to see how many of them have been hit by the explosive mines that are used in war today. They constitute a unique group of healthy and strong patients in need of dynamic and light prosthetic solutions for living a healthy life and be able to play and do sports.

Our newly acquired knowledge in this area can be a way to help children on the ground in war-torn countries. Partial foot prostheses with high dynamics can be produced using prefabricated orthosis. With that learned experience, there is an opportunity to help several young people with these solutions.

Statement of the objective / learning objectives

1. Understand basics solutions for partial foot prothesis.
2. Understand manufacturing techniques and material selections.
3. Understand the clinical criteria for selecting different types of solutions.



Technical track | P&O Fabrication techniques

7.05 The Use of Preserved Organic Matter in an Aesthetic Finish for Laminated Prosthetic Devices

Sky Kapoor

George Brown College, Toronto, Canada

Abstract

The aesthetics of a custom wearable, everyday device are important for the prosthetic patient population. An interesting or aesthetically pleasing device can increase the frequency of device use and increase patient motivation towards rehabilitation (Sansoni et al., 2016). While methods of customization for these devices exist, including the use of fabrics and resin pigments, little is known about the preservation of organic matter as a form of customization for prosthetic devices. This presentation will demonstrate drying techniques for organic materials such as foliage and flowers, as well as fabrication considerations for devices that incorporate these materials. The primary method to be demonstrated includes spray-gluing pressed foliage onto prosthetic layup prior to laminating with clear or pigmented orthocryl resin. This method ensures that there is no moisture present, which will maintain a high quality of lamination. Taking inspiration from popular resin preservation methods and drying techniques (Datta, 2016, Thamiselvan et al., 2021), a few different methods will be tested in a thin finishing lamination on a fabricated device during an educational field placement at Ottobock Canada. Some examples of methods that will be tested include dehydration, pressing, and the use of different resin types.



Statement of the objective / learning objectives

Attendees of the ISPO conference will learn what has been determined as the best method for preserving two-dimensional organic materials such that they last within a laminated prosthetic device, which will allow them to perform a new type of customization that can be applicable to a patient's personal interests or desires.



Technical track | P&O Digital technologies

7.06 Optimizing conventional and digital fabrication workflows using data-driven methods to reduce wasted time, wasted materials and reduce errors

Paul Prusakowski, CPO

OPIE Software, Gainesville, FL, USA. Gainesville Prosthetics, Gainesville, USA

Abstract

New software applications are being tested on a group of American and Canadian privately owned Orthotics and Prosthetics (O&P) facilities who perform a combination of inhouse and outsourced fabrication. The pilot study is evaluating how the implementation of data-driven workflows, dashboards, and analytics tools can significantly enhance operational efficiency. The focus of the program expands beyond simply the mechanical and physical production aspect of fabrication, but also takes into consideration the complexities and variations of funding agency requirements that complicate the process, as well focus on enhanced communication between clinicians, technicians, and administrative support staff.

Grounded in Lean Six Sigma principles, the pilot focuses on reducing waste, variation, and cycle time while promoting standardized work processes and improved flow. Throughout the study, participating facilities leverage real-time data and analytics to make informed decisions, optimize their workflows, and identify areas for continuous improvement. This submission will share the outcomes and lessons learned from the pilot, highlighting how these tools help create a more agile, efficient environment within each facility. By aligning with the Lean Six Sigma philosophy of defect prevention and process optimization, we hypothesize that participants will successfully achieve measurable improvements in both efficiency and consistency, paving the way for ongoing process innovation in the O&P profession.

Statement of the objective / learning objectives

Attendees will be exposed to new ways of using data supported workflows to approach the challenges that affect every O&P facility that manages the complexity of in-house or outsourced fabrication.



Technical track | P&O Digital technologies

7.07 3D printed spinal orthosis for idiopathic scoliosis in low to middle income country, case report

Peeraya Ruthiraphong, Narudon batasuk

Ramathibodi Hospital, Mahidol University, Bangkok, Thailand

Abstract

Introduction

Spinal orthosis with good compliance is recommended treatment for idiopathic scoliosis. However, conventional orthosis in hot weather like Thailand is difficult. Some patients got bullied at school due to bulky appearance. 3D technology could help in these issues. However, the commercial CAD-CAM software is expensive for our country insurance (cover 235 USD /brace). Therefore, we developed the Hybrid technique to reduce the cost.

Objective

- Study the efficacy of hybrid technique of spinal orthosis in idiopathic scoliosis.

Study Design

- Case report

Methods

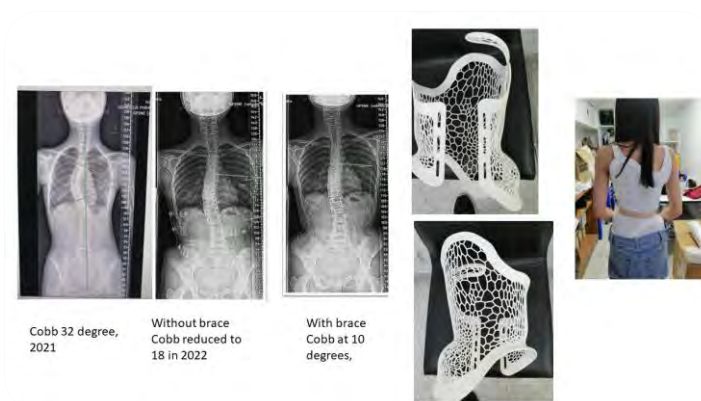
Orthosis was made by using semi - Digital Fabrication to adjust and correct the alignment of the spine. Plaster cast was molded around the patient and correct the alignment using modified cheneau brace. Then we use 3D Ipad scanner to scan the molded cast and using free software program to create and design the spinal brace for 3D printed, made from nylon filament. The design was created to make it ventilated and thin as much as possible while still maintain biomechanics correction.

Results

A 14 years old girl with scoliosis cobb angle (apex T10) at 20 degrees progress to 32 degrees, due to poor compliance. Our orthosis could reduce the angle to 18 degrees. After one year, the angle could be reduced to 10 degrees. She used the brace until the age of 16, and the angle was less than 10 degrees at the end of treatment.

Conclusion

The hybrid method could help make 3D spinal orthosis for idiopathic scoliosis patient.



Statement of the objective / learning objectives

Using the hybrid method to make 3d scoliosis brace and save cost -effectiveness in low to middle income country



Technical track | P&O Fabrication techniques

7.08 Inspection, Safety, and Maintenance of Metal Orthotic Components

Sean McKale

Becker Orthopedic Appliance Co., Troy, USA

Abstract

This technical course provides an in-depth exploration of metal orthotic components, focusing on inspection, safety protocols, and maintenance best practices. The course will cover key decision-making criteria for determining when to perform a complete refabrication, adjust the alignment, replace partial components, or modify metal surfaces. Attendees will gain practical insights into assessing wear, stress points, and potential structural compromises to ensure the highest standards of orthotic safety and function.

Participants will also learn about patient-specific maintenance protocols, including how to instruct patients on routine care practices. Emphasis will be placed on techniques for educating patients during in-office visits, ensuring they understand how to perform minor upkeep tasks and recognize signs that require professional evaluation.

Statement of the objective / learning objectives

Inspection for wear corrosion, and structural integrity. When to refabricate, replace or adjust components. Techniques for aligning devices. Replacement of partial components and modifications to surfaces. Pt education for daily maintenance. Best practices for follow-up.



Technical track | P&O Material science

7.09 How to break a socket the right way (and why users will benefit)

Jeffrey Erenstone

American Orthotic and Prosthetic Association, Lake Placid, USA

Abstract

In an effort to meet emerging regulatory requirements and to provide support for innovators, the “AOPA Socket Guidance Workgroup (SGW)” was formed in 2020, to provide the prosthetic community with evidence-based clinical best-practices and methods in the field of prosthetic socket structural analysis. The workgroup includes expert representatives of the clinical community, manufacturers of engineered components, commercial providers of prosthetic sockets and/or socket materials, and both academic and government researchers from the United States, United Kingdom and Europe.

As a first activity, we assessed the knowledge gaps regarding the requirements for such structural tests, beginning with transtibial prosthetic sockets. The results of this study are published in a discussion paper entitled, “Mechanical testing of transtibial prosthetic sockets: a discussion paper from the American Orthotic & Prosthetic Association Socket Guidance Workgroup”. We identified knowledge gaps in four domains:

1. the shape and composition of a mock residual limb, required to support and generate *in vivo* representative loading within the socket,
2. prosthetic socket coordinate systems and alignment,
3. the components and requirements of test specimens, and
4. test conditions, loading parameters, and acceptance criteria.

The discussion paper describes these knowledge gaps in detail, and recommends potential solution approaches based on literature review, group consensus around existing knowledge, or the formation of new study groups. Our intent is for recommendations to spur the community to fill these knowledge gaps.

This presentation will further explain the findings in the discussion paper and the work that SGW has done since to close the gaps.

Statement of the objective / learning objectives

Review of the current state of knowledge regarding socket strength testing and the work that AOPA SGW is doing to close the gaps in knowledge in the interest of providing strength guidelines for socket manufacturers



Technical track | P&O Equipment & tools

7.10 Fabrication of a ZIP (Zwolle Isala Prosthesis) for transtibial prosthesis users

Jeroen Olsman¹, Wim Bergman²

¹OIM Orthopedie, Zwolle, Netherlands. ²Isala, Zwolle, Netherlands

Abstract

The Zwolle Isala Prosthesis (ZIP) is supplied as a transtibial prosthesis as the first prosthetic device within the multidisciplinary treatment team at the Isala Hospital in Zwolle, the Netherlands. The ZIP has the characteristics of a full prosthesis, with all the features of a regular transtibial prosthesis.

Immediately after amputation, the lower leg is placed in an ORD. A cast is then applied to prevent oedema and the possible development of flexion contracture. Weekly cast changes take place in the plaster room to monitor this process closely, and after five to six weeks the ZIP is applied. The interplay between the plaster technician and the CPO in this process is essential. It is a team effort between two disciplines to deliver a functional lower leg prosthesis in two hours. Therefore, it can be considered a direct fitting method. The ZIP is individually sized and manufactured in the hospital plaster room. The ZIP is made from material that is regularly used in the plaster room (synthetic plaster). Special adapters are used to ensure correct power transmission between the socket and the foot. Major advantages of the ZIP are the short delivery time, lower cost of materials and re-use of the adapters.

In this session we will explain the process of providing ZIP, including a demonstration, and discuss the advantages and disadvantages.

Statement of the objective / learning objectives

1. Explain that there are more methodologies for quickly providing a functional lower leg prosthesis that is relatively cheaper than common available products.
2. Give first insight in how to produce the ZIP.



Technical track | P&O Digital technologies & wheelchair and postural support fabrication techniques

7.11 Implementation of CAD design into Special Seating and the challenges faced

Harry Booth

Blatchford, Sheffield, United Kingdom

Abstract

11 Years ago we made the decision to switch all traditional Special seating manufacturing to an automated process. We reviewed several different systems before making the choice to go with our current CAD software provider. When switching our manufacturing techniques we came across several challenges and through this presentation we will share our journey of bringing Special seating into the 21st century. Today we make 100% of our Special seating systems using this technology.

Our original goals were to create leaner manufacturing processes whilst implementing more sustainable fabrication techniques alongside improving our quality with superior repeatability. We also wanted to improve and modernise our patient experience and confidence.

Prior to moving to digital technology we would move large plaster moulds around not just the UK but Worldwide which of course creates cost, logistical and environmental issues.

We could not have completed the challenge without close collaboration with our patient facing clinical team making major changes to their clinical practice. To aid the transition we moved one of our clinical team into the implementation team working closely with Manufacturing, Quality Assurance and Information Technology to ensure all sections were aligned as we changed all processes.

When facing the inevitable obstacles along the way all members of the team would come together to collaborate on a solution.

The wider manufacturing and facilities teams worked together to create space to install a 7 Axis Robot that would enable us to mill the large intricate shapes required for our seating systems.

Statement of the objective / learning objectives

How to implement a digital solution into Seating manufacture and the problems faced



Technical track | P&O Digital technologies & wheelchair and postural support fabrication techniques

7.12 Additive Seating Systems for the Support of Individuals with Severe Multiple Disabilities: Current Applications and Future Prospects

Jan-Hendrik Warnke

RAS-Team, Melle, Germany

Abstract

In this presentation, we will explore the innovative field of additive manufacturing, specifically focusing on the development of seating solutions for individuals with severe multiple disabilities. Traditional seating options, produced using conventional methods, often fall short in addressing the multiple and complex needs of this patient group, leading to discomfort and restricted mobility.

Additive seating shells, created through 3D printing technology, offer a new approach by accommodating the unique anatomical and functional requirements of each individual.

We will examine the TPU materials and design principles behind these seating systems, highlighting their superior capabilities compared to traditional foam materials. We will discuss how they provide optimal support and effectively accommodate complicated deformities and scoliosis, ensuring that our most affected patients are optimally positioned, thereby enhancing their overall quality of life.

Additionally, the presentation will showcase real-world applications and success stories from various patients and their diverse health aids. These examples illustrate how these solutions have transformed care for individuals with severe disabilities and the benefits they offer over previous technologies.

Looking to the future, we will contrast the potential and sustainability of additive manufacturing with traditional subtractive techniques. With advancements in 3D printing, we can expect even more personalized and efficient solutions that can adapt to the evolving needs of users, revolutionizing the sector of health aids and assistive devices in terms of market relevance.

Statement of the objective / learning objectives

Participants will learn about the benefits of additive manufacturing for the production of seating systems, including design flexibility, material efficiency, sustainability potential, customization options, and ergonomic solutions in various applications with best practice examples.





Technical track | P&O Fabrication techniques

7.13 Functionality and effects of the positioning elements and their combinations with wheelchairs

Rodrigo Moreira

Otto Bock Mobility Solutions GmbH, Berlin, Germany

Abstract

Taking basic anthropometric measurements of the user is the beginning of the process, but it is not limited to that. It is up to professionals (ATP, physiotherapists, occupational therapists, doctors, etc.) to decide on the configuration of the wheelchair, without neglecting the influence and final decision of the user himself as a participant of the process.

It is necessary to develop contextualized clinical reasoning necessary to convert measurements and subsequently guide in the process of making essential decisions in the process of appropriately wheelchair.

A deep understanding of the biomechanical principles that influence the use of the wheelchair is developed, discerning how factors such as gravity, body position and force vectors affect the user's performance and comfort. Furthermore, the analysis of positioning elements, such as the direction of forces and vectors and the intensity of the application of supports, provide results regarding the user's functionality, as well as identifying how adjustments to wheelchair settings can optimize posture and mobility.

With the aim of integrating theory into practice, it allows professionals to rethink and practice wheelchair prescription through real life scenarios. The ultimate goal is to discuss the possibility of making assertive choices and interventions that improve the quality of life and autonomy of wheelchair users, not forgetting the biomechanical and physical implications.

It is expected to increase confidence considering body structures, baseline condition, participation and activity, as well as the influence of internal and external factors, contributing to more effective and personalized care for the needs of users.

Statement of the objective / learning objectives

It is hoped that participants will feel confident in applying an approach based on knowledge of biomechanics and physics in the prescription of wheelchairs, contributing to a more effective and personalized service to users' needs.



Technical track | P&O Fabrication techniques

7.14 Partial Hand Prosthesis Interface and Socket Design: Casting, Modification, and Fabrication

Chris Baschuk

Point Designs, Bountiful, USA

Abstract

This instructional course will explore the essential principles of interface and socket design for partial hand prostheses, focusing on casting techniques, plaster model modification, and socket fabrication. Tailored for clinicians with a foundational knowledge of upper limb prosthetics, the course aims to refine advanced skills specific to partial hand applications.

The course will introduce participants to the six fundamental principles of partial hand socket design: palmar platform, thenar hook, hypothenar hook, metacarpal cap, hypothenar window, and dorsal desert. These principles form the basis for achieving a secure fit, optimized load distribution, and patient comfort. Case-based examples will be used to illustrate how these principles contribute to effective socket designs that maximize functionality.

Participants will gain hands-on experience with casting methods tailored for partial hand prostheses, ensuring precision and personalization. Detailed instructions on plaster model modification will be provided to enhance fit and alignment, followed by a step-by-step guide to socket fabrication, incorporating advanced materials and techniques like additive manufacturing. Attendees will engage in interactive discussions on real-world challenges, reinforcing the practical application of these principles.

By the conclusion of the course, attendees will be able to apply these skills to improve patient care and implement sustainable, innovative solutions.

Statement of the objective / learning objectives

1. Understand the six fundamental principles of partial hand prosthesis socket design.
2. Apply casting, model modification, and socket fabrication techniques.
3. Incorporate sustainable design practices to enhance clinical outcomes.



Technical track | P&O Material science & fabrication techniques

7.15 More efficient and more sustainable fabrication processes in O&P industry

Lars Hellmich, [Tino Hartmann](#)

Ottobock SE, Duderstadt, Germany

Abstract

We want to show different fabrication processes with which O&P professionals cannot only save time during fabrication of a fitting, but also work with more sustainable materials that create less waste.

In addition we will open up a box of tips and tricks that will help form a more efficient and innovative working procedure in the technician's workshops.

Not only processes or materials, but also machinery will be a cornerstone in our industry's future. We will demonstrate equipment and workflow patterns that will guide the industry into the next level of efficiency and quality.

Statement of the objective / learning objectives

Visitors will learn new procedures on how to run their workshops more efficient and more sustainable. Each process is easily implementable and will make an effortless transition from ISPO to the workbench.



Technical track | P&O Fabrication techniques

7.16 Advancing Techniques in Orthotic Ankle Joint Fabrication: Design, Materials, and Manufacturing Processes

Sean McKale

Becker Orthopedic Appliance Co., Troy, USA

Abstract

This program delivers a comprehensive technical exploration of metal orthotic ankle joint fabrication, focusing on precision manufacturing techniques, material science, and mechanical performance. The course covers cutting-edge fabrication methods, providing fabricators with the knowledge and skills to optimize orthotic function, durability, and patient outcomes.

Statement of the objective / learning objectives

Learners will have the opportunity to understand the influence on change in materials, spring technology, and fabrication techniques have on outcome and performance to AFO's when mechanical joints are being used.



Technical track | P&O Material science

7.17 Silicones – an innovative material with high potential in individualized O&P care

Michael Schaefer¹, Tim Baumeister²

¹POHLIG GmbH, Traunstein, Germany. ²Pohlig GmbH, Traunstein, Germany

Abstract

The Silicone-Technology offers many possibilities for use in technical orthopedics due to its excellent mechanical properties and the associated elastic behavior. Unfortunately, this material is still far too rarely used in the everyday life of the orthopedic technician and in his workshop. Since silicones are very sensitive to processing due to their chemical composition and cross-linking characteristics, rules must be observed and special precautions taken in the workshop.

In particular, the combination of different silicones - and also the combination with other materials – will allow special solutions in everyday care and enables an end product with a wide variety of mechanical characteristics. After an introduction to material science and material selection, the following workshop will shed light on the special do's and don'ts when processing silicones.

Using successful areas of application in prosthetics and orthotics, the potential of this material will be explained with selected care examples.

In addition to the important prosthetic applications in the area of distal extremity care after Finger-, Hand- and Foot amputations, the possibilities of a high-performant socket design in the area of leg prosthetics and orthoprosthesis as well as the successful applications area of orthotics are also presented.

The various possibilities of using the material both in mold making and in free shaping result in highly individual orthopedic technical care solutions and greatly enrich the selection of individual solution approaches for the orthopedic technician providing care.

Statement of the objective / learning objectives

After an introduction to the elastomeric material silicone and its processing specifics, the following course will provide various applications in individual socket construction, prosthetics of the lower and upper extremities as well as orthotics.



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