2023 MÉXICO
ISPO 19TH WORLD CONGRESS
Guadalajara, Mexico
24 - 27 April 2023
The Art and the Science

19th World Congress of the International Society for Prosthetics and Orthotics

Guadalajara, Mexico

24 – 27 April 2023

The Art and the Science

ABSTRACT BOOK

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Preface

This abstract book represents the work of contributors to the 19th World Congress of the International Society for Prosthetics and Orthotics (ISPO), held in Guadalajara, Mexico from 24 to 27 April 2023. 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. Taking inspiration from the vibrant backdrop of Guadalajara's cultural and contemporary art scenes, the 19th World Congress theme 'The Art and the Science' invites reflection on these two critical aspects of prosthetic, orthotic and mobility care. The Art can refer to elite craftsmanship and clinical experience that is applied when providing appropriate services for assistive technology consumers. Art can also relate to the personalisation and artistic aspects of device design that incorporates the user's personality and preferences, moving an assistive device beyond "just" a piece of technology. 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 interdisciplinary programme features invited keynote lectures, symposia, instructional courses, free paper and poster presentations, as well as exhibitor workshops. 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 Committee for quality and relevance. Symposia present thematically related research addressing significant problems or controversies in prosthetics, orthotics, mobility and assistive devices, and aim 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 submitted for free paper and poster presentations were peer reviewed by experts invited by the World Congress Scientific Committee 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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Abstracts

Keynote lecture

1.01 Knud Jansen Lecture: Art & Science: An equation that requires passion!

Rosielena Jované C.

ISPO Panama - ISPO Uniendo Fronteras and Sales manager / Int'l Customers, Becker Orthopedic, Troy, USA

Abstract

Craft and Technology are intrinsically linked, and we can delight in the artistic work of O&P professionals in bringing beauty to the shape and form of devices, leading to body movement through our inherent creativity and genius in enabling restoration through rehabilitation. This a common narrative from early lovers of natural laws creating the underlying knowledge through scientific research.

The human right to mobility and freedom to move was enshrined in Common Law a 1000 years ago, inspired by the passion shown in the artistic work of craftsmen, scientists, technologists, therapists, medical practitioners and many other specialists, as they research to discover, validate with prototypes, manufacture, compose and build what we will subsequently use for the goal that was identified.

The extraordinary scientific and technological evolution that we have been able to experience has facilitated the participation of disabled people in activities of daily living and offered us the opportunity to be true artists in everything that we do. Between science and artistic and technological development we find a direct link that evolves in an interwoven way, motivated by the passion that energizes our actions.

In our varied and complex field of continuous learning and work the multi-disciplinary team members complement each other in the same way as our ISPO society is nourished, grows and progresses thanks to the contributions of its members. Their respective and different specialties combine, evolve and bring strength to our continuing quest for knowledge in order to mitigate the disability that affects those who need our help.

1.02 IC2A Inspirational Lecture: Learning to fall… and rising up

Ana Paulina Chavira-Mendoza

Journalist, prosthetic user, Mexico City, Mexico

Abstract

Since I was a child, I fell a lot. But beyond clumsiness, I never thought that I would have to learn to fall because I was going to have only one leg. And later because I would wear a prosthetic leg that sometimes defies the laws of gravity.

I've been wearing my prosthesis for 25 years and I've been through a lot of falls… and not just the physical ones! How was it that I learned how to fall but, more important, how to get up? What inspired me? What motivated me to keep on going?

Although not having a leg sometimes seemed like the end of the world, on many occasions it turned out to be the best opportunity in life.

Keynote lecture

1.03 The Alternative Limb Project: The path to self-expression – 10 years on

Sophie de Oliveira Barata[1], Chris Parsons[2]

[1]Alternative Limb Project, Lewes, United Kingdom, [2]Design Prosthetics Ltd, Lewes, United Kingdom

Abstract
In this talk, Sophie and Chris will discuss the key stages, successes and challenges of the Alternative Limb Project.

Chris will briefly discuss his prosthetic career history and why he believes in the importance of the congress theme "The Art and the Science". He'll go on to talk about his collaboration with Sophie and the Alternative Limb Project and how this has changed aspects of his clinical approach, explaining the crossover between a medical device and wearable prosthetic art and how he brings his clinical experience into the creative process to produce "evocative, provocative and inspirational routes for individual expression for amputees and those with limb difference". He will then introduce Sophie to tell her story.

Sophie will describe what it was like to start out as a technician being an artist in this medical field, and how that has led to inspiring a generation of designers to help bridge the world of medicine and art. She will outline how she works closely with prosthetists such as Chris to create interesting wearable designs that not only inspire the general masses but empower the wearer through engagement and ownership, reflecting something other than fit and function. Finally, Sophie will describe the processes involved in some of the works undertaken by the Alternative Limb Project and how they have contributed to changing the general public's perceptions of amputees and challenged insurance companies about replacing like for like.

Keynote lecture

1.04 Modelling, models and masterpieces: Translating research into clinical practice

Nachiappan Chockalingam

Staffordshire University, United Kingdom

Abstract
Evidence-based guidelines are important for effective clinical management. Without this evidence and appropriate scientific optimisation, the use of assistive devices results in poor treatment outcomes and poor patient experience. Although best practice guidelines have been published for describing orthotic interventions, there are gaps such as the lack of standardisation of the terminology.

Using our research data this talk will start by highlighting the need for further, structured work in this area. Currently, there is a paucity of detail reported in research studies regarding the design and material used in various orthotic interventions. Such a lack of detail not only has the potential to affect the validity of the reported outcomes and the ability to reproduce the studies but could also misinform clinical practice. Whilst arguing for wider research on clinical effectiveness and cost-effectiveness of orthotic interventions, the talk will propose practical “next steps” on reducing the ambiguity of the description of the devices used.

The talk will also discuss that whilst scientific approaches underpin the development of interventions, artistic aspects of device design are extremely important to improve patient compliance. Devices which are not utilised by the user result in a failed intervention, regardless of the underpinning scientific approaches. Then advances in technology will be presented; we now have modelling techniques to help understand individual movement strategies and to provide a meaningful interpretation of segmental dominancy using patterns of movement control. Combining the resulting biomechanical knowledge with appropriate design characteristics we can create masterpieces to provide effective management and monitoring of interventions. The talk will conclude by focusing on how the current clinical practice needs to evolve to meet future needs including telehealth options.

Keynote lecture

1.05 The Northwestern University sub-ischial socket: A journey from idea to development, research, dissemination, and implementation

Stefania Fatone

University of Washington, Seattle, USA

Abstract
Our journey to develop a sub-ischial socket for persons with transfemoral amputation began about 15 years ago sparked by an idea that had its roots in the clinical practice of my colleague and collaborator Ryan Caldwell. This idea and partnership between a clinician and a researcher launched us on a journey that led to United States Department of Defense funding for development of what became a straightforward and standardized sub-ischial socket technique that can be taught to prosthetists. Since then, we have engaged in dissemination activities aimed at translating this technique into practice in parallel with conducting clinical trials aimed at exploring the efficacy and effectiveness of the sub-ischial socket technique. Dissemination has taken many forms, including presentations at conferences and meetings, publications in peer reviewed journals and trade magazines, and conducting hands-on workshops for prosthetists all around the world. Our experience with these efforts illustrates the breadth of activities required of clinicians and investigators to see their research ideas implemented in clinical practice. Sustained effort is required to accomplish this and it is not without challenges. I hope that our journey inspires others to merge clinical creativity with science and research to influence clinical practice for the benefit of all prosthesis and orthosis users.

Symposium: Seating and wheelchair

2.01 Launch of the WHO Wheelchair Provision Guidelines

Kylie Shae[1], Chapal Khasnabis[1], Frederico Montero[1], Claude Tardif[2], Alex Kamadu[3], David Constantine[4], Rachel Cowan[5], Almah Kuambu[6]

[1]World Health Organization, Geneva, Switzerland. [2]International Society for Prosthetics and Orthotics, Brussels, Belgium. [3]International Society for Wheelchair Professionals, Pittsburgh, USA. [4]Wheelchair Provision Guidelines Development Group, Bristol, United Kingdom. [5]Wheelchair Provision Guidelines Development Group, Birmingham, USA. [6]Wheelchair Provision Guidelines Development Group, Port Moresby, Papua New Guinea

Abstract
Join WHO, ISPO and the International Society of Wheelchair Providers in celebrating the launch of WHO Wheelchair Provision Guidelines. Wheelchairs are one of the most commonly used mobility devices, and have the potential to enhance individual's health, independence, productivity and quality of life. However, many people are denied access due to a lack of services and/or have poor outcomes due to their needs not being matched to the best wheelchair solution for them.

These Guidelines build on lessons learned from the 2008 WHO Wheelchair Guidelines and have drawn on the growing body of knowledge of best practice in wheelchair provision in order to provide evidence-based recommendations and best practice guidance to support countries in developing or improving essential wheelchair services. The Guidelines aim to ensure wheelchair users everywhere have the opportunity for timely access to, and support to use, an appropriate wheelchair through wheelchair services that are people-centred and responsive to their individual needs and goals.

The session will include presentations from a range of speakers and a Q&A.

Statement of the objective / learning objectives
Attendees will hear perspectives from wheelchair users on the status of wheelchair provision globally, learn how the Guidelines were developed using the WHO Guidelines methodology, and have an overview of the Guideline recommendations.

Symposium: Rehabilitation medicine and surgery

2.02 How about the treatment of stiff knee gait post-stroke?

Corien Nikamp[1,2], Erik Prinsen[1,2], Martin Tenniglo[1,3]

[1]Roessingh Research and Development, Enschede, Netherlands. [2]University of Twente, Enschede, Netherlands. [3]Roessingh, Centre for Rehabilitation, Enschede, Netherlands

Abstract
Stiff knee gait is a common gait deviation observed after stroke and characterized by a decreased peak knee flexion during swing. Overactivity of the rectus femoris muscle is often related to this reduced peak knee flexion, and stiff knee gait is linked to limited walking speed, stumbling and falls. This symposium will include basic scientific research on the treatment options for stiff knee gait post-stroke with implementation of results into clinical practice.

The symposium will start with scientific research performed at Roessingh Research and Development and includes the results of a RCT on botulinum toxin injections in the rectus femoris after stroke, as treatment option for a stiff knee gait. Patient examples and clinical recommendations from this RCT will be discussed.

The symposium will continue with a stroke case from the clinical practice of Roessingh, Centre for Rehabilitation. The clinical gait analysis and treatment options will be discussed, including botulinum toxin injections and surgical intervention like rectus femoris transfer.

To conclude, we will present a special case study of the Roessingh Diagnostic Centre, concerning a young stroke patient that used to exercise at high level (triathlons) and requested for a rectus femoris transfer surgery to improve running. We will demonstrate the clinical decision making process of this case as, to our knowledge, no scientific evidence of such a surgical intervention to improve running post-stroke is available. The debate highlights the importance of including situations other than straight line walking in clinical decision making, related to the ambitions of the patient.

Statement of the objective / learning objectives
To get insight in the scientific evidence of treatment options of stiff knee gait post-stroke and to understand how this evidence is incorporated in clinical decision making of treating stroke patients presenting stiff knee gait.

Symposium: Education

2.03 Intra- & interprofessional experiences in O&P education: What does it look like and where is it going?

Jeremy Sherman[1,2], Lisa Abernethy[1], Ashley Mullen[1]

[1]Baylor College of Medicine, Houston, USA. [2]New Life Brace and Limb, Houston, USA

Abstract
Orthotic and prosthetic (O&P) education programs must introduce students to a plethora of content, including the rehabilitation team and component manufacturers. Given the educational requirements as outlined by the International Society for Orthotics and Prosthetics and national accreditors, interweaving manufacturer-created content and inter-professional learning experiences can be a challenge for educators. This symposium will provide evidence-based recommendations and evaluate programmatic approaches to intra- and interprofessional education in orthotics and prosthetics.

Part one will focus on intra-professional collaboration. O&P has a variety of roles within the profession, including but not limited to technicians, manufacturers, and administrative staff. We will discuss considerations for incorporating various O&P professionals into clinician-level curricula through active learning methodologies.

Part two will focus on interprofessional collaboration. Orthotists and Prosthetists must communicate effectively with physicians and therapists in order to ensure the most appropriate and effective plan of care. We will provide examples of interprofessional activities with medical and therapy students which offer ways explain professional roles and establish communication pathways.

Part three will focus on future ways to integrate intra- and interprofessional education into the spectrum of learning, from classroom instruction to clinical residency and professional development. We will apply principles from parts one and two to discuss the intricacies of the rehabilitative care team and workplace dynamics.

Statement of the objective / learning objectives
Attendees will be able to define intra- and interprofessional education, apply evidence-based teaching methodologies, and discuss the application of educational approaches to “real-world” clinical scenarios.

Symposium: Outcome measurements

2.04 A national approach to collect patient experience data for orthotic/prosthetic providers in Australia: The AOPA consumer experience programme

Leigh Clarke[1], Emily Ridgewell[1], Michael Dillon[2]

[1]The Australian Orthotic Prosthetic Association, Melbourne, Australia. [2]La Trobe University, Melbourne, Australia

Abstract
Patient experience surveys are widely used to measure healthcare quality. When collected in a transparent and standardised way, patient experience data can be used by orthotic/prosthetic (O&P) service providers to identify areas for improvement and track the effectiveness of interventions to improve patient experience over time. The aggregation of these data across O&P service providers can be used to establish a national benchmark that allows individual service providers to compare their own service to others across the country. The national benchmark data can also be used by professional associations to identify opportunities for targeted education that supports services providers to improve patient experience and to monitor the effectiveness of initiatives. When made publicly available, these data can also be used by patients to help make an informed and well-evidenced decision about their choice of service provider.

In this symposium we describe the AOPA Consumer Experience Program (CEP) – a national approach to the systematic collection, analysis, and reporting of patient experience data for orthotic/prosthetic providers in Australia. We provide an overview of the CEP and describe the development of the CEP's novel components: the survey instrument, a real-time reporting portal, and national benchmarking. In addition, the symposium will outline the anticipated benefits of the CEP and share the challenges of developing and implementing this program on a national scale, including perspectives from enrolled service providers.

We provide detailed information about the CEP to support others wishing to implement similar national-level patient experience programs, in their own jurisdictions.

Statement of the objective / learning objectives
Attendees will learn about: the motivation to develop the AOPA Consumer Experience program, how the CEP works, the program's innovative features, the benefits of the program, and the implementation challenges.

Symposium: Orthotics: Lower limb neurological

2.05 Microprocessor stance and swing control orthoses are a milestone for patients with lower limb paresis dependent on knee-ankle-foot orthoses

Andreas Kannenberg[1], Shane Wurdeman[2], Arun Jayraman[3], Andreas Hahn[4]

[1]Otto Bock Healthcare LP, Austin, USA. [2]Hanger Clinic, Austin, USA. [3]Shirley Ryan Ability Lab, Chicago, USA. [4]Otto Bock Healthcare Products Ges mbH, Vienna, Austria

Abstract

Locked knee-ankle-foot orthoses (LKAFOs) that force patients to always walk with a stiff orthotic leg are the standard of care for individuals with knee instability due to neuromuscular or central nervous disease. Technological “advances”, made decades ago, such as posterior-offset KAFOs and stance control orthoses lock the orthotic knee during stance and unlock it for free swing. However, the benefits of these orthoses are primarily limited to level walking. Thus, orthotists and KAFO users are faced with a tremendous technology and clinical benefit gap compared to the prosthetic options for patients with amputations. A microprocessor stance and swing control orthosis (MP-SSCO – C-Brace®) that closes this gap has been available for about 10 years. The symposium will give a comprehensive overview on the clinical research performed with the C-Brace. It will summarize all published studies and present yet-unpublished clinical results of two ongoing trials. One study is investigating the potential benefits of the MP-SSCO in the post-acute rehabilitation of patients with incomplete spinal cord injuries. The second trial is an international, randomized, multi-center study with 75 current KAFO users at 14 sites in 4 countries. Preliminary results shortly after completion of the study showed statistically significant and clinically meaningful improvements in risk of falling, actual falls, performance-based and patient-reported function and mobility. First subgroup analyses revealed important differences between patients with different underlying conditions and types of conventional orthoses currently used. The complete statistical analysis will give orthotists valuable guidance for the differential orthotic treatment of their KAFO patients.

Statement of the objective / learning objectives

1. Understand the current body of evidence for the MP-SCCO.
2. Be able to apply the evidence on differential benefits of the MP-SSCO on patient groups with different medical conditions and current KAFO types.

Symposium: Orthotics: Lower limb neurological

2.06 Precision orthotics: Evidence and new technologies to individualise ankle foot orthosis stiffness

Niels Waterval, Merel Brehm

Amsterdam UMC, Amsterdam, Netherlands

Abstract
In many diseases such as neuromuscular disorders and cerebral palsy, ankle foot orthoses (AFOs) are applied to normalize the gait pattern and augment walking ability. However, a large percentage of the provided AFOs do not normalize the gait pattern and/or improve walking ability, leading to suboptimal treatment effects and non-use. As the effect of AFOs on improving gait depends largely on their mechanical properties, an inadequate match between AFO properties and patient impairments can explain part of this ineffectiveness. To maximize treatment effects of AFOs, the stiffness needs to be optimized for each individual user, which we have coined Precision Orthotics.

In this symposium, we will demonstrate the beneficial effects of applying Precision Orthotics in the prescription of AFOs as demonstrated by clinical trials in Cerebral Palsy, Neuromuscular diseases and Neurological disorders. Thereafter, we will demonstrate two innovative techniques that are currently being developed to optimize AFOs quickly. Regarding the first technique, a demonstration about how forward dynamic simulations work, what they have taught us about AFO individualization and how they might be used to predict the optimal AFO stiffness will be given. With regards to the second technique, we show a newly developed stiffness-adjustable AFO for which the stiffness can be changed instantaneous during walking. This allows for a rapid optimization procedure, making it easier to implement optimization of AFO stiffness in daily practice. The first tests with the ADJUST-AFO will be conducted in the winter of 2022.

Statement of the objective / learning objectives
Participants will learn about the beneficial effects of Precision Orthotics and become familiar with innovative techniques to implement Precision Orthotics in clinical practice in the near future.

Symposium: Gait and balance

2.07 Instrumented gait analysis in the fields of prosthetics and orthotics: Are we doing it right?

Erik Prinsen[1,2], Corien Nikamp[1,2], Nerrolyn Ramstrand[3], Saffran Möller[3]

[1]Roessingh Research and Development, Enschede, Netherlands. [2]University of Twente, Enschede, Netherlands. [3]Jönköping University, Jönköping, Sweden

Abstract
Instrumented gait analysis has become the gold standard to assess gait-related outcomes in the fields of prosthetics and orthotics. However, there is no consensus on the best way to perform an instrumented gait analysis or how to report the results. In addition, while the majority of trials have investigated kinematic and/or kinetic parameters during straight-line overground walking, one may question whether those conditions are most clinically relevant.

This symposium challenges the current practices in instrumented gait analysis by offering three new perspectives gained in both orthotic and prosthetic gait research. The first challenge is whether normalizing the gait cycle from heel contact to heel contact forms the best base for comparing gait analysis over time. What if the main changes occur in shifting the subphases in gait? How will this influence the results if we do not take this into account? The second challenge is whether we know what the day-to-day variation of the gait pattern is. How large is this variation? How do we know whether differences identified in the gait pattern are true differences or the mere results of normal spread in gait data? How many steps should we collect? The third and final challenge is whether we are collecting outcome measures that are clinically relevant to the orthotic and prosthetic user. Should we focus only on spatiotemporal, kinematic and/or kinetic variables of gait? Are there other outcome variables related to effort and attention that are more meaningful? What do these outcome measures show us?

Statement of the objective / learning objectives
The learning objectives of this symposium are offering a critical reflection on current gait analysis practices and presenting a starting point on how to move this field forward.

Symposium: Prosthetics: Lower limb

2.08 Body-device interface interactions: Things you should know about mechanobiology

Arjan Buis[1,2], Marisa Sargent[1], Anton Johannesson[3], Morag Robertson[1]

[1]University of Strathclyde, Glasgow, United Kingdom. [2]University of Rwanda, Kigali, Rwanda. [3]Ossur, Reykjavik, Iceland

Abstract
Understanding how load is transferred from the prosthetic socket to the weight bearing structure, the skeleton, is still limited. Considerable efforts are therefore required to further optimise body-device interface design and reduce instances of discomfort and injury. One of the next frontiers in this area is the mechanobiology of body-device interactions. The aim of this symposium is to discuss in a multidisciplinary team from the researcher, user, and clinician perspective.

1. what is already known about body-device interface mechanobiology,
2. where the most significant gaps in our understanding are, and
3. how this information could benefit the design, prescription, and management of body-device interfacing technologies.

More specifically, an introduction to prosthesis-related tissue injuries will be given, which also discusses the reaction of skeletal muscle to prosthesis-related loading, as well as open challenges in the prosthetic interface system. Beside the risk for deformation-induced soft tissue injury, mechanical loading can also affect the vascular supply. Current results from oximetry studies will therefore be reviewed and the need for further research highlighted. Lastly, different approaches to postoperative treatments and shape capturing methods will be discussed from a clinical perspective, which have a direct influence on pressure distribution across the residual limb and therefore the mechanobiological environment.

The session will conclude with an interactive discussion between the panel members and the audience focussing on ways that mechanobiology can and should influence prosthetic design and decision making.

Statement of the objective / learning objectives
To provide an understanding of the interplay between mechanics and biology within the residual limb, present current research methods to explore this relationship, highlighting the importance of considering mechanobiology for creating a successful prosthesis-limb interface.

Symposium: Low- and middle-income countries

2.09 Sustainable design of lower limb prosthetic components for low-resourced regions

Tim Bryant[1,2], Heinz Trebbin[3], Jan Andrysek[4,5,6], Eduardo Sotelo[7], Thanh-Duc Nguyen[8]

[1]Queen's University, Kingston, Canada. [2]Centre for Health Innovation, Kingston, Canada. [3]DOI ortho-innovativ GmbH, Durach, Germany. [4]University of Toronto, Toronto, Canada. [5]Bloorview Research Institute, Holland Bloorview Kids Rehabilitation Hospital, Toronto, Canada. [6]LegWorks, Inc., Toronto, Canada. [7]Horus Prosthetics, Lima, Peru. [8]Department Human-Machine Interaction, Fraunhofer Institute for Manufacturing Engineering and Automation, University of Stuttgart, Stuttgart, Germany

Abstract
This symposium will address the availability of high-quality lower limb prosthetic components in low-resourced regions. Prosthetic device design processes can be described in four phases: i. Needs analysis; ii. Scientific research; iii. Product development and testing; and iv. Manufacturing and distribution. Best practices in these phases must be undertaken for products intended for all prosthesis users. However, there are significant challenges to providing sustainable devices for low-resourced regions. Case studies of knee and foot component design will be discussed by scientists, manufacturers, clinicians and NGOs. Three presentations will be followed by a panel discussion with questions from the audience.

1. NGO Experiences. This presentation will focus on the needs for lower limb devices in low-resourced regions and the strategies employed by international NGOs over the past 30 years to address these issues.

2. Prosthetic Knee and Foot Design Research. This presentation will describe design principles and research studies undertaken to develop two unique devices and challenges faced in making them available for low-resourced regions. The All-Terrain (AT) Knee is a 4-bar prosthetic knee joint that fulfills the security needs of low mobility users while still meeting the demands of active amputees. The Niagara Foot is a durable component that can be individually adapted to control the mechanical response for a broad range of users.

3. Applications and Challenges. Clinical experiences with knee and foot devices available in low-resourced regions will be described. Issues of affordability, durability, system compatibility and long-term sustainability will be discussed, and challenges identified for future work.

Statement of the objective / learning objectives
Participants will gain knowledge of sustainable design practices for lower limb components used in low-resourced regions. An interdisciplinary paradigm will be used that includes viewpoints from science, engineering, clinical, societal, manufacturing, NGO, and business perspectives.

Symposium: Prosthetics: Lower limb transfemoral

2.10 Influence of co-morbid health and component selection on mobility and fall risk among older diabetic/dysvascular amputees

Phillip Stevens[1,2], Shane Wurdeman[3,4]

[1]Hanger Institute for Clinical Research and Education, Salt Lake City, USA. [2]Department of Physical Medicine and Rehabilitation, University of Utah Health, Salt Lake City, USA. [3]Hanger Institute for Clinical Research and Education, Austin, USA. [4]Department of Biomechanics, University of Nebraska at Omaha, Omaha, USA

Abstract

While much of the historical evidence in lower limb prosthetic rehabilitation has relied upon smaller studies conducted among younger, traumatic amputations, the older diabetic/dysvascular amputee has represented the majority of individuals in the United States with increasing prevalence across the world. Drawing upon a series of peer-reviewed multi-site retrospective analyses of real-world outcomes, this presentation will challenge conventional assumptions regarding older diabetic/dysvascular amputees. In the Mobility Analysis of AmpuTees (MAAT) series, evidence found that diabetes was not a significant predictor of mobility with a prosthesis (n=596, MAAT 2), the integration of microprocessor knees (n=450, MAAT 3) and microprocessor ankle-foot mechanisms (n=738, MAAT 5) are associated with increased mobility, and patients report good quality of life years after dysvacular amputation (n=341, MAAT 6). Additionally, an analysis of 11,995 lower limb prosthesis users provided normative mobility data to understand specifically how individual patients are performing relative to their peers (MAAT 7). Further, in the first study within the Stability And Falls Evaluation in AMPutees (n=881, SAFE-AMP) series, it was noted that a microprocessor knees significantly reduces odds of an injurious fall among diabetic, above-the-knee amputees. This presentation will enrich awareness of current trends in effective prosthetic rehabilitation for the older diabetic/dysvascular amputee.

Statement of the objective / learning objectives

Attendees will learn the impact of comorbid health conditions on prosthetic mobility in older patients, and the methods available to positively impact prosthetic mobility and fall risk mitigation including utilization of modern technology.

Symposium: Device fabrication and design

2.11 Digital transformation of prosthetic and orthotic services

Ben Oldfrey[1], Edward Lemaire[2], Jeff Erenstone[3]

[1]University College London, London, United Kingdom. [2]University of Ottawa, Ottwawa, Canada. [3]Operation Namaste, Lake Placid, USA

Abstract
35–40 million people globally need prosthetic and orthotic (P&O) services, with the global need expected to double by 2050. WHO estimates that only 5–15% of the people who could benefit from assistive products have access to appropriate devices. To improve access to services, digital technologies could be a facilitating factor.

Traditionally, manufacturing prostheses and orthoses depends on several steps and processes, requiring a high degree of craft expertise. It is a labor and infrastructure-intensive process that requires machinery and tools, deployed through facilities that can be costly to establish and operate.

Digital transformation of the manufacturing process could be one of the most promising methods to meet the growing need for prosthetic and orthotic services. However, discussions continue within the prosthetics and orthotics community about the potential opportunities for, and concerns about, digital transformation linked to the manufacture of prosthetic and orthotic devices, as well as provision of services aimed at improving access and service quality.

This symposium will share recent work undertaken by ISPO and GDI Hub to better understand the current evidence for digital transformation for manufacturing of prostheses and orthoses and discuss how barriers in the evidence base could be overcome. It will cover the following areas:

1. Systematic review and global survey outcomes:

- Level of evidence and practice for digital processes and products across:
  - Prosthetics
  - Orthotics
- Gaps & Recommendations

3. Expert Panel bringing together clinical, industry and academic points of view on how to respond to these gaps together and fully potentiate digital fabrication.

Statement of the objective / learning objectives
We will overview the level of evidence for different digital products and processes that could transform prosthetic and orthotic manufacturing and give recommendations for how the community could address current barriers.

Symposium: Healthcare policy and services

2.12 Introducing the WHO Standards for Prosthetics and Orthotics Assessment Package: A new tool to support standards implementation and data collection

Louise Puli[1], Chapal Khasnabis[1], Claude Tardif[2], Anders Eklund[3], Emma Tebbutt[1]

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Abstract
World Health Organization (WHO) published Standards for Prosthetics and Orthotics, consisting of the Standards (Part 1) and an Implementation Manual (Part 2), in 2017. Developed in collaboration with the International Society for Prosthetics and Orthotics (ISPO) and a wide group of international specialists, the document presents Standards for countries to use in developing or strengthening essential, affordable, accessible, effective, efficient, safe prosthetics and orthotics services of high quality.

The Standards Assessment Tool has been developed to help countries to objectively measure the degree to which the WHO Standards are being implemented. It guides the users through the assessment and generates a score on the implementation for each Standard and Standard Area. It also provides recommendations on steps that can be taken to increase Standards implementation and thereby further develop and strengthen prosthetics and orthotics services.

Statement of the objective / learning objectives
By the end of the symposium, participants will be aware of the prosthetic and orthotic standards and of the assessment tool developed to measure the degree to which the standards are implemented

Symposium: Education

2.13 ICRC's approaches to the training and education of prosthetists and orthotists, present and future

Subhash Kumar Sinha[1], Mohammad Jubayer Hossain[2], Mamta Kumari[3], Nizar Akhtar[4], Aziz Ahmad[5]

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Abstract

The Rehabilitation workforce is one of the six pillars of strengthening Rehabilitation in Health System and achieving Rehabilitation 2030 goals. The Education and Training of rehabilitation professionals is key to improving quality and sustainability of physical rehabilitation programs in any country. The International Committee of the Red Cross (ICRC) has been supporting more than 10 education programs in low- and middle-income countries since 2005, acquiring vast experience in this field.

During the symposium on Education, the ICRC will present its experience in conducting/supporting formal training, will share the challenges faced due to uncertain political or security situations related to infrastructure, curriculum, employment, brain drain, etc and how these have been overcome.

The ICRC's internal capacity and access to experts in delivering continuous professional development and "on the job" training helps with developing the capacity of local trainers in the short term and upgrading of their qualifications in the long term. Conventional training methods are used alongside blended learning modes respecting international standards. Building capacity of the local partner institutions and developing a regional education and training hub are the preferred approaches of the ICRC. The goal is sustainable education programmes that ensure quality of services.

Three presentations from the Asian, African, and Middle Eastern contexts will present and discuss challenges, facilitators, and opportunities in their education projects. Educators, clinical practitioners, policy makers and exhibitors will all learn from the ICRC experience. Ideas generated through participation in the discussion will help shape the new ICRC Education and Training strategy.

Statement of the objective / learning objectives

The symposium will provide an overview of the ICRC approaches to the Training and Education of Prosthetists and Orthotists as well as present challenges, facilitators and opportunities faced in low-and middle-income countries.

Symposium: Prosthetics: Lower limb transfemoral

2.14 Prosthetic knee selection for individual patients: Technical, biomechanical, clinical and evidence considerations

Andreas Kannenberg[1], Shane Wurdeman[2], Phil Stevens[3], Malte Bellmann[4], Andreas Hahn[5]

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Abstract
Prosthetic knee joints may utilize a variety of stance control mechanisms – lock, friction-brake, 4-bar, multiaxial, non-microprocessor and microprocessor-controlled hydraulic – and swing control mechanisms – lock, friction, non-microprocessor and microprocessor-controlled pneumatic or hydraulic. All mechanisms have specific safety and mobility benefits but also specific requirements to the patient´s residual function(s) to operate them safely and effectively. Therefore, the prosthetist is tasked with the challenge to match the physical (and cognitive) abilities, safety and mobility needs of the patient with the best-suited prosthetic knee mechanism. Unfortunately, clear recommendations for prosthetic knee selection for individual patients are currently lacking. This symposium will present technical, biomechanical, clinical, and evidence considerations to guide the prosthetist in determining the best knee mechanism for an individual patient. It will cover the pros and cons of all non-microprocessor and microprocessor-controlled prosthetic knee mechanisms, discuss technical, biomechanical, clinical, and evidence considerations for prosthetic knee selection including a decision tree for non-microprocessor-controlled knee mechanisms, debunk myths on certain knee mechanisms, and provide guidance to clinicians through the maze of manufacturer claims. The technical, biomechanical, and clinical considerations of knee selection will be further strengthened by a review of the published clinical and scientific evidence on the various prosthetic knee mechanisms.

Statement of the objective / learning objectives
1. Understand the differences between the different types of prosthetic knee mechanisms.
2. Understand the criteria for selecting different types of non-microprocessor knees.
3. Understand the clinical criteria for selecting microprocessor-controlled knees.

Symposium: Gait and balance

2.15 Balance and postural control of people with lower limb amputations: Perspectives from an interdisciplinary group of professionals

Cleveland Barnett[1], Bill Miller[2], David Rusaw[3], Sarah Anderson[4], Aditya Dhariwal[2]

[1]Nottingham Trent University, Nottingham, United Kingdom. [2]The University of British Columbia, Vancouver, Canada. [3]Jönköping University, Jönköping, Sweden. [4]La Trobe University, Melbourne, Australia

Abstract

Balance, postural control and issues related to falling and the fear of falling are major problems for people with leg amputations. Structural changes after an amputation that affect balance and postural control include asymmetry of limb length. The inability to actively control posture via an intact foot and ankle complex on the affected side as well as altered sensory input may affect postural control. Such changes can be considered intrinsic factors as these are specific to the individual. Prosthetic restrictions that attempt to mitigate the above intrinsic limitations can be considered extrinsic factors. These intrinsic and extrinsic factors interact to determine an individual's balance which is a key determinant of their likelihood of falling and/or fear of falling.

The aim of this symposium is to bring together representatives from a variety of related fields relevant to lower limb amputation to provide a holistic view of the topic and future directions.

As a basis for the symposium, the progress and current results of a scoping review to summarise the current state of research in balance and postural control will be presented. Based on this, we aim to explore future directions in both clinical care and research. The review will be summarised in two categories: intrinsic factors (person/patient-related) and extrinsic factors (prosthesis/environment).

We will also provide additional viewpoints from a variety of perspectives, highlighting the interdisciplinary nature of this issue. These include practical aspects of physical therapy, balance and self-confidence and biomechanics, among others.

Statement of the objective / learning objectives

The aim of the symposium is to communicate the different approaches to research on this topic, in addition to the issues arising in clinical practice. Participants are be encouraged to join in the discussion.

Symposium: Prosthetics: Lower limb transfemoral

2.16 Evidence-based clinical practice guidelines and novel approaches to transfemoral socket interface design

Marlo Ortiz[1], Michael Schaefer[2], Jason Kahle[3], Malte Bellmann[4]

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Abstract
Over 20 percent of individuals living with limb loss have above the knee amputees (AKA). The most reported prosthetic problems, including disuse are related to the socket. An uncomfortable socket has been deemed the primary complaint among prosthetic users. The socket interface is the most crucial aspect of the prosthesis, as it stabilizes the pelvis during stance, provides the user prosthetic control and influences how the components will function. Despite the problems reported, advancements in socket designs have not kept pace with other prosthetic technological advancements. For decades traditional Ischial-ramus containment (IRC) has been and currently remains the standard socket design.

The advent of newer approaches such as vacuum, liner alternatives, flexible interfaces, custom silicone, and advanced rigid frame designs have created improved versions of the AKA sockets. These alternatives are clinically available and recent reports have demonstrated the benefits of alternative socket design to increase patient comfort and performance. While the traditional IRC design reportedly assists in coronal stability and aid in femur adduction during the gait cycle by incorporating high trim lines, research has demonstrated that novel alternative approaches in AKA socket interface design can equally possess coronal stability, while providing improved comfort, range of motion and gait. These improvements can lead to increased use and improved activities of daily living in real-world situations. Alternative designs have demonstrated equivalence or superiority to traditional IRC in key functional indicators such as gait, balance, mobility, pressure, comfort, and preference without indications of compromise compared to traditional IRC.

Statement of the objective / learning objectives
Clinical practice guidelines with high quality evidence will demonstrate newer advanced novel approaches to transferal socket interface e design. Alternative designs can empower clinicians to offer creative choices to their patients while improving overall outcomes.

Symposium: Prosthetics: Upper limb

2.17 Factors associated with elevated well-being in individuals with upper limb amputation

Phillip Stevens[1,2], Shane Wurdeman[3,4]

[1]Hanger Institute for Clinical Research and Education, Salt Lake City, USA. [2]Department of Physical Medicine and Rehabilitation, University of Utah Health, Salt Lake City, USA. [3]Hanger Institute for Clinical Research and Education, Austin, USA. [4]Department of Biomechanics, University of Nebraska, Omaha, USA

Abstract

Following upper limb amputation, well-being is threatened by limitations in upper limb function, interruptions to prior employment, impacts on activity and participation, and a range of common pain experiences. The roll of prostheses in restoring well-being among upper limb amputees has not been fully explored. Drawing upon a series of recent publications, this session will introduce observed usage patterns (unilateral vs bilateral engagement, captured via instrumented accelerometry (n=22)) as well as self-reported preferences in prosthetic engagement across one and two-handed activities (n=411). The relationship between bimanual functional capacity (as measured by a recently validated custom PROMIS short-form (n=269)) and well-being based on a retrospective analysis of patient-reported outcomes (n=250) will be presented, along with the associated impacts of activity and participation levels, prosthesis satisfaction, pain interference, daily wear times and times since amputation. Viewed collectively, these publications suggest that well-being is best pursued through thoughtful prosthetic prescription and training that addresses the restoration of bimanual function in those activities native to an individual's current activities and participation.

Statement of the objective / learning objectives

Attendees will observe the quantified engagement trends of upper limb prostheses and their relationships with self-reported usage patterns. The relationship between bimanual engagement, prosthesis satisfaction and activity and participation with self-reported well-being will be described.

Symposium: Orthotics: Spinal

2.18 Digital orthotic design and management of adolescent idiopathic scoliosis

M. S. Wong[1], Babak Hassan Beygi[1], Alex Kee[2], Lydia Shang[1], Echo Liu[1], JoJo Zou[1]

[1]The Hong Kong Polytechnic University, Hong Kong, Hong Kong. [2]Prince of Wales Hospital, Hong Kong, Hong Kong

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 evidence 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 and design of spinal orthosis to AIS will be introduced and updated clinical findings will be discussed in the symposium.

Symposium: Orthotics: Lower limb neurological

2.19 Biomechanics and gait training of ankle-foot orthoses for individuals post-stroke

Hiroshi Hashimoto[1,2], Toshiki Kobayashi[3], Sumiko Yamamoto[4], Soji Tanaka[5]

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Abstract

Various designs of ankle-foot orthoses (AFOs) are used for individuals post-stroke in clinical settings. It is important to know the biomechanical effects of AFOs on gait, and adjust the AFO stiffness/resistance and alignment appropriately for each individual to improve their gait.

AFO stiffness/resistance in plantar flexion affects rocker functions, toe clearance during swing phase, and upper body alignment. Appropriate stiffness/resistance can reconstruct the rocker functions for smooth movement of affected limbs. Excessive stiffness/resistance may induce negative effects, such as excessive flexion or hyperextension of the knee joint.

AFO stiffness/resistance in dorsiflexion is necessary for some individuals to assist insufficient activity of the plantar flexors, but this may impede smooth dorsiflexion in stance phase for others. Inappropriate dorsiflexion stiffness/resistance of AFOs could induce hyperextension or excessive flexion of the knee joint. AFO alignment also affects ankle and knee joint movement throughout the stance phase.

In order to advance gait improvement, gait training using AFOs is indispensable. Knowledge about AFO functions can facilitate optimal selection or design of AFOs and provide better gait training. Gait training with AFOs can optimize muscle activity of the lower limbs during gait in individuals post-stroke. It is crucial to evaluate each individual to properly design training tactics.

In this symposium, biomechanics of AFOs, AFO's clinical effects, and gait training with AFOs in individuals post-stroke will be discussed from an interdisciplinary perspective of engineers, biomechanists, orthotists and physical therapists. Some case studies will also be included to show practical applications.

Statement of the objective / learning objectives

- To discuss biomechanical effects of AFOs on gait in individuals post-stroke.
- To discuss gait training with AFOs for stroke rehabilitation.

Symposium

2.20 Sustainable prosthetic and orthotic assistance in Ukraine

Jon Batzdorff[1], Antonina Kumka[2], Anton Johannesson[3], Claude Tardif[4], Oksana Lytvynenko[5]

[1]ProsthetiKa, Santa Rosa, USA. [2]Ukraine Prosthetic Assistance project, Hamilton, Canada. [3]Ossur, Oslo, Norway. [4]International Society for Prosthetics and Orthotics, Brussels, Belgium. [5]Ortsabo, Kharkiv, Ukraine

Abstract
Ukraine has had a sudden increase in need for prosthetic and orthotic services by prosthetists, orthotists, doctors and therapists. Usual resources in Ukraine are overwhelmed by the need. There has been a large outpouring of aid and assistance to Ukraine in all areas of health care and rehabilitation. This symposium will explore the existing system for providing P and O services in Ukraine, the current needs, and some of the programs that have been deployed by both domestic and international organizations and teams to meet those needs.

Statement of the objective / learning objectives
Attendees will learn about emergency response in prosthetic and orthotics in general and about specific emergency response in Ukraine, identifying short term versus long term goals.

Symposium: Education

2.21 Students' perception of prosthetics and orthotics education in East Africa

Akouetevi Aduayom-Ahego[1,2,3], Robert Clement Hakorimana[4], Anarème Kpandressi[5]

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Abstract
According to the World Health Organization, people in need of assistive devices globally will be beyond two billion by 2050 and only one in 10 could get access to the assistive product. Eighty percent of people living with some form of disability worldwide live in low-resource countries. In sub-Saharan Africa, progress in training and provision of prosthetics and orthotics (P&O) services has been observed. However, the perceptions of the quality of the training program from the students in East Africa specifically in Rwanda, Kenya, and Uganda have not been explored. The profession of P&O in sub-Saharan Africa faces many challenges in strengthening its educational ethos as well as meeting the huge demands on quality training.

While there is a huge demand for P&O services in sub-Saharan Africa, this symposium will highlight the students' perceptions of the current training programs. We will discuss the potential factors influencing the program as the overall teaching and learning curriculum.

The speakers with their professional experiences in the sub-Saharan African region will discuss the current status of P&O education in Africa in general. Specifically, presenters will highlight the students' perceptions of prosthetics and orthotics education in Rwanda, Kenya, and Uganda. Further action plans to address the current challenges the field is facing will be recommended.

Statement of the objective / learning objectives
Participants will be aware of the current status/challenges and development of P&O education in East Africa and practical action plans for stakeholders will be discussed.

Symposium: Education

2.22 Interprofessional rehabilitation education: Developments, opportunities and benefits for the prosthetics and orthotics profession

Martina Lukin[1], Larisa Hoffman[2,3], Angela Patterson[4,5], Shala Cunningham[6,7], Cheryl Footer[2]

[1]Physiopedia, Tbilisi, Georgia. [2]Physiopedia, Evergreen, Colorado, USA. [3]Regis University, Denver, Colorado, USA. [4]Physiopedia, Omaha, Nebraska, USA. [5]Creighton University, Omaha, Nebraska, USA. [6]Radford University, Virginia, USA. [7]Physiopedia, Virginia, USA

Abstract

Rehab 2030 established the need to strengthen and integrate Prosthetists / Orthotists (POs) and other rehabilitation professions into health systems around the world. Unfortunately, limited opportunities in entry-level education and continuing professional development has impacted the rehabilitation workforce capacity, particularly in low-resourced areas. Multidisciplinary courses that are widely available, easily accessible and offer opportunities for interprofessional education (IPE) may offer a solution by enabling the education of more rehabilitation professionals and promising more effective and efficient education.

We explore the opportunities and benefits of multidisciplinary learning across rehabilitation professions including PO, Physiotherapy, Occupational Therapy and Speech and Language Pathology and introduce a world where rehabilitation providers learn alongside each other in the classroom and in clinical practice, sharing knowledge and resources and drawing upon the distinctive skills connected with their unique professions in person-centred care. A key step towards making this vision a reality is to better understand the education, competencies, standards and practice expectations across the professions, drawing upon commonalities and appreciating differences. We present the outcomes of the process undertaken by an international and interprofessional rehabilitation team in developing a framework to review, compare, and contrast education strategies and expectations across rehabilitation professions.

The wider benefits of interprofessional collaboration for the PO profession include improved ability to educate more PO with limited human resources as well as improved awareness of the role of PO within other rehabilitation professions and across the wider health system thus ensuring stronger interdisciplinary collaboration and rehabilitation service provision worldwide.

Statement of the objective / learning objectives

To identify multidisciplinary collaborative learning opportunities across rehabilitation professions, including Prosthetics and Orthotics, and discuss the benefits and possibilities of interprofessional education.

Symposium: Prosthetics: Lower limb transfemoral

2.23 Safe travels: Gait strategies and features of prosthesis design that support balance when walking with a transfemoral prosthesis

Matthew Major[1,2], Cleveland Barnett[3], Hiroaki Hobara[4]

[1]Northwestern University, Chicago, USA. [2]Jesse Brown VA Medical Center, Chicago, USA. [3]Nottingham Trent University, Nottingham, United Kingdom. [4]Tokyo University of Science, Tokyo, Japan

Abstract
Walking with a transfemoral prosthesis carries inherent risks to balance due to the lack of joint control and sensory feedback when using conventional prosthetic systems. For this reason, people with lower limb loss frequently experience falls and fall-related injuries, many of which occur while walking. Transfemoral prosthesis users must rely on their residual anatomy and compensatory mechanisms to manage prosthesis motion and ground forces to ensure forward progression, knee stability, and foot clearance. In this symposium, we will discuss aspects of gait that transfemoral prosthesis users demonstrate to maintain balance across different mobility scenarios and how features of the prosthesis can support safe movement. Additionally, we will introduce clinical and biomechanical measures used to quantify balance and their respective insight into the question of gait stability. Our symposium will discuss three specific topics through a series of three talks: 1) the management of ground forces and limb segment dynamics to support balance in walking, 2) how combinations of different commercial prosthetic feet and knees interact with the user to support balance and mobility, and 3) the influence of systematically adjusting features of prosthesis design on aspects of safe mobility. This symposium will be relevant to both researchers and clinicians with an interest in measuring and promoting safe mobility for transfemoral prosthesis users.

Statement of the objective / learning objectives

1. Understand biomechanical challenges of maintaining safe gait for transfemoral prosthesis users.
2. Identify elements of transfemoral prosthesis design that contribute to walking safely.
3. Describe clinical and biomechanical measures of balance and gait stability.

Symposium: Education

2.24 Evidence-based practice in education for prosthetic orthotic occupations

Helen Cochrane[1,2], David Rusaw[1,3], Ashley Mullens[4], Sue Spaulding[5], John Brinkman[6]

[1]ISPO, Brussels, Belgium. [2]University of Pittsburgh, Pittsburgh, USA. [3]Jonkoping University, Jönköping, Sweden. [4]Baylor College of Medicine, Houston, USA. [5]University of Washington, Washington, USA. [6]Northwestern University, Chicago, USA

Abstract

This symposium aims to present the current state of 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.

The symposium will follow on from the Global Educators Meeting (GEM) in June 2022 the symposium will present the findings of the educator focus groups held during the GEM and discuss the educators survey.

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.

The objective of this symposium are to help educators in prosthetic orthotic occupations;

- become more aware of the current evidence, best practices and the work currently ongoing to advance the evidence base for teaching in the field.
- cultivate collaborations among educator peers.
- develop and diversify educational practices to stimulate an effective learning environment.

Statement of the objective / learning objectives

The objectives of this symposium are to help educators in prosthetic orthotic occupations;

- become more aware of the current evidence, best practices and the evidence base
- cultivate collaborations
- develop and diversify educational practices

Symposium: Prosthetics: Lower limb transtibial

2.25 Assessment of stump-socket interaction load: Critical appraisal of state-of-the-art measurement techniques to quantify in-socket tissue stress and strain

Han Houdijk[1], Arjan Buis[2,3], Niels Jonkergouw[4], Morag Robertson[2], Alex Dickinson[5]

[1]Dept Human Movement Sciences, University Medical Centre, University Groningen., Groningen, Netherlands. [2]Dept Biomedical Engineering, University of Strathclyde, Glasgow, United Kingdom. [3]College of Medicine and Health sciences, University of Rwanda., Kigali, Rwanda. [4]Military Rehabilitation Centre Aardenburg, Doorn, Netherlands. [5]Faculty of Engineering and Physical Science University of Southampton, Southampton, United Kingdom

Abstract
Prosthetic socket fit related discomfort and pain are among the most prevalent problems experienced by prosthetic users. Despite exciting developments in socket design and manufacturing, they remain a considerable challenge for the prosthetist. This is partly due to the fact that tissue load occurring inside the socket during use are complicated to quantify.

Over the years, measurement techniques have been developed to quantify tissue load and deformation within the socket, some with clinical application potential. These techniques include, amongst others, ultrasound, oximetry and pressure measurement, and numerical modelling for prediction.

These techniques assess different aspects of tissue load and response. Ultrasound can quantify tissue deformation and especially residual bone movement within the socket. Oximetry can be used to assess the oxygenation of the stump tissue, which is affected by load as it can influence blood saturation and perfusion. Finally, pressure and shear stresses at the stump-socket interface can be measured by dedicated sensors. Results from these techniques can be used to in image based finite element analysis, to better understand tissue mechanics and adaptation and guide socket fitting.

In this symposium, we'll critically discuss the state-of-the-art in the application of such technology to assess and improve socket fit. Questions to discuss are: 1) what is the current state of these techniques? 2) what is the validity of these assessments? 3) what is the current clinical applicability? 4) what future development are required? Three experts in the field will deal with these questions based on their recent research results.

Statement of the objective / learning objectives
In this symposium the attendees

- get insight in the state-of-the-art of several methods to quantitatively assess socket-stump interaction.
- Critically discuss validity and potential clinical application of these methods with the presenters.

Symposium: Prosthetics: Lower limb transfemoral

2.26 Improving the safety of direct skeletal fixation: Essential information to develop failsafe devices

Peter Lee[1], Laurent Frossard[2], Juan Ochoa[3]

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Abstract

Lower limb amputees with Direct Skeletal Fixation (DSF) prostheses require a failsafe device to protect the bone and implant from mechanical overload. Although several failsafe devices have been developed, they are each based on different design criteria particularly related to the type of load (direct forces, bending moments, or torsional moments) they protect against and the magnitudes of loads at which the devices are triggered. Consequently, the extent of protection against overload varies between devices and makes comparisons between devices problematic. To address some of the challenges associated with testing failsafe devices, the ARC Training Centre for Medical Implant Technologies (cmit.arc.edu.au) hosted a virtual workshop with major DSF implant manufacturers in August 2020. Critical questions raised at the event included: Are standards required for the failsafe device? What are the safety concerns relating to the failure of a failsafe device? Is it to prevent bone fracture? Is it to avoid implant failure? What type of prosthetic loading profile data is currently used by engineers to inform the design of the failsafe device? The proposed symposium aims to address some of these questions by presenting:

1. Limitations of using the current ISO10328 to test failsafe devices.
2. The state-of-the-art in-vivo measurement techniques and data of loadings in patients with DSF.
3. Experimental and computational modelling technique to develop a safety envelope for designing failsafe devices.

The overarching goal is to establish a test standard for DSF failsafe devices to protect against mechanical overload and to ensure patient safety.

Statement of the objective / learning objectives

Identify the critical relationship between safety, efficacy and daily loading profile applied on Direct Skeletal Fixation.

Symposium

2.27 The O&P Global Project: Uniting national member associations

Leigh Clarke[1,2], Emily Ridgewell[1,3], Michael Dillon[1,3]

[1]O&P Global, Melbourne, Australia. [2]The Australian Orthotic Prosthetic Association, Melbourne, Australia. [3]La Trobe University, Melbourne, Australia

Abstract
Regulation of the O&P workforce is critical to ensure people have access to safe and effective services. Regulation of a profession builds government and stakeholder confidence which strengthens practice (e.g., independent prescribing) and supports workforce growth (e.g., practitioner retention). There are nine core regulatory standards for allied health professions, including minimum education/training, competency standards and code of conduct as examples. Globally few countries have all nine regulatory standards in place for O&P (Clarke et al., 2022).

In contrast, other allied health professions (e.g., physiotherapy, occupational therapy) are well regulated globally and enjoy the aforementioned benefits. Regulation of these professions is supported through a global organisation that guides a network of national associations and supports national-level regulation.

Recently, there have been calls for the establishment of an equivalent global body for O&P (Clarke, 2019; Clarke, 2021) to support the development of national O&P associations and professional regulation for O&P. The O&P Global project has been established to lead the investigation, development, and public consultation to establish this global body for O&P.

This symposium will introduce the full suite of allied health regulatory standards and explore the benefits to workforce growth and development. It will outline the extent to which these regulatory standards are in place globally for O&P. Finally, the symposium will introduce the O&P Global project including the upcoming global consultation.

We invite delegates to collaborate with O&P Global, participate in the consultation and subscribe for updates: https://www.op-global.org/connect

Statement of the objective / learning objectives
Attendees will learn how improved national-level regulation will support growth and development of the O&P profession and improve access to high-quality care, and the role the O&P Global Project in achieving this aim.

Symposium: Prosthetics: Upper limb

2.28 The science of overuse injuries after upper limb absence and the art of treating it

Sietke Postema[1], Corry van der Sluis[1], Pamela Gallagher[2], Tallie van der Laan[1], Anneliek Peters[1]

[1]University of Groningen, University Medical Center Groningen, Department of Rehabilitation Medicine, Groningen, Netherlands. [2]Dublin Psychoprosthetics Group and School of Psychology, Dublin City University, Dublin, Ireland

Abstract
To gain the highest level of functioning in individuals with upper limb absence (ULA; acquired or congenital), we should pay more attention to prevention and treatment of overuse injuries. Overuse injuries may be specific, for example carpal tunnel syndrome and tendonitis, or non-specific, such as chronic musculoskeletal complaints of neck or back. Whether or not a prosthesis is used, individuals with ULA have a two times higher risk for development of overuse injury compared to the general population. These injuries are known to increase disability and are related to poorer general and mental health. Our review about overuse injuries showed that both biomechanical and psychosocial risk factors play a role, making it challenging to treat these injuries successfully. In the past years, we have published several studies about overuse injuries in individuals with ULA and we aim to bring the results together in this symposium. We will start with presenting the current scientific knowledge on overuse injuries in individuals with ULA. While using the ICF-model, we will reveal biomechanical and biopsychosocial risk factors known in this population, such as compensatory movements, muscle fatigue and personal factors. As we hypothesize that one of the risk factors for overuse injuries is a mismatch in capacity and performance, we will have a look at the scientific background of this hypothesis and elaborate on what this means for treatment. By addressing these concepts, we invite the audience to discuss with us the art of preventing and treating overuse injuries in individuals with ULA.

Statement of the objective / learning objectives
To gain an overview of the current scientific knowledge on prevalence and biomechanical and psychosocial risk factors of overuse injuries in individuals with upper limb absence, and to discuss the art of treating these injuries.

Symposium: Education

2.29 ExceedOnline: Legacy of covid pandemic on prosthetic and orthotic education: Adoption, adaptation, advancement for innovative solutions

Sisary Kheng[1], Carson Harte[2], Audrey Harte[2]

[1]Exceed Worldwide/National Institute of Social Affairs, Phnom Penh, Cambodia. [2]Exceed Worldwide, Belfast, United Kingdom

Abstract
Prosthetic and Orthotic (P&O) education worldwide was significantly impacted by the Covid pandemic. The majority of P&O programmes were on campus with face-to-face training prior to Covid with few components of virtual education. Covid restrictions, lockdowns, travel restraints and other on-site teaching activities provided opportunities for creative responses, alternative learning and teaching P&O in a new setting, and the ultimate development of a virtual programme. The focus on the development of students' core competencies and faculty's capacity and capability in virtual P&O education ranges from situational analyses, Training Need assessments for both students and faculty for effective teaching and confident learners, technology assessment, curriculum revision, Learning Management System reviews, online mentoring/tutoring, and student feedback system. ExceedOnline resulted from the experience of P&O education in South East Asia training programmes coupling from the impacts of Covid. The management and leadership commitment to the continuation of students' education evolved international networks, experience exchanges, students' collaboration, resource sharing, and modified learning/teaching models for responsive and resilient learning for students from diverse backgrounds with support from local clinical/technical mentors. The advancement of P&O education post-Covid is seen to be inevitably and sustainable with a potential hybrid model that will enhance better access to P&O training worldwide. Successful shifts to virtual/hybrid mode need adaptation to engaging/dynamic curricular activities, learner-focused, strategically planned, and efficiently managed with appropriate technology to the local context and needs of an individual learner, resource investment, and capacity development.

Statement of the objective / learning objectives

- Share experiences on the development of ExceedOnline Education
- Link P&O programmes to work together responding to the learning needs of students during the pandemic
- Facilitate resources for online education worldwide drawing from international collaborations

Symposium: Training and therapy

2.30 A clinical framework for lifelong care for people living with lower limb loss

Natalie Vanicek[1], Christopher Kevin Wong[2], Bill Miller[3]

[1]University of Hull, Hull, United Kingdom. [2]Columbia University Irving Medical Center, New York, USA. [3]University of British Columbia, Vancouver, Canada

Abstract
Lower limb loss is a lifelong condition. Many healthcare professionals focus on helping patients maintain their health, daily activities and quality-of-life. Yet, many patients do not receive sufficient follow-up care tailored to their personal, often complex, needs. These may relate to issues with their mobility and functional gait performance, or to managing their prosthesis, or engaging in more physical activity. Consequently, many patients lead more sedentary lifestyles, which exacerbates existing health comorbidities, and suffer from musculoskeletal pain and experience more social isolation.

We recognize that it is important for health professionals to identify innovative ways to support patients in the long-term to improve their outcomes. In this symposium, we will discuss a clinical framework for providing comprehensive lifelong care for people living with limb loss. We will share the experience of three researchers from different countries (USA, UK, and Canada). Specifically, we will discuss clinical rehabilitation guidelines emphasizing how manual therapy could be utilized to optimize functional movement potential. We will also discuss the implementation of a community-based exercise program and its impact on physical and mental health outcomes. Finally, we will discuss the potential of an online, self-management program designed to equip patients with skills to better manage their condition. The session will conclude with an interactive discussion between the panel and audience focusing on strategies for overcoming barriers to lifelong care within the context of different healthcare frameworks.

Statement of the objective / learning objectives
This session will focus on the provision of lifelong care to help patients achieve their long-term goals and expected outcomes. We will explore innovative approaches to enhance physical and social involvement in daily living.

Basic instructional course: Training and therapy

3.01 Phantom motor execution treatment using augmented and virtual reality to relieve phantom limb pain

Corry K. van der Sluis[1], Maria Munoz-Novoa[2], Shahrzad Damercheli[3], Max Ortiz-Catalan[3]

[1]University Medical Center Groningen, Groningen, Netherlands. [2]University of Gothenburg, Gothenburg, Sweden. [3]Chalmers University of Technology, Gothenburg, Sweden

Abstract
Phantom limb pain (PLP) remains difficult to treat, despite a huge number of available treatments. About 30-80% of persons with a limb amputation experience PLP, which can have a major impact on daily life functioning. The Phantom Motor Execution (PME) program, developed by Prof. Max Ortiz Catalan and his team, uses phantom exercises in augmented and virtual reality to treat PLP. The patient sees himself through a webcam on a computer screen, where a virtual limb is projected over their stump. Electrodes on the remnant limb are used to control the virtual limb. In this way, the patient (re)learns to move his phantom limb, which in turn reduces PLP. A recent international randomized controlled trial into the effectiveness of the PME treatment showed that six months after finishing the treatment, half of the participants still had significantly less PLP. This treatment has since then been improved by using Phantom Motor Imagery (PMI) to facilitate phantom movements prior to execution, as well as by incorporating sensory training using a tactile display. Since this treatment might be an interesting addition to current treatment methods for many rehabilitation teams, we propose an instructional course to demonstrate the PME treatment. The first part of the instructional course will cover theoretical aspects and quantitative and qualitative research results, followed by an explanation of the different parts of the treatment. The second part of the instructional course will be a live demonstration of the treatment.

Statement of the objective / learning objectives
Participants will learn about theoretical aspects of PLP, they will learn about the content of the novel PME treatment and how they could apply this to their own clinical practice.

Basic instructional course: Sports and physical activity

3.02 Sport as a physical and psychological rehabilitation tool for the amputee patient (El deporte como herramienta de rehabilitación física para el paciente amputado)

Alejandra Siller

CIDOP, San Luis Potosí, Mexico

Abstract
Sport has an important role in the lives of all individuals, but it has benefits beyond those applicable to all for individuals with a disability. According to studies less than 40% of the amputee patients participate in sports.

There are many barriers that contribute to this number including physical impairments, prosthesis failure, psychological beliefs, clinician´s lack of knowledge, etc. Clinicians need to understand the power that sports have on the amputee.

Sports has many benefits, besides from the physiological effects on the body it also reduces the focus on the impairment and focuses on the person's ability, leading to greater self-confidence. It reduces the sense of isolation, frustration, and inferiority increasing their sense of inclusion. It delays loss of independence and symptoms of depression. I have seen all this since I founded an amputee soccer team 3 years ago.

Clinicians can use different assessment tests prior to recommending to the amputee patients which sport is best for them. They should consider past medical history, medications, wound assessment, prosthesis, Amp Pro Test, VO2 Max, and the most important the objectives of the patient.

The sessions need to be followed under supervision. This will help to avoid any chance of injury. With the proper guidance, the risk of injury to physically disabled individuals is no greater than that to athletes without disability.

Improving the clinician´s knowledge of sports impact and how to apply it can eradicate many barriers for the amputee to participate in and get all the benefits.

Statement of the objective / learning objectives
Contribute through my clinical experience and knowledge so that other clinicians can learn about and apply the benefits of sport to their patients. Learning to evaluate, adapt the sport and enjoy.

Basic instructional course: Sports and physical activity

3.03 Adapting physical activity training to mixed ability groups of people with lower limb amputation (UR:Enabled)

Miranda Asher[1], Kiera Roche[2]

[1]Walk:Enabled, London, United Kingdom. [2]LimbPower, Surrey, London, United Kingdom

Abstract
Supporting participation in physical activity (PA) for people with lower limb amputation (PLLA) who are sedentary is an important factor in facilitating long term rehabilitation, quality of life, and longevity. Our responsibility as clinicians and researchers is to offer interventions which both improve components of fitness and address the range of barriers experienced by PLLA: capacity (physical ability and associated limitations of the prostheses), safety (perceived, potential, and experienced physical injury and pain), and psychosocial (availability of suitable resources or locations and the attitudes of self and others).

While a well fitted prosthetic limb is crucial for weight bearing activities, prosthetic wear can be limited for periods of time (e.g., due to skin issues, availability of components, recasting) and individuals should not be excluded or remain sedentary during these periods. Therefore, we must adapt interventions to allow participation in PA both when the limb cannot be worn and, with or without a sports limb.

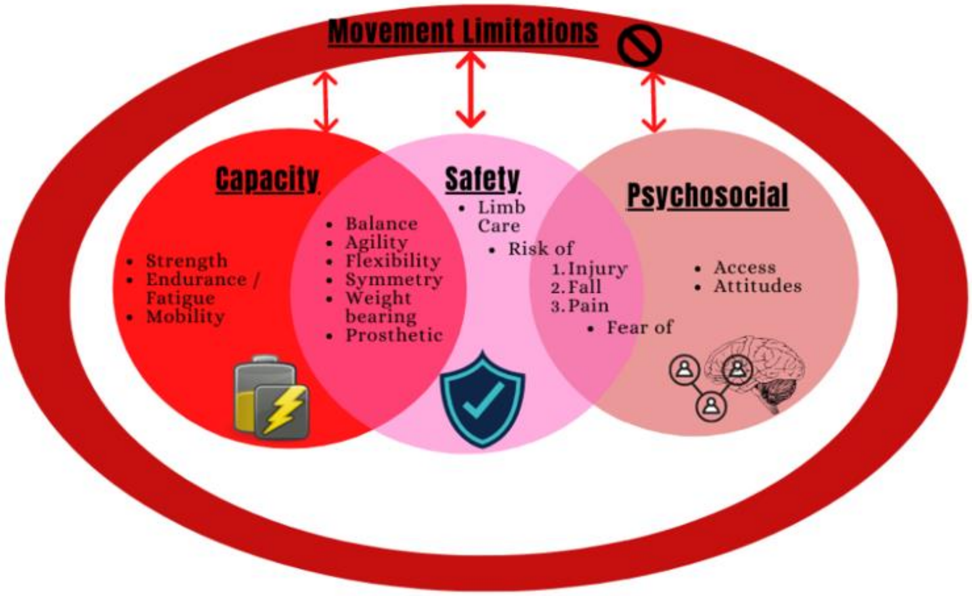

Figure 1. 1Barriers to participation in physical activity for people with lower limb amputation

UR-Enabled is a bespoke and adaptive programme which has undergone a successful feasibility trial. This unique programme can be used by a range of clinicians and exercise specialists to support PLLA participation in PA. The programme includes agility challenges which can be sufficiently adapted to accommodate each individual's current ability in order to limit the risk of injury, while remaining demanding enough to elicit physical improvement. Adapted challenges can be practiced at home (reducing barriers associated with costs and locations) and performed in the group (allowing competition) all factors which keep participants engaged and motivated.

Statement of the objective / learning objectives
(1) Experience exclusion, a group activity where your needs have not been accommodated.
(2) Develop working knowledge on adapting agility exercises, building on established methods, to address the range of barriers experienced by PLLA.

Basic instructional course: Prosthetics: Lower limb transtibial

3.04 No gait lab? Let us play with alignment and gait deviations

Carolina Schiappacasse[1,2], Damiana Pancho[1,3], Favio Montané[4,5]

[1]British Hospital, Buenos Aires, Argentina. [2]Clínica Las Araucarias, Buenos Aires, Argentina. [3]Clinica Las Araucarias, Buenos Aires, Argentina. [4]Maimonides University, Buenos Aires, Argentina. [5]O&P Educational Portal, Buenos Aires, Argentina

Abstract

A PMR doctor will be lecturing on levels of amputation and pathologies of the stump and generalities of amputations and then we will have a PT talking about basic and advanced training for lower limbs amputees and then a CPO will talk about different prostheses, alignment, and biomechanics.

We will then present cases and analyse them from a multidisciplinary approach.

Statement of the objective / learning objectives

To understand the concepts related to the management of TT to improve their knowledge and apply this concept in their clinic.

To understand the importance of a multidisciplinary approach as a tool for their practice

Basic instructional course: Low- and middle-income countries

3.05 Peer group training among people living with a spinal cord injury in rural Cambodia

Pia Nolstedt[1,2], Rune Nilsen[1,2]

[1]Rehabilitation Science Organisation, Oslo, Norway. [2]Sophies Minde Ortopedi, Oslo, Norway

Abstract
A spinal cord injury (SCI) is often described as one of the most devastating injuries one can experience. People with a SCI in Cambodia are underserved in the healthcare system and at risk of short life expectancy, pressures sores, urinary tract infections, psychological problems and tend to score low in all domains that people consider important for quality of life.

This instructional course will establish how studies, activities, and projects from 2009 until today, have led to the collective conclusion that peer group training is an appropriate recommendation for people living with SCI in a low-resource setting, such as rural Cambodia. In addition to general knowledge about SCI, quality of life and the challenges posed by limited healthcare resources, this course will demonstrate how peer group training can be implemented in a nonurban environment. Furthermore, the need for appropriate assistive technology will be discussed.

Statement of the objective / learning objectives
Attendees will learn how peer group training may be implemented in low-resource settings and gain a deeper understanding of how peer group training can impact quality of life among people living with spinal cord injury.

Basic instructional course: Outcome measurements

3.06 Integrating biomechanical-based instrumentation with performance-based outcome measurement in prosthetics and orthotics in resource-limited settings

Gary Guerra[1], Manunchaya Samala[2], Sirirat Seng-iad[2]

[1]Exercise and Sport Science Department at St. Mary's University, San Antonio, Texas, USA. [2]Sirindhorn School of Prosthetics and Orthotics, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

Abstract
Biomechanics has been the cornerstone of Prosthetics and Orthotic research for many decades. Outcome measurement is a standardized instrument used in clinical and research settings to evaluate change in patient performance to an intervention. Outcome measures are broadly categorized as patient-reported (PROM), performance-based (PerfOM) and biomechanical outcome measurement.

This course will explore the biomechanical assessments readily accessible in resource-limited settings, the integration of biomechanical assessments with performance-based outcome measurement, and how such information can guide development and promote our understanding and use of current outcome measurement in orthotics and prosthetics. The contents also cover the possibilities and challenges of incorporating biomechanical-based and performance-based instrumentation and outcome measurement into undergraduate prosthetic and orthotic education and clinical services.

Statement of the objective / learning objectives
Aims to provide prosthetic and orthotic professionals with technically-rich knowledge on cost-effective biomechanical-based measurements and their integration with performance-based measurement for clinical and research instrumentation, as well as prosthetic and orthotic education in austere settings.

Basic instructional course: Prosthetics: Upper limb

3.07 Bilateral upper limb loss and occupational therapy: An overview of resources, adaptive equipment and prosthetic training

Shawn Johnson

Enhancing Skills for Life, Houston, USA

Abstract

Upper limb loss is rare compared to lower limb loss. Bilateral upper limb or quadruple limb loss is even more rare and presents extensive challenges as there is no remaining arm/hand to help perform daily self-care tasks. Because of this, these individuals will be completely dependent on others for some period of time to help with their most basic needs like eating, bathing, dressing, and toileting.

This course will focus on the process of bilateral upper limb loss rehabilitation. Resources and adaptive equipment for activities of daily living (ADL's) will be addressed as well as pre-prosthetic and post prosthetic therapy needs. Along with an experienced team, Occupational Therapists skilled in the area of bilateral upper limb loss, can help individuals missing both arms be quite independent, either with or without prosthetic arms. Key aspects of this process include knowledge of the resources, adaptive equipment and connections with peers, either virtually or in person.

Please be advised that there are entire conferences dedicated to this topic, so this course won't be able to cover the entirety of this topic in one hour but aims to offer resources and information for limb loss individuals and health care providers.

Statement of the objective / learning objectives

After this course, participants will be able to list pre and post prosthetic therapy needs, bilateral upper limb loss/absence adaptive equipment for ADL's as well as helpful resources including Enhancing Skills for Life.

Basic instructional course: Education

3.08 Applying the clinical practice guidelines for use of AFO or FES post stroke: Shared decision-making in action

Lisa Brown[1], Therese Johnston[2]

[1]Boston University, Boston, USA. [2]Arcadia University, Glenside, USA

Abstract

The application of Ankle Foot Orthosis (AFO) or Functional Electrical Stimulation (FES) to address the activity limitations and participation restrictions of individuals with gait dysfunction is common practice post stroke. The Clinical Practice Guideline (CPG) for the Use of AFO and FES Post-Stroke provides evidence to guide the shared decision-making process. This educational session will focus on knowledge translation by demonstrating the application of a clinical decision-making framework focused on implementing the CPG. Videos and a case-based approach will be used to exemplify the shared clinical decision-making process applying Action Statement 2: AFO or FES to Improve Gait Speed in Chronic Stroke. Using a hypothesis driven exam, the case will present a patient specific participation and activity limitation related to gait speed. The examination process will include gait analysis highlighting common gait deviations post stroke and use of the appropriate outcome measures. The potential device effects to consider in the chronic phase of stroke will be discussed. A comparison of FES and various AFO types and their potential impact on gait speed will be illustrated to recommend the most appropriate device type. Clinical decision-making considerations will be highlighted to emphasize the need for a patient centred approach to best meet the needs of the individual. Evidence from the CPG will be highlighted in the case and integrated throughout the presentation to further guide decision making.

Statement of the objective / learning objectives

- Perform a hypothesis driven exam to identify gait deviations in an individual with chronic stroke
- Apply The CPG for the Use of AFO or FES Poststroke into the shared decision making for a patient case

Basic instructional course: Seating and wheelchair

3.09 Evolution of standards in the wheelchair sector: Standardising products, services and training

Mary Goldberg, Jon Pearlman

University of Pittsburgh, Pittsburgh, USA

Abstract

There is an immense global need to standardize wheelchair products, services, and training as mechanisms to increase access to wheelchairs for the 75 million people worldwide in need (WHO, 2018). The prosthetics and orthotics community has long been committed to quality wheelchair service provision. ISPO led a consensus conference over 15 years ago to support the first globally led guidelines development for wheelchairs. This session will describe the history of the development of standards and related documents including the World Health Organization 'Guidelines on the provision of manual wheelchairs in less resourced settings', follow-on World Health Organization wheelchair service standards led by ISPO and the International Society of Wheelchair Professionals, and various product standards that are recognized by the International Standards Organization and other bodies. We will also describe the inclusion of wheelchair content in professional rehabilitation organizations' education standards and the role they can play in competency development of future providers. We will also cover other products like certification for individuals and service accreditation that serve as models for ensuring quality provision. In the interactive portion of the course, we will select 2-3 attendees' countries as case studies and identify how the presence or lack of wheelchair standards have influenced provision and brainstorm action plans for adoption and implementation.

Statement of the objective / learning objectives

- Describe three ways standards can help promote access to quality provision.
- Identify at least two published standards for wheelchairs.
- Identify at least one strategy for how to implement standards.

Basic instructional course: Paediatrics

3.10 Peculiarities in orthoprosthetic care of children with congenital malformations

Michael Schaefer, Tim Baumeister

POHLIG GmbH, Traunstein, Germany

Abstract

The individual care of children with congenital malformations requires specialist knowledge of the clinical pictures, but also an intense cooperation of all disciplines involved in the care team (doctors, therapists, friends, family, orthopedic technicians).

Compared to children with amputation loss, children with congenital malformations do not feel the loss of the missing body part. The experience of many fittings shows that the acceptance of prosthetic aids in the first years of life is essentially determined by the functional benefit and the wearing comfort. The focus here is on ensuring the best possible age-appropriate development and participation with children of the same age.

The following course is intended to systematically discuss and clarify the everyday requirements for the prosthetic fitting of the upper and lower extremities as well as the technical realization in the design of the individual fitting solutions using various examples from these two major fitting areas. The differentiated consideration of longitudinal and transverse defect forms and their consequences also has a significant influence on the design and configuration of the corresponding aids. The effects of endangered joint malpositions as well as additional surgical treatment measures must be included in the layout of the aids.

It should be shown that a targeted supply of aids, taking into account the daily recurring needs, supports and promotes the age-appropriate development of the children.

A final outlook is intended to show solution approaches for the requirements and possibilities of future care concepts for people with congenital malformations.

Statement of the objective / learning objectives

The variety of congenital malformations and their effects on the mobility and functionality of the child require a deficit-oriented approach in the treatment. The course is intended to highlight the essential features of care.

Basic instructional course: Education

3.11 The Alternative Limb Project: Bridging the creative and clinical

Chris Parsons[1,2], Sophie De Oliveira Barata[1]

[1]The Alternative Limb Project, Lewes, United Kingdom. [2]Design Prosthetics Ltd, Lewes, United Kingdom

Abstract
This will be a fun and interactive workshop. Starting with creative divergent and forced thinking games, brainstorming for creative idea generation. With practical elements, we will explore examples of the types of demands for alternative prosthetics and understand how to translate those ideas into reality.

Ending with focus groups and case studies to explore creative solutions for hypothetical clients. We will leave you inspired and unconstrained.

Statement of the objective / learning objectives
Participants will be familiar with the creative/design processes, emphasis on the creative as part of the clinical approach. Mitigating risk through planning and the importance of establishing partnership parameters.

Basic instructional course: Rehabilitation medicine and surgery

3.12 Interdisciplinarity at the heart of prosthetic rehabilitation for patients with upper limb amputation

Marie-Helene Forest, Josee Dubois, Natalie Habra

IRGLM, Montreal, Canada

Abstract
Upper limb amputations significantly impact many aspects of a person's function. Early interdisciplinary patient care is therefore of utmost importance in order to address the patient's individual needs and disabilities. The goal of this interdisciplinary care is to optimize the patient's autonomy with and without a prosthesis, and maximize their performance satisfaction during activities of daily living, ultimately, improving their quality of life.

This presentation will explain the bases of interdisciplinarity, including a review of the current literature on the subject. How these concepts were adapted to the Quebec (Canada) health care system will then be described. The advantages of an interdisciplinary team approach for upper limb amputations will be exposed, detailing the different therapeutic interventions used for this population. Finally, the application of this team approach for prosthetic rehabilitation will be illustrated through a case study of a patient with upper limb amputation.

Statement of the objective / learning objectives
Understand the importance, role and strengths of the interdisciplinary team (physiatrist-occupational therapist-prosthetist) as it relates to prosthetic rehabilitation for upper limb amputations

Basic instructional course: Low- and middle-income countries

3.13 Capacity building in prosthetic and orthotic education in Tanzania

Pia Nolstedt[1,2], Rune Nilsen[1,2]

[1]Rehabilitation Science Organisation, Oslo, Norway. [2]Sophies Minde Ortopedi, Oslo, Norway

Abstract
There is a huge need for well-trained prosthetists orthotists who can fit assistive devices, such as prosthetics and orthotics, especially in low-income countries.

This instructional course will provide insight on how Rehabilitation Science Organisation (ReSciO) has structured and conducted a three-year capacity-building project for teachers at the Tanzanian Training Center for Orthopeadic Technologists. The course will emphasize the importance of appropriate assistive technology regarding the community and context in which you are working, as well as the significance of recipient-determined project content in terms of ensuring long-term benefits. Furthermore, the concept of “training the trainers” with the goal of building a sustainable knowledge base will be discussed and the mutually beneficial effects of capacity-building on the workforce of tomorrow, for both recipient and instructor, will be reviewed.

Statement of the objective / learning objectives
Attendees will gain a deeper understanding of appropriate assistive technology in low-income countries, be presented with a real-world example of how collaboration and capacity-building may be implemented and learn about the “training the trainers” concept.

Basic instructional course

3.14 Health Economics 101: An introduction to health economic evaluations and their use in prosthetics and orthotics

Leigh Clarke[1,2], Michael Dillon[1]

[1]La Trobe University, Melbourne, Australia. [2]The Australian Orthotic Prosthetic Association, Melbourne, Australia

Abstract
Health Economic Evaluations (HEEs) bring together the costs and benefits of interventions to establish a cost-benefit ratio. This ratio allows the cost-benefit of one intervention to be compared to another (e.g., the decision to invest in rehabilitation services for people living with stroke, or extend the list of available componentry for people living with limb loss).

Given that HEEs provide the evidence to inform these sorts of difficult policy and investment decisions, high-quality HEE research is critical to ensure that the limited healthcare funding is invested into interventions that produce the greatest benefit. Despite the importance of HEEs, there are only a small number of prosthetic and orthotic HEEs which limits the ability of policy makers and funders to compare the costs and benefits of different prosthetic and orthotic interventions and consider them alongside other healthcare priorities.

If we are to help inform these policy and investment decisions into the future, we need to build a greater understanding of HEEs. As such, in this instructional course we will discuss:

- different types of HEE evaluations and the policy and investment decisions they’re designed to inform,
- key method design consideration such as time horizons, user or funder perspectives, choice of outcome or benefit measures,
- the unique challenges of conducting high-quality HEEs prosthetics and orthotics.

We hope that the symposium will help reduce barriers to accessing and understanding HEEs and encourage greater awareness.

Statement of the objective / learning objectives
Attendees will gain introductory knowledge of the different types of health economic evaluations, their key method features, and the unique challenges of conducting high-quality prosthetic and orthotic health economic evaluations.

Basic instructional course: Seating and wheelchair

3.15 Importance of appropriate wheelchair maintenance for improving the safety of wheelchair users

Anand Mhatre[1], Lorena Rodriguez[2]

[1]Ohio State University, Columbus, USA. [2]Instituto Nacional de Geriatría, Mexico City, Mexico

Abstract
Wheelchair users experience wheelchair part failures every 2-3 months in low- and middle-income countries (LMICs) and rural areas of high-income countries. One-third of part failures lead to adverse physical, social, psychosocial, and economic consequences to wheelchair users, which increases the public health and personal burden. Wheelchair maintenance has been found to reduce the frequency of wheelchair breakdowns, but compliance with maintenance is extremely low. Our research shows an overall lack of maintenance training and knowledge. Few training programs exist in research settings. But, they include generic maintenance tasks, lack appropriateness to user ability and wheelchair design, and do not reflect how and where the wheelchair is being used. This has led to poor maintenance adoption and, subsequently, a rise in wheelchair part failures and adverse consequences to the user.

Our interactive course will poll the audience as we present three studies. The first study will introduce wheelchair failures occurring globally and demonstrate the impact of wheelchair maintenance on failures. The second study will introduce WheelTrak, a smartphone-based, low-cost, scalable maintenance application that leverages artificial intelligence tools to provide maintenance recommendations tailored to wheelchair use. The third study demonstrates the application of the technology in Mexico; we are conducting a human subjects trial in Mexico to develop usage-based maintenance schedules and perform usability testing. As we present the study, we will engage practitioners and clinicians in a brainstorming session on maintenance tasks for users and service providers. Overall, our course will highlight the importance of appropriate maintenance in wheelchair service provision.

Statement of the objective / learning objectives
Participants will learn about prevalent wheelchair part failures, reactive repair practices and the need for usage-based maintenance led by appropriate technology. Participants will understand the barriers and facilitators for maintenance reported by our study subjects.

Basic instructional course

3.16 Silicone as an outstanding material for individual approaches in O&P

Michael Schaefer, Tim Baumeister

POHLIG GmbH, Traunstein, Germany

Abstract

The specific and diverse properties, such as elasticity, biocompatibility, high density, smooth surface characteristics, individual colour design options, changeability of the mechanical material behaviour give the material silicone a special position in the production of individual orthoses and prostheses.

Due to the complex requirements for processing this material, the material has not yet been able to establish itself across the board in orthopaedic workshops. This material is very sensitive to contamination and environmental conditions in the workshop.

Specialized equipment is often required for professional processing, which does not normally exist in an orthopaedic technical workshop and the professional use of which must first be learned. Too little teaching and specialist knowledge is taught about this material in schools of our profession and universities, which also hinders its spread.

The instructional course is intended to illuminate the special features of the material selection and processing of this elastic material as well as give an insight into the everyday supply of specialized suppliers. Based on various individual fitting solutions from the field of O&P, the special features of this material in everyday use can be demonstrated as examples and individualized fitting solutions relevant to everyday life using this technology can be shown to the audience. In particular, the versatility of a differentiated material selection, the influencing of the material properties and the various possible applications with regard to specific physical requirements in the production of an individual prosthesis or orthosis made of silicone come into their own.

Statement of the objective / learning objectives

Although silicone can demonstrate many successful supply solutions as an elastic material in O&P, its processing has not yet established itself in workshops worldwide. This course aims to create understanding and break down barriers.

Basic instructional course

3.17 "Digital Center Management System": A digital solution supporting the physical rehabilitation to enhance the services provided to health services users

Alice Charline Boubour[1], Aïcha Benyaich[1], Phalla Keo[2], Un Samkol[3]

[1]ICRC, Geneva, Switzerland. [2]ICRC, Phnom Pehn, Cambodia. [3]MoSVY, Kompong Speu, Cambodia

Abstract

About 2.4 billion people are currently living with a health condition benefiting from rehabilitation (WHO 2019). This estimated need for rehabilitation is increasing every year especially in conflict and development countries, where only 5 to 15% (ICRC) of People with Disabilities receive support for mobility needs. There is also an important informational gap on sex, age and disability reducing the effectiveness of humanitarian response.

To address those needs, the International Committee of the Red Cross (ICRC) developed a digital tool; "the Digital Centre Management System" (DCMS), an open-source solution supporting data collection and management of the Physical Rehabilitation (PR) Center. It includes an Electronic Medical Record (EMR) on Open-MRS and an Enterprise Resource Planning platform on Odoo (ERP).

The EMR enables the collection "at point of care" of the information about Health Service Users (HSU), service delivery (physiotherapy, assistive technology…), referrals, assessment and evaluations, follow-up and repairs, according to international standards (International Classification of Function). The ERP enables the management of procurement system, manufacturing, invoicing, maintenance, HR, and dormitory. Both supports the efficiency of the PR services with disaggregated data collection.

In November 2020, the DCMS was piloted in Kampong Speu Center (Cambodia) with 35 employees, where 15'735 HSU have been registered (until 30 August 2022). During this period, the DCMS contributed to positive outcomes, monitoring the services based on "HSU centered approach" with a better transparency. Today the DCMS is deployed in seven PR Centers and is planned to be deployed at the global level for ICRC partners.

Statement of the objective / learning objectives

The DMCS facilitates an optimized (clinical) decision-making that meets the increasing needs in the rehabilitation sector and provide a support to the management of the PR Center when delivering assistive technologies and physical rehabilitation services.

Basic instructional course: Training and therapy

3.18 Training in assistive products: Introducing the WHO's innovative online open access training resource to grow the global AT workforce

Kylie Shae[1], Louise Puli[1], Ritu Ghosh[2], Almah Kuambu[3], Emma Tebbutt[1]

[1]WHO, Geneva, Switzerland. [2]Mobility India, Bangalore, India. [3]National Orthotics and Prosthetics Service, Port Moresby, Papua New Guinea

Abstract
The World Health Organization (WHO) and UNICEF co-published the Global Report on Assistive Technology (Global Report) in 2022 which showed that there is a large, unmet need for assistive technology worldwide. Recommendation three of the Global Report is to: Enlarge, diversify, and improve human resource capacity. The Global Report suggests that reaching adequate personnel capacity at all levels (community/primary, secondary and tertiary) will demand a combination of AT specialists and generalists, as well as shifting roles of other professionals in task-shifting and task-sharing models.

In this interactive instructional course, WHO will introduce participants to Training in Assistive Products, a new WHO open access resource to support growing the global assistive technology workforce through increasing access to fit-for-purpose training.

Training in Assistive Products (TAP) aims to build capacity at community and primary health care level, to enable the workforce to recognise those who may benefit from assistive products, and to provide simple, priority assistive products safely and effectively. TAP is free and accessible to all.

TAP can also be used to deliver AT curriculum within pre-service education, such as nursing or occupational therapy degrees, or as continuing professional development for many health professionals who wish to add simple AT provision to their skillset.

Participants will learn about TAP, it's features, functions and uses and will hear from people with experience of implementing TAP. Following this, participants will have the opportunity to interact with TAP, explore the suite of TAP resources, and ask questions.

Statement of the objective / learning objectives

1. Raise awareness of the potential of TAP to grow the global assistive technology workforce.
2. Build understanding and capacity in effective use of the TAP platform, its resources, and country implementation.

Basic instructional course: Healthcare policy and services

3.20 The evolution of assistive technology and rehabilitation in Togo, West Africa: Strategies, achievements and human resource development

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Abstract
Assistive technology and rehabilitation in low- and middle-income countries face many challenges which stem from lack of government policies, strategies and funding, low production and limited quality, financial barriers, and lack of human resources. Many reports and scientific papers have evidenced this situation. In Africa, precisely in Togo, all the above-mentioned challenges were evident until recently when reflexions, and strategies from the government and supported by international NGOs started to emerge towards overcoming the challenges and developing assistive technology and rehabilitation sectors. Through the new strategies and special involvement of key national and international stakeholders, a lot could be achieved, and a new day is rising for assistive technology and rehabilitation in Togo. During this symposium, we will share the previous specific challenges we faced in the country, the strategies that were developed, the initiatives and the actions taken as well as the achievements, including the development and availability of human resources.

Statement of the objective / learning objectives
The participants will learn from the different strategies implemented to develop assistive technology and rehabilitation sectors and the great achievements and this would be beneficial for those whose countries are in a similar situation.

Advanced instructional course: Rehabilitation medicine and surgery

4.01 Prosthetic care for bionic bone-anchored limbs: From practical experience to clinical guidelines

Laurent Frossard[1,2], Stefan Lau[3], David Lee Gow[4]

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Abstract
Bionics bone-anchored prostheses (BAP) using osseointegrated implants are gaining recognition as a suitable alternative prosthetic attachment, particularly for young, active, non-vascular individuals suffering from lower or upper limb amputations who experience unattainable complications with conventional socket prostheses.

Bionics BAP required specific prosthetic care. The fitting of components is critical to maintain Goldilock’s loading zone during rehabilitation and beyond that are critical to promote osseointegration, avoid loosening, minimise challenging loading and falls, as well as breakages of residual bone and implant parts. Altogether, suitable prosthetic care can contribute to prevent recurrent superficial and deep infections.

As a primary point of care, Prosthetists can impact the clinical efficacy and safety of bionics solutions. Often, they can only partially rely on peer-reviewed evidence to make clinical decisions when treating this unique type of users. Clearly, prosthetic care clinical guidelines are missing.

Consequently, this lack of practical information about recommendations and alignment of bionics BAP leaves Prosthetists more exposed to make ill-informed clinical and business decisions (e.g., risk of litigations).

This symposium will outline the importance of components to ensure clinical safety of BAP (e.g., evidence-based prescription state-of-the-art components). Prosthetists with decades of experience working with bionics BAP will share valuable insights (e.g., pitfalls and solutions). Finally, we will suggest some directions to take toward a collegially agreed standard of prosthetic care for the fitting of BAP.

Altogether, the symposium will contribute to further delineating the specific roles of prosthetists and developing prosthetic care clinical guidelines around the provision of bionics solutions.

Statement of the objective / learning objectives

1. Understand the importance of prosthetic care for bionics solutions.
2. Minimise ill-informed clinical decisions in absence of standard of care.
3. Appreciate pitfalls and risks associated with the delivery of prosthetic care for BAP.

Advanced instructional course: Education

4.02 Teaching methodology in times of crisis

Marcelo Alvarez, Christian Schlierf

Human Study, Nuremberg, Germany

Abstract
The Covid 19 pandemic has changed the world and certainly it has changed the approach of training and education in the field of Prosthetics and Orthotics.

Human Study is known as an ISPO accredited Blended Learning Education Program for more than 15 years and yet, the impact of the crisis was high, despite that a lot of e-learning methods have already been in place by standard. Especially the elements of clinical hands-on demonstrations, training and examination where still challenged to a great extent.

This instructional course aims to present solutions that were developed by Human Study, based on the organization’s vast experiences in Blended Learning Methodology, to effectively deliver clinical training and clinical examinations without onsite presence of the educator teams. While looking into these new methods in general, a detailed look on its effectiveness and potential risks, but also necessary adaptations to address various context, will be provided, in order to discuss the outcome of these methods when applied under different circumstances.

Along this instructional course, Human Study will provide a detailed insight to the new methods and tools developed and share effective methods for their safe application.

Statement of the objective / learning objectives
Attendees will gain a detailed insight to new methods and tools, developed to enable clinical elements of P&O education in times of pandemic crisis and share effective methods for a safe application.

Advanced instructional course: Seating and wheelchair

4.03 The Wheelchair Educators' Package (WEP): A tool to integrate wheelchair-related content into prosthetics and orthotics curricula

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Abstract
Only 5-15% of the 75 million people worldwide that require a wheelchair to fulfill their human rights have access (WHO, 2018). This lack of access increases inequity and limits the ability for countries to meet their obligations under the United Nations Convention on the Rights of Persons with Disabilities.

Although lack of access to an appropriate wheelchair is a multifaceted issue, recent evidence highlights limited wheelchair service delivery education in professional rehabilitation programs worldwide. Indeed, only 50% of Prosthetics & Orthotics educational programs. This situation perpetuates a rehabilitation workforce that often lacks the competencies required for comprehensive wheelchair service delivery.

The WEP was developed as an online, 'living' resource to guide educators in the integration of wheelchair content into university health care professional programs and regional training center curricula. Developed by a team of wheelchair provision experts from across professions and settings, the WEP is intended to be applicable worldwide.

Given the established growing global need for access to appropriate wheelchairs and the expressed focus on educational strategies to increase these competencies in the global prosthetic and orthotics (P&O) community (ISPO Education Standards for Prosthetic/Orthotic Occupations), this course will focus on providing participants with a walk-through of the WEP and with practical examples on how to use it provided by instructors. Additionally, participants will be provided with a supported real-time exploration of the WEP and discussions covering integration within multiple contexts.

Statement of the objective / learning objectives

- describe the Wheelchair Educators' Package (WEP) purpose and content;
- identify how the WEP can enhance wheelchair education provided within P&O programs;
- understand how the WEP may be adapted to improve utility within multiple contexts.

Advanced instructional course: Rehabilitation medicine and surgery

4.04 Rehabilitation of bone-anchored prosthesis users: Worldwide lessons learned and the way ahead

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Abstract
Persons with a lower extremity amputation who aim to regain their walking ability are generally provided with a conventional socket-suspended prosthesis. However, up to 63% of the prosthetic users suffer from chronic skin problems and pain associated with the socket. These problems have a negative impact on their quality of life (QoL), function level, activity level, and participation level.

Bone-anchored prostheses (BAP) using a transcutaneous osseointegration implant (OI) are gaining popularity as a solution for socket-suspended prosthesis users suffering from socket-related problems. The BAP using a screw type OI was introduced in 1990. Since then, various osseointegration implants have been developed (e.g. the press-fit OI) and surgical techniques altered (e.g. two-stage vs single stage). This had an impact on the rehabilitation programs. In addition, insight in the adverse events and functional outcomes after OI surgery also led to evolution of rehabilitation programs.

Presentations will be delivered by experts in rehabilitation care, providing long-term (Sweden, 33 year), mid-term (The Netherlands, 14 year), and short-term (United States, 4-year) experience with BAP care after a lower limb amputation. Topics covered include the philosophy behind the programs and the differences, the evolution of the programs, the procedure and necessity to combine usual care with data collection for research purposes and to facilitate a continuous learning cycle, and facilitate reimbursement, and the pitfalls when setting up a new BAP treatment centre.

Statement of the objective / learning objectives
Long-term, mid-term, and short-term experience in BAP user rehabilitation, including the philosophy behind the programs (both screw type and press-fit type OI's), the evolution, and the implications for the future.

Advanced instructional course: Orthotics: Lower limb neurological

4.05 Why orthotic treatment should be a first line approach for early gait rehabilitation following stroke

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Abstract
This multidisciplinary workshop will build upon the November seminar 2022 of the same title which provides an in-depth background to the reasoning for this approach. For those who did not see this event, a recording may be viewed on the ISPO website.

The workshop will commence with an overview highlighting the main objectives identified.

These include:

- Assessment and decision making
- Simulation
- Prompt Provision
- Treatment planning
- Review and progression

These objectives will then be practically demonstrated in a live patient assessment by a physiotherapist and orthotist during the workshop.

The physiotherapist's and orthotist's assessment will be demonstrated and shared including an assessment technique for orthotists; The Hemiplegia assessment test which assess patient's ability and deficits as well as providing indications for orthotic design. Techniques for simulating the effect and impact of orthotic intervention will be demonstrated.

Treatment by provision of a temporary orthosis will be demonstrated for the patient using a removable cast made the previous day to the presentation. Details of the method will be shared. The cast will be tuned during the symposium.

Dosage of orthotic treatment and physiotherapy intervention for both in and out of the orthosis will be discussed along with prescription development for improvement and recovery.

Statement of the objective / learning objectives
To understand and assess when this approach is appropriate. To be able to communicate the importance of this approach to other members of an MDT

Advanced instructional course: Gait and balance

4.06 New insights for orthotic and prosthetic alignment from research with wearable sensors

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Abstract
Over a decade of research into orthotic and prosthetic gait optimization through controlled alignment will be presented. Findings from this peer-reviewed, published research will be used to illuminate new insights into the alignment process of lower limb mobility aids that will enhance the traditional observational gait analysis used in clinics today.

Wearable, wireless gait instruments have been created that do not greatly add to the mass or bulkiness of ankle foot orthoses (AFO) or transtibial prostheses being used by a patient. The design, performance, and validation of the wearable gait instrumentation developed will be described as well as their intended purpose as clinical tools to provide orthotists and prosthetists with real-time quantitative feedback on kinetic and kinematic measures of gait throughout alignment.

Artificial intelligence techniques analyse the wearable sensor data to help guide the orthotist/prosthetist by transforming the quantification of gait into the interpretation of function in a clinically meaningful way. Attendees will learn how the data are wirelessly streamed to custom tablet apps for visualization, interpretation, and reporting by the clinician. Video examples of real AFO and transtibial prosthesis patient interactions during gait optimization will be presented.

Statement of the objective / learning objectives
Participants will be able to interpret kinetic and kinematic effects of changing alignment on an articulated AFO and a transtibial prosthesis as measured by embedded wearable sensor systems. Strategies for gait optimization will be taught.

Advanced instructional course: Rehabilitation medicine and surgery

4.07 International update on bone anchored prosthesis for individuals with limb amputation

Jan Paul Frölke[1,2], Jason Stoneback[3], Aditya Khemka[4], Robert Turcotte[5]

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Abstract
Bone-anchored prosthesis (osseointegration implants) are currently regarded as an excellent solution for prosthetic attachment in individuals with a transfemoral or transtibial amputation, who are unable to wear a socket. New developments in surgical technique, implant design and safety connectors widen the indication field for individuals with short residuum, small bone-implant contact area, reduced muscular leverage or poor bone quality.
In this instructional course, experienced surgeons from different areas around the globe will give an update on this field and discuss future perspectives. Selection of patients, preferred surgical techniques and available implants will be discussed from an international perspective also including various reimbursement issues.

Statement of the objective / learning objectives
In this advanced instructional course, surgeons, prosthetists and rehabilitation physicians will learn about the current international state of art regarding bone anchored prostheses in individuals with limb amputation.

Advanced instructional course: Prosthetics: Lower limb ankle & foot

4.08 The experience of providing self-aligning and micro-processor ankle-feet to bilateral transtibial prosthetic users in Scotland: Who benefits?

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Abstract

This advanced instructional course (IC) is intended for prosthetists, physiotherapists and rehabilitation consultants who wish to gain an insight into the experience of providing self-aligning and micro-processor ankle-feet to bilateral transtibial (BTT) prosthetic users, from the perspective of the Scottish Specialist Prosthetic Service (SSPS).

SSPS has been providing self-aligning ankle-feet to high activity users since 2015. The majority of BTT prosthetic users have had their amputations in quick succession due to dysvascular causes which adds to their multi-morbidity. In addition, the gait challenges are fourfold: limited ability to self-select their cadence; increased step width; hip-hitching and greater metabolic effort; all compounded with limited standing balance. Despite this, there is a growing body of evidence that users with BTT will achieve greater prosthetic mobility than those with a unilateral transfemoral amputation. To this end it is crucial to optimise their mobility and function to overcome environmental barriers such as uneven terrain so that quality of life can be improved as much as possible.

This Instructional Course will give an overview of the literature around this cohort and details of the features of the self-aligning ankle-feet available currently i.e. non energy storage and return (ESR), increased range of motion, torsion and shock absorption. Data analysis of measures gathered pre and post provision e.g. L-Test, 2 min TWT, Activities Balance Confidence score shall be reported. We will outline who have and have not benefitted from these ankle-feet prescriptions and why. Using case studies, we will highlight the rehabilitation implications and prescription implications.

Statement of the objective / learning objectives

This will assist the audience to accurately identify which type of ankle-foot is the most practical to the bilateral transtibial user, whilst developing an understanding of the unique challenges faced by this specific cohort.

Free paper session: Prosthetics: Lower limb - Gait biomechanics

5.01.1 Effect of side load carriage on limb loading and unloading in individuals with unilateral transtibial amputation

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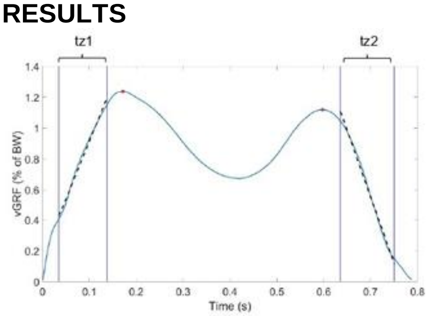
BACKGROUND
Asymmetrical weight transfer in individuals with lower limb amputation, which has been demonstrated by increased loading rates (LR) on their intact limb, may elevate the risk of secondary musculoskeletal injuries and loss of mobility [1-3]. Carrying a load may exacerbate the asymmetrical limb loading, depending on which side, prosthetic or intact, an individual with unilateral transtibial amputation (UTTA) carries it.

AIM
The purpose of this study was to examine limb loading and unloading rates (LR & ULR) in individuals with UTTA while carrying a side load. We used the vertical ground reaction force (vGRF) as a surrogate for limb loading.

METHOD
Ten individuals with UTTA (2 female, age: 46±15 yr, mass: 96.3±16.7 kg, height: 1.8±0.1 m) provided informed consent to participate in this institutional review board-approved study. Each participant wore the Sierra foot (Freedom Innovations) in their prescribed size and stiffness category, and carried a padded load of 30 lbs while walking overground at their self-selected speed with no load, load on their prosthetic side, and load on their intact side across five embedded force plates (AMTI). A motion capture system (Vicon) recorded the vGRF data at 1,200 Hz. The data were analyzed using MATLAB (Mathworks) to calculate LR and ULR (Figure) and in R (RStudio) for statistics.

RESULTS



$$LR = \frac{\Delta vGRF1max}{\Delta t(20\%<tz1<80\%)}$$

$$ULR = \frac{\Delta vGRF2max}{\Delta t(20\%<tz2<80\%)}$$

Figure. A method for calculating LR as the slope of vGRF over 20-80% time window (1st black dotted line) of tz1 (1st blue vertical lines), and ULR as the slope of vGRF over 20-80% time window (2nd black dotted line) of tz2 (2nd blue vertical lines). First and second red dots represent 1st and 2nd peak vGRF, respectively.

Side	No load	Intact	Prosthetic
LR_{int}	6.72(2.17)	6.91(2.98)	7.18(4.05)
LR_{pro}	5.76(1.65)	5.50(1.73)	6.27(2.12)
ULR_{int}	7.57(2.11)	7.01(2.46)	7.31(2.40)
ULR_{pro}	7.06(3.13)	6.74(2.01)	7.19(3.14)

Table. Mean(SD) of LR and ULR in %bodyweight/second for each limb and load condition. Subscripts: int (intact), pro (prosthetic).

Although LR_{int} was on average higher than LR_{pro} (Wilcoxon P = 0.036), no significant difference was found across load conditions (no load vs. intact load, no load vs. prosthetic load, intact load vs. prosthetic load), and between LR_{int} vs. LR_{pro} or ULR_{int} vs. ULR_{pro} within each load condition (Table).

DISCUSSION AND CONCLUSION
We found no change in LR or ULR whether carrying no load, a load on their intact side, or a load on their prosthetic side, which suggests that participants quickly adapted their gait to accommodate the side loads and provide a more symmetrical limb loading and unloading. Additional research is required to confirm these adjustments to LR and ULR with a larger subject sample and discover the compensations used.

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5.01.2 Walking coordination in lower limbs of individuals with unilateral transfemoral amputation

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BACKGROUND

Individuals with unilateral transfemoral amputation (uTFAs) ambulate by using the two different lower limbs. They show different kinematic and kinetic characteristics in gait. Coordinating the two lower limbs to generate effective gait patterns reflects a skilled control mechanism in the neuromusculoskeletal system. Continuous relative phase (CRP) tools can quantify the lower limb coordination during gait in uTFAs. Understanding the coordination might help the prosthetic gait rehabilitation.

AIM

The aim of this study was to understand the coordination differences between the right limb of able-bodied individuals, the prosthetic limb, and intact limb of uTFAs.

METHOD

Thigh, shank and foot segment angles during preferred speed overground walking in 14 uTFAs and 14 able-bodied individuals were obtained using a 3D motion capture system. The sagittal plane CRP angle at the thigh-shank and shank-foot couplings were calculated based on the segment angles. The right limb of able-bodied individuals (control), prosthetic limb, and intact limbs of uTFAs were compared with each other. Statistical analyses for the discrete parameters (e.g., Mean CRPshank-foot) were performed using SPSS, significant levels were set as $p<0.05$. Time series of CRP angle curves during the gait cycle in each limb were compared by using statistical parametric mapping method (SPM) derived from random field theory.

RESULTS

The mean CRPshank-foot value and its variability in prosthetic limb were significantly smaller than the other two limbs. No significant differences were observed in the mean CRPthigh-shank values in three limbs. SPM revealed significant differences in the CRPshank-foot curves during stance phase. Post hoc test revealed that the control and intact limbs were significantly different during the first half of the stance phase. Significant differences were found by SPM in CRPthigh-shank curves during almost the entire gait cycle, post hoc test revealed significant differences in middle of the gait cycle between the control and intact limbs. The CRPthigh-shank in the prosthetic limb was significantly different in stance phase compared to the intact limb and in the early stance compared to the control limb.

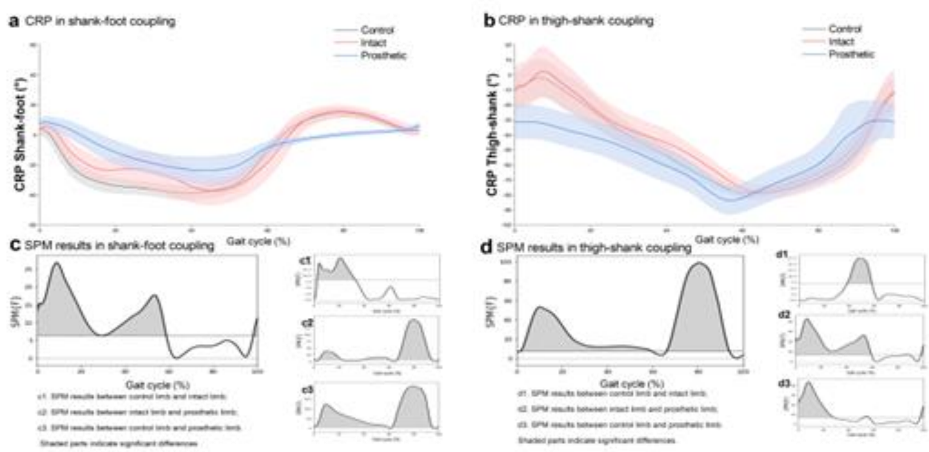

Figure. CRP curves and SPM results

DISCUSSION AND CONCLUSION

The smaller mean CRPshank-foot value in the prosthetic limb might be due to the fact that the prosthetic shank-foot is a passive structure and generate no voluntary movement during gait. Similar mean CRPthigh-shank values were achieved, while the SPM revealed significantly different patterns in three limbs. This indicated that specific strategies were applied in each limb in coordinating the thigh-shank coupling. Findings suggest that uTFAs are applying different strategies to coordinate each limb while walking.

5.01.3 Sagittal and transverse ankle angle coupling can influence prosthetic socket transverse plane moments

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BACKGROUND

The intact foot and ankle comprise a complex set of joints that allow rotation in multiple planes of motion. One of these joints, the talo-crural joint, is inclined downwards and laterally, coupling dorsiflexion (plantarflexion) of the foot with internal (external) rotation of the shank. This sagittal:transverse ankle angle coupling is not replicated in prosthetic feet and ankles.

AIM

This research aims to determine if there is a sagittal:transverse ankle angle coupling ratio that minimizes transverse plane socket torque.

METHOD

A novel, Torsionally Active Prosthesis was used to couple sagittal and transverse plane motions using a 60-watt motor. An embedded controller generated transverse plane rotation trajectories corresponding to sagittal:transverse coupling ratios of 1:0 (i.e., rigid), 6:1, 4:1, 3:1, 2:1. After prosthesis fitting, each subject was allowed ~15 minutes to acclimate. Subjects then walked multiple trials in a straight line (ST), and around a 1m radius circle with the prosthesis on the inside (PI) and outside (PO), at self-selected speed. The coupling ratio order was blinded to the subject and randomized. Repeated measures ANOVAs with significance at $p<0.05$ were used to detect differences between conditions.

RESULTS

Ten males with transtibial amputations provided informed consent to participate in this institutional review board-approved protocol (90±10 kg, 1.76±0.06 m, 54±16 years; 7 trauma, 2 diabetic, 1 infection). The results suggest a quadratic relationship between transverse plane moments and the sagittal:transverse ankle angle coupling ratio with a minimum at 6:1 (see figure). However, only the 6:1 vs. 2:1 and the 3:1 vs. 2:1 ratios during ST walking and the 6:1 vs. 2:1 and the 6:1 vs. 3:1 during PO walking were statistically different in pairwise comparisons ($p<.05$).

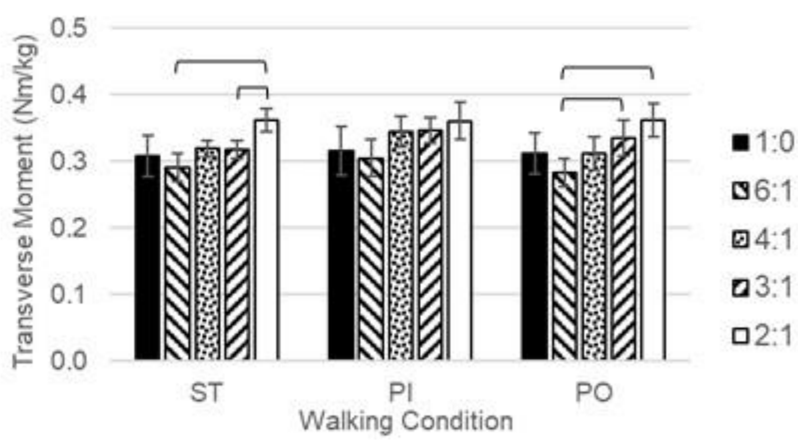

Fig. Transverse-plane socket moments normalized to body mass while walking straight (ST) and with prosthesis on inside (PI) and outside (PO) around a circle. Legend indicates coupling ratio. Brackets indicates pairwise significant difference.

DISCUSSION AND CONCLUSION

The trends exhibited suggest a coupling ratio of 6:1 may reduce transverse plane moments during straight and circle walking, while a coupling ratio of 2:1 or 3:1 may increase them. Future field studies using the Pivot-Flex Foot, a passive device that can produce a 6:1 coupling, aim to determine if it can reduce prosthetic socket transverse plane moments, discomfort, and incidence of residual limb skin injuries vs. a standard of care.

ACKNOWLEDGEMENTS: Dept. of Veterans Affairs, Rehabilitation Research & Development Service (RX002456 & RX002974).

5.01.4 Ground clearance and compensatory strategies – influencing factors for lower limb prosthetics

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BACKGROUND

Tripping is a safety risk for lower limb amputees, and it is mainly affected by ground clearance during prosthetic side swing phase. To compensate for a lack of ground clearance, compensatory movements can be performed, but reduce walking efficiency and are therefore unwanted. Thus, a prosthesis that provides a technical solution for ensuring adequate ground clearance during swing phase on the prosthetic side is desirable[1-3].

AIM

The aim of this pilot study was to investigate influencing factors of different prosthetic components and alignments on the resulting ground clearance and possible compensatory strategies.

METHOD

The following influencing factors were investigated: different prosthetic knee joint principles (monocentric and polycentric), swing phase control, ap-position of the prosthetic knee joint and foot, length of the prosthesis. Three unilateral transfemoral amputees participated in this study. Kinematic and kinetic parameters were recorded in a gait laboratory with a 12-camera optoelectronic system (Vicon, GB) and two piezoelectric force plates (Kistler, CH) embedded in a 12-m walkway. The measurements were performed during level ground walking with self-selected slow, mid, and fast velocity.

RESULTS

Multiple systematic effects were observed. With increasing maximum knee flexion angle in swing phase minimum ground clearance (MGC) was increased. Differences of up to 42 mm were measured. A more anterior shifted knee joint and more posterior shifted foot also resulted in increased MGC of up to 23 mm. Main compensatory strategy for inadequate ground clearance was plantar flexion on the contralateral side during prosthetic side swing phase (vaulting).

DISCUSSION AND CONCLUSION

The results showed that the prosthetic alignment as well as the swing phase control of the prosthetic knee joint have a strong impact on the resulting ground clearance and compensatory strategies. A more anterior aligned prosthetic knee joint and a more posterior aligned foot can enhance ground clearance. Furthermore, a swing phase control that enables adequate knee flexion independent to the walking velocity is crucial for ensuring ground clearance.

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5.01.5 Bilateral transfemoral amputees are at risk of hip joint disease when using articulated prostheses

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BACKGROUND

Bilateral transfemoral amputations (BTF) were more common than unilateral transfemoral amputations among United Kingdom military personnel wounded in the Afghanistan conflict [1]. Commercial BTF prostheses include full-length articulated (microprocessor knees and dynamic response feet) and fore-shortened non-articulated stubbies. Anecdotal evidence shows that amputees who regularly use articulated prostheses also use stubbies on occasion when they feel tired. However, the biomechanical effects of these prostheses on musculoskeletal system function and loading are unknown. Biomechanics can be used to understand these effects.

AIM

Using biomechanics approaches, this study aims to compare BTF function and loading during level-ground walking between full-length articulated and stubby prostheses.

METHOD

Four BTF male traumatic amputees (age 36±3 years) underwent gait analysis with full-length articulated and stubby prostheses. Musculoskeletal modelling was performed using Freebody [2]. Comparison analyses between prostheses were performed using a repeated measures design.

RESULTS

Full-length articulated prostheses introduced larger stride length (by 0.5m, p=.001) and walking speed (by 0.3m/s, p=.009) than stubbies. Cadence was lower with articulated prostheses by 12.6 steps/min (p=.037) than stubbies. BTF with articulated prostheses showed increased peak hip extension angles (of 10.1°), flexion moment (of 1.0Nm/kg, p=.002) and second peak hip contact force (of 3.8 bodyweight, p=.011) than stubbies.

DISCUSSION AND CONCLUSION

Lower walking speeds indicate lower functional abilities with stubbies than articulated prostheses. The higher cadence with stubbies indicate attempts to maintain similar speeds to articulated prostheses. BTF adopted longer strides to swing the full-length prosthesis from larger hip extension, leading to larger hip flexion moments and contact forces, which cause joint degeneration [3]. Conversely, stubbies present hip loading similar to able-bodied people [4]. Prosthesis choice should be based on activity goals and joint health factors. Future work should investigate fatigue.

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Free paper session: Outcome measurements - Limb loss

5.02.1 Sharing data in prosthetics and orthotics: Does synthetic data hold the key?

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BACKGROUND
In prosthetics and orthotics, patient datasets are often small and lack statistical power, limiting their benefit to clinical practice. Data sharing would help to overcome this problem. However, privacy and ethical issues are barriers to sharing data. Generating synthetic data sets, mimicking the original clinical data, may overcome these issues. However, it is not clear whether synthetic data generation processes are appropriate for common prosthetic and orthotic data.

AIM
To explore the efficacy of using synthetic data generation processes on clinical data commonly used in prosthetic and orthotic practice.

METHOD
Clinical (CLIN) datasets from the UK (National Health Service) and Sweden (https://swedeamp.com/) were obtained. Synthetic data (SYN) were generated from these CLIN datasets using the open-source R package ‘synthpop’ [1] with the default classification and regression tree (CART) procedure employed [2]. The similarity of the CLIN vs. SYN data was assessed visually by comparing univariate distributions. Coefficients from inferential statistical analyses and relationships between were also contrasted between data sets.

RESULTS
Demographic information such as age (61.7±16.9; SYN 60.1±18.7 years) and clinical information such as the number of physiotherapy (CLIN 18.3±18.9; SYN 15.8±15.7 visits) and prosthetic visits (CLIN 9.8±5.7; SYN 10.0±4.6 visits) were comparable between data sets. Sockets comfort scores were also similar between data sets (CLIN 7.3±2.4; SYN 7.3±2.5). The positive relationship between the LCI-5 and ABC scores followed the same pattern in both CLIN ($r_s(88) = .862$, $p < 0.001$) and SYN ($r_s(89) = .754$, $p < 0.001$) data sets (Figure 1).

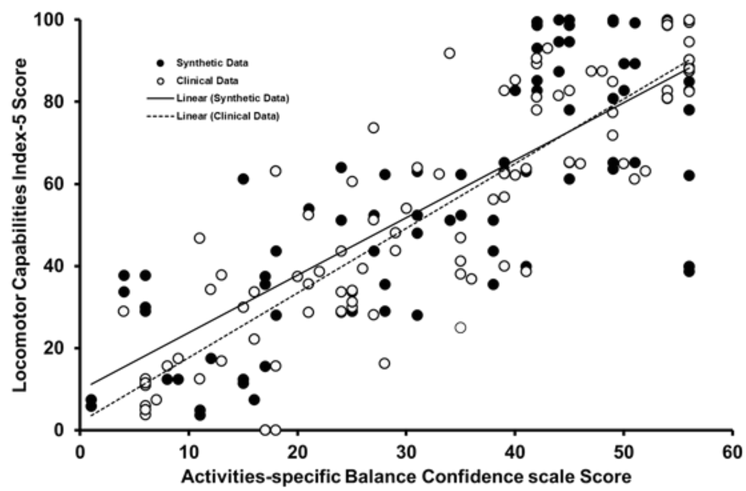

Figure 1. Visual representation of the relationship between LCI-5 and ABC scores using both clinical and synthetic data sets.

DISCUSSION AND CONCLUSION
The initial analyses presented here show that applying synthetic data generation processes, even to relatively small (n<100) clinical datasets sets, results in useful and representative synthetic data. It may be possible to share this anonymised synthetic dataset, more easily and more widely compared to sensitive clinical data. Further work to determine whether the data type, sample size and data characteristics influence the efficacy of synthesis is ongoing.

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5.02.2 A review of outcome measures for patients with lower 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

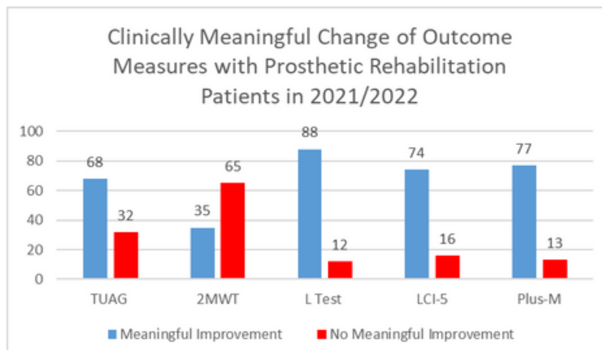
The aim of this service evaluation is to review the changes in patients' outcome measures discharged from prosthetic rehabilitation in 2021/2022 and establish if they are clinically meaningful based on the current evidence.

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 2022 to look into trends.

RESULTS

38 patients' results from 2021/2022 were reviewed and are reported as a percentage of all patients in whom there was a complete data set. For our objective measures, the TUAG (68%) and L Test (88%) had a clinically meaningful improvement. With the 2MWT while there was an improvement in time, it was only clinically meaningful in 35% of patients. Patient self-reported measures LCI-5 and Plus-M showed positive improvements in scores which were clinically meaningful. SIGAM scores were improved in 79% or patients and remained static in 21%. 21% achieved SIGAM E or F and 34% achieved D (ability to walk over 50 metres with or without aids).



Full completion of outcome measures was observed for TUAG and 2MTWT. Patients with complete measures were: L-Test 89%; LCI-5 71% and Plus-M 34%.

DISCUSSION AND CONCLUSION

Ongoing outcome measure collection will allow reviews of a future larger data set. Work needs to be done to improve completion of all measures both at initial assessment and discharge. Prosthetic physiotherapy outcome measures were analysed reviewing clinically meaningful change. Apart from 2MWT, all outcome measures used had a higher percentage of patients with a clinically meaningful change than with no clinically meaningful change, indicating a positive effect from their prosthetic rehabilitation.

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ACKNOWLEDGEMENTS: Miss C.Boobier (rotational physiotherapist) for initial review and analysis of outcome measures data. Physiotherapy team for ongoing data completion/recording.

5.02.3 COMET: Clinical Outcome Measures Electronic Toolkit mobile app for multi-lingual evaluation of patient outcomes

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BACKGROUND

Orthotic and prosthetic (O&P) professionals are under increasing external demand to provide evidence-based clinical care and demonstrate positive patient performance [1,2]. However, it can be challenging to efficiently incorporate the collection of outcome measures into the clinical workflow due to time and resource constraints. Additionally, outcome measures are commonly completed in the English language, resulting in the collection of these measurements simply being skipped for patients whose preferred language is non-English.

AIM

The aim was to develop an outcome measures mobile app that supports O&P practitioners in efficiently administering the measurements, automatically calculating the results, and providing the outcome measures in a patient's preferred language.

METHOD

Validated outcome measures that are typically in paper format were identified and digitally transformed for inclusion in a mobile app. Features were implemented in the app to display each question with response options for an individual outcome measure, automatically calculate the resulting score, and generate a PDF report of the results. Language switching features included in the app allow the patient to select their preferred language to complete the outcome measure. Once the patient completes the outcome measure, the results can be reviewed in the health care provider's preferred language.

RESULTS

Clinical Outcome Measures Electronic Toolkit (COMET) mobile app allows users to easily select the appropriate measure for a patient to complete, administer the test, and use that data immediately to inform clinical decisions (Figure 1). COMET includes a variety of patient-reported outcome measures and timed physical tests, such as Numeric Pain Rating Scale, Socket Comfort Score, and 10-Meter Walk Test. The app can be used in English or Spanish. At completion of the measure, a PDF can be exported in English or Spanish that documents the patient's responses and can be included in the electronic medical record or shared with the patient. The COMET mobile app has been released to iOS and Android App Stores for O&P clinics to download and use.

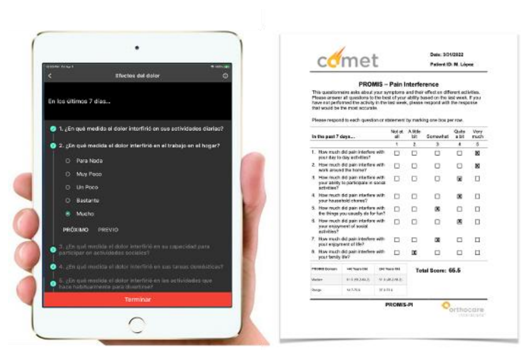

Figure 1. COMET mobile app displayed in Spanish and PDF report in English

DISCUSSION AND CONCLUSION

COMET can be used to measure, record, and analyze the outcome measure data that support evidence-based clinical care and quantify patient outcomes. The first languages available in the app are Spanish and English. The mobile app is designed to be easily extended to other languages when valid translations are available. Furthermore, the mobile app can instantly switch between patient-preferred and provider-preferred languages to reduce communication barriers and increase understanding between patients and providers.

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5.02.4 Daily life activity in individuals with an established amputation above the knee - an accelerometer study

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BACKGROUND

Mobility restriction following lower limb amputation might lead to a sedentary lifestyle affecting health. Today step-monitors or accelerometers have added the possibility to assess activity in normal life [1]. However, in amputees most studies have focused on number of steps taken with the prostheses, leaving out activity information without wearing the prosthesis. This study was initiated to enhance knowledge of daily activity among prosthetic users and to what degree the prosthesis is used.

AIM

To report daily activity in individuals with an established transfemoral amputation or knee- disarticulation and to describe the amount of activity that was performed with the prosthesis.

METHOD

This study included 42 individuals with an established unilateral transfemoral amputation or knee-disarticulation, using prosthesis in daily life since >1 year and able to walk 100 m with no more support than one stick/crutch. Participants gave descriptive information and prosthetic mobility was assessed. The participants were then supplied with two activPAL™ accelerometers [2] placed on the non-amputated thigh and prosthesis, respectively. The accelerometer recordings lasted for 7 continuous days. Instructions included to “live life like normal”, make short dairy notes and to send the devices back in a pre-paid envelope. The mean of the daily activities was calculated and compared between the non-amputated and prosthetic side. The study has ethical approval.

RESULTS

Simultaneous accelerometer data were obtained for 39/42 participants (92% for 7 days). The study group (n=39; 22 men,17 women) was between 21-79 years, had amputation due to trauma (59%), tumor (28%) or other cause (13%) and had used prosthesis in mean 24 (SD 17.3) years at assessment.

Accelerometer data from the non-amputated side showed that the participants took in mean 6125 steps/day, performed 38 sit to stand transitions/day, and spent 1.5 h/day in walking. In addition, mean time/day in sitting was 10.2 h, standing/walking was 5.0 h and laying was 8.7 h. The prosthesis was used for in mean 73% of all steps (4449 steps), 85% of all sit-to stands (32 sit-to stand) and 68% of time spent in walking (1.0 h/day walking). There were no differences between sex, but large individual differences.

DISCUSSION AND CONCLUSION

This study shows a method to assess physical activity in daily life among prosthetic users. However, some pitfalls during accelerometer registrations were observed and must be considered. In conclusion the results showed that established users of transfemoral or knee-disarticulation prostheses uses their prosthesis to a large extent in their daily activities, although the largest part of the day was spent in sitting position.

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ACKNOWLEDGEMENTS: Funding was by grants from the Swedish Government (ALFGBG-725641 and ALFGBG-766480) and the Eivind o Elsa K:son Sylvan Foundation.

5.02.5 Case studies of the use of outcome measures to demonstrate medical necessity of prosthetic and orthotic devices for individual patients.

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BACKGROUND

In many healthcare systems, demonstration of the medical necessity of interventions for individual patients is a key requirement of insurance coverage policies. By experience, many prosthetists and orthotists struggle with the understanding of the concept of medical necessity and meeting its requirements for healthcare payor approval. This paper will present three case studies from the U.S. of how medical necessity was established and insurance approval obtained using outcome measure assessments.

AIM

The aim of these case studies was to demonstrate that the assessment of outcomes to establish medical necessity of O&P devices is suitable and successful for obtaining healthcare payor approval.

METHOD

Prosthetists and orthotists who received denials of their applications for prosthetic or orthotic devices from the healthcare insurances of their patients contacted the Reimbursement Department of a manufacturer in the U.S. After review of the medical and prosthetic/orthotic records and a phone interview of the patients, the reimbursement specialists gave advice on what unmet patient needs to document and what outcome measures to assess to demonstrate medical necessity of the prosthetic/orthotic devices requested. The individual cases were followed until payor approval was obtained.

RESULTS

Three case studies whose claims were originally denied by the patients´ insurances will be presented: (1) a patient with an above-knee amputation using a mechanical prosthetic knee but requesting a microprocessor knee, (2) a patient with a paresis of leg muscles after spinal surgery using a locked KAFO but requesting a C-Brace, and (3) a patient with a transtibial amputation requesting a replacement of his powered prosthetic foot. The phone interviews found that the records of all 3 patients were missing important unmet needs that helped establish medical necessity of the requested devices, such as falls and fall-related injuries, pain, and restrictions to the daily routine and work. Assessments of suitable patient-reported outcomes over the phone and performance-based outcomes in the clinics helped establish medical necessity that ultimately resulted in approvals of the requested devices by the patients´ insurances.

DISCUSSION AND CONCLUSION

Medical necessity means to weigh unmet patient needs and potential benefits of an intervention against its potential risks to protect patients from unnecessary adverse effects. Healthcare payors have adopted this concept to control access to interventions they consider “too expensive”. Proper understanding and leveraging the components of medical necessity and outcome measures help overcome that barrier and increase approval rates of prosthetic and orthotic technology for the benefit of patients.

5.02.6 Measuring changes in mobility, comfort and pain over prosthetic treatment milestones for individuals with lower limb loss

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BACKGROUND

Using Outcome measures (OMs) in clinical care has many benefits. However, to be clinically applicable, the OM must be easy to use, and the score must have meaning. The Minimal Detectable Change (MDC) is one way to give a score meaning, as it specifies a threshold above which change has occurred. By measuring changes in these outcomes over time, one can quantify the effect of prosthetic intervention and determine numerically if the anticipated goal was met.

AIM

This study seeks to provide evidence of the 1) ability of four commonly used OMs to measure changes in mobility, comfort, or pain at different treatment milestones, and 2) usability of these measures in the clinical setting.

METHOD

A retrospective chart review of OMs collected between January 1, 2015 and July 15, 2021 was conducted. The OMs included the Socket Comfort Score (SCS), Pain Scale (PS), 2 Minute Walk Test (2MWT), and Prosthetic Limb Users Survey of Mobility (PLUS-M). For individuals with a recent amputation, measures were taken 2-3 weeks after their first prosthesis fitting (baseline) and at discharge from rehabilitation. For individuals needing a replacement socket, data was collected at initial evaluation and definitive delivery. Changes in measures were calculated and compared to the published MDC values and those calculated from this study. To identify usability, 5 clinicians who collected the data were asked for feedback.

RESULTS

Twenty-seven individuals with transtibial amputation provided data during rehabilitation and 81 individuals with lower limb amputations provided data while getting a replacement socket. For individuals in rehabilitation, the PS and PLUS-M most commonly captured a change, while for individuals getting a replacement socket, the PS and SCS did (Table 1). Clinicians reported that the SCS was easy to conduct and provided patients and prosthetists helpful feedback, and that the 2MWT was easy to conduct but most useful during rehabilitation. Clinicians' feedback regarding the PS and PLUS-M varied, as some found patients have more challenges completing them.

Table 1: Average Changes in Scores and Minimal Detectable Changes at Specific Milestones

Outcome Measure	Number of participants with OM taken	Change in Score Mean (SD)	MDC from Literature	% of participants that changed by MDC	MDC Calculated	% Changed by MDC Calculated
Individuals with Transtibial Amputations in Rehabilitation from Baseline to Discharge						
SCS	24	1.56 (2.30)	2.82 [1]	19%	1.38	30%
2MWT	20	37.9 (29.9)	34.4 [2]	35%	37.0	35%
PS	17	2.0 (1.8)	1.97 [1]	53%	0.95	71%
PLUS-M	26	9.09 (9.8)	4.5 [1]	55%	4.7	50%
Individuals with Lower Limb Amputations receiving a Replacement Socket from Initial Evaluation to Definitive Fitting						
SCS	77	3.1 (2.5)	2.82 [1]	45%	1.82	67%
2MWT	72	13.8 (13.0)	34.4 [2]	6%	50.2	3%
PS	67	2.3 (2.6)	1.97 [1]	49%	1.98	49%
PLUS-M	80	4.37 (3.8)	4.5 [1]	37%	4.9	36%

DISCUSSION AND CONCLUSION

The OMs did not frequently show a statistically significant change had occurred at treatment milestones. The clinicians preferred using the SCS and 2MWT in the clinical setting, as they were easy to use and understand, but they were often the least responsive to measuring change. This highlights the need for OMs which are sensitive to measuring changes in treatment and are easy for patients and prosthetists to use, as a critical component of the successful use of OMs.

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ACKNOWLEDGEMENTS: Thank you to the team at Barber Prosthetics Clinic for support of this study.

Free paper session: Paediatrics - Lower limb prosthetics

5.03.1 Defining paediatric prosthetic knee technical specifications: an inverse dynamics approach using a novel open sim model of a child with limb-loss

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BACKGROUND

Prosthetic knees for children with knee-disarticulation amputation in low-resourced environments lack essential features for increasing gait symmetry and walking speed such as swing phase control, which can be specified as a torque requirement [1]. As children are not simply small adults, their prosthetics require unique specifications for the changing environment of childhood growth. The field lacks the toolset to identify these unknown technical specifications. A modelling tool can determine the torque requirements of a swing phase control mechanism throughout growth.

AIM

This study aims to develop a novel inverse dynamics model of a child with knee-disarticulation to determine the technical specifications of prosthetic knee swing phase torque required to best emulate able-bodied gait throughout growth.

METHOD

3D gait data of 10 able-bodied children was gathered (height 1.41±0.16m). For each participant two models were created from a validated OpenSim model of an able-bodied child [2]. This model was first linearly scaled for each participant, and a corresponding knee-disarticulation amputation model produced by removing the bodies below the knee and replacing with prosthetic componentry. Long established low-cost prosthetic componentry and a novel polycentric knee were chosen, and inertial properties determined using a reaction board and oscillation technique [3]. The ankle joint was fixed, and the polycentric instantaneous centre of rotation defined. For each participant, inverse dynamics were conducted and torque requirements for the prosthetic knee derived [4].

RESULTS

Figure 1a shows differing prosthetic inertial properties impacts on the torque required from the knee joint during swing phase for one participant. All participants showed the same trend.

Results determined whether a trend between the growth parameter height and knee torque exist. The prosthetic knee joint extension torque at the start of swing – the instigation of the swing phase control mechanism (SPCM) – is correlated with the height of the child (Figure 1b).

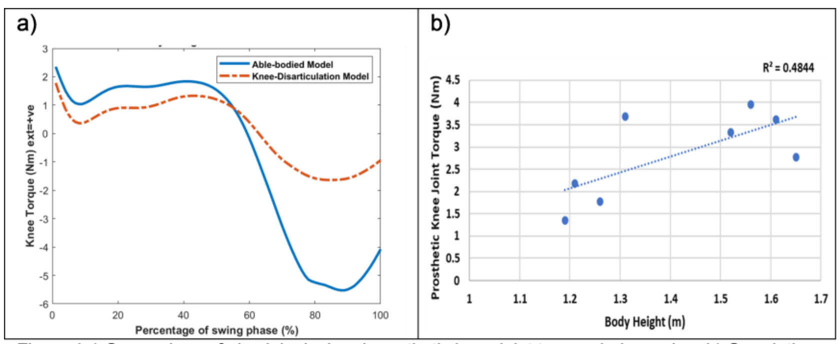

Figure 1a) Comparison of physiological and prosthetic knee joint torque during swing. b) Correlation between body height and prosthetic knee joint torque

DISCUSSION AND CONCLUSION

This research produced the first OpenSim musculoskeletal model of a child with limb-loss. The model determined the torque requirements for a swing phase control mechanism. As anticipated, the inertial properties of the prosthetic limb impacted the knee torque required to emulate the ideal able-bodied kinematics. For the first time, the child's body height was shown to influence the torque required from an SPCM. These flexible models are appropriate for multiple future studies and current results should influence paediatric prosthetic design.

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ACKNOWLEDGEMENTS: This work was supported by the EPSRC grant EP/S02249X/1 for the Centre for Doctoral Training in Prosthetics and Orthotics.

5.03.2 Development of the Children's Amputee Mobility Predictor

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BACKGROUND
Outcome measures are utilized for people with lower limb loss to determine their functional capacity by assessing their activities of daily life (ADL) performance. The types of ADLs evaluated in children are different from those for adults and include, but are not limited to, standing up from the floor, running, and throwing or kicking a ball. Currently, there is no assessment that evaluates ADLs specifically for children with lower limb loss.

AIM
The study purpose was two-fold: 1) to develop the Children's Amputee Mobility Predictor (CAMP), and 2) to determine the reliability of the CAMP.

METHOD
The CAMP tasks and operational definitions were developed and agreed upon by a focus group of interdisciplinary rehabilitation professionals and informed by the Amputee Mobility Predictor (AMP) [1]. Social validity was examined using ratings provided by children with lower limb loss or their families. Participants observed recordings of a child performing CAMP tasks and scored their relevance to performance of ADLs. A five-point Likert scale was used (1 = non-relevant and 5 = completely relevant). A convenience sample of children with lower limb loss was recruited and completed two trials of the CAMP within a 14-day interval; intra-rater and Inter-rater reliability were calculated.

RESULTS
The CAMP includes 26 tasks with scores adjusted to fit children in different age groups: 1) 2-3 Years Old, 2) 4-5 Years Old, 3) 6-7 Years Old, and 4) 8-18 Years Old. The total CAMP scores ranged from 0-59 with a prosthesis and 0-55 without a prosthesis. The CAMP tasks demonstrated excellent social validity, with scores relevance ranging from 4.0 to 5.0. To date, the CAMP was examined in 9 children with lower limb loss and a mean age of 6.1 years (SD 3.4). The CAMP has demonstrated good intra-rater reliability ($r=0.87$, 95% CI:0.37-0.97) and excellent interrater ($r=0.92$, 95% CI: 0.66-0.98) reliability.

DISCUSSION AND CONCLUSION
The CAMP's development and social validity testing included a diverse group of stakeholders. Study results show that the CAMP includes a range of ADLs for children with lower limb loss that are socially valid. The results suggest that the CAMP evaluates and quantifies multiple functional capabilities of children with lower limb loss. The results of our initial analysis appear to be promising. More robust results will be presented at the conference.

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ACKNOWLEDGEMENTS
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5.03.3 Effect of limb lengthening surgeries on the use of extension-prosthesis for lower limb deficiencies

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BACKGROUND

Lower limb deficiencies result from congenital pathologies, trauma, infection, malignancies. Treatment include limb lengthening surgeries that advanced greatly during the last 2 decades. Until surgery is relevant or until surgery achieves adequate length, patients are fitted with Extension-prosthesis for mobility and independent ADL. These are personally fitted to deformity, body dimensions and functional goals, and are usually very cumbersome. Some choose Extension-prosthesis as their sole solution. Adults will continue to use Extension-prosthesis or change to wheelchair mobility.

AIM

We evaluate the evolution in use of Extension-prosthesis in paediatric patients, considering the increase in limb lengthening surgeries.

METHOD

Retrospective review of all patients, aged <18 years, who were prescribed with Extension prosthesis between the years 2000-2021. Data included demographics, medical diagnoses, surgeries, prosthetic prescriptions, and usage. Patient data was collected from our national orthotics and prosthetics institute clinics databases.

RESULTS

Forty patients were prescribed an Extension prosthesis (26 males). Data for one patient was incomplete. Diagnoses included congenital deficiencies (n=35), trauma (n=1) and infection (n=3). There were 30 unilateral and 9 bilateral cases. Thirty-five percent (n=14) of patients did not undergo surgery and continue using an Extension-prosthesis. Sixty-five percent (n=25) of patients had surgery including hip stabilization, deformity correction, lengthening, amputation or combinations of these. For 13 of these patients, the prescription was changed to shorter orthoses, shoes, prostheses, wheelchair usage or no device; twelve patients still need an Extension-prosthesis.

DISCUSSION AND CONCLUSION

The evolution of limb lengthening surgeries may change the orthotic/prosthetic needs of children and thus affect mobility and use of assistive devices during the child's growth.

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5.03.4 Understanding the development of crawling in typically developing infants and children with limb loss

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BACKGROUND

Crawling is variable and unpredictable, but it is being accepted as an important aspect of mobility development in infants. Studies indicate that approximately 93% of infants progress through at least one stage of crawling during development of locomotion [1,2]. Our understanding of crawling in both typically and atypically developing infants has been hindered by the multiple difficulties of applying traditional motion analysis techniques to this form of gait. Consequently, no normative data exist with which to understand atypical development.

AIM

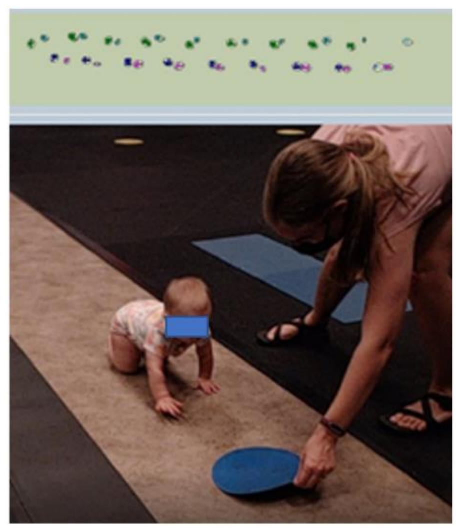
This study seeks to quantify kinetic and temporospatial aspects of stages of crawling using a novel, non-invasive technique in typically-developing children and children with limb loss. Comparisons will provide information for clinicians to improve therapies towards more typical mobility development.

METHOD

Crawling was assessed using a 4.2m (14’) x 0.6m (2’) Zeno pressure transducer mat (Protokinetics, Havertown PA). The mat incorporates a distributed array of 1 cm^2 force sensors that output 16 levels of pressure. PKMAS4 software, originally designed for animal-based studies of quadrupedal gait, is used to capture infant crawling.

Following informed parental permission, subjects were placed on one end of the mat and encouraged to crawl. The mat surface provides a contrasting color, and a variety of encouragement techniques were used to promote a crawling response. Five primary outcome measures were assessed: crawling speed, cadence, percent limb support, anterior-posterior pressure ratio, and bilateral pressure ratio.

RESULTS



The study is in progress. We have completed a pilot with a longitudinal typically developing infant from the age of onset of crawling to the transition to walking (Fig. 1). The pilot showed an age-related increase in speed and cadence, except when a new pattern was adopted. Kinetic asymmetries were present both anterior-posterior and bilateral, even in a typically developing infant. Normalized A-P ratios showed a shift of weight-bearing from hands to legs with development.

The study also showed that the mat hardware could be more optimally tuned to the expected pressure range encountered in a study of only small children. Consequently, hardware and gain changes have been implemented in our pressure mats to improve pressure discrimination. The ongoing study is using the optimized hardware to test development in 75 typically developing infants and 15 children with limb loss.

DISCUSSION AND CONCLUSION

The preliminary data and subsequent baseline tests have shown that the method is feasible. In the small pilot, a transition between crawling patterns showed a surprising choice to sacrifice speed to gain motor pattern development. In addition, analysis of both bilateral and A-P force ratios showed that the kinetics of quadrupedal crawling sometimes approach trilateral loading, with one limb remaining largely unloaded throughout the cycle.

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Free paper session: Gait and balance - Amputee gait

5.04.1 Gait requires elevated muscle activation of the hip flexors in the residual limb of unilateral transfemoral and through-knee amputees

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BACKGROUND

The loss in musculoskeletal capacity for unilateral transfemoral and through-knee amputees makes walking more demanding than for able bodied persons [1]. It is well documented that unilateral amputees adopt compensatory asymmetrical gait strategies [2]. However, how these gait changes affect the resultant muscle recruitment strategies and how these link to acute muscle fatigue is not known. Optimising muscle activations will address this fatigue and so increase functionality.

AIM

Quantify hip muscle force activations of unilateral transfemoral and through-knee amputees to inform the development of a rehabilitation intervention to optimise muscle activations and so reduce fatigue.

METHOD

3 Gait trials were collected of 6 unilateral transfemoral (5) / through-knee (1) amputees. Muscle forces were quantified with FreeBody [3], an inverse dynamic musculoskeletal model validated for amputees [4]. Linear scaling to an able body anatomical dataset was used for the intact side and a bilateral transfemoral anatomical dataset for the amputated side which is adapted to account for atrophy. The datasets were selected for each subject using regression models that reduce error in predictions [4] [5].

RESULTS

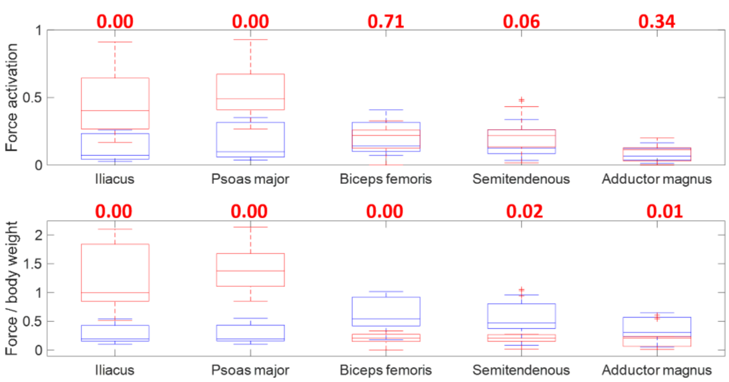

Fig.1. Muscle activations (force/maximum force potential) and force magnitude (normalised to body weight) are plotted for the muscles which showed significant ($p<0.05$) differences between the intact (blue) and residual limb (red). P values presented in red.

DISCUSSION AND CONCLUSION

Our results demonstrate increased recruitment of the iliacus and psoas major in the residual limb, likely due to the loss of the plantar flexors. The increased activation of these muscles indicates risk of fatigue. The reduced recruitment of the hamstrings and adductor magnus in the residual limb is expected, as these muscles become functionally compromised when re-attached in the surgery. Methods to enhance muscle recruitment strategies, targeting the relief of the residual limb hip flexors, are required to reduce fatigue.

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ACKNOWLEDGEMENTS: UK Engineering and Physical Sciences Research Council (EPSRC) grant EP/S02249X/1 for the Centre for Doctoral Training in Prosthetics and Orthotics

5.04.2 Force transmission capacity of the lower limb amputees with bone-anchored prostheses compared with socket prostheses and persons with hip replacements

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BACKGROUND

Restoring the ability to stand and walk with an exoprosthesis is considered as fundamental rehabilitation goal after lower extremity amputations. An essential prerequisite for achieving this goal is adequate force transmission between the prosthesis and the body. For centuries, prosthetic sockets have been shaped and manufactured for the purpose of force transmission. Transcutaneous osseointegrated prosthesis systems (TOPS) offer an alternative. However, the knowledge about the effect on gait mechanics of both anchorages is rare.

AIM

Does bone anchorage of an artificial limb permit a more normal force transmission and centre of gravity (COG) movement during level walking compared to a socket prosthesis used by transfemoral amputees?

METHOD

Parameter: During walking the vertical component of ground reaction force (GRF) and the bodyweight cause the vertical motion of centre of gravity. The GRFs of both legs are in normal subjects identical. For unilateral impaired leg function the GRF is expected to be reduced. Thus, GRF seems to be a suitable parameter measuring the force transmission capacity of leg.

Measurement: Instrumented gait analysis (VICON-cameras, Kistler force plats).

Subjects: 15 healthy persons (NA), 9 unilateral TF-amputated persons with bone fixed prostheses (TF-Osseo), 9 unilateral TF-amputated persons with socket prostheses (TF-Socket) and 18 patients with unilateral hip replacement (HTEP). All participants walk several times at comfortable walking speed (SSWS), slower and faster.

RESULTS

The speed dependency of GRF is significantly different between the groups (Fig. 1A). Lowest forces were measured for TF-Osseo, in contrast the highest contralateral. Group HTEP shows values which are similar of NA (Fig.1B). The vertical COG movement of the subjects in groups NA and HTEP has an extent of about 3.5 cm for both legs at a speed of 1.3 m/s. The symmetry of the COG movement of both legs is also noticeable in the TF-Osseo amputees. However, the height movement is 5 cm. The amputees with socket prostheses do not move the COG symmetrically. During the prosthesis-side stance phase, the vertical movement is about 3.5 cm, as in subjects NA and HTEP, but about 4.5 cm during contralateral stance.

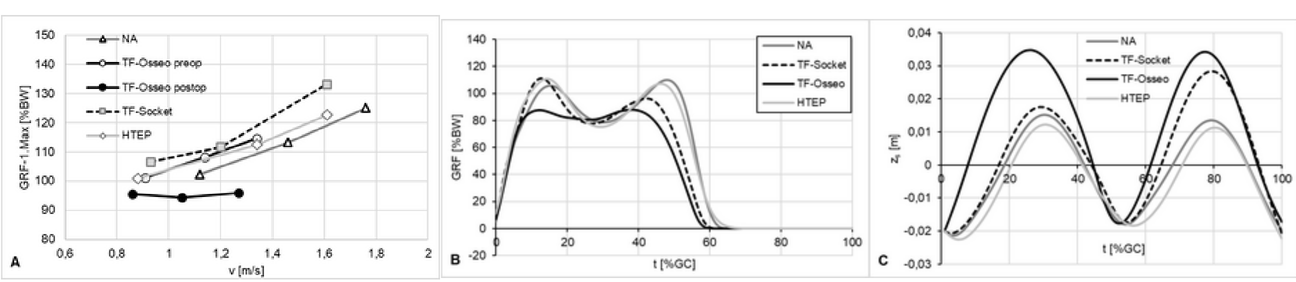

Figure 1: Maximum of GRF (A), vertical GRF at 1.3 m/s (B), vertical movement of COG (C)

DISCUSSION AND CONCLUSION

Osseointegrated amputees have a special gait mechanism that has a relieving effect on the prosthetic leg. The force transmission is asymmetrical, as in socket prosthesis wearers. Expecting a normal gait pattern also remains unrealistic due to the continued lack of muscles and joints. Individuals with HTEPs have this advantage. Therefore, according to this study, bone-anchored exoprostheses can be recommended for transfemoral amputees when the rehabilitation goal with the patient is a walking speed lower than 3 km/h.

5.04.3 Comparison of balance and gait speed between transtibial prosthetic users with pin lock and vacuum assisted suspension systems

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BACKGROUND
There is a potential deterioration of gait and balance in lower limb amputees compared to able-bodied subjects [1]. In addition, the type of prosthesis is known to affect locomotor abilities [2-3]. Pin lock and vacuum-assisted suspension systems are widely used in transtibial amputees however, it is not clear whether there is any difference between them in terms of balance and gait speed [4-5].

AIM
To compare balance and gait speed between transtibial prosthetic users with pin lock and vacuum-assisted suspension systems.

METHOD
Thirty-nine unilateral transtibial amputees (pin lock n=21, vacuum assisted n=18), able to walk 30 meters independently and use the prostheses for at least six months, participated in the study. Gait capacity was assessed with 2-minute walk test (2MWT) in terms of distance. Timed Up & Go (TUG) and Functional Reach (FR) tests were used to assess balance. Because the body length was found different between groups, distance parameters were normalized by dividing the distances to the body length. The research procedure was approved by the local ethical committee, and all participants signed an informed consent form.

RESULTS
Age, amputation reason, years of amputation, body weight, and body mass indexes were similar between groups (p>.05). However, body length and numbers of male subjects were higher in the vacuum-assisted group (p<.05). Normalized TUG and FR distances were better in the vacuum-assisted group (p<.05), but there was no difference between groups regarding walking speed (p>.05, Table 1).

Table 1. Comparison of characteristics, balance and gait speed between groups.

		Pin lock (n=21)	Vacuum assisted (n=18)	p
Age (years, Mean ± SD)		52.8 ± 9.5	48.6 ± 12.4	.185
Gender (n,%)	Male	12 (57.1)	16 (88.9)	.028*
	Female	9 (42.9)	2 (11.1)	
Amputation reason (n,%)	Vascular	14 (66.7)	7 (38.9)	.083
	Trauma	7 (33.3)	11 (61.1)	
Body length (cm, Mean ± SD)		169.3 ± 9.0	176.5 ± 9.3	.020*
Body weight (kg, Mean ± SD)		74.5 ± 16.1	82.2 ± 11.0	.265
Body mass index (kg/cm^2, Mean ± SD)		25.8 ± 4.5	26.4 ± 3.6	.746
Years of amputation (Mean ± SD)		9.5 ± 12.0	11.6 ± 13.3	.955
N. 2MWT (Mean ± SD)		77.7 ± 15.1	81.8 ± 18.9	.464
N. TUG (Mean ± SD)		5.6 ± 1.0	4.5 ± 1.3	.003*
N. FR (Mean ± SD)		14.3 ± 4.3	20.9 ± 4.9	<0.001*

*p<0.05, N, normalized

DISCUSSION AND CONCLUSION
Transtibial amputees using the vacuum-assisted suspension system prosthesis have better balance than the pin lock users. Our results show that the vacuum suspension may improve balance abilities in transtibial prosthetic users in accordance with previous studies.[2,4] Protective role of vacuum-assisted suspension against fallings should also be investigated with prospective studies in the future.

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5.04.4 Do prosthetic and non-prosthetic limbs react differently to simulated tripping falls in individuals with unilateral transtibial amputation?

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BACKGROUND

Individuals with unilateral transtibial amputation (UTTA) are at high risks of falling especially when they encounter destabilizing perturbations.[1] This population exhibited asymmetric movement patterns when performing various activities, and these patterns may be manifest during postural perturbation and subsequent recovery.[2] Understanding the side-to-side differences in tripping and fall recovery response can be valuable in developing more effective rehabilitation protocols and prosthetic components to reduce fall risks in individuals with UTTA.

AIM

Compare the fall recovery responses between conditions where the prosthetic and non-prosthetic limbs were perturbed in individuals with UTTA.

METHOD

Participants were exposed to unexpected, unilateral perturbations during walking on a split-belt treadmill. Five events were identified from the stepping recovery responses: perturbation onset (Onset), contralateral limb off (Contra Off; when the contralateral limb is lifted off the ground), contralateral limb contact (Contra On; when the contralateral limb makes the first ground contact of the first recovery step), ipsilateral limb off (Ipsi Off), and ipsilateral limb contact (Ipsi On).We extracted the durations that comprised the fall recovery: the unloading and swinging durations of each step. Knee and hip joint range of motion corresponding to each duration were also extracted for our comparisons.

RESULTS

The duration of the first recovery step (dRS1) and the swing time of this step (dSwing1) were significantly longer when the non-prosthetic limb was perturbed in which the movement was executed by the prosthetic limb. No significant differences were observed in the second recovery step. The knee and hip range of motion were not significantly different side to side.

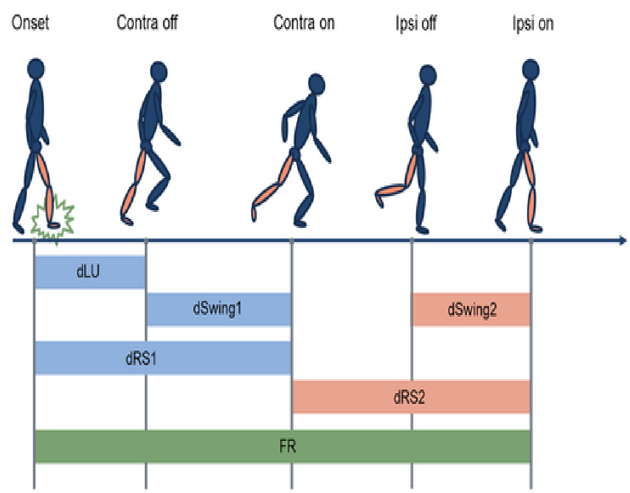

Figure 1. Responses during a walking perturbation trial.

DISCUSSION AND CONCLUSION

Our findings indicated that it takes longer time for the prosthetic limb to perform the initial recovery step after a perturbation. The slower movement was mainly attributed to the longer swing time. The prosthetic limb stepping performance (i.e., quickness) may be a benchmark for improvement when prescribing training and componentry. Furthermore, individuals with UTTA may be at a higher risk of tripping falls when the non-prosthetic limb is perturbed during walking.

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ACKNOWLEDGEMENTS: National Institute of Health and International Society of Biomechanics.

5.04.5 Changes in gait speed in new lower limb prosthetic users within the first three months after inpatient prosthetic rehabilitation

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BACKGROUND

Self-selected gait speed in new lower limb prosthetic users is slower than healthy populations at time of discharge from inpatient prosthetic rehabilitation [1]. It is currently unknown whether new lower limb prosthetic users have the capacity and if so, to what extent, increase their gait speed. Nor is it known if either self-selected or fast gait speed changes once new lower limb prosthetic users return to the community after their inpatient admission.

AIM

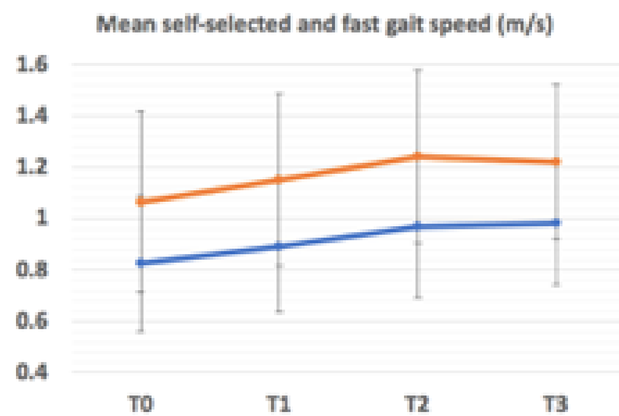
To measure changes in self-selected and fast gait speed in new lower limb prosthetic users at time of discharge from inpatient rehabilitation and in the 12 weeks period after discharge into the community.

METHOD

All people 18 years or older who underwent first major (transtibial or higher) unilateral lower limb amputation and were prescribed their first prosthesis during inpatient rehabilitation were identified from the rehabilitation unit at the Princess Alexandra Hospital. Participants completed inpatient prosthetic rehabilitation as per usual care before completing a comfortable (self-selected) and fast 10-metre-walk test prior to discharging from hospital the following day (T0). Participants returned at 2 (T1), 6 (T2), and 12 weeks (T3) post discharge to complete follow-up comfortable and fast 10-metre-walk tests. Repeated measures ANOVA was performed to track changes in gait speed over time.

RESULTS

Nine participants (89% male, 89% trans-tibial amputation level, 89% dysvascular aetiology) completed the study. Mean (95%CI) self-selected gait speed increased from 0.83m/s (0.53, 1.09) at T0, to 0.89m/s (0.64, 1.14) at T1, to 0.97m/s (0.69, 1.24) at T2, with fastest self-selected gait speed of 0.98m/s (0.74, 1.22) observed at T3 ($F = 4.837$, $p = 0.048$). Mean (95%CI) fast gait speed increased throughout the study protocol from 1.06m/s (0.71, 1.42) at T0, to 1.15m/s (0.82, 1.49) at T1, to 1.24m/s (0.90, 1.58) at T2, before slowing on average slightly at T3 to 1.22m/s (0.92, 1.52) ($F = 1.204$, p – 0.386).



DISCUSSION AND CONCLUSION

Participants in this study made improvements in self-selected and fast gait speeds after discharge from inpatient prosthetic rehabilitation but remained slower than healthy populations [2]. These results also demonstrate that new prosthetic users are, on average, able to increase their walking speed if needed. It appears that the rate of improvement in both self-selected and fast walking speeds slows by three months post discharge from inpatient rehabilitation.

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5.04.6 Relation between the kinematic gait profile score and daily activity data in individuals with amputation above the knee

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BACKGROUND

Gait while using a transfemoral or knee-disarticulation prostheses have been shown to affect the lower limb kinematics involving the hip, pelvis and spine often resulting in an asymmetrical gait [1-2]. The kinematic gait profile score (GPS) is a clinical index, based on instrumented gait analysis, which can be used to describe overall gait pathology [3].

The impact of asymmetrical gait on the daily activity among prosthetic users needs to be further explored.

AIM

To explore the relation between the kinematic gait profile score and daily activity data in established prosthetic users with a transfemoral amputation or knee-disarticulation.

METHOD

This ethical approved study included 23 individuals with a unilateral transfemoral amputation (TFA) or knee-disarticulation (KD), using prosthesis in daily life since >1 year. All individuals were able to walk 100m with no more support than one stick/crutch. An unaided gait analysis was performed using a 16-camera motion capture system and 4 synchronized force plates. A 2-minute walk-test was conducted and the PLUS-M questionnaire was answered. Finally, an activity monitor (activPALTM), was attached to the prosthesis to record 7 days of everyday activity. The mean of daily activities was calculated and compared with the GPS-score using Pearsons Correlation test.

RESULTS

The study group consisted of 12 men and 11 women (n=19 TFA, n=4 KD; mean age 50 years (21-75), being prosthetic users since mean 20 years (2-54). Amputation was due to trauma (n=11), tumour (n=8) or other cause (n=4).

The mean GPS-score was 10.3 (6.6-14.9). Accelerometer data showed a mean of 4729 (1061-9976) steps/day and mean 1.03 (0.27-1.94) hours/day spent in walking. The mean 2-minute walk-test was 138 (76-241) meter and mean PLUS-M T-score was 51.3 (38.6-67.1). Table 1 present the correlation statistics between measures.

Table 1. Correlations between GPS-score and data on prosthetic activity and mobility

	Mean number of daily steps with prosthesis	Mean hours of daily time walking with prosthesis	Mean 2-minute walk-test	Mean Plus-M T-score
GPS-score	-0.62, p=0.002	-0.62, p=0.002	-0.45 p=0.036	-0.33 p=0.13

DISCUSSION AND CONCLUSION

In established prosthetic users with TFA/KD a more symmetrical gait pattern was moderately to highly related to more daily prosthetic steps, more walking and a longer distance covered during the 2-minute walk-test. Self-reported prosthetic mobility showed no correlation to symmetrical gait.

In conclusion this study showed clear relationship between a more symmetrical prosthetic gait pattern and higher everyday prosthetic activity, emphasizing the importance of appropriate rehabilitation and gait training.

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Free paper session: Orthotics: Lower limb – Ankle foot orthoses I

5.05.1 360° Treatment concept for lower limb orthotic interventions – a case series

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BACKGROUND

This case series uses a 360° treatment concept for the orthotic intervention in patients with neurological or functional deficits of the lower limb. A biomechanical analysis is crucial for the stabilization and the application of individually adjusted corrective forces to obtain the best possible control of stance and gait. [1]

AIM

This paper aims to demonstrates the benefits of a structured lower limb orthotic intervention including an accurate patient assessment and an orthotic configuration which considers the biomechanical forces for the selection of the correct components and fabrication technique.

METHOD

Three neurological patients with lower limb mobility impairment were selected to make individual orthotic configurations with an online tool. The casting position was biomechanically optimized [2] and the orthoses were fabricated with the functional components required to compensate the deficits. The orthoses were aligned on the workbench, statically and dynamically to provide stability in stance and restore the physiological gait as much as possible. Two tests were performed in a randomized order; one at baseline with standardized shoes and a second with the optimally adjusted orthosis. The kinematic outcome measures were analysed. Additionally, two functional tests were included: the Timed Up and Go and a 6-Minute Walking Test.

RESULTS

The results observed confirm an improvement in the velocity, step length, cadence and gait symmetry. The functional tests showed a reduction in the time required for the chores and more endurance in general while the stability and trunk balance were noticeably better. The structured intervention method included bench alignment to match the optimal position of each patient, a static alignment to control the placement of the joints relative to the base of support and adjustments made if necessary to obtain a correct tibial inclination and stable stance. The dynamic alignment was checked to adjust the plantar flexion and dorsiflexion range of motion and the resistance/assistance forces of the springs. Furthermore, a bending and torsion resistant orthosis was applied to maximize the function of the components. All of these aspects contributed to the good results of the orthotic intervention.

DISCUSSION AND CONCLUSION

It can be concluded that a 360° treatment orthotic concept is advantageous. The components should be adjusted to the patient's needs and the structural stiffness of the orthoses should maintain the biomechanically optimized alignment and enhance the function of the components provided. A good orthotic intervention stabilizes the patient during stance and supports the physiological gait pattern improving functionality and consequently increasing the participation and quality of life of the subjects with lower limb impairment.

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ACKNOWLEDGEMENTS: FIOR & GENTZ GmbH provided the components for the fabrication of the orthoses.

5.05.2 Comparison of static and dynamic shank to vertical angle measurements for ankle-foot orthosis optimisation in standing and walking.

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BACKGROUND

During ankle foot orthosis (AFO) prescription, clinicians use shank to vertical angles (SVAs) to guide shank kinematic optimisation at temporal mid-stance (TMST), which is considered to facilitate typical walking [1]. The static SVA, measured in standing, may mimic the dynamic SVA at TMST [1] and is easier to measure. However, evidence comparing static and dynamic SVAs is conflicting, whilst various shank models and TMST definitions are used [2-4], leading to the validity of the static SVA to be questioned.

AIM

Using 3-dimensional gait analysis (3DGA), assess the difference between various 3D shank models. Assess static SVA validity by determining the correlation between static and dynamic SVA measures.

METHOD

Participants (22-38yrs, 6M:6F) underwent 3DGA, using the CAST marker array [6], 13 opto-electric cameras (QUALISYS, Sweden) and two force-plates (AMTI, USA). Three additional markers on the proximal, mid, and distal anterior tibial border (ATB), defined four 3D shank models to calculate the SVA, the knee and ankle joint centre intersect, and the full, proximal, and distal ATB. Table 1 details the SVA conditions tested. For each, SVAs were measured from the four models simultaneously, using 3DGA, with the mean determined across three repeats. Pearson's correlation coefficients the SVA conditions and models were determined, with 30% of the gait cycle and the joint centres model as the gold standard baseline.

RESULTS

Comparison of 30% GC SVAs measured using the 3D shank models: Compared to the joint centre model, the full (r=0.86, P=0.000) and proximal ATB (r=0.84, P=0.001) had similar, significantly high correlations, whilst the distal ATB model was not significantly correlated (r=0.57, P=0.052).
Comparison between static and dynamic SVAs using the joint centre model: There was a significantly strong correlation (r=0.92, P=0.000) between the dynamic measures (30% GC and TMST), however, weak, insignificant (P<0.05) correlations between 30% GC and static conditions. Marching (r=0.41) produced the highest, whilst normal standing (r=-0.08) and EWD (r=0.09) showed no correlation.

Table 1. SVA conditions and how they were measured within the study. EWD = Equal Weight Distribution, GC = Gait Cycle

SVA Condition	Posture	Pose	Measurement Tool
30% GC	Instance of 30% of GC	Dynamic	3DGA
TMST	Frame at which head, trunk and pelvis were aligned vertically over the centre of the foot [1]	Dynamic	3DGA + goniometer to identify fram
Normal standing	Standing, feet shoulder width apart and soft knees	Static	3DGA
Ball throwing	Standing immediately after throwing/catching a ball five times	Static	3DGA
Marching	Immediately after marching on the spot 10 times	Static	3DGA
EWD	Standing with force vector passing through the mid-point of the foot in the sagittal plane	Static	3DGA with live force vector display

DISCUSSION AND CONCLUSION

Strong correlations for the full and proximal ATB models and TMST condition are beneficial to clinical practice as they aid visual measuring of the SVA, using video. However, the low correlation between static and dynamic SVAs, highlights the need for further work to assess validity for clinical settings.

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ACKNOWLEDGEMENTS: Supported by the UK EPSRC grant EP/S02249X/1 for the Centre for Doctoral Training in P&O.

5.05.3 User’s preference during prescription of off-the-shelf carbon ankle foot orthoses

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BACKGROUND

The prescription process of off-the-shelf ankle-foot orthoses (AFOs) is ambiguous. The choice for a specific AFO is often based on the preference of treatment team, knowledge of available products and/or clinical experience. Although the user’s preference has been identified as important, it is often not considered. Moreover, it is unclear whether users preference of AFO is related to the functional performance of an AFO.

AIM

Investigate if the AFO preference corresponds with a better efficacy in terms of L-test performance.

METHOD

Fourteen individuals with reduced ankle push-off power were fitted with two off-the-shelf carbon AFOs (Sprystep Max and BlueRocker). After AFO fitting, individuals performed a L-test on both AFOs and choose their preferred AFO (baseline). Subsequently, participants used both AFOs at their home for four weeks. In the first two weeks, participants were instructed to wear each AFO consecutively for one week. The order of the AFOs was randomized across subjects. Thereafter, individuals wore both AFOs according to their own preference for another two weeks. Finally, individuals returned for a follow-up measurement in which they performed L-tests and indicated their preferred AFO again.

RESULTS

The L-test was performed in 30.6 s for both the preferred (SD 8.9) and less preferred AFO (SD 7.7, $p=0.98$). At baseline, 64% (9/14) preferred the AFO in which they performed best on the L-test. After four weeks, L-test performance improved 4.2 s (SD 2.9, $p<0.001$) for the preferred and 3.8 s (SD 3.6, $p=0.002$) for the less preferred AFO indicated at follow up. At follow up, 71% (10/14) chose the best AFO according to their L-test performance. The preference of the AFO changed in 43% (6/14) of the participants after the four weeks home use. The L-test performance at follow up was 26.3 s (SD 6.8) for the preferred AFO and 26.9 s (SD 7.4) for the less preferred AFO ($p=0.08$).

DISCUSSION AND CONCLUSION

The user’s preference was mainly in accordance with the performance on a functional test. However, some participants performed worse with their preferred AFO, indicating user preference seems not related to functional performance alone. Furthermore, AFO preference changed in a substantial part of the participants after home use, suggesting that a habituation period at home may be helpful in the prescription process to increase AFO adherence.

ACKNOWLEDGEMENTS: All Sprystep Max and BlueRocker AFOs were provided at no costs by Thuasne and Basko, respectively.

5.05.4 Effectiveness of ankle foot orthoses for patients with weakness of the plantar and dorsiflexors: biomechanical comparison of different orthotic concepts

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BACKGROUND

Patients with both plantar and dorsiflexor weakness often show abnormal knee loading in addition to instabilities of the ankle joint. This can be treated using ankle-foot orthoses (AFO) that utilize effects of the ground reaction force (GRF) [1,2]. Options are jointless carbon fibre orthoses (JLO) and articulated orthoses, which can be further differentiated into AFOs with conventional ankle joints (small ROM, rigid stops – CAJ) and those with expanded ROM and customizable resistance to both movement directions ("reactive-dynamic ankle" – RDA [3]).

AIM

The aim of the present study was to compare the effectiveness of different AFO concepts for supporting movement patterns of daily living using biomechanical parameters.

METHOD

Seven patients (91±15kg, 1.85±0.10m, 57±15y) with plantar and dorsiflexor weakness resulting from various neurological conditions (manual muscle test grades 1-3 [4]) were enrolled in the study. All patients currently use an RDA-AFO (4 bilaterally, 3 unilaterally) and have previous experience with either JLO or CAJ. Four orthotic configurations (RDA, CAJ, JLO, no orthosis - WO) were studied during the following movement patterns: self-paced level walking at medium speed, walking up and down an incline (10°), and standing on an incline (+10°, 0°, -10°). Kinematic data was measured with an optoelectronic system (VICON) coupled with two force plates (KISTLER) to measure GRF.

RESULTS

Walking without orthoses, two patients showed knee hyperextension, one a distinct crouch gait, two a tendency towards crouch gait, and two normal knee joint characteristics. The unphysiological dorsi and plantarflexion WO was reduced by all AFO-types. With CAJ, excessive reductions of 6-7° dorsiflexion and 7-9° plantarflexion at push-off were measured in all tasks compared to RDA and JLO (p<0.01). This effect was accompanied by reduced horizontal propulsion forces, reduced peak ankle power at push-off and partially abrupt knee extension during stance. No significant differences were found between RDA and JLO; both AFOs stabilised the ankle and normalised knee movement and loading (Fig.1). When standing WO, slightly increased knee flexion (2-12°) and forward trunk inclination (1-5°) were found in all tasks. All AFOs show a normalising effect when standing uphill.

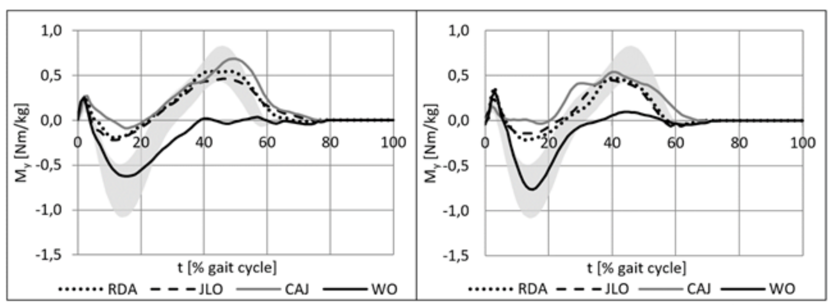

Fig.1: External orthotic side sagittal knee moment walking up an incline. Group mean curve of bilaterally (left) und unilaterally (right) affected patients. Norm data of healthy control group shown as grey shaded area.

DISCUSSION AND CONCLUSION

CAJ restrict the physiological dynamics of locomotion and lead to partially abnormal knee loading. RDA and JLO show considerably greater patient benefits. In the studied movement tasks, these two orthosis concepts show similar effects and largely normalise movement and loading patterns of the knee. For more demanding activities, e.g., steeper inclines or uneven surfaces, patients anecdotally report advantages of RDA over JLO. These activities should be investigated in future studies.

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5.05.5 Spring-like ankle foot orthoses increase ankle work and reduce compensatory hip work in severe but not in mild push-off deficits

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BACKGROUND

People with plantar flexor weakness generate less ankle push-off work while walking. This reduced push-off work is compensated for by inefficient hip compensations, causing walking energy cost to increase [1]. Spring-like dorsal leaf ankle foot orthoses (AFOs) can potentially support push-off work. However, whether this support reduces hip compensations and whether all people are able to increase push-off power is unknown.

AIM

We aim to determine whether spring-like dorsal leaf AFOs reduce compensatory hip work in people with bilateral plantarflexor weakness. Additionally, we aim to determine in which patients the spring-like AFO is most effective in normalizing joint work distribution.

METHOD

We included 18 people with bilateral plantar flexor weakness due to a neuromuscular disease. 3D gait analysis at self-selected walking speed with shoes only and with a dorsal leaf AFO with an optimized stiffness for walking energy cost was performed. To account for differences in walking speed, we calculated the relative joint work generated at the individual joints of the right leg for the whole gait cycle and different gait phases. Participants were divided into “responders,” the 10 participants in which ankle work increased (difference>0), and 8 “non-responders,” for whom ankle work decreased. Differences between conditions were tested using dependent t-tests, and differences between responders and non-responders with independent t-tests.

RESULTS

No differences in the relative contribution of ankle, knee and hip work were found between walking with and without AFO ($p>0.499$). However, a higher percentage of positive ankle work was generated during push-off when walking with AFO (shoes: 72.4±27.1 vs AFO: 85.3±9.1%, $p=0.026$) while positive hip work shifted from pre-swing (shoes: 34.1±10.4 vs AFO: 31.9±7.4%, $p=0.038$) to loading response (shoes: 11.9±9.8 vs AFO: 18.0±11.0%, $p=0.022$). In the responders, hip work decreased significantly compared to the non-responders when using the AFO (responders: -5.8±10.3% vs non-responders: +3.6±6.8%, $p=0.040$). Responders had relatively less ankle work when walking without AFO compared to non-responders (8.5±3.7 versus 24.2±11.1, $p=0.001$).

DISCUSSION AND CONCLUSION

We showed that spring-like AFOs increased ankle work and reduced compensatory hip work compared to shoes only in people with severe, but not in those with mild ankle push-off deficits. In this latter group, the AFO even increased hip work, especially of the extensors in early stance. These findings implicate that in people with severe push-off deficits, stiffness optimized spring-like AFOs have beneficial effects on joint work distribution, which may reduce overuse symptoms and reduce walking energy cost.

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Free paper session: Prosthetics: Upper limb - Device outcomes

5.06.1 Sensory substitution of elbow proprioception to improve myoelectric control of upper limb prosthesis

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BACKGROUND
Current myoelectric prostheses lack proprioceptive information and rely on vision for their control. Sensory substitution is increasingly developed with non-invasive vibrotactile or electrotactile feedback, but most systems are designed for grasping or object discriminations, and few were tested for online control in amputees.

AIM
The objective of this work was to evaluate the effect of novel vibrotactile feedback on the accuracy of myoelectric control of a virtual elbow by healthy subjects and participants with an upper-limb amputation at the humeral level.

METHOD
Sixteen healthy participants and 7 transhumeral amputees performed myoelectric control of a virtual arm under different feedback conditions: vision alone (VIS), vibration alone (VIB), vision plus vibration (VIS + VIB), or no feedback at all (NO). Reach accuracy was evaluated by angular errors during discrete as well as back-and-forth movements. Healthy participants' workloads were assessed with the NASA-TLX questionnaire.

RESULTS
Reach errors were higher in NO than in VIB, indicating that our vibrotactile feedback improved performance as compared to no feedback. Conditions VIS and VIS+VIB displayed similar levels of performance and produced lower errors than in VIB. Vision remains therefore critical to maintain good performance, which is not ameliorated nor deteriorated by the addition of vibrotactile feedback.

DISCUSSION AND CONCLUSION
Our novel vibrotactile feedback improved myoelectric control of a virtual elbow as compared to no feedback. Although vision remained critical, the addition of vibrotactile feedback did not improve nor deteriorate the control and was preferred by participants. Longer training should improve performances with VIB alone and reduce the need of vision.

ACKNOWLEDGEMENTS: Thanks to the PRM department of Percy military hospital and the Institute Robert Merle d’Aubigné of Valenton.

5.06.2 Evaluation of a new low-cost body-powered hand system

Laura Miller[1,2], Kristi Turner[1], Frank Ursetta[1], Levi Hargrove[1,2]

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BACKGROUND

The impact of upper limb loss on individual's function and participation is compounded by the difficulty in accessing resources and trained personnel in developing countries. We have developed a socket system that can be fabricated with limited resources [1] as well as a hand system that could be combined in a fitting kit. The low-cost hand (LCH) is designed to be fabricated for under $100 USD using an internal sheet metal frame and injection-molded outer cosmetic shell.

AIM

The goal of this study is to evaluate, in US home trials, a new prosthetic hand and socket system designed for use in low- and middle-income countries.

METHOD

Three individuals with transradial level limb absence were fit with socket systems. They completed home trials randomizing the Ottobock voluntary closing hand and a LCH prototype. The LCH was voluntary closing with an optional back lock. The passive thumb could be positioned lateral for a flat palm, medial for a tripod grasp, and at a mid-point for a cylindrical grip. After each home trial, participants completed the Box and Blocks Test, the Activities Measure for Upper Limb Amputees (AM-ULA), Southampton Hand Assessment Procedure (SHAP) and the Jebsen-Taylor Test. Participants also provided subjective feedback on each. The project was approved by the Northwestern University IRB.

RESULTS

Participants were comfortable in the socket system for the two 2-week home trial. They able to move more blocks with the LCH (19.25+3) than with the Ottobock hand (14.00+3.11). Scores were also higher for the LCH than the Ottobock for the SHAP index of function scores (44.67+3.21 vs 36.33+5.77) and AM-ULA (13.52+3.25 vs 12.41+1.40). Jebsen scores were better (lower) for the Ottobock hand (268.00sec+27.78) compared to the LCH (281.39sec+10.10). Subjectively, participants found the three locking positions for the thumb useful but had difficulty operating the button to enable or disable the back-lock feature. The additional degree-of-freedom at the proximal interphalangeal (PIP) joint also made picking up small objects more difficult.

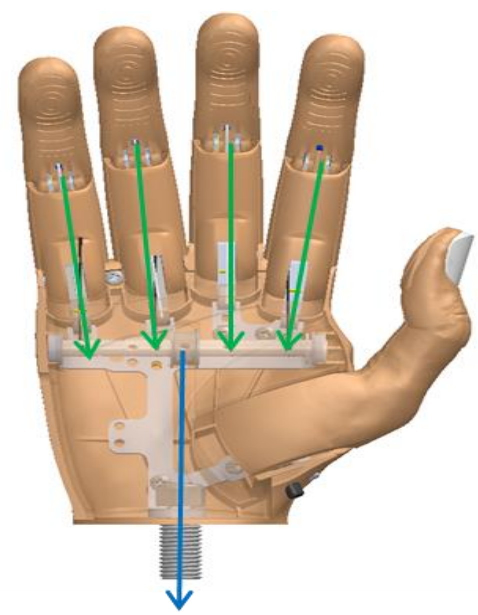

Figure 1. Mechanism of the low-cost hand. Thumb can be rotated to 3 different locking positions.

DISCUSSION AND CONCLUSION

The new LCH demonstrates improvement in function for individuals with transradial level absence. However, additional design refinements may be beneficial. Though trained on the back lock, users did not find the mechanism to be intuitive. Trials with the PIP joint immobilized will be repeated to determine if fine grasp is improved. This may also improve long-term durability. Following current trials and improvements in design, international trials will then be planned.

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5.06.3 Progress towards an inclusive fit-for-purpose upper limb prosthetic device for Ugandan context

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BACKGROUND

When designing purely mechanical prosthetic hands, it is generally assumed that there is a trade-off between highly life-like cosmetic hands with limited functional restoration, and highly functional non-anthropomorphic devices. In this study, we describe a process of designing fit-for-purpose upper limb prosthetic devices for the Ugandan context by leveraging a discrete choice-based co-design and co-selection approach, and 3D printing to support the local manufacture of prosthetic devices for upper limb amputees.

AIM

To explore how a discrete choice-based co-design and co-selection approach, and 3D printing can contribute to designing fit-for-purpose prosthetic devices for upper limb amputees in Uganda.

METHOD

We divided the codesign process into two phases. In phase one, 21 co-designers with any level of upper limb amputation were presented with a digital selection tool showing four images and videos of terminal devices ranging from purely cosmetic to very functional. Co-designers were asked to make discrete choices based on activities of daily living identified from the earlier interviews [1]. Based on the findings of phase one, 17 of the 21 co-designers were then presented with three models of a selected passive terminal device and asked to make a subjective rating of the shape, colour and texture. We then explored methods of 3D printing to make a terminal device.

RESULTS

Co-designers in phase one demonstrated a preference for a terminal device that resembled a hand, but still had some functionality.

Phase two co-designers found the general shape of the passive terminal device acceptable, although some adjustments were recommended, such as separating the thumb from the other fingers or separating all fingers to give it a more realistic appearance. The texture for the selected commercial device was preferred, as it felt smoother, while the texture of the 3D-printed device was not explicitly criticised. In terms of colour, a brown passive device was favoured over pitch-black because it was closer to the skin tone.

DISCUSSION AND CONCLUSION

Because it facilitates user involvement throughout the design process, co-design has potential to positively impact design of fit-for-purpose prosthetic devices since it leads to more acceptable products. Although 3D printing as a local manufacturing technique has pros and cons, it is worth exploring for prosthetic device manufacturing in resource-limited settings. To satisfy both functionality and cosmesis, we developed both a passive and a functional terminal device, which can be fitted onto an adjustable socket depending on the user’s need.

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ACKNOWLEDGEMENTS: This work was funded by the UK government GCRF through the EPSRC and NIH, grant number EP/R013985/1.

5.06.4 A comparison between multi-grip and standard myoelectric hand prostheses on all ICF-levels and cost-effectiveness

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BACKGROUND

Multi-grip myoelectric hand prostheses hands (MHP), with five movable and jointed fingers, have been developed to increase functionality. However, literature comparing MHPs with the standard myoelectric hand prostheses (SHPs), only capable of producing one grip, is limited and inconclusive. No studies on cost-effectiveness of these hands exist to our knowledge.

AIM

To compare MHPs with SHPs on all categories of the International Classification of Functioning, Disability, and Health-model (ICF-model) and on cost-effectiveness.

METHOD

I. 14 MHP users (64% male, mean age=49 years) participated. Measurements and within-group comparisons performed within the ICF-categories ‘Body Function’ and ‘Activities’ included joint angle coordination, Refined Clothespin Relocation Test(RCRT), Tray-task, Box and Blocks Test, and the Southampton Hand Assessment Procedure(SHAP), These were executed with MHP and SHP one week apart.

II. 19 SHP users (68% male, mean age=58 years) and 14 MHP users (part I) participated. Measurements and between group comparisons performed within the ICF-categories ‘Activities’, ‘Participation’, and ‘Environmental Factors’ included RAND-36, EQ-5D-5L, visual analogue scale (VAS), Dutch Quebec User Evaluation Satisfaction assistive Technology (D-QUEST), and patient-reported outcome measure assessing preferred usage features of upper limb prostheses (PUF-ULP).

III. Cost-effectiveness: 106 prosthetic users completed a cost questionnaire (societal perspective), EQ-5D-5L, PUF-ULP.

RESULTS

I. ‘Body Function’ and ‘Activities’: 10 of 14 users of MHPs had similar joint angle coordination patterns with an MHP as with an SHP. The RCRT in the upward direction was performed slower in the MHP condition compared to the SHP condition. No other differences in functionality were found.

II. ‘Activities/Participation’: MHP users had a lower EQ-5D-5L utility score; experienced more pain or limitations due to pain (i.e., measured with the RAND-36). ‘Environmental Factors’: MHPs scored better than SHPs on the VAS-item holding/shaking hands. The SHP scored better than the MHP on five VAS-items (i.e., noise, grip force, vulnerability, putting clothes on, physical effort to control) and the PUF-ULP.

III. In the cost-effectiveness-study, MHPs appeared to be more than twice as expensive as SHPs, mostly due to higher acquisition costs and MHPs were not cost-effective compared to SHPs.

DISCUSSION AND CONCLUSION

No relevant differences between MHPs and SHPs were found on any of the ICF-categories. MHPS were not cost-effective compared to SHPs. This underlines the importance of carefully considering whether an MHP is the most suitable option for an individual who wishes to use a myoelectric prosthesis hand.

Free paper session: Psychosocial issues / quality of life - Psychological, social and economic issues I

5.07.1 Social and community participation following traumatic lower limb amputation: an exploratory qualitative study

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[1]La Trobe University, Melbourne, Australia. [2]Monash University, Melbourne, Australia

BACKGROUND
Lower limb amputation (LLA) is a life altering condition that can result in severe disability. In Australia, more than 8000 LLAs are performed each year (1). Amputation as a result of traumatic injury is typically performed in younger patients with fewer medical comorbidities. In this population, the physical and psychosocial disability persists several years following amputation. The long-term experience following LLA is reported to have a negative impact on activity levels and participation in social and community functioning (2).

AIM
To explore barriers and facilitators to social and community participation experienced by people at least two years post-traumatic lower limb amputation (LLA)

METHOD
An exploratory qualitative study of people with traumatic LLA in Victoria, using semi-structured interviews was undertaken using the Braun and Clarke model of thematic analysis.

RESULTS
Participants highlighted barriers to participation being the inaccessibility of the built environment and the physical challenges associated with prosthetic mobility. Factors that further limited social and community engagement included chronic and complex health concerns experienced as a result of their injuries with these resulting in physical and emotional distress for some. Participants highlighted that following traumatic LLA the benefit of peer-support networks and the value of supportive community groups in assisting the transition to their pre-amputation family, work, and social roles. Participants also felt that a strong, positive attitude and being self-motivated were important to aid in their return to social and community participation.

DISCUSSION AND CONCLUSION
Following traumatic LLA, people experience a number of physical, psychological and environmental challenges to participation beyond two years post-amputation. The role of peer-support networks, community groups and personal attitudes are important facilitators to assist a return to family, work, and life roles.

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5.07.2 Understanding mental and behavioral health in individuals with physical disabilities and limb loss

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BACKGROUND

Physical disability, including limb loss, often represents a life-altering event. A recent ACA survey found that physical and mental health affect one another [1]. In many healthcare systems, care for individuals facing limb loss is managed by orthopedic physicians, prosthetists, and physical therapists. These disciplines often lack training in mental and behavioral health, and patients are provided tools to navigate the physical changes, but not the mental changes.

AIM

The purpose of this study was to assess mental health issues in a large sample of individuals with physical disability, and to specifically determine provision of mental and behavioral health care in individuals with limb loss.

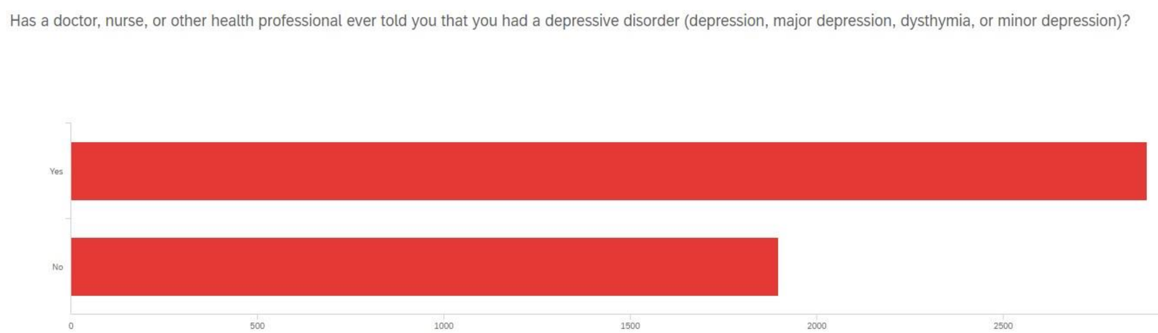
METHOD

A custom survey was developed using validated instruments related to disability, mental and behavioral health, and quality of life. This included the NIH Common Data Elements for Lower Limb Loss Research, which aggregates instruments such as PROMIS, Disability Rating Scale, WHO QoL, Social Support Questionnaire, and CES Depression Scale. The 15-minute survey, with branching for specific physical conditions, was administered using Qualtrics (Seattle, WA) to adults in the United States who self-identified as an individual with a physical disability.

Aggregate results were analysed to determine prevalence, type, and degree of mental health issues. Sub-populations related to prosthetics and orthotics were analysed to further assess access to mental health care and resources.

RESULTS

Complete results were received from 4,889 individuals with physical disabilities. The majority acquired their disability between the ages of 19-39 years (N=2,015). Among all respondents, the most commonly reported comorbidities were depression (Fig. 1) and anxiety, with 1,172 and 1,333 indications that these severely influence daily functioning, respectively. 2,348 individuals (48%) indicated causation, answering that “My mental health became worse as a result of my physical disability.”



In O&P-specific populations, 1,012 individuals reported using an assistive device. Among 80 individuals with limb loss, difference, or impairment, 48 indicated poorer mental health as a result. Over 60% reported a clinical diagnosis of a depressive disorder. Over 41% received no mental or behavioral healthcare related to their limb loss. Among those who did, 29% received it from a provider not trained in mental health or from a peer support group.

DISCUSSION AND CONCLUSION

The survey indicated high prevalence of mental health issues among individuals with physical disabilities, and the correlation between physical and mental health. Many individuals received no specifically trained clinical care. In open responses, individuals reported that they did not expect the degree of physical limitations they face. Beyond the physical, however, several reported direct mental health impact, such as feeling unwanted or misunderstood. The O&P profession should consider improved ways to infuse mental health resources into patient care.

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5.07.3 Association of psychosocial issues in females with transtibial amputation

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BACKGROUND

Dating back to the prehistoric times, one of the oldest known surgically performed procedures are lower extremity amputations. Factors associated with positive adjustment to limb loss include greater time since amputation, more social support, greater satisfaction with the prosthesis, active coping attempts, an optimistic personality disposition, and a lower level of amputation in the case of lower limbs. Additionally, older adults were more depressed than younger adults during the first year and a half after an amputation.

AIM

The aim of the present study was to determine the correlation of psychosocial issues in females following with transtibial amputations.

METHOD

The study was conducted on 90 females with transtibial amputation from PRSP, CFRC and Indus hospital Muzaffargarh. A nonprobability convenience sampling technique was used to collect data. Two questionnaires were administered to assess social issues (WHOQOL scale-BREF) and psychological issues (HAMD).

RESULTS

There were 65 amputations caused by trauma (72%), 17 amputations caused by disease (19%) and 8caused by diabetes (9%). The multinomial regression indicates age and social isolation are positively correlated for QOL (r=1.03, OR=2.81) and transport (r=0.86, OR= 2.81) respectively. This indicates that as age increases social issues decrease Similarly, age of participant has a weak negative correlation with anxiety (r= -0.20, OR=0.81) and depression (r= -0.04, OR= 0.95) respectively. This indicates decreased depression and anxiety with increased in age.

DISCUSSION AND CONCLUSION

This study concluded that there are considerable psychosocial problems in female amputees. This study also showed that most female patients have a psychosocial problem. Younger patients have more psychosocial issues as compared to older patients because they felt sadness and worried about the future; most patients stopped their education due to disability. However, psychosocial issues decreased with education. The majority of the patients have problems in traveling because of accessibility.

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5.07.4 Prosthesis users' perceptions of daily life – a phenomenographic study

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BACKGROUND

Clinicians involved in prosthetic rehabilitation have expressed difficulties in adopting a person-centred approach to care. This has been attributed in part to difficulties in helping clients shape their expectations of rehabilitation outcomes [1]. Increased knowledge of the personal experiences of people who have undergone a limb-amputation can provide clinicians and their clients with important knowledge to facilitate holistic, person-centred consultations and to generate realistic expectations of what life will be like as a prosthesis user.

AIM

The aim of this qualitative study was to explore the personal experience of living life as an active lower-limb prosthesis user.

METHOD

A qualitative, phenomenographic approach was adopted to shed light on perceptions of everyday life of lower-limb prosthesis users. Phenomenography was chosen as a research method as it focuses on understanding different ways in which people experience a phenomenon (i.e., life as a prosthesis user) rather than identifying common themes [2]. 15 active prosthesis users participated in semi-structured interviews and open-ended questions were used to explore the phenomenon. Interview transcripts were analysed using the seven principles outlined by Dahlgren and Fallsberg [3]; familiarization, articulation, condensation, comparison, grouping, labelling, and contrasting.

RESULTS

Participants' perceptions of life as a prosthesis user resulted in a hierarchy of categories (figure 1). Results indicated that, after a period of existential adjustment, prosthesis users were motivated to move on from their amputation and live active, fulfilling lives. The extent to which they were able to adjust was perceived to be facilitated by social interactions with other prosthesis users, access to relevant information and their ability to balance desired activities against their physical and/or cognitive capacity. Social media played a particularly important role in establishing connections with other prosthesis users, as well as being perceived as a useful source of information.

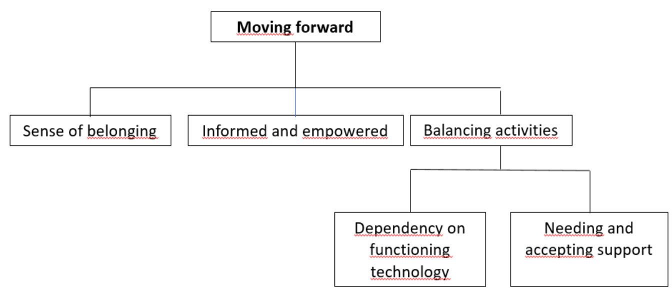

Figure 1. Hierarchy of categories

DISCUSSION AND CONCLUSION

Results can provide staff with a clearer picture of issues that are perceived as important by their clients, as well as knowledge to assist their clients in expressing their personal goals and values. The extent to which participants in this study could move forward with life post amputation was dependent upon existential adjustment but also influenced by external factors. Interactions with other prosthesis users served as an informal form of peer support as well as a valued source of information.

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5.07.5 Optimising prosthetic product design using Kansei engineering

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BACKGROUND

To optimise user satisfaction, prosthetic products should be comfortable, functional and have an appearance which is appreciated and accepted by the end user [1]. Kansei engineering uses product development methods which aim to translate end-user perceptions and feelings regarding specific product features into concrete design parameters and to determine which specific elements are most likely to evoke a positive emotional response from a user [2].

AIM

The aim of this presentation is to demonstrate how the principles of Kansei engineering can be used to design lower-limb prostheses which match the types of feelings and the image a client desires from their device.

METHOD

We will describe the process we are using to capture the image and psychological feelings individual clients wish to achieve in their device and match these with specific prosthetic design features. This is done by using focus groups and individual interviews to capture adjectives (Kansei words) describing prosthetic limbs and then aggregating these words down to a limited number which are considered to best represent the product. We then ask clients to rate a range of products with different design characteristics on analogue-visual scales and use prediction modelling to link design attributes and product ratings.

RESULTS

Specific design features of limb prostheses evoke very different emotional responses from prosthesis users. Feelings towards a particular design are highly individual and are influenced by personal characteristics of the client as well as design features related to colour, texture, and form. Results of our work will demonstrate how specific Kansei words are linked to prosthetic products and can be used in a dialogue with a client to personalise their device and ultimately optimise their level of satisfaction with the product.

DISCUSSION AND CONCLUSION

Product development within the field of prosthetics has tended to focus heavily on functionality and there has been limited attention to the aesthetics and the types of feelings that are induced by specific design parameters. Prosthetic users have different expectations for their device and results from our work can be used in a client consultation to select design features which match individual client preferences for their device.

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ACKNOWLEDGEMENTS: This work is financed by the Swedish Knowledge Foundation. In-kind support was provided by TeamOlmed, Aktiv Ortopedteknik and UNYQ.

5.07.6 Quality prosthetic service provision – a phenomenographic study of clients' perceptions

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BACKGROUND

Clients' perceptions are central to quality healthcare improvement providing important insights into levels of quality care as a function of overall satisfaction [1]. Investigations into the quality of prosthetic services have tended to use quantitative methods to measure specific aspects of client satisfaction [2]. However, responses to quantitative measures of client satisfaction may differ from qualitative experiences [3].

AIM

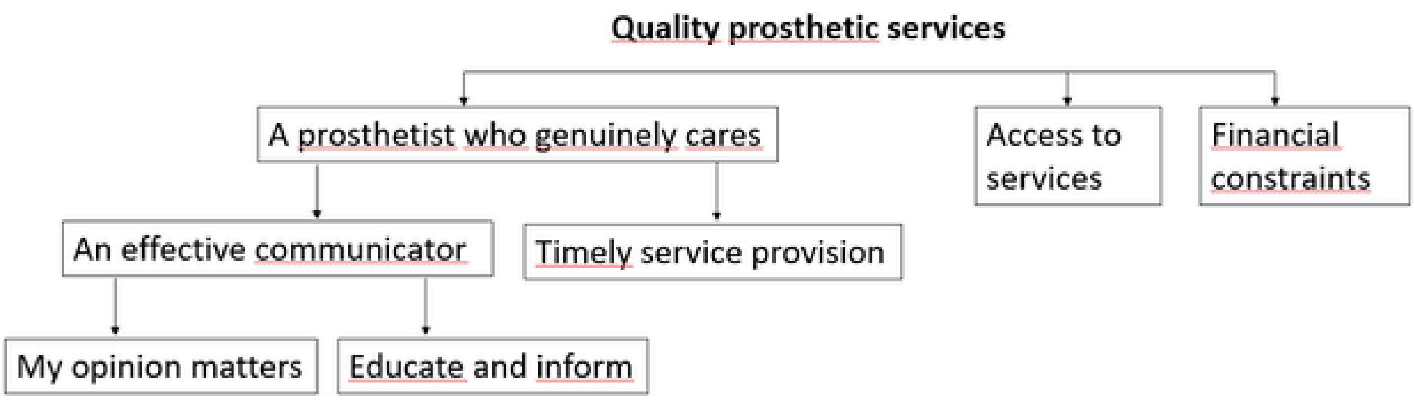
To explore lower-limb prosthesis users' personal experiences of prosthetic service provision.

METHOD

A phenomenographic approach was used to further understanding of how prosthesis users experience the prosthetic services they receive. 15 lower-limb prosthesis users participated in semi-structured interviews and open-ended questions were used to explore their perceptions of prosthetic services. Interviews were transcribed verbatim and analysed using methods outlined by Dahlgren and Fallsberg [4].

RESULTS

A hierarchy of categories that contribute to clients' perceptions of quality prosthetic service provision was generated (figure 1). Participants experienced variation in the quality of prosthetic services received and tended to seek out facilities where the treating prosthetist was perceived as genuinely caring about their client and where services were considered easy to access. Financial constraints were considered to influence service quality, but these constraints were perceived as being beyond control of the treating clinician.



DISCUSSION AND CONCLUSION

This study provides insights into areas of prosthetic service delivery that are prioritised by prosthesis users and should be considered as part of quality improvement processes. These include improving the communication and pedagogical skills of clinicians, timely provision of services and exploring possibilities to improve access to services.

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ACKNOWLEDGEMENTS: This work was financed by the Swedish Knowledge Foundation. In kind support was provided by TeamOlmed, Aktiv Ortopedteknik and UNYQ.

Free paper session: Developing the O&P workforce

5.08.1 Regulation of the global orthotist/prosthetist workforce: what can we learn from allied health professions with international-level regulatory support?

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BACKGROUND
By 2050, the global demand for orthotic/prosthetic services is expected to double [1] which the orthotist/prosthetist (O&P) workforce is not well placed to meet. Strengthening O&P workforce regulation will be key to meeting future demand, however little is known about the extent of O&P regulation nor the mechanisms through which regulation could best be strengthened. Several allied health professions have international-level regulatory support that may serve as a model for strengthening O&P regulation.

AIM
To describe the national-level regulation of the O&P workforce globally, and the international-level regulatory support provided to allied health professions.

METHOD
Two environmental scans benchmarked the national-level regulation of the global orthotist/prosthetist workforce and the regulatory support provided by non O&P international allied health professional bodies using a set of nine core practitioner regulatory standards (core standards). These included Minimum Training/Education, Entry-level Competency Standards, Scope of Practice, Code of Conduct and/or Ethics, Course Accreditation, Continuing Professional Development, Language Standard, Recency of Practice, and Return-to-Practice. In addition, each identified country was also categorised by income status (i.e., High-, Upper-Middle-, Lower-Middle-, and Low-Income countries).

RESULTS
Some degree of regulation of the O&P workforce was identified in 30 (15%) of the world's 197 countries. All core standards were present in 6 of these countries. Countries of higher income status had more core standards in place than countries of lower economic status. International-level professional bodies were identified for 14 of 20 allied health professions. International bodies for the physical therapy (8 core standards) and occupational therapy (5 core standards) professions provided regulatory support to help national associations meet most of the core standards.

Given the small proportion of countries that have national practitioner regulatory standards in place, most O&Ps are working under little-to-no regulation. This presents an opportunity to develop rigorous national-level regulation that can support workforce growth to meet future workforce demands.

DISCUSSION AND CONCLUSION
There are significant financial and expertise barriers that hinder the development of a more regulated O&P workforce, particularly for Low- and Lower-Middle-Income countries. Therefore, we recommend the establishment of an international professional body with the express purpose to support national-level regulation of O&Ps, and subsequently increase access to high-quality orthotic/prosthetic care – something that can only be achieved through a well-regulated profession.

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5.08.2 The changing demographics of the orthotist/prosthetist workforce in Australia: 2007, 2012 and 2019

Emily Ridgewell[1,2], Leigh Clarke[1], Sarah Anderson[2], Michael Dillon[2]

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BACKGROUND

Previous workforce analyses conducted in 2012 [1] revealed a small orthotist/prosthetist (O&P) workforce with a low practitioner prevalence (i.e., number of O&P practitioners per 100,000 Australians). Since this time, there have been major changes to the profession (e.g., avenues for skilled migration, introduction of a second O&P training school and the introduction of the National Disability Insurance Scheme) which require up-to-date workforce data.

AIM

The aim of this research was to compare demographics of the O&P workforce in Australia, and each state/territory, between 2007, 2012 and 2019.

METHOD

This retrospective time series analysed data from Australian Orthotic Prosthetic Association member database and Australian Bureau of Statistics (ABS) population reports [2]. De-identified demographic data were exported and summarized for the nation and for each state/territory. Service location was classified as metropolitan or regional/remote using employer postcode in keeping with the ABS standards. Changes in practitioner age were analysed using the Kruskall-Wallis H test. Changes in gender and service location were analysed using the Chi-square test of homogeneity. The absolute number of practitioners and practitioner prevalence were described.

RESULTS

Between 2007 and 2019, workforce size increased 130% from 179 to 410 practitioners. Practitioner prevalence increased 90% from 0.85 to 1.62 practitioners per 100,000 Australians. Median practitioner age reduced between 2007 and 2019 (41.5 vs 35 years, $p=0.001$). The proportion of female practitioners increased between 2007 and 2019 (30% vs 49%, $p<0.05$); noting a substantial reduction in the proportion of female practitioners over age 40 (22%) compared to males (49%). The proportion of practitioners servicing a regional/remote location did not change over time.

DISCUSSION AND CONCLUSION

The Australian O&P workforce became younger and more female. While the proportion of females in the workforce increase over time, these data indicate difficulty retaining female practitioners over age 40 years of age which may impact future workforce capacity. Research is needed to: explore workforce barriers in geographic areas with continued low practitioner prevalence, and the reasons why practitioners leave the profession. These data can help inform workforce initiatives to retain a younger and more female workforce.

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5.08.3 An exploration of the UK prosthetic and orthotic workforce

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BACKGROUND

Workforce data for people working within the prosthetics and orthotics (P&O) profession in the UK is incomplete [1,2] resulting in an unknown national picture. This prevents accurate service planning and projection requirements. There is very limited additional data from the statutory regulator Health and Care Professions Council (HCPC). To design and plan services and to ensure an adequate workforce to meet future demands, detailed data on the workforce is required.

AIM

This study captured a wide variety of demographic and work-related information relating to the current and future UK P&O workforce. The results will help inform national and local planning of P&O services.

METHOD

Available data on the UK P&O workforce was reviewed and any gaps were identified. The analysis of this data guided the design of mixed methods cross-sectional online survey aimed at the entire UK P&O workforce, including prosthetists/orthotists, prosthetic/orthotic technicians, prosthetic/orthotic support workers and current prosthetic/orthotic students/apprentices. This survey was conducted during Autumn 2022 and focused on four key areas 1) Demographics 2) Current role 3) Skills 4) Career goals.

RESULTS

A scoping review of workforce data available for the P&O workforce in the UK highlighted a dearth of data. The National Health Service (NHS) does not code the P&O workforce that it currently contracts. The contracted sector accounts for 70% of the P&O UK workforce [2]. The HCPC with which all UK prosthetists and orthotists must be registered to practice has data [3] based on 31% of the P&O registrants (346/1,114) but only looked at a small number of demographic factors. The data does not supply information on skills, place of work, current role, career goals, skills, or training needs. It also doesn't include the wider workforce (e.g., technicians and support workers).

The workforce-wide survey devised by this research team is the first to be undertaken on the P&O workforce in the UK.

DISCUSSION AND CONCLUSION

There is currently limited data on the P&O workforce, with neither the HCPC nor the NHS recording sufficient data to understand the national workforce and inform future service design. This lack of data requires urgent attention.

This is the first study to gather detailed information on the entire UK's current and future P&O workforce, gathering views on demographics, employment, salaries, education, skills, and views on future requirements for the workforce.

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ACKNOWLEDGEMENTS: Financial support for this study was provided by the British Association of Prosthetists and Orthotists.

5.08.4 Exploring national human resource profile and trends of Prosthetists/Orthotists in South Africa from 2002 to 2018

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BACKGROUND

The World Health Organization (WHO) in 2017 estimated that around 35-40 million people require prosthetic or orthotic services. The Framework and Strategy for Disability and Rehabilitation 2015-2030 for South Africa highlights a shortage of human resources for disability and rehabilitation services to manage the various risks and types of impairments faced by the population.

AIM

To describe the demographic trends of Prosthetists/Orthotists (P/O) registered with the Health Professions Council of South Africa (HPCSA) from 2002 to 2018.

METHOD

The study was a retrospective record-based review of the Health Professions Council of South Africa (HPCSA) database from 2002 until 2018. The database of registered Prosthetists/Orthotists was obtained from the HPCSA.

RESULTS

Data were analysed using the Statistical Package for the Social Sciences (SPSS version 22.0). In 2018, there were 544 P/Os registered with the HPCSA with a ratio of 0.09 P/Os per 10,000 population. There has been an average annual increase of 6% from 2002 to 2018. The majority (71.9%) of P/Os are located in the more densely populated and urbanized provinces, namely Gauteng, KwaZulu-Natal and Western Cape. The majority of registered P/Os identified as white (61%) followed by Black (22%), Indian (7%) and Coloured (2%). Most of registered P/Os are under the age of 40 years (54.2%) and males make up 73% of the registered P/Os.

DISCUSSION AND CONCLUSION

This study highlighted the unequal spatial distribution trends of P/Os which could be accounted for by South Africa's apartheid history and subsequent slow pace of transformation. Addressing the existing shortages is necessary to expand access to P/Os services and to ensure the motivation, planning and provision of adequate infrastructure to provide these services. The study presents a compelling case for the prioritization and strengthening of workforce for the achievement of effective universal health coverage for persons with disabilities.

5.08.5 Need assessment for continuous professional development of Prosthetists & Orthotists working in ICRC partner Physical Rehabilitation Centers in Pakistan

Abdul Nasir, Hasan AL-AGELE, Abdul Haseeb

ICRC, Islamabad, Pakistan

BACKGROUND

Continuous professional development (CPD) is required for enhancing the skills and knowledge of the professionals for quality services to patients[1]. Prosthetic and Orthotic services in Pakistan can be better provided by improving P&O's competencies for professional development. Graduates in Pakistan have limited opportunities and access to professional development[2]. ICRC Pakistan is supporting 17 Physical Rehabilitation Centers (PRCs) for P&O services. To develop a need based CPD plan for partner P&O's, ICRC decided to come up with a comprehensive plan of action.

AIM

This study was aimed at identifying the training and capacity building needs of P&Os in Pakistan to pave ways for developing a tailor-made CPD program for P&Os working in ICRC supported PRCs.

METHOD

This study represents formative research to identify the needs of the clinical staff in terms of CPD. A training needs assessment questionnaire for P&Os was designed using SurveyMonkey. All the questions were closed-ended. The survey questionnaire was validated by a team of P&Os and PTs within the ICRC Physical Rehabilitation Program before disseminating to respondents from ICRC supported PRCs. Samples were taken through convenient sampling method. Inclusion criteria for participation in the study questionnaire was P&Os working in the ICRC supported PRCs as clinicians and supervisors while trainee P&Os and P&Os working on non-clinical positions were excluded. Data was collected using online tool survey monkey (https://www.surveymonkey.com/).

RESULTS

Total 40 out of 65 respondents completed the survey of 9 questions. Female respondents were 31% (12). ISPO cat-2 graduates were 82% (33), whereas 7.7% (3) were each Masters in P&O & BS in P&O without ISPO categorization while 2.56% (1) respondent was ISPO cat-1 graduate. Respondents having experience between 2 and 6 years were 65% (26), whereas 12.5% (5) respondents had under 2 years' experience. Regarding specific P&O module, 65% (26) of respondents chose to strengthen their knowledge and skills in Ischial containment socket, while 62.5% (25) chose designing and prescription of lower-limb orthotics. Spinal orthotics & Transtibial prosthetics were chosen by 37% & 35% respondents respectively. When asked about competencies related to P&O procedures, 75% (30) chose significance of biomechanical significance on device function. Clinical Assessment, Dynamic alignment & gait were chosen equally by 55% (22) respondents.

DISCUSSION AND CONCLUSION

This study was important to obtain the first-hand feedback of the practitioners. P&Os are willing to learn new socket design. They want to learn about clinical decision making, prescription principles and to enhance their competencies in biomechanical principles, dynamic gait assessment and dynamic alignment.

In a CPD plan, all areas of required competencies for clinical reasoning and biomechanical concepts should be considered. similarly priority need to be given to modern prosthetic designs which can be fabricated within existing technology

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Free paper session: Footwear - Footwear

5.09.1 Efficiency of subsensory vibration on balance of healthy elderly and subjects with reduced plantar foot sensation

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BACKGROUND
Postural instability is considered a normal result of aging and is caused by some diseases like neuropathy.

AIM
The purpose of present study was to analyze and compare the effect of subthreshold vibration that was applied to the plantar surface of feet on balance control of healthy elderly and young subjects with simulated decreased plantar feet sensation.

METHOD
24 subjects (12 elderlies and 12 young persons with decreased plantar feet sensation) were included in this randomized crossover study with double blinded design. Participants were divided into intervention groups; 1) orthopedic shoe with vibration mechanism on and 2) orthopedic shoe with vibration off. Primary outcomes were Center of Pressure (COP) parameters including mean velocity, phase plane portrait, standard deviation (SD) of amplitude, and SD of velocity. Secondary outcomes were Berg Balance score and Timed Up-and-Go (TUG). The standing balance tested with different conditions; eye opened/closed and foam/rigid surface. General linear mixed models tests were used for statistical analysis.

RESULTS
Study showed very large effect sizes (Partial Eta Squared, $\eta 2>0.2$) with application of vibration in compared to vibration off for COP parameters with greater effects in condition with more baseline fluctuations. There was significant change in Berg balance test (Cohen d: 0.6, CI= -0.215 to -1.421). The time on TUG test was decreased and it was approached significance (P=0.06).

DISCUSSION AND CONCLUSION
The immediate effect of study showed that subthreshold vibration can improve static and dynamic balance in healthy elderly people and people with decreased plantar feet sensation. By conducting more studies with conclusive results in the field of vibration effectiveness in the elderly, we can hope to reduce the rate of falls in the elderly.

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5.09.2 Users' satisfaction with diabetic foot offloading devices and service in the 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 and fitted 206 cases with different types of offloading devices. 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 questions (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. Of users received once is 64.7% while 35.3% received twice or more. 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).

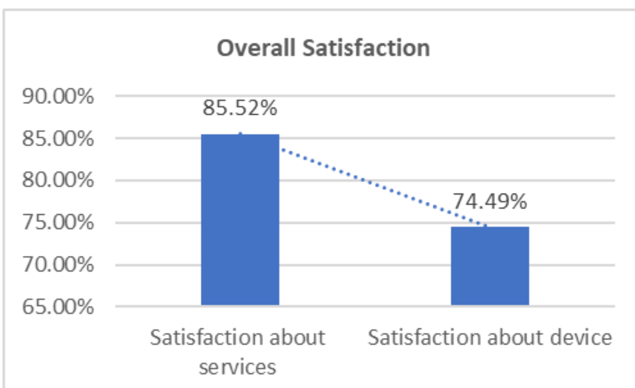

Figure 1. Overall Satisfaction

DISCUSSION AND CONCLUSION

The results of the study provide opinions and experiences from 167 DF patients who received offloading devices/shoes, 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.

5.09.3 Effect of insoles on pain, foot posture and plantar pressure in children with flexible flatfoot: one-year follow up

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BACKGROUND

Flexible flatfoot is a common foot problem since childhood, which may include loss of height of the medial longitudinal arch, valgus of the hindfoot, and abduction of the midfoot relative to the hindfoot.[1] It has been reported in studies that custom-made insoles may play a beneficial role in normalizing the forces acting on the feet of individuals with flexible flatfoot and reducing pain.[2,3]

AIM

To investigate the effects of long-term use of insoles on foot posture, plantar pressure and pain in children with flexible flatfoot.

METHOD

Fifty-four children (19 girls, 35 boys) with flexible flatfoot were included in the study. Foot postures of the children were evaluated with the Foot Posture Index (FPI), plantar pressures were evaluated with a pedobarograph (Medilogic, platform basic; Germany), and pain was evaluated with the Visual Analog Scale (VAS). Peak pressure values were calculated for each region by dividing the foot plantar pressure measurements into 7 regions. Evaluations were made before and after treatment. CAD/CAM insoles were applied to use with sports shoes.

RESULTS

The mean age of the children included in the study was 10.1±3.4 years, and the mean body mass index was calculated as 21.1±4.9 kg/m². Significant improvement was found in FPI and VAS scores after treatment ($p<.05$). Peak plantar pressures were increased under 2-5 toes, lateral forefoot, midfoot, and lateral heel in both feet ($p<.05$). It was decreased under medial heel for the left side ($p<.05$). Big toe, medial forefoot peak pressures did not change in time ($p>.05$, Table 1).

Table 1. Comparison of pre-treatment and post-treatment assessments

Variables		Pre-treatment	Post-treatment	p*
		X±SS		
VAS (cm) (n=27)		4.7±1.3	2.8±1.2	**<0,001**
FPI (n=54)	Right	7.2±1.8	6.7±1.9	**0.001**
	Left	6.8±1.4	6.4±1.5	**0.004**

*p: Wilcoxon Signed Rank Test, VAS: Visual Analog Scale, FPI: Foot Posture Index.

DISCUSSION AND CONCLUSION

Custom made insoles can improve pain and foot posture in developing children. In addition, lateralization of peak plantar pressures during walking may help to achieve better plantar pressure distribution.

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5.09.4 Validation of an industrial test platform for foot health devices

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BACKGROUND

The current standard for innovation of insoles, orthotics and footwear is inefficient due to a reliance on product prototyping and in-vivo testing to drive design decisions. One key area of high risk is product testing that requires gait laboratory studies with human participants, often to assess how clinical biomechanical criteria are met by a specific product design. These tests can be slow, costly, and difficult to perform, and consequently impact the innovation process.

AIM

This industry-linked project aimed to develop and validate a physical test platform for the performance evaluation of insole, orthotic and footwear products, thus informing design decisions and enabling product claims to be substantiated.

METHOD

A test platform comprising three parts was developed: (1) A phantom-foot comprising a rigid, 6-segment skeletal system [1] and phantom-plantar tissue structure, which represented a healthy Japanese 65kg male sample [2], (2) KUKA KR160 robotic arm to load the foot similar to in-vivo walking gait and (3) Measurement system capturing pressure, force and foot kinematics to characterise changes in foot biomechanics as a result of a foot care product. Validation tests included compression of the phantom-plantar tissue to determine alignment to cadaveric material properties [3] and cyclic loading to determine agreement with healthy in-vivo datasets for biomechanical outcomes: peak pressure, plantar contact area and joint segment kinematics.

RESULTS

Within stance phase, the phantom-calcaneus segment reproduced close alignment to in-vivo gait motion in the sagittal (NRMSE=0.58) and coronal planes (NRMSE=0.10), and the phantom-midfoot in the coronal plane (NRMSE=0.08) when normalised to the mean. Peak sub-heel plantar pressure aligned closely to in-vivo results (366.6kPa and RMSE=13.4 kPa) however, sub-heel contact area was significantly lower (21.12 cm^2 and RMSE=11.16cm^2) and the Young's modulus of the phantom-plantar tissue greater than cadaveric samples (1.374MPa and difference from target=0.174MPa).

DISCUSSION AND CONCLUSION

The test platform reproduced broadly representative peak plantar pressure measurements under the heel and in the timings of peak loading forces. Bone segment kinematics demonstrated good agreement for the target region (heel). This system enables improved product design, objective product evaluation and will enable evaluation of products pre-post wear to assess ongoing performance and suitability. Further work will allow direct comparison between the test platform and in-vivo clinical gait laboratory studies to validate the system for evaluation of product performance.

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5.09.5 Orthotic pressure sensing insole using FSR (Force Sensitive Resistor) Sensor for people suffering from foot pronation

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BACKGROUND

Impact forces during running or walking propose that impact forces are input signals that produce muscle tuning shortly before the next contact with the ground to minimize soft tissue vibration and reduce joint & tendon loading. During stance phase, the forces act as an input signal processing a muscle reaction. Orthotics reduce muscle activity.

AIM

To correct the foot pattern during walking, running.

To increase the body's natural shock absorbing capability, to reduce suffering from knee pain, metatarsal pain and other disorder caused by over pronation, and under pronation.

METHOD

The design of pressure-sensing insole using FSR sensor is to help the people suffering from foot pronation. The force distribution of a user's foot measured using FSR sensors, while ATMega 16 and a custom printed circuit board (PCB) collect and process the force data. If force thresholds are exceeded, the software attempts to vary the stiffness of the insole in order to adjust the forces to an acceptable level. The software does this by triggering solenoid valves and an air compressor to control air-flow inside the shoe that will modify its stiffness. The design of the pressure-sensing insole has data collection, processing system and control of the shoe variable stiffness.

RESULTS

The analysis of patient facing foot problems like pain in the knee, metatarsal pain, problems with Achilles tendon caused by incorrect foot posture, was studied on 6 participants. The process begins when the user's foot strikes. Sensors placed around the sole of the shoe, pick up the difference in resistance. This is then translated and interpreted through ATMega 16 microcontroller. In microcontroller, a pressure threshold value is set. If the pressure exceeds the threshold value, then the microcontroller suggests an action in order to correct the pronation or supination involved. Microcontroller gives the command to the air compressor to fill the air in the shoe through valves. It provides the air support in a shoe, after providing air support to the feet the compressor gets off when again pressure exceeds the threshold value then process repeat again.

DISCUSSION AND CONCLUSION

This orthotic device is designed to adapt the changing condition of foot strike and automatically take an action to correct the posture of the foot. When foot pronation is detected, the compressor automatically starts and provides the air support in the sole. After providing air support the compressor automatically shuts off. When exceeding pressure is detected again the compressor turns on and provides air support again in the sole to avoid pain in the knee, metatarsal pain, Achilles tendonitis caused by incorrect foot posture.

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Free paper session: Prosthetics: Lower limb - Gait and components

5.10.1 Objective assessment and understanding of using machine learning: Applications in individuals with unilateral trans-tibial amputation.

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BACKGROUND

In research, machine learning algorithms can provide an objective assessment and understanding of gait. Translating these methods into clinical practice has demonstrated the ability to classify pathologies correctly supporting the specialists during diagnosis and treatment recommendations. Using machine learning algorithms to understand the differences between the gait of individuals with lower-limb amputation and able-bodied individuals can help provide better prosthetic rehabilitation. This study will highlight how such methods can be implemented to understand the differences between two groups during research.

AIM

This study aimed to demonstrate an objective method to find differences between the gait of individuals with trans-tibial amputation and able-bodied individuals using machine learning algorithms.

METHOD

Eleven individuals with unilateral trans-tibial amputation (UTTAs) (age 50±12y; height 1.7±0.1m; mass 83.94±13.59kg) and thirty able-bodied individuals (ABs) (age 39±20y; height 1.7±0.1m; mass 73.76±14.02kg) provided informed consent to participate. Participants walked along a 15m walkway at self-selected walking speed. For all trials, kinetic and kinematic data were captured at 1000 Hz and 100 Hz, respectively. The twenty biomechanical variables measured were commonly reported in the literature during the investigation of forward progression and dynamic stability. Principal component analysis (PCA) was applied for data reduction and discriminant function analysis (DFA) was applied for feature selection and classification of the data [1].

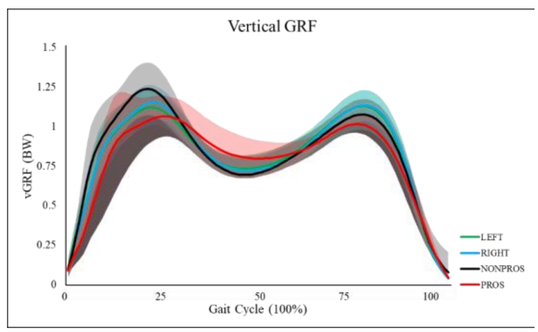

Figure 1. The mean ± standard deviation of the vertical GRF profile of the prosthetic (PROS) and non-prosthetic (NONPROS) limbs of UTTAs and the left and right limbs of ABs.

RESULTS

The overall results indicated that the prosthetic and non-prosthetic limbs of UTTAs differed from the right and left limbs of ABs, and the eigenspectrum of PCA and the DF spectrum allowed the causal factors of these differences to be established. Using PCA, the causal factors between the two groups were vertical ground reaction force (GRF), sagittal hip joint moment and sagittal knee joint angle. Using DFA, the causal factors were medio-lateral GRF, vertical GRF and sagittal knee joint angle. Both PCA and DFA, identified the vertical GRF as a parameter which differs between UTTAs and ABs, and this difference can be seen in the profile of the vertical GRF (Figure 1).

DISCUSSION AND CONCLUSION

Using PCA and DFA, it was possible to objectively identify which parameters differ between the group of individuals with unilateral trans-tibial amputation and the able-bodied individuals. The results demonstrated that important parameters which differ between these groups are vertical GRF and sagittal knee joint angle. This highlights the importance of machine learning algorithms as automatic gait recognition tools which can be used in research and clinical settings to get a better overall understanding of the group under investigation.

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5.10.2 Material properties and performance in running specific prostheses: a literature review

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BACKGROUND

Running specific prostheses (RSPs) operate as a leaf spring to return energy during unloading. Although material properties of RSPs can affect running performance, manufacturers do not consistently report them. Instead, they place their RSPs into arbitrary stiffness categories recommended to clinicians based on the user's body mass/size and their expected activity [1,2]. In use, various running activities metabolically different from one another [3], and it can be challenging to match a foot to an individual and activity.

AIM

The present study systematically reviewed existing literature to characterize and compare numerical values of RSP stiffness and hysteresis and evaluated how these properties affect athletic performance in individuals with limb loss.

METHOD

We conducted a comprehensive search strategy through twelve well-known databases from inception until April 2022. Additionally, we searched the following publishers to ensure a thorough search: Elsevier, Nature, Frontiers, and SAGE. Database-appropriate search syntax was used based on the following, intended to capture articles about both limb prostheses and their material properties:

(prosthe* OR cheetah OR blade) AND (run OR running) AND (mechanical OR stiff* OR energy OR hysteresis OR modulus) NOT (implant).

We included all studies in which at least one RSP was assessed for mechanical properties and studies that evaluated the relationships between these mechanical characteristics with any aspects of the running performance.

RESULTS

The initial search process generated 3,048 articles. Among those, 15 fully matched criteria and were included in the review. Mechanical stiffness was calculated as load divided by deflection. In studies that used a material testing machine, the peak load ranged from 1000 N up to 3500 N, with 1500-2000 N applied in most studies. The loading rate varied from 50 mm/s to 100 mm/s. Loading techniques varied across the reviewed studies. Some loaded the prosthesis up to the maximum amount, sometimes in a linear ramp profile and other times with static loading or drop testing, while others used cyclic loading-unloading at a specific frequency. The prosthetic placement in the testing machine also varied. Subsets of studies assessed properties and performance, based on speed, step length, reaction force, and metabolic cost.

DISCUSSION AND CONCLUSION

Several studies did not report the numerical data for material properties despite measuring them. Relatively few articles measured both material properties and running performance and assessed correlations. Poor outcome reporting and lack of consistency in measuring RSP material properties suggest the need to develop a standard guideline on measurement and reporting of RSP material properties. Clinicians would benefit from objective, data-based comparisons of the attributes of different RSPs; however, inconsistencies in the literature do not currently permit this.

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5.10.3 Should transtibial prosthetic dynamic alignment be tuned first in the sagittal plane or in the coronal plane?

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BACKGROUND

Dynamic alignment of transtibial prostheses is important because it affects energy expenditure and gait. It should be adjusted in sagittal and coronal planes. However, it is unclear in which plane the adjustment should be performed first. As socket reaction moment (SRM) is reported to be sensitive to alignment changes, it is likely that effects of alignment change on out-of-plane SRM (i.e., effects of sagittal alignment changes on coronal SRM) may be helpful to determine the appropriate order of dynamic alignment[1,2].

AIM

The aim of this study is to investigate the appropriate order of dynamic alignment in sagittal and coronal plane using SRM.

METHOD

Ten participants with transtibial amputation were asked to walk under twelve alignment changes (3-degree flexion and extension, six-degree adduction and abduction of the socket, anterior, posterior, lateral, and, medial translation of the socket, and three-degree dorsiflexion and plantarflexion, six-degree inversion and eversion of the foot) to measure walking speed and out-of-planes SRM. In the sagittal plane, peak extension and flexion moments, and %stance of peak extension and flexion moment were extracted. In the coronal plane, SRM at 5%, 20%, and 75% stance were extracted. Data was classified into six groups and repeated measures of ANOVA or Friedman tests were performed ($p<0.05$).

RESULTS

It is found that the alignment changes of the foot did not affect out-of-plane SRMs. There were no significant differences in walking speeds. There were significant differences of 20% stance of coronal SRM under sagittal socket alignment changes (baseline alignment, posterior translation of the socket, flexion, $p=0.02$). Other socket alignment conditions did not significantly affect out-of-plane SRM.

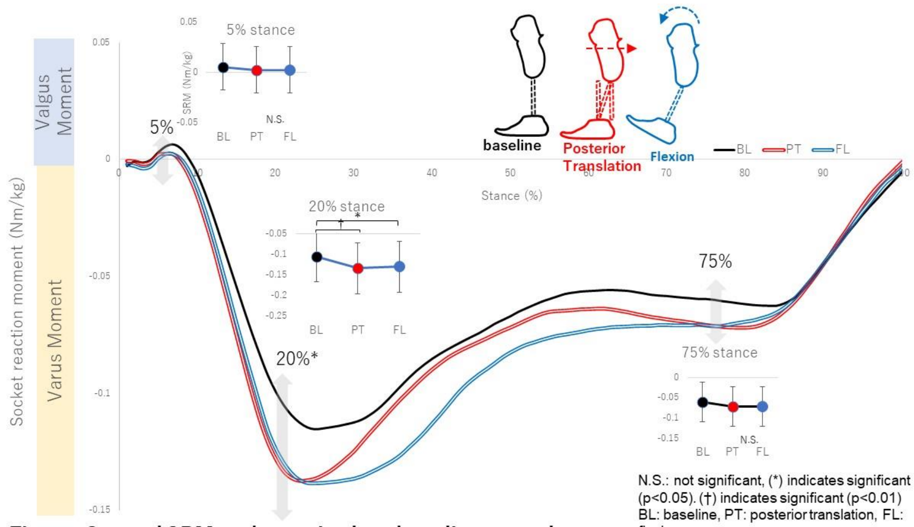

Figure: Coronal SRM under sagittal socket alignment changes

DISCUSSION AND CONCLUSION

Previous studies showed that socket alignment changes in sagittal plane affected coronal SRM, however, coronal alignment changes did not. If coronal alignment is adjusted first, it will not affect sagittal SRM. However, after sagittal alignment is adjusted consequently, this might affect the coronal SRM, which have been determined by the first adjustment of coronal alignment. Therefore, it is recommended that the adjustment of transtibial alignment is should be performed first in the sagittal plane, and then in the coronal plane.

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5.10.4 A data-driven approach to prosthetic system mechanical characterization using sparse identification of nonlinear dynamics

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BACKGROUND
Prosthetic feet typically demonstrate non-linear mechanical behaviour and this has previously been modelled with lumped-parameter, viscoelastic systems [1,2]. Addition of componentry such as hydraulic ankles and shock-absorbing pylons (SAPs) makes modelling these prosthetic systems more complex and difficult, as their interactions must often be inferred or estimated. Recently, data-driven non-linear dynamical modelling tools have been developed for the identification of equations governing unknown, complex mechanical systems [3].

AIM
This work characterized and modelled assembled prosthetic systems (ankle, foot, and SAP) with unknown dynamics at critical instances during stance phase; Initial Contact (IC), Midstance (MS), and Terminal Stace (TS).

METHOD
Twelve systems of different component assemblies were tested at three orientations: Horizon and Odyssey K3 (College Park Industry, USA), two hydraulic ankle resistance settings, and three SAPs (Fillauer, USA) of varying stiffness. Systems were loaded to 1230 N and unloaded to 100 N at 200 N/s five times [4]. The first four cycles were used to identify the governing equation with the Sparse Identification of Nonlinear Dynamics with control (SINDYc), while the last cycle served as validation [3]., Root Mean Squared Error (RMSE) was calculated between measured and modelled hysteresis curves, and absolute and relative errors are presented for energy returned.

RESULTS
The dynamics of the system were accurately modelled with a non-linear differential equation (Figure 1) [3]. The output from the SINDYc algorithm for all prosthetic systems was a nonlinear ordinary differential equation, including a squared displacement term. Where the behaviour is governed by the current displacement and force. The range of the RMSE for the models were 0.19 to 0.46 mm for IC, MS 0.05 to 0.18 mm for MS and 0.49 to 1.26 mm at TS. The models tended to slightly underestimate the measured energy return across all orientations. The absolute difference ranged from -4.33 to 2.31 % energy returned.

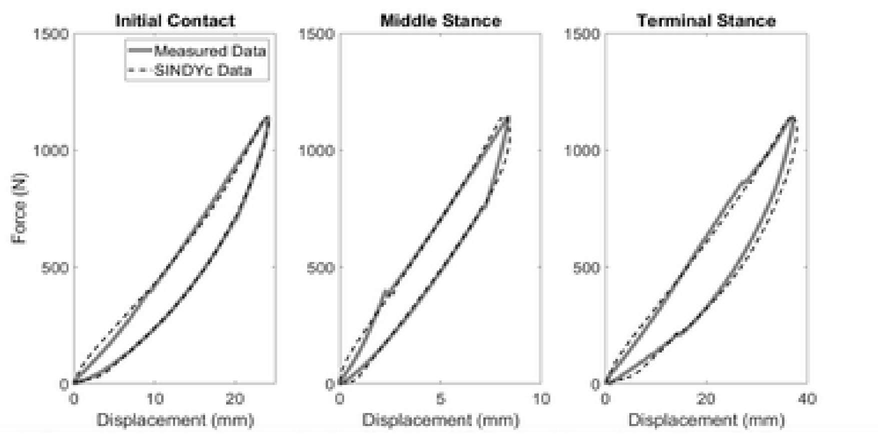

Figure 1. Force displacement curves for the Odyssey K3 Foot ankle system with an SAP.

DISCUSSION AND CONCLUSION
We have demonstrated that without prior knowledge of the system, we can derive dynamics through generalized equations and accurately model a prosthetic system's loading-unloading response at critical moments during stance phase. This novel data-driven characterization method permits universal interpretable comparison of mechanical behavior across prosthetic systems and can be incorporated into a simulation of prosthesis user response and virtual prosthetic design platforms. Future work involves modelling across the entirety of stance phase.

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5.10.5 Effect of prosthetic stiffness on intact limb loading in a change of direction task

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BACKGROUND

Increased loading on the intact limb (IL) of people with transtibial amputation (PTTA) compared to that experienced by people without disability is thought to be related to the higher rates of overuse injury in the intact limb. In walking and running the increased loading on the IL has been associated with the reduced propulsion during push-off from the prosthesis [Morgenroth et al, 2011]. No research has been conducted on how the IL behaves in a change of direction (CoD) task.

AIM

The first aim of the research was to determine if the stiffness of the prosthesis influenced the loading on the IL. The second aim was to determine if there are differences in the load on the IL compared to controls.

METHOD

Data were collected during a controlled CoD task for 18 participants (9 PTTA, 9 matched controls) using motion capture integrated with a force platform. PTTA used a BladeXT prosthesis with their prescribed stiffness and 1 grade stiffer. Vertical ground reaction force peak (Fz) and the time from ground contact to 1 body weight (Fzs) plus the body's vertical (vVPel) and horizontal velocity (hVPEL) at touchdown (TD) which are sensitive to the propulsive impulse by the prosthetic side were analysed by paired t-tests to assess the effect of prosthetic stiffness. The GRF variables were analysed to determine differences in load on the IL compared to controls using independent t-tests.

RESULTS

Changing the stiffness of the prosthesis affected horizontal velocity at TD and the loading rate on the IL. There was no difference in loading between the PTTA and Controls.

Table 1. Mean (SD) loading and TD characteristics in the prescribed prosthesis and 1 category of stiffness higher; and the loading for the prescribed prosthesis compared to control.

	Prescribed	Stiff
Fz (N/kg)	24.5 (4.4)	24.0 (4.3)
Fzs (s)	0.03 (0.007)	0.04 (0.007)*
vVPel (mm/s)	-519 (212)	-424 (238)
hVPEL (mm/s)	1734 (167)	1816 (152)*
	Prescribed	Control
Fz (N/kg)	24.5 (4.4)	21.6 (2.8)
Fzs (s)	0.03 (0.007)	0.04 (0.01)

*Indicates a significant difference at $p<0.05$

DISCUSSION AND CONCLUSION

When executing a controlled, low-velocity CoD task, changing the stiffness of the prosthesis altered the horizontal velocity at TD. This indicates the stiffness affected the propulsive capacity of the prosthetic limb. Increasing prosthetic stiffness led to reduced vertical loading rate. There was no evidence of higher load on the IL compared to matched controls. This is in contrast to movements such as running and walking.

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ACKNOWLEDGEMENTS: The time to change the device stiffness was donated by Chas A Blatchford and Son.

5.10.6 Predicting the effect of prosthetic alignment on knee moment using IMUs

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BACKGROUND
The gait of transtibial amputation patients is dependent on prosthetic setup and alignment. Inappropriate position of the prosthetic foot relative to the socket could lead to osteoarthritis or low back pain [1]. However, the interpretation of optimal prosthetic alignment is subjective [2]. The use of inertial measurement units (IMUs) in conjunction with machine learning allows the measurement outside the gait laboratory and could assist the prosthetist in finding the optimal prosthetic alignment.

AIM
The aim of this study is to use IMU measurements and machine learning to predict changes in knee moment caused by differences in prosthetic alignment.

METHOD
Motion capture data of eleven unilateral transtibial amputees walking at self-selected gait speed were collected and data from 5 IMUs were obtained. The amputees walked with optimized prosthetic alignment defined by a prosthetist (reference), eversion of prosthetic foot and 7 further alignment perturbations. The knee moment was calculated using inverse dynamics. A Long Short-Term Memory network was trained for the reference condition. The knee moment of the prosthetic side was predicted for the reference and eversion conditions of one patient using unseen IMU data as input. Statistically significant differences between conditions were analysed using statistical parametric mapping (SPM) paired t-test ($p<0.05$).

RESULTS
The eversion of the prosthetic foot increased the knee rotation moment both in inverse dynamics and in prediction during the stance phase (Figure 1). However, SPM did not reveal significant difference in the peak knee rotation moment. Statistically significant differences were observed in the beginning of the gait cycle and during the swing phase for inverse dynamics. The decrease of knee rotation moment at the end of the gait cycle was predicted in our results, but to a lesser extent. The SPM of the prediction also showed a statistically significant difference in eversion condition at around 65% of the gait cycle, which was not observed in inverse dynamics (Figure 1).

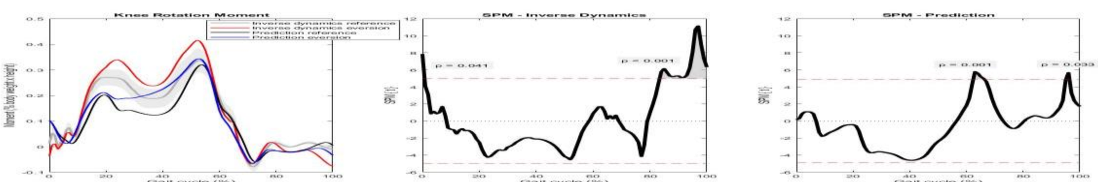

Figure 1. Knee rotation moment and SPM from inverse dynamics and prediction for reference and eversion conditions

DISCUSSION AND CONCLUSION
We were able to predict knee moment, but the network was not capable to predict all changes observed in inverse dynamics. Possible explanations are the inter-individual variability of amputees and a relatively small number of subjects, which may affect the neural network training. The results indicate that the IMU can be used to predict altered knee moments in transtibial amputees as a function of improper prosthetic alignments.

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ACKNOWLEDGEMENTS: The work was funded by the Bundesministerium für Wirtschaft und Energie (Germany) ("VarioFit" no. 16KN089720).

Free paper session: Orthotics: Lower limb - Proximal and AFO

5.11.1 The immediate effects of dorsiflexing the footplate of a rigid ankle-foot orthosis (AFO) on lower limb kinematics and user feedback

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BACKGROUND
Rigid ankle-foot orthoses (AFOs) are widely used within clinical practice to address pathological gait. A literature review search illustrated AFO footplate variations are under investigated, despite this being a key design feature in AFO prescription. There are currently no studies investigating how dorsiflexing the footplate would affect lower limb kinematics and user feedback.

AIM
To evaluate the effects of dorsiflexing the footplate on hip, knee and ankle kinematics and user feedback.

METHOD
Healthy participants (n = 10) were provided with rigid AFOs with full-length footplates. Participants were tested under four test conditions: shoe-only, rigid AFO with 0° of dorsiflexion at the footplate, rigid AFO with 15° of dorsiflexion at the footplate and rigid AFO with 30° of dorsiflexion at the footplate. Data on hip, knee and ankle kinematics was obtained from midstance to pre-swing. User feedback was established through verbal free text comments and scoring the visual analogue scale.

RESULTS
The most preferred condition was the AFO with 15° of dorsiflexion at the footplate (n = 6), followed by the AFO with 30° of dorsiflexion at the footplate (n = 4), the least preferred condition was the AFO with 0° of dorsiflexion at the footplate (n = 0). Participants described the dorsiflexed footplates as 'more natural', 'easier to walk in' and 'smoother' compared to the flat footplate. No statistically significant differences were observed; however, trends in hip, knee and ankle kinematics were identified.

DISCUSSION AND CONCLUSION
The most significant finding in this study is identifying 100% of the participants preferred a dorsiflexed footplate over a flat footplate. We recommend orthotists consider dorsiflexing the footplate of rigid AFOs as part of routine clinical practice. Further research is required to comprehend the effects of dorsiflexing the footplate on pathological gait and to determine a suitable prescription criterion.

5.11.2 Prescription practices for rigid ankle-foot orthoses among UK orthotists

Paul Charlton[1], Nicola Eddison[2], Michael Gandy[3], Nachiappan Chockalingam[2]

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BACKGROUND

The authors recognize that the design of bespoke rigid AFOs should be tailored to the individual needs of each patient. However, there is a need to understand common clinical practice among orthotists as to the design of bespoke rigid AFOs for the adult, male population. This may help inform the production of guidelines for AFO prescription.

AIM

To investigate whether there is a consensus on baseline AFO design among UK orthotists.

METHOD

After necessary ethics and research governance approvals from Staffordshire University Research Ethics Committee, this cross-sectional online survey was distributed to UK orthotists by the British Association of Prosthetists and Orthotists to all its member orthotists (n = 334). The survey consisted of 25 questions, largely close-ended (n = 24) (see online supplementary file 1, http://links.lww.com/POI/ A95). The questions were based on a typical bespoke AFO specification form used by orthotic manufacturers, in addition to the knowledge of experienced clinicians and researchers.

RESULTS

A total of 100 survey responses were received. Seventy-one percent (n = 71) of the respondents said that they had a standard baseline prescription for adult bespoke rigid AFOs. Those who answered “no” (n = 29) were presented with a further open-ended question, which asked how they decided on the specifications for their AFOs. AFO material and reinforcements Fifty-one percent (n = 51) of the respondents chose 4.5 mm copolymer polypropylene as the material from which to fabricate the AFO. Other responses included 3 mm (n = 4) and 6 mm (n = 5) copolymer polypropylene and 4 mm (n = 1), 4.5 mm (n = 20), 5 mm (n 5 1), and 6 mm (n = 4) homopolymer polypropylene. One participant chose carbon fiber.

DISCUSSION AND CONCLUSION

Respondents had varying levels of orthotic experience, ranging from less than 1 year (n = 6), 2–5 years (n = 25), 6–10 years (n = 25), 11–15 years (n = 15), to more than 15 years (n = 31). The results indicate a clear consensus of a baseline prescription for AFO design for an adult male, as described in this study.

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ACKNOWLEDGEMENTS: The authors would like to thank all participants who responded to this survey in addition to their clinical work.

5.11.3 Optimization of the design of rigid ankle foot orthoses (AFOs)

Panagiotis Chatzistergos[1], Nicola Eddison[1,2], Nachiappan Chockalingam[1]

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BACKGROUND

Currently, there are no guidelines which dictate how an AFO prescribed to be rigid should be designed to ensure it is rigid enough to do the job it is designed to do [1]. Material thickness and the design of reinforcing features can significantly affect AFO stiffness. However, their effect on AFO stiffness is not quantified and thus remains poorly understood.

AIM

To quantify the effect that AFO thickness and the design of reinforcing features have on AFO stiffness and to set the basis for quantitative guidelines for the design optimisation of rigid ankle AFOs.

METHOD

A polypropylene AFO was produced according to UK standard practice and its stiffness was experimentally measured for 30Nm [2] of dorsiflexion (Figure 1a). Its geometry and mechanical characteristics were utilised to create a finite element (FE) model of a typical rigid AFO. Following validation, the model was used to quantify the effect of material thickness and reinforcement design (i.e., reinforcement placement and length) on stiffness. A final set of AFO samples were produced to experimentally confirm key findings.

RESULTS

AFO stiffness decreased linearly with thickness down to a thickness of 3.60mm (Figure 1b). Further thinning after this point led to buckling for the same external load and thus to a substantial further reduction in stiffness. With regards to the placement of reinforcement elements, FE modelling showed that stiffness is maximised when reinforcements are placed at the anterior-most position possible. These key findings were experimentally confirmed. The stiffness of an AFO reinforced according to standard practice with lateral and medial ribbing was 4.4Nm/deg±0.1Nm/deg. Instructing the technician to move the riggings anteriorly increased stiffness by 22%. Further stiffening is achieved by ensuring they extend from the footplate to at least two-thirds of the AFO's total height.

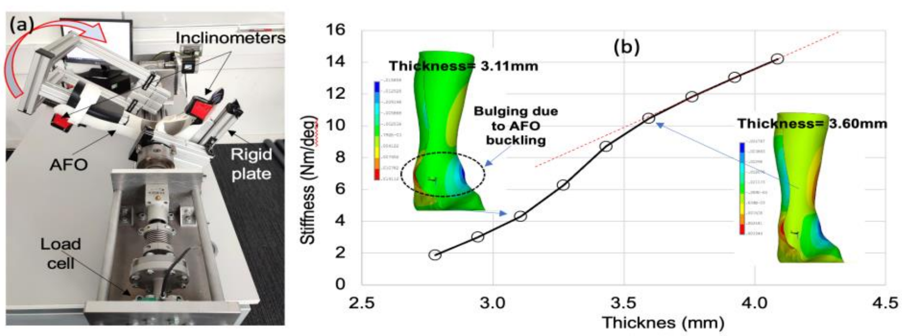

Figure 1: (a) The testing set-up for the measurement of flexural stiffness of AFOs. (b) The effect of thickness on AFO stiffness. The deformed shapes and distributions of mediolateral displacements (in meters) for two selected AFO scenarios are also shown; one scenario where there is buckling (thickness=3.11mm) and one where there is no buckling (thickness=3.60mm).

DISCUSSION AND CONCLUSION

There is a threshold of thickness below which the AFO cannot effectively resist flexion and it buckles (figure 3). For the reference AFO and for the loading conditions studied here this threshold was 3.6mm. Reinforcement elements should be placed at the anterior-most position that is possible and they extend from as close to the footplate to at least two-thirds of the AFO's total height.

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ACKNOWLEDGEMENTS: The authors would like to thank Peacocks Medical Group for the provision of AFO samples.

5.11.4 The effect of offloading knee braces on pain

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BACKGROUND
Knee Osteoarthritis (OA) is a degenerative disease. The pathological changes contribute to pain and inflammation. This can have an adverse effect on quality of life impacting both physical and psychological parameters. OA management aims to control knee pain, improving function and quality of life. Inactivity and disuse can compound joint damage as the absence of mechanical loading induces further cartilage degeneration, highlighting the importance of activity. Offloading knee braces can be used to reduce pain, permitting increased pain-free activity.

AIM
This pragmatic review looks at the effect of offloading knee braces use on pain.

METHOD
Between 1st April 2021 and 31st March 2022, patients were referred into the Orthotics department at Sandwell General Hospital via Trauma and Orthopaedic consultants, physiotherapists and GPs. To quantify patient's pain the Oxford Knee Score (OKS) was used. This was developed to categorise patients suffering with OA in their knees, giving a score out of 48. It allowed the comparison before and after intervention. At the initial assessment an OKS was taken. Six weeks following the supply of an offloading knee brace another OKS was taken over the phone.

RESULTS
138 patients were provided with offloading knee brace(s). Bilateral braces were counted as one patient. Out of 138, 110 results were collected. The OKS for the 110 patients used in the sample were representative of the 138. 28 could not be contacted for the planned review; these patients were representative.

85% reported an improvement of OKS, reduction in pain. 90% reported an improvement in stability and that they could walk for longer without pain, permitting increased activity.

There was no relationship between the initial OKS and the degree of pain reduction, suggesting that offloading knee braces are appropriate for different pain levels and OA severities.

17 from 110 patients reported rubbing. Five were resolved with five with further fitting guidance. 12 patients required an alternative brace.

Three patients presented with more pain, not related to rubbing, therefore discontinued use.

Oxford Knee Scores Changes	110 patients
>20	1
+ 15 – 20	7
+ 10 – 14	17
+ 5 – 9	28
+ 1 – 4	40
0	14
Reduction of Oxford Knee Score	3

DISCUSSION AND CONCLUSION
Overall, patients reported a reduction in knee pain and increased stability when mobilising with an offloading knee brace. It should be noted that the review took place during a period when other treatments could have been occurring simultaneously. The six week follow up period helped overcome this and represents Orthotic specific results; however the pragmatic approach of this review is reflective of actual clinical practice, and highlights the benefits of offloading knee braces

5.11.5 Effect of two types of ankle foot orthosis on thoracic and pelvic movements of patients with stroke during gait

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BACKGROUND

Impairments of trunk movements in the gait of stroke are often reported. Ankle foot orthosis (AFO) is commonly used to improve the gait of stroke, however, the effect of different types of AFOs on the thorax and pelvis during the gait of stroke has not been clarified.

AIM

This study aimed to investigate the effect of different designs of the AFOs on the gait of stroke from the perspectives of thoracic and pelvic movements through clinical trials.

METHOD

Thirty-four patients with stroke were randomly allocated to undergo 2 weeks of gait training by physiotherapists while wearing a rigid AFO (RAFO) with fixed ankle or an AFO with an oil damper (AFO-OD) that provides plantarflexion resistance and free dorsiflexion. A motion capture system was used to measure shod gait without an AFO at baseline and after training with and without the allocated AFO. Two-way repeated ANOVA, Wilcoxon signed-rank test, and Mann-Whitney U test were performed for the data after the gait training to know the effect of different kinds of AFOs.

RESULTS

Twenty-nine patients completed the study (AFO-OD group: 14, RAFO group: 15). Interactions were found in pelvic rotation angle, change of shank vertical angle (SVA) in stance, and paretic to non-paretic step length, which all were increased in AFO-OD group ($p<0.05$), the SVA decreased in RAFO group ($p<0.05$). Main effects were found in pelvic rotation at contralateral foot off, and thoracic tilt at foot off when an AFO was worn. SVA was positively correlated with pelvic rotation in AFO-OD group ($r=0.558$), with pelvic tilt at contralateral foot off ($r= 0.670$), and with pelvic tilt at initial contralateral contact ($r= 0.568$) in RAFO group. At initial contact, pelvic rotation was positively correlated with thoracic rotation in both groups. See Figure 1 for more details.

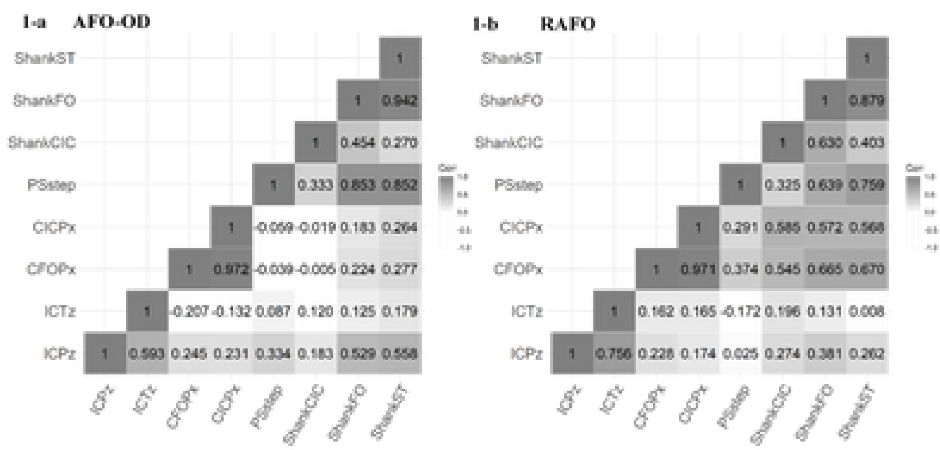

Figure 1. Correlation coefficient between parameters: 1-a. AFO-OD group; 1-b. RAFO group
ICPz: pelvic rotation angle at initial contact; ICTz: thoracic rotation angle at initial contact; CFOPx: pelvic tilt angle at contralateral foot off; CICPx: pelvic tilt angle at contralateral initial contact; PSstep: paretic to non-paretic step length; ShankCIC: shank vertical angle at contralateral initial contact; ShankFO: shank vertical angle at foot off; ShankST: the change of shank vertical angle in the stance.

DISCUSSION AND CONCLUSION

This randomized controlled trial assessed the effect of a rigid AFO, which relatively stopped both dorsiflexion and plantarflexion, and the AFO-OD which generated plantarflexion and enabled free dorsiflexion on gait of stroke. Pelvic rotation and lower limb kinematics exhibited significant improvements with AFO-OD, reflecting more desirable gait performance. On the other hand, the increase in thoracic in-phase rotation might expose the effect of insufficient trunk control and dissociation movement.

5.11.6 Optimizing KAFO fittings: What is the effect of different orthotic ankle joints?

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BACKGROUND

Conventional orthotic ankle joints (CAJ) allow a limited dorsi- and plantarflexion restricted by stops. A group of novel orthotic ankle joints enables both an adjustable control of dorsiflexion and plantarflexion as well as an increased range of motion (ROM). This novel generation of orthotic ankle joints is well established in AFO fittings [1,2]. However, there is only little data on the patient benefits in KAFOs [3].

AIM

In the present study, the aim was to evaluate the biomechanical effects of the new orthotic ankle joint generation in KAFOs.

METHOD

Five patients, fitted unilaterally with a microprocessor-controlled KAFO (C-Brace) and having previous experience with the SCO E-MAG Active were enrolled in the study (3male, 2female, 48±16 years, 171±9 cm, 81±20 kg). In the investigation, the orthotic ankle joint Nexgear Tango (NGT) representing the novel generation was tested. Its modular construction allows for configuring it as a CAJ or NGT. Four orthotic configurations (C-Brace and E-MAG Active with NGT and CAJ) were analysed biomechanically during level walking, short steps, ascending and descending ramps (10 deg), and standing on inclines. Kinematic data were measured with an optoelectronic system (VICON) coupled with two force plates (KISTLER).

RESULTS

During level walking with NGT, significantly increased mean maximal dorsiflexion angles were measured (+7.1° for C-Brace, +7.6° for SCO, $p<0.05$). The orthotic side mean external peak extension moment at mid stance was slightly reduced by 0.12 Nm/kg for both KAFOs. During ascending ramps, the mean maximal dorsiflexion with NGT was significantly increased (+8.7° for C-Brace, +11.4° for SCO, $p<0.05$), together with an improved ratio between decelerating and accelerating horizontal ground reaction forces and reduced external knee peak extension moment (-0.16 Nm/kg for C-Brace, -0.24 Nm/kg for SCO). During descending ramps, the motion pattern was dominated by the orthotic knee joint principle. For biomechanics during uphill standing, an increased dorsiflexion (+4°, $p<0.05$) with NGT was found for both KAFOs, combined with a more regular lower limb loading.

DISCUSSION AND CONCLUSION

The increased and controlled dorsiflexion with NGT may enable an improved roll-over behaviour of the orthotic limb with easier swing phase initiation independent of the KAFO principle. In SCOs, increased reliability of switching from locked into unlocked state can be expected.

The novel ankle joint principle may improve the functionality of KAFOs, especially in more difficult motion patterns. Therefore, the new principle represents an additional option to optimize individual KAFOs.

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Free paper session: Paediatrics - Orthotics

5.12.1 Effect of orthoses on balance in children with cerebral palsy: Solid AFO versus ankle-foot orthoses footwear combination

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BACKGROUND

Ankle Foot Orthoses (AFO) are a fundamental rehabilitation strategy to facilitate balance and walking in children with cerebral palsy (CP), yet reviews [1,2] suggest that efficacy of the solid AFO (SAFO) with 90-degree alignment remains equivocal. A novel decision tree of orthotic prescription proposes a patient-specific method for adjusting AFO alignment and integrating footwear modifications (Ankle Foot Orthoses-Footwear Combinations, AFO-FC [3].

AIM

The purpose of this study was to examine the effect of the AFO-FC approach on balance as compared to the SAFO (with uniform alignment and without shoe modifications) in children with CP.

METHOD

A randomized cross-over study. Inclusion criteria: bilateral spastic diplegia, Gross Motor Function Classification System (GMFCS) II or III, abnormal leg segment alignment during stance, sufficient calf muscle length/tone for 90-degree ankle dorsiflexion, triplanar midfoot bony alignment, and 4 to <10 years of age. 19 children with CP were recruited and randomized to SAFO (n=10) or AFO-FC (n=9) and followed for 3 months. Average age was 6.9 (4.2–9.8) years, GMFCS levels II (15) and III (4), and 15 were male. AFOs were fabricated at the same lab, cast/fit by the same orthotist, and wore consistent footwear modified per group. Pediatric Balance Scale (PBS) was administered with devices/shoes.

RESULTS

Baseline total PBS scores were similar at 32.7 (SD 10.6) and 31.5 (15.8) (p=0.84) for the AFO-FC and SAFO groups, respectively. After wearing assigned devices for 3 months, the AFO-FC group had significantly increased total scores compared to the TSAFO group [45.5 (13.5) vs.35.0 (16.7), p=0.03, Figure 1].

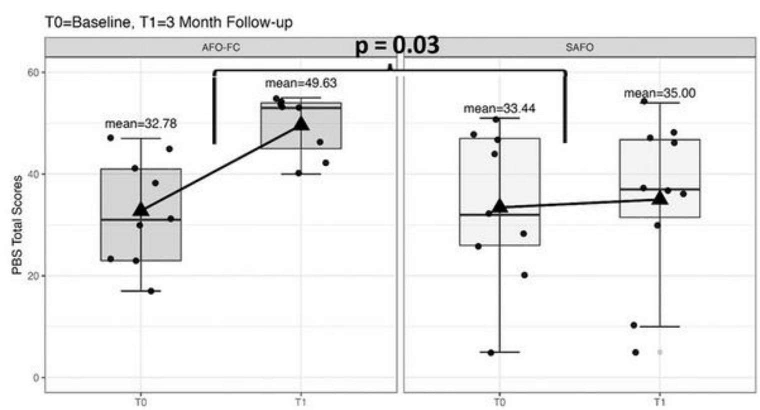

Figure 1. Pediatric Balance Scale (PBS) total scores at baseline and after 3 months of wear for the Ankle Foot Orthosis-Footwear Combination (AFO-FC) and Solid Ankle Foot Orthosis (SAFO) groups

DISCUSSION AND CONCLUSION

Results suggest that the AFO-FC approach had a positive effect on balance in ambulatory children with spastic diplegic CP as compared to SAFOs. Documented AFO-FC improvement is 2 times the PBS Minimal Clinically Important Difference (MCID) of 5.8, while the change in total score for SAFO did not reach the MCID. Simple clinical outcomes of balance have potential to inform orthotic management and should be interpreted along with patient/parent reported and community-based outcomes.

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ACKNOWLEDGEMENTS: Funded by NIH (Award #R21HD094823). https://clinicaltrials.gov/ct2/show/NCT0375671

5.12.2 Gait Outcomes Assessment List (GOAL): Randomized trial of orthotic management in ambulatory cerebral palsy

Kristie Bjornson[1,2], Stefania Fatone[2], Michael Orendurff[3], Chuan Zhou[2], Garth Shippen[4]

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BACKGROUND

Ambulatory children with Cerebral Palsy (CP) demonstrate altered lower limb biomechanical alignment in walking, experiencing activity limitations that negatively influence their ability to participate in daily life. A fundamental strategy to facilitate walking in children with CP are Ankle Foot Orthoses (AFO), however reviews [1,2] suggest equivocal evidence for efficacy of the solid AFO with 90-degree alignment. A patient specific algorithm of orthotic prescription [3] proposes a method for AFO alignment combined with footwear modifications (Ankle Foot Orthoses-Footwear Combinations, AFO-FC).

AIM

This study examined the effect of the AFO-FC on parent-reported gait priorities and functional mobility compared to the SAFO (with uniform alignment and without shoe modifications).

METHOD

A randomized cross-over study design. Inclusion criteria: bilateral spastic diplegia, Gross Motor Function Classification System (GMFCS) II or III, abnormal leg segment alignment during stance, sufficient calf muscle length/tone for 90-degree ankle dorsiflexion, triplanar midfoot boney alignment, and 4 to <10 years of age. 19 children with CP were randomized to SAFO (n=10) or AFO-FC (n=9) and followed for 3 months. Average age was 6.9 (4.2–9.8) years, GMFCS levels II (15) and III (4), and 15 were male. AFOs were at the same lab, cast/fit by the same orthotist, and consistent footwear (Figure 1). Parents completed the Gait Outcomes Assessment List (GOAL).

RESULTS

Results suggest that the AFO-FC approach, as compared to SAFO, has a significant positive effect on parent report of overall gait priorities and functional mobility in ambulatory children with spastic diplegic CP. Physical activity domain and total score increased 1 to 2 times more than the mean absolute differences of 5 for the test-retest GOAL. AFO-FC approach should be considered in the orthotic management of ambulation in children with CP. Parent-reported outcomes have potential to inform orthotic management and should be interpreted along with clinic and community outcomes.

Figure 1. AFO-FC with shoe modifications and SAFO without shoe modifications.

DISCUSSION AND CONCLUSION

Results suggest that the AFO-FC approach, as compared to SAFO, has a significant positive effect on parent report of overall gait priorities and functional mobility in ambulatory children with spastic diplegic CP. Physical activity domain and total score increased 1 to 2 times more than the mean absolute differences of 5 for the test-retest GOAL. AFO-FC approach should be considered in the orthotic management of ambulation in children with CP. Parent-reported outcomes have potential to inform orthotic management.

REFERENCES

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ACKNOWLEDGEMENTS: Funded by NIH Award #R21HD094823. https://clinicaltrials.gov/ct2/show/NCT0375671.

5.12.3 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. In this study we present data relative to patients with brachy and plagiocephaly that use cranial orthoses.

AIM

To demonstrate the efficiency of cranial orthoses in aiding recovery of plagio and brachycephaly. Bring the values of CI and CVAI as close as possible to their recommended values, CI value being used in brachycephaly and CVAI value in plagiocephaly.

METHOD

The size of the anteroposterior (AP), mediolateral (ML), diagonals and perimeter of the cranium of six 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
- CVAI=($Diagonal_{major}$-$Diogonal_{minor}$/$Diagonal_{major}$)*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.

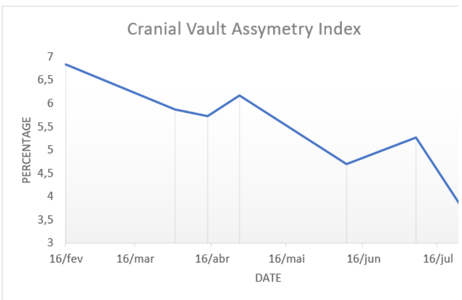

Chart 1 Evolution of patient 1, female who started treatment at 6 months of age

RESULTS

Of the 6 patients from which the measurements were taken, 2 of them suffered from plagiocephaly and 4 from brachycephaly. In plagiocephaly the patients showed an average improvement of 0.55% and 0.08% per month on its CVAI (main measure of plagiocephaly improvement). Improvements are visible in the charts below.

As for the four remaining patients, they all had cases of brachycephaly, with one of them having acute case at 99% CI. These patients showed an average improvement of 0.25%, 0.23%, 0.41% (corresponding to the patient with 99%CI) and 0.70%. Thus, the mean CI monthly rate in all patients was -0,34434% while CVAI was -0,03614%.

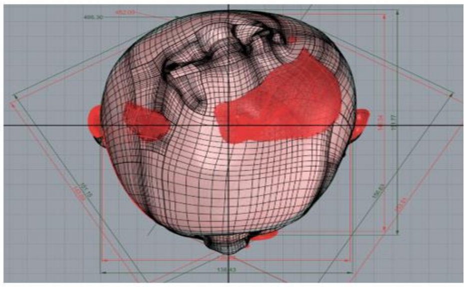

Figure 2 First(red) and last(green) measurements of patient 1

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. This study lacks a bigger patient pool as well as a control group.

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5.12.4 Bracing Complications in Congenital Talipes Equinovarus

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BACKGROUND
Congenital Talipes Equinovarus (CTEV) is a developmental disorder that involves one or both feet fixed in plantarflexion and supination. The Royal Children's Hospital (RCH) has utilised the Ponseti method since 2003, which involves serial casting, heel cord tenotomy and boots and bar wear until the age of 4years. At present there is a lack of short to medium term studies in the CTEV population that cover casting, surgical interventions, and brace fitting complications.

AIM
At present there is a lack of short to medium term studies in the CTEV population that cover casting, surgical interventions, and brace fitting complications.

METHOD
Subjects: 984 charts reviewed; 279 patients included.

Apparatus: Retrospective analysis of medical files from RCH CTEV patients. Chart reviews performed between October 2021- April 2022.

Procedure: Clearly defined brace fitting complications where identified pre-audit and agreed on by all clinicians.

Descriptive statistics and the Chi square test were used to analyse brace fitting complications and requirements for subsequent surgery.

RESULTS
Brace fitting complications were identified in 51.42% with no significant difference between Mitchell and Markell boots. The rate of pressure sores was statistically significant between the two boots with Mitchell boots at 22.9% vs Markell's at 12.6% (p=0.0009). 19.8% of patients required brace changes, of those 57% were outside the Ponseti brace protocol. There were 13% of children who had behavioral intolerance which led to premature abandonment of bracing.

Parental non-compliance was found to be 33.2%. This resulted in 31.2% of the total population requiring re-casting.

Tibialis tendon transfer (TATT) rate for those aged 6+ was 44%. Patients with parents refusing to apply the boots and bar or admitting to non-compliance with the recommended hours were significantly more likely to require this surgical procedure (OR=2.3).

Lost to follow-up rates: 0-4 years old: 23.9%, 4-10 years old: 32.5%.

DISCUSSION AND CONCLUSION
Bracing complications are common in the CTEV population at The Royal Children's Hospital. Pressure sores more commonly affected patients treated in the Mitchell boot.

Non-compliance doubles the patient's chance of requiring a tibialis anterior tendon transfer. The reported rate of a TATT is from 11% [1] - 53% [2]. Our rate of TATT was 44%.

This study has improved the education provided to the CTEV population and has highlighted the need for improved departmental processes.

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5.12.5 Reliability and validity of assessing lower limb muscle architecture of patients with cerebral palsy using ultrasound: a systematic review

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BACKGROUND

Abnormalities of lower-limb muscle architecture have been typical characteristics in patients with cerebral palsy (CP), which were associated with an individual's locomotion ability. A comprehensive understanding of muscle architecture could facilitate appropriate treatment decision-making for patients with CP. While numerous studies have documented the application of ultrasound imaging in assessing the muscles of CP patients, a structured overview of its reliability and validity has been lacking.

AIM

To systematically review the reliability and validity of the architecture measurements of lower-limb muscles obtained using clinical ultrasound in patients with CP.

METHOD

Databases of Medline, PubMed, Cochrane library, Web of Science, ScienceDirect, and Embase were systematically searched with the keywords "cerebral palsy", "muscle", and "ultrasound" on 30th August 2022. English articles were selected if assess the reliability and/or validity of architecture measurements of lower-limb muscle obtained from ultrasound in CP patients. Two reviewers independently extracted relevant data and assessed the methodological quality of the included articles using the criteria appraisal instrument. The data were analysed and synthesized qualitatively.

RESULTS

Among the eleven selected articles, most focused on the gastrocnemius of CP children aged 3.8-12.1 years and did the ultrasound assessment in a position with the muscle resting. Five selected studies were of high quality, including two investigating inter-rater reliability, one analysing intra-&inter-rater reliability, and two focusing on validity. Nine and three selected studies focused on reliability and validity analyses, respectively. The ultrasound measurements of muscle thickness (intra-), muscle length (intra-&inter-), cross-sectional area (intra-&inter-), muscle volume (intra-&inter-), fascicle length (intra-&inter-), and pennation angle (intra-&inter-) showed high reliability, with most of intraclass correlation coefficient values > 0.9. Moderate-to-excellent correlations between ultrasound and magnetic resonance imaging measurements were observed for muscle thickness, cross-sectional area, and muscle volume (correlation coefficient=0.62-0.99). Most of these findings were supported by a limited level of evidence.

DISCUSSION AND CONCLUSION

Ultrasound presented high reliability and validity in the architectural assessment of lower-limb muscles in patients with CP, which, however, were supported mainly by a limited level of evidence. More high-quality reliability-validity studies on CP are needed. Nevertheless, ultrasound has the potential to serve as a useful tool for the assessment of muscle and ultimately facilitate the clinical management of patients with CP.

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Free paper session: Prosthetics: Lower limb - Osseointegration methods and techniques

5.13.1 The world's first steps on Transcutaneous Pelvic Osseointegration – A case series of prosthetic management in hip disarticulation with osseointegration.

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BACKGROUND
Hip disarticulation Amputees (HDAs) are rare, comprising only 1–3% of all lower limb amputees (1). Regardless of the presence of comorbidities, only 10–35% are able to walk with a hip prosthesis (2). Given the low numbers of patients, solutions for the ones that wish to increase mobility are scarce. We were presented with a series of hip disarticulation with osseointegration cases and had to develop a prosthetic approach to extend functionality in daily life of these individuals.

AIM
In this paper we aim to report the development of the process of designing the prosthetic attachment, fitting and functional outcomes in these rare cases of hip disarticulation with osseointegration.

METHOD
Document 3 patients with hip disarticulation and osseointegration, of whom 1 had necrotizing fasciitis, 1 traumatic amputation and 1 infection. In 2 patients the operation was done as the first definitive procedure. All patients completed a minimum of 6weeks static loading prior prosthetic intervention.
We divided our approach in 4 phases and analysed them chronologically.

- Phase 1- Initial fitting and static alignment. First 3D prototype Pelvic Angle Connection (PAC) linking prosthetic hip joint to osseointegration abutment.
- Phase 2 – Dynamic alignment and mobility training. Design adjustments in prototype and fitting with aluminium PAC.
- Phase 3 – Fitting definitive prosthesis including bespoke designed PAC in titanium.
- Phase 4 – Follow up/planning ongoing care.

RESULTS
In addition to hip disarticulation and osseointegration, the first case had a transtibial amputation with osseointegration on the contralateral side. It was the first bilateral case with osseointegration at the pelvic level and contralateral amputation case documented in the world. There were no guidelines and a trial and error approached was challenging on all levels.

The process of developing the PAC was long and challenging but allowed to establish a new way to approach prosthetic treatment options at this amputation level. All 3 patients were able to use a prosthesis to complete daily activities such as self-care, housework, participate in the community using a prosthesis and walking aids: (n=2) 2 crutches, (n=1) 1 crutch. One patient uses his prosthesis to do his farm work and one was able to achieve her ultimate goal of returning to horseback riding!

DISCUSSION AND CONCLUSION
Fitting prosthesis to hip disarticulation amputees with osseointegration successfully is possible and undoubtedly one of the most demanding tasks in lower limb prosthetics. This experience has shown that it can be done successfully. Major points for success were patient motivation, multidisciplinary team approach and high level of commitment from all parties involved. There are still future improvements to be implemented and we are looking forward to continual learning to improve patient mobility outcomes.

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ACKNOWLEDGEMENTS: We would like to thank our patients, who pushed us thinking outside the box to find solutions and inspire us!

5.13.2 Six-Dimensional Failure Envelope for Osseointegrated Bone-Implant Construct

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BACKGROUND

Osseointegrated implants have several advantages over sockets when used to attach a prosthetic limb to an amputated femur. However, these implants are associated with a high rate of femoral fractures (5% within 12 months) [1]. A well-designed fail-safe device (weak link) that sits between the prosthetic limb and osseointegrated implant may reduce the fracture rate. To design such a device it is imperative to be able to differentiate between safe and unsafe loads for the bone-implant construct.

AIM

We aimed to quantify all loading combinations of forces and moments that, when applied on the osseointegrated implant, were just sufficient to fracture the femur – thereby creating a novel 6-dimensional failure envelope.

METHOD

A patient-specific finite element model of one right femur with an osseointegrated implant was created from CT data (details in [2]). A set of 116,444 six-dimensional (6D) unit vectors defined unique linear combinations of three moment and three force components that were applied to the distal end of the implant. The force and moment components were scaled up gradually until the femur fractured. Femoral fracture was assumed when the volume of contiguous failed elements reached 350 mm3 [3].

RESULTS

A 6-Dimensional failure envelope with 116,444 points defining its surface was generated in 25 hours of computing time (Fig. 1). The bone-implant construct was more than three times stronger under forces in the superior-inferior direction than under forces in the transverse plane. It was also twice as strong under bending moments as it was under torsional moments applied at the distal end of the implant.

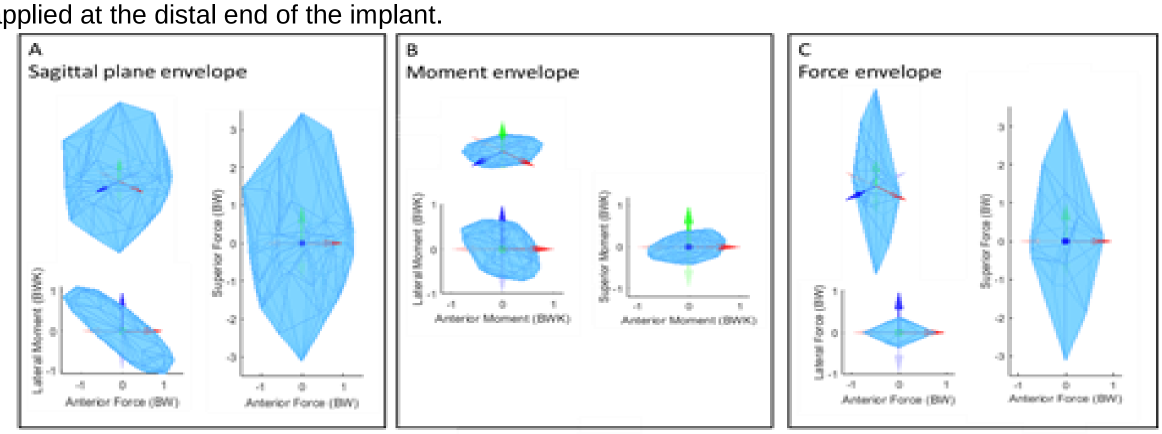

Figure 1. The six-dimensional (6D) failure envelope for the amputated femur with an osseointegrated implant. Box A – three views of the 3D envelope for the sagittal plane. Box B – three views of the 3D moment envelope. Box C – three views of the 3D force envelope. Units: 1 BW = 1 Body Weight = 814 N, 1 BWK = 1 Body Weight applied laterally at the Knee = 125 Nm.

DISCUSSION AND CONCLUSION

The methods used in this study were capable of generating a failure envelope within a reasonable computing time frame (25 h) and gave comprehensive information about the strength of the bone-implant construct. A limitation of the proposed method is that the modelling needed to be linear and therefore assumed complete osseointegration between the implant and bone.

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ACKNOWLEDGEMENTS: Australian Research Council, Blatchford UK

5.13.3 Press-Fit Osseointegrated Reconstruction and Rehabilitation of Above Knee Amputees - Minimum 5-year Follow-up

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BACKGROUND

Osseointegration has been established as a promising approach for the reconstruction of amputated limbs, particularly for amputees suffering from problems related to the traditional socket-mounted prosthesis (TSP). While Osseointegration was originally developed with a screw fixation design, several Osseointegration devices adopting a modern press-fit design have also been introduced. In this study, we report on the medium-term outcomes among 93 patients rehabilitated with the two most common press-fit osseointegration implant used worldwide.

AIM

This study reports on the 5-year outcomes among 93 patients rehabilitated with the two most common press-fit osseointegration implant used worldwide.

METHOD

This is a cross-sectional analysis of an ongoing clinical database containing a cohort of Osseointegration patients treated in several centres worldwide. We analysed a total of 93 patients with an average follow-up time of 6.52 years (range 5.01-10.54). Patients with unique customized implants were excluded. Functional, Quality of Life Outcomes and patient surveys were collected during follow-up and analysed referencing hospital records. All postoperative adverse events (infection, revision surgery, fractures, and implant failures) were also analysed.

RESULTS

Crude analysis of the data indicated that all 93 patients continue to use their osseointegrated prosthesis. Significant improvements for all outcome measures were detected compared to pre-operative conditions. However, several adverse events including 19 implant revisions, 8 periprosthetic fractures and 43 surgical debridement interventions due to deep infection were also reported where 12 patients underwent multiple debridement’s. A detailed analysis was performed on each adverse event type to evaluate possible causes.

DISCUSSION AND CONCLUSION

At 5 years post-surgery, Osseointegration continues to provide amputees with improvements on function and quality of life which were previously unattainable via the socket-mounted prosthesis. This represents a great improvement over the 50% abandon rate commonly reported with the TSP. However, the benefits are accompanied with a relatively high risk of adverse events. Further research in standardizing clinical practice and the development of better implant may offer a reduction to these risks.

5.13.4 An FE Model Investigating the Bone-implant Interface of Osseointegrated Prosthetics to better Understand how Forces are Transferred under Loading

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BACKGROUND

Osseointegrated prostheses (OIP) represent a viable solution to the issues faced by transfemoral amputees using socket-based attachment methods. The bone-anchored fixation method enables loads to be transferred through the musculoskeletal system directly, circumventing the need for a socket. Mechanical complications such as bone fracture, loosening, and implant failure represent a barrier to OIP success - it is important to understand the mechanical profiles of these implants under loading and how it affects the anatomical health of users.

AIM

To simulate the bone-implant interface under loading using a 3D finite element (FE) model and quantify force distribution. Produce hypotheses on bone remodelling and implant failure to inform implant design and rehabilitation protocols.

METHOD

Eight femur models (4 female) were generated from healthy adult CT scans and material properties extracted from grayscale values. Bone-implant assemblies were formed as 3D FE models (minimum element size 3mm) and the bone subdivided into seven Gruen Zones (GZ). The model was fixed proximally and a static load from the literature applied at the distal face of the implant abutment[1]. FE analysis data were filtered and statistical analyses undertaken to understand differences in stress and strain between: bone, implant and adapter; male and female anatomy; and Gruen Zones. Non-parametric tests were used as the data were skewed and variance was non-homogenous. Significance tested at $p<0.05$.

RESULTS

Median stresses and strains were: bone (1.53MPa, 0.406%); implant (17.49MPa, 0.014%); adapter (10.89MPa, 0.008%). No significance was observed between genders. Bone analysis showed significantly higher strains in the proximal femur (GZ4), decreasing distally along the bone. Significantly lower levels of stress were seen in GZ1 and GZ7. In contrast to strain, highest stresses were seen in GZ2 and GZ6. Pairwise comparison showed significance between all zones except lateral-medial pairings. [Fig.1]

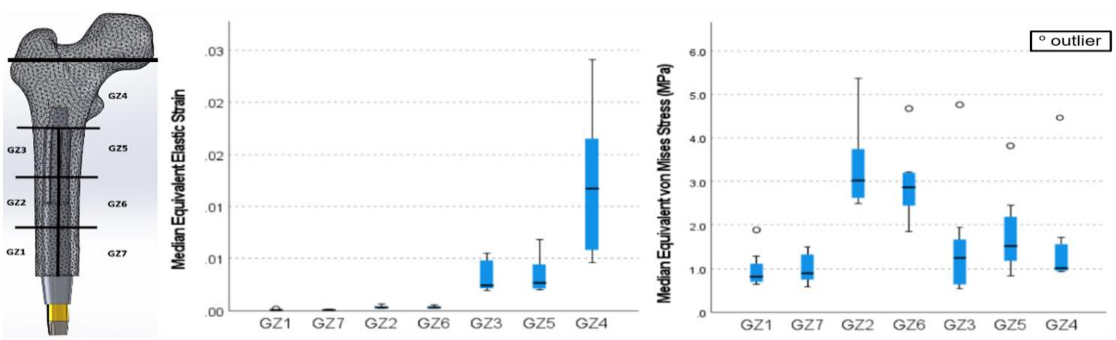

Figure 1: a) GZ locations b) Median Equivalent Elastic Bone Strain per GZ c) Median Equivalent Von Mises Bone Stress per GZ

DISCUSSION AND CONCLUSION

The model interprets force transmission across the bone-implant interface. Results support statements in the literature highlighting the occurrence of fractures in the proximal femur, whilst low stress distally compared to loading in healthy bone[2] demonstrates stress shielding. This model enables the quantification of force distribution, allowing predictions of bone remodelling and mechanical complications.

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ACKNOWLEDGEMENTS: This work was supported by the UK EPSRC grant EP/S02249X/1 for the Centre for Doctoral Training in Prosthetics and Orthotics.

5.13.5 Experimental Validation of a Composite Femur with an Osseointegrated Implant

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BACKGROUND

Osseointegrated implants for lower limb amputees have been gaining popularity over the past few decades as an alternative to conventional socket-based prostheses. Although computational modelling is often used to study the loading conditions of these bone-implant constructs, there has only been one study validating such a model [1]. Therefore, there is a need to validate a broader range of these bone-implant construct models fitted with different implant designs.

AIM

The aim of this project was to validate a specimen specific computational model fitted with an Osseointegration Prosthetic Limb (OPL) implant.

METHOD

The implant was surgically fixed into a composite femur, and a finite element (FE) model of the bone-implant-construct was generated using a set of QCT images. Four triaxial strain rosettes were bonded to the proximal-medial, proximal-anterior, distal-medial and distal-anterior sides of the femoral shaft. A vertical load of 1BW (600N) was applied to the femoral head while the distal end of the implant abutment surface was clamped rigidly. These loading and boundary conditions were replicated in the FE model, and the respective experimental and computational principal surface strains calculated, compared, and fitted with a linear regression model.

RESULTS

Maximum and minimum principal strains obtained experimentally and computationally fit the linear model with a Concordance Correlation Coefficient (CCC) of 0.938, which is similar to previous results [1]. Minimum principal strains at the proximal end of the femoral shaft recorded errors between experimental and computational values at 34% and 1% for the medial and anterior rosettes, respectively, while maximum principal strain at the proximal-medial side recorded a 15% error between measured and simulated values.

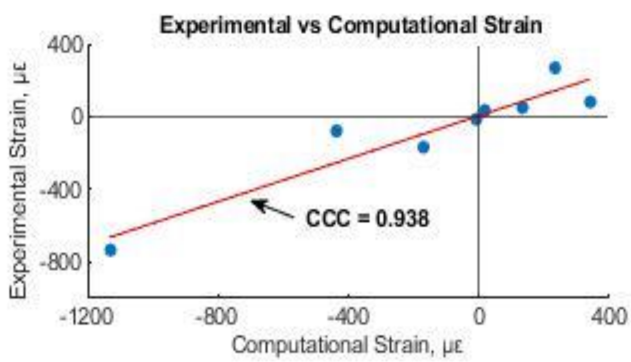

Figure 1: A linear regression model fitted the experimental and computational results with a Concordance Correlation Coefficient (CCC) of 0.938.

DISCUSSION AND CONCLUSION

The computational model is in good agreement with the experimental results for strain values obtained at the proximal femur. However, discrepancies between the experimental measurements and model predicted strain values were high at the distal end (>50%), which was previously reported to be caused by modelling criteria sensitivity [1]. Experimental validation of implanted cadaveric femurs is underway and will focus on improving modelling accuracy by better representing the bone-implant interactions and material properties.

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ACKNOWLEDGEMENTS

Australian Research Council, Blatchford Inc. UK, Osseointegration Group Australia

5.13.6 Optimalization of patient selection in persons with a bone-anchored prosthesis.

Charlotte van Vliet-Bockting, Robin Atallah, Jan Paul Frölke, Ruud Leijendekkers

Radboudumc, Nijmegen, Netherlands

BACKGROUND

Persons with a lower limb amputation (LLA) using a socket suspended prosthesis (SSP) are often limited by socket-related problems. Consequently, general and disease-specific health-related quality of life (G-HRQL and D-HRQL) are negatively affected. An osseointegrated implant (OI) may solve this problem by elimination of the prosthetic socket (PS). We intend to include persons for OI-surgery with a favourable ratio between potential adverse events related to OI-surgery and potential improvement in HRQL. A tool to assess these persons is absent.

AIM

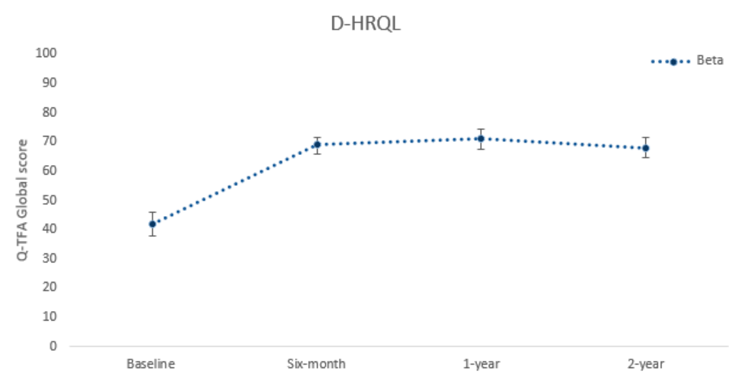
1.Describing change in G-HRQL and D-HRQL in persons with LLA after OI-surgery and rehabilitation at six-months, one-year, and two-year follow-up compared to baseline. 2.Establishing an association model for 2-year follow-up change in G-HRQL and D-HRQL. 3.Describing 2-year follow-up safety-related outcomes.

METHOD

All consecutive persons who underwent OI-surgery in the Radboudumc between 05-2014 and 04-2020 were eligible for this study. 1.G-HRQL was assessed, from 09-2017, using the SF-36 physical component score (PCS) and mental component score (MCS). D-HRQL was assessed, from 05-2014, using the Q-TFA global-score. 2.The initial association models included the following factors at baseline: a) G-HRQL; 6MWT, G-HRQL, prosthetic use, amputation level, and age. b) D-HRQL; 6MWT, D-HRQL, prosthetic use, prosthetic comfort, amputation level, BMI, cause of amputation, and age. 3.Adverse events were analysed for the entire cohort and included; infection, implant failure (breakage or loosening), stoma problems (hypergranulation/keloid formation or stoma redundant tissue), and periprosthetic fracture.

RESULTS

196 persons were eligible for inclusion. This preliminary analysis included 131 participants (G-HRQL: n=44, D-HRQL: n=131). 96% had an unilateral amputation and trauma was the main cause of amputation. Amputation level: 72% TFA, 22% TTA, 4% knee-exarticulation, 1% foot-amputation, 1% received OI after primary amputation. 19% did not use a prosthesis. 1) SF-36-PCS and Q-TFA global-score improved significantly at all timepoints compared to baseline ($p< 0.001$). SF-36-MCS did not change significantly at all timepoints compared to baseline ($p\geq 0.353$). 2.Low baseline G-HRQL had a significant association with improvement in G-HRQL between baseline and two-year follow-up and explains 34.6% of this change in the study population. High 6MWT and low D-HRQOL had a significant association with improvement in D-HRQL between baseline and two-year follow-up and explains 43.1% of this change in the study population. 3.Adverse events have not yet been analyzed.



DISCUSSION AND CONCLUSION

G-HRQL PCS, D-HRQL, and the overall situation as amputee at 2-years after OI-surgery improved compared to baseline. Persons are most eligible for OI-surgery if they have a high age, high 6MWT, and a low G-HRQL and D-HRQL at baseline. These findings are helpful to optimize patient selection. We intend to include persons for OI-surgery with a favourable ratio between potential adverse events and potential improvement in HRQL. As adverse events were not analysed, a favourable ratio is not known yet.

Free paper session: Psychosocial issues / quality of life - Psychological, social and economic issues II

5.14.1 Barriers and facilitators to community reintegration for people following traumatic upper-limb amputation.

Sarah Anderson[1], Abby Hutchinson[1], Jemma Keeves[2], Kate D'Cruz[1]

[1]La Trobe University, Melbourne, Australia. [2]Monash University, Melbourne, Australia

BACKGROUND
Amputation of an upper limb has immediate, profound and potentially lifelong implications in daily living. This includes reintegration to community-based roles and activities. Although major upper limb amputation (at the wrist level and above) accounts for a small number (3%) of the near 2,000 major amputation procedures performed yearly in Australia [1], studies examining the differences between people's experiences following upper limb amputation, suggest the experiences of this small cohort should be recognised as both unique and complex.

AIM
The purpose of this study is to explore and better understand people's lived experience of community reintegration following a traumatic upper limb amputation, including the influence of various barriers and facilitators.

METHOD
Approach: Grounded within a constructivist epistemology, this exploratory and inductive qualitative study utilised semi-structured interviews and thematic content analysis to investigate barriers to community integration.
Subjects & Procedure: Data was collected via individual, in-depth interviews of ten adults who have sustained a major upper limb amputation within Australia. Topics for exploration include transitioning from rehabilitation and centre-based therapy to community-based services, engagement in everyday community-based tasks and functional prosthetic use in the community.
Data Analysis: Data was collected and analysed concurrently, with two investigators undertaking coding and analysis using Braun and Clarke methods.

RESULTS
Three key themes were identified from the data.

- **Finding new ways of being and doing**: Participants reflected following ULA there was a need and process of physical, cognitive and functional adaptation.
- **Drawing upon the support of others**: A recognition of the influence of others on perceptions of self-worth and abilities to motivate and empower to reintegrate back into the community.
- **Positioning self at the centre of recovery**: A sense of loss of identity at time of amputation, as well as the motivation to reintegrate into the community as part of re-establishing or re-defining one's self was identified. IA dynamic association between themes acknowledges their interaction and inter-connectedness within the participant experience. The influence of time on all themes was recognised by the participants, most notably on adaptive processes.

DISCUSSION AND CONCLUSION
The three themes identified in understanding peoples experience of community reintegration following ULA, focused on change, support and self-efficacy. These themes all interacted, however their influence was not equal. Environmental factors were less prominent than personal factors. Positive personal factors were able to overcome environmental barriers. Persistence and resilience were identified as more being facilitative than the functionality of a prosthesis or equipment.

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ACKNOWLEDGEMENTS: This work was funded through an Epworth Medical Foundation Research Grant.

5.14.2 Identifying and linking prosthetic outcomes to the ICF: a step to inform the benefits measured in prosthetic health economic evaluations

Leigh Clarke[1,2], Michael P Dillon[1], Alan Shiell[1]

[1]La Trobe University, Melbourne, Australia. [2]The Australian Orthotic Prosthetic Association, Melbourne, Australia

BACKGROUND

Prosthetic research seems focused on measuring gait-related outcomes that may not adequately measure real-world benefits of prosthetic interventions. Systematically cataloguing a comprehensive range of outcomes is an important steppingstone towards developing a holistic way to measure the benefits of prosthetic interventions for future health economic evaluations.

AIM

This study aimed to identify and catalogue the outcomes measured in lower-limb prosthetic research using the ICF framework and a custom clinical framework, and thereby describe the existing research focus and identify evidence gaps.

METHOD

A structured literature search identified systematic reviews of lower-limb prosthetic interventions. Reported outcomes were extracted from included studies and linked to the ICF- and a clinical-framework by two independent linkers in accord with the ICF linking rules [1]. The Gwet's AC1 was used to quantify agreement between the two independent linkers.

RESULTS

The structured search identified 848 systematic reviews of which 28 met the inclusion criteria. From the 28 systematic reviews, 1297 outcomes were extracted, with 1060 linked to the ICF framework. Most outcomes linked to ICF second- (63.8%) or third-level categories (33.4%), such as Gait Pattern Functions (b770, 49.8%). Most of these outcomes (31.2%) describe temporospatial, kinematic or kinetic gait measures as categorised by the clinical framework. There was strong agreement between independent linkers (81.19%; AC1 = 0.81; 95% 0.79-0.83, p<0.001).

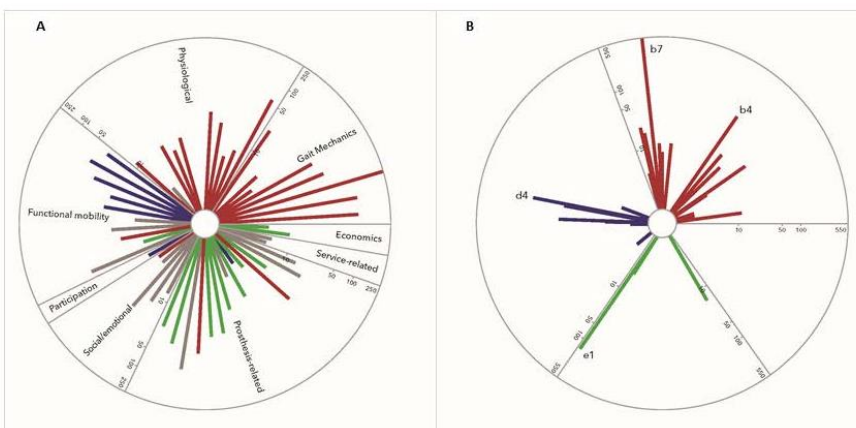

Figure 1. Frequency of prosthetic outcomes linked to (A) the clinical framework (domains and categories) and (B) the ICF framework (components and chapters). Colours represent ICF components: red: body functions (b); blue: activities and participation (d); green: environmental factors (e); grey: not linked (e.g., nc, nd, pf).

DISCUSSION AND CONCLUSION

Lower-limb prosthetic research is focused on laboratory-based measures of gait. There are evidence gaps describing participation in real-world activities. Investigating and measuring real-world activities is important, in particular to inform policy and investment decisions, that ultimately determine the prosthetic interventions available for people with limb-loss.

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ACKNOWLEDGEMENTS: This work was supported by a research grant from the AOPA-COPL (RFP 043018).

5.14.3 Health Economic Evaluations in orthotics: a systematic review

Leigh Clarke[1,2], Michael P Dillon[1], Alan Shiell[1]

[1]La Trobe University, Melbourne, Australia. [2]The Australian Orthotic Prosthetic Association, Melbourne, Australia

BACKGROUND

Health economic evaluations are essential to support health care policy and investment decisions. HEEs in orthotics are in their infancy often focused on the cost-effectiveness of short-term interventions for acute conditions (e.g., ankle braces for acute ankle sprain), rather than custom-made interventions used by people with disabilities. Understanding the evidence gaps and method design issues in the existing literature can help inform the design of future HEEs and advance knowledge to inform policy and investment decisions.

AIM

This systematic review aimed to critically appraise the existing orthotic/prosthetic health economic evaluation literature with a focus on determining evidence gaps, critical method design issues, and determining the extent to which the literature informs orthotic policy and investment decisions.

METHOD

Search strings related to the intervention (e.g., orthosis) and health economic evaluations were developed and tested. A comprehensive range of databases were searched using intervention and HEE related terms. The Consolidated Health Economic Checklist – Extended and the Checklist for Health Economic Evaluation Reporting Standards were used to identify issues with method design and reporting. Data extraction and appraisal was conducted by two reviewers. Given the heterogeneity of the published literature, a narrative review was conducted to examine factors that most introduce bias.

RESULTS

The systematic search yielded nine orthotic HEEs. Studied were narrowly focused on acute and chronic clinical presentations including: ankle sprain, carpal tunnel syndrome, heel ulcers, chronic plantar heel pain, rheumatoid arthritis of the foot, and osteoarthritis of the knee (Table 1).

Author	Type HEE	Design	Interventions
Chesterton et al., 2018	CUA and CEA	Trial-based	Night Splints vs Steroid Injection
Cooke et al., 2009	CUA and CEA	Trial-based	Tubular Bandage vs Below Knee Cast, Aircast Ankle Brace, and Bledsoe Boot
Fatoye et al., 2016	CUA	Model-based	Semi-rigid ankle brace vs Taping
Janssen et al., 2014	CEA	Trial-based	NeuroMuscular Training and Semi-rigid ankle brace vs Semi-rigid ankle brace (alone) and NeuroMuscular Training (alone)
Jeffcoate et al., 2017	CUA and CEA	Trial-based	Usual care vs Fibreglass heel cast
Olmsted et al., 2004	Cost-minimisation	Model-based	Semi-rigid ankle brace vs Taping
Rome et al., 2017	CUA and CEA	Trial-based	Simple Insoles vs Custom Made Foot Orthoses
Ring and Otter, 2014	CEA	Trial-based	Pre-fabricated vs Custom Made Foot Orthoses
Woods et al., 2017	CUA	Model-based	12 non-pharmacological interventions, inc Insoles and Braces

Table 1: Summary of HEE study design and interventions of included orthotic HEEs

Critical appraisal of the literature identified method design (e.g., cost identification and valuation) and reporting issues (e.g., lack of detail about the study population) that limited the extent to which this literature can inform policy and investment decisions.

DISCUSSION AND CONCLUSION

HEEs comparing a wider variety of interventions are required, particularly for commonly used orthoses (e.g., ankle-foot orthoses) and clinical presentations (e.g., post-stroke). There are opportunities to strengthen future orthotic HEEs by adopting method design features (e.g., micro-costing and sensitivity analyses) as recommended in HEE appraisal and reporting tools.

5.14.4 Ambulatory and Social Performance Status After Transfemoral Prosthetic Rehabilitation: Age, Gender, and Marital Status Perspective

Shafiq Khan

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BACKGROUND
This study aims to determine the association of ambulatory and social performance status of transfemoral prosthetic users with their age, gender, and marital status.

AIM
Aims to determine the association of ambulatory and social performance status of transfemoral prosthetic users with their age, gender, and marital status.

METHOD
A cross-sectional study was conducted on 400 transfemoral prosthesis users. The sample consisted of both genders, aged 10-60 years, using the appliance for at least one year using non-probability convenience sampling method recruited from the Pakistan Institute of Prosthetic and Orthotic Sciences from July 2019 to December 2019. Lower extremity functional scale and 36-item short-form health survey questionnaire were used for data collection. Then, the obtained data were analysed.

RESULTS
Ambulatory status as measured by the total lower extremity functional scale revealed significant association ($P<0.001$) with age with the highest score belonged to the age group of 10-30 years. Also, it has a significant association ($P=0.003$) with marital status, with the highest scores belonged to single individuals. However, no significant ($P=0.705$) gender association was noted though scores were higher for the male gender. Regarding social performance as measured by the 36-item short-form health survey questionnaire, significant associations ($P<0.05$) were found between most domains of SF-36 with age groups with the highest scores for the age group of 10-30 years. Also, a significant association was found with the gender with higher scores in females in most domains. At the same time, no significant association with marital status was noted in most domains.

DISCUSSION AND CONCLUSION
Ambulatory status has a significant association with age and marital status with no significant gender association. In contrast, social performance has a significant association with gender, while most domains reveal a significant association with age groups. However, no association with marital status is present.

Free paper session: Education - Education I

5.15.1 Effectiveness of Online Teaching in Prosthetics and Orthotics Education in Covid-19 Pandemic: Students' Perspective

Sadeeq Ali[1], Naveed Ahmed[2]

[1]OsloMet university, Oslo, Norway. [2]Keele university, Staffordshire, United Kingdom

BACKGROUND
In response to Covid-19, universities and colleges requested their teachers and students to stay home to maintain social distancing to control the spread of Covid-19. All the teachings in universities and colleges were shifted to online teaching. In Prosthetics and orthotics education, students are required to attend clinical patients, do practical work to fabricate prosthetics and orthotics devices, face-to-face demonstrations, and class lecture to be able to achieve their learning outcomes.

AIM
The aim of this study was to see the effectiveness of online teaching in prosthetics and orthotics education in Covid-19 pandemic.

METHOD
This study is based on an online cross-sectional survey design. This survey was conducted among the prosthetics and orthotics education students. The respondents of the study were selected using convenience snowball sampling. We first collect the details of the prosthetics and orthotics schools from International Society of Prosthetist and orthotist (ISPO) website and other online resources. The survey was then designed on google forms, and its URL was circulated to PO students via the prosthetics and orthotics schools, researchers, social media, email, and through organizations.

RESULTS
Total 299 respondents from 15 countries participated in this study. Majority of the respondents have found that they did not clearly understand the ideas and concepts through online teaching and additionally online discussion was not better than in class face-to-face discussion. The results revealed that online learning is not effective in developing patient assessment, casting, fabrication, fitting, and communication skills. These results indicate that there is significant difference between the mean values of knowledge (Mdifference= 0.221, $t=2.705$, $p<0.009$), accessibility (Mdifference= -0.778, $t= -6.02$, $p<0.000$), psychological effect (Mdifference= 0.474, $t=3.828$, $p<0.000$) and satisfaction (Mdifference= -0.464, $t= -2.84$, $p<0.006$) between the developed and non-develop countries. Majority of the respondents (54.1%) were not satisfied with the online teaching.

DISCUSSION AND CONCLUSION
Online teaching can improve the theoretical and management aspects of the students but to develop the verbal communication and clinical skills during the clinic may be more difficult in prosthetics and orthotics education. Online teaching is a useful alternative to face-to-face teaching in other fields of education, but it is less effective in more clinical and practical based subjects.

5.15.3 A Novel Approach for Guiding Orthotic and Prosthetic Education Program Transition to Client-Centric Training

Christopher Hovorka

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BACKGROUND

Curriculum in U.S. Orthotic and Prosthetic (O&P) practitioner education is significantly informed by the NCOPE Master's Curriculum Guide [1] which contains limited practitioner knowledge and skills content and substantial device knowledge and skills content. Advances in technology and changes in healthcare suggest a need to expand curricular content in evidence-based client assessment, and treatment. Hence, a shift toward client-centric education may enable future O&P graduates to cope with evolving demands in healthcare [2].

AIM

Various approaches in clinician training were evaluated to inform a new client-centered model of O&P practitioner education. The goal is to enable future graduates to manage new challenges and opportunities in technology and healthcare.

METHOD

A literature review was conducted on theory, design, and outcomes of clinical education (focusing on client-centered training) and on project-based learning. Thirty-five articles were identified of which 16 articles on clinical education and five articles on project-based learning were reviewed. Article content was examined for relevance and application to training O&P clinicians within a scope of practice [3], particularly in such areas where training is less informed (e.g., evidence-based best-practice of client assessment, prognosis, formulation of the treatment plan, and assessment of treatment outcomes).

RESULTS

Three conceptual frameworks have the potential to be adapted to O&P clinician education. The ICF provides a unifying biopsychosocial framework for classifying the consequences of disease [4,5] and can help students understand the interaction between function and disability, and development of treatment plans using the whole-person perspective [6,7]. The POP model adapts ICF to clinical O&P processes [8] whereby aspects of the ICF are conceived as different levels of functioning, and the client's goals related to activities are realized by achieving goals related to body functions and structures. The modified CanMEDS (Figure 1), a framework for practitioner training, adds the provider dimension to ICF by characterizing core competencies healthcare providers must exhibit, thereby establishing a template for training O&P students in areas they need to cultivate [9].

Figure 1. The Modified CanMEDS Framework.

DISCUSSION AND CONCLUSION

Collectively, the modified CanMEDS practitioner training model, in conjunction with the ICF and POP model presents a comprehensive framework in which students in O&P can learn how to use the ICF for O&P client-centered practice [10]). This approach provides a wider "lens" in which to view the client, formulate goals, and translate the plan of care to address the client's needs and to produce evidence for clinical outcomes.

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5.15.4 Survey of continuous professional development of Ortho-Prosthetist Professionals through job training at the ICRC-supported Physical rehabilitation centres.

Anum Ishtiaq, Abdul Haseeb, Abdul Nasir, Hamid Dawood

ICRC, Islamabad, Pakistan

BACKGROUND
Continuous professional development for Ortho-Prosthetist professionals is essential to improve knowledge, skills, and quality. It helps to maintain the high standards of services and ensure that the professionals are up to date with industry change by constantly updating their skill set and filling in gaps in competencies and knowledge. ICRC supports 18 rehabilitation centres in Pakistan and does capacity building through formal and on-the-job training.

AIM
This survey aims to collect feedback from the P&O trainees to incorporate the suggestions and provide tailor-made training regarding future demands.

METHOD
In Pakistan rehabilitation centres, most of the P&Os are lacking practical skills at the entry level. To upgrade their skills, ICRC and rehab centre management are doing capacity building of P&Os through on-job and formal training. We developed an online questionnaire through google forms and validated it by presenting and discussing it with P&O colleagues. We set the inclusion and exclusion criteria for this study. All the P&O professionals and technicians working in ICRC-supported rehabilitation centres and receiving training were included. The P&Os working in a managerial post and non-P&O professionals were excluded. The questions concerning content, frequency, and mode of ICRC training.

RESULTS
The survey form was sent to 50 P&Os, out of which 27 P&Os answered the survey. It shows that 70% of study participants have more than 5 years of experience. Among them, 63% prefer on-job training over the formal training that ICRC provides in Pakistan. 90% of the participants prefer group training of a -week duration. Several training types exist, but 100% of our participants choose theory and practical blended methods performed on actual service users. More than 50% of the participants preferred training on Transfemoral & Hip disarticulation prosthesis, Knee ankle foot, and Thoraco-lumbosacral orthosis. More than 70% were interested in reviewing assessment and rectification procedures. Schedule timing preference was a whole working day, and 60% expected coaching sessions to integrate their learning into clinical practice. As a result, 70% feel that on-job training is productive and recommendable.

DISCUSSION AND CONCLUSION
The on-job training method is well-perceived in the Pakistan P&O community. It might bring results in improving the quality of services. The results comfort the evidence that it is essential that activity has to include the assessment of training material preferences, as well as pedagogy and the inclusion of suggestions from the professionals in the preparation phase of the training.

We can do face-to-face interviews for in-depth study, but our lack of time and resources was a big challenge.

5.15.5 Roles of ISPO-NMS Cambodia for Continuing Professional Development and Capacity Building of Clinicians and Technicians through Covid pandemic-Twinning, Inspiring, Influencing

Chanvichet Kheng[1,2], Sisary Kheng[3,4,5]

[1]Cambodian Association of Prosthetists and Orthotists, Phnom Penh, Cambodia. [2]Department of Prosthetics and Orthotics (National Institute of Prosthetics and Orthotics), Phnom Penh, Cambodia. [3]University of Salford, Manchester, United Kingdom. [4]National Institute of Social Affairs, Phnom Penh, Cambodia. [5]Exceed Worldwide, Phnom Penh, Cambodia

BACKGROUND
The Cambodian Prosthetist and Orthotist Association (KhAPO) was established in December 2002 by a group of qualified prosthetists/orthotists, engineers, and technicians. The aim of NMS Cambodia is to empower prosthetists/orthotists in Cambodia to achieve the quality of prosthetic and orthotic services to a high standard with international practice guidelines. In 2014, KhAPO became ISPO-NMS Cambodia and has been twinning with ISPO Norway. The main mission of ISPO NMS Cambodia is **"Enhancing Quality of Life through Retention of Professionals"**.

AIM
The aim of this paper is to share experiences on how NMS plays important roles in mentoring, coaching, capacity building, and monitoring of quality standards of practice throughout the pandemic for its members from both twinning and local resources.

METHOD
NMS-Cambodia used Training Need Assessments, Surveys, Satisfaction Questionnaires, and Performance Reviews by managers at different clinics as well as virtual focused group discussions with members, board members and executive committees to identify the topics for continuing professional development activities, mentoring, coaching programmes, and also capacity assessment, and evaluation post-training programme. A team of two and four senior professionals were assigned to support specific topics and mentoring/coaching activities at various clinics based on their areas of expertise. The Twining programme with ISPO-NMS Norway has contributed to an assignment of an international mentor for ISPO-NMS Cambodia where the team could reach out and request professional support and advice as necessary.

RESULTS
In November 2021, KhAPO arranged a virtual annual congress and invited speakers within the profession as well as the interdisciplinary team to share experiences among members and other professions. It has been evidenced that there is a tremendous bank of knowledge and experience in the Cambodian members since they have been working across a number of clinics in Cambodia, with exposure to international experiences such as Japan, Australia, Norway, Sri Lanka, Philippines, Indonesia, Thailand, Tanzania, Malaysia, Malawi, and America.

Upon the reopening to normal services, KhAPO also revised its strategic plan, and activities to respond to the changes that were left by Covid. KhAPO has been working with partner organizations to provide onsite training and traveled to scared centers in the provinces around Cambodia to provide adaptive training based on different resource settings which has been feedback with positive results.

DISCUSSION AND CONCLUSION
Despite uncountable COVID impacts on direct clinical services, NMS-Cambodia has been working to adapt our activities to respond to government restrictions. Virtual training workshops were conducted in collaboration with all eleven rehabilitation centers in Cambodia. KhAPO believes that the profession will live on if there is a will from the association to enhance the quality of service, standards of care, and continual improvement of interventions provided by both clinicians and technicians in a multidisciplinary approach to care.

ACKNOWLEDGEMENTS: ISPO-NMS Norway, Exceed Worldwide, Department of Prosthetics and Orthotics (National Institute of Social Affairs), ICRC, H&I, Access, and MoSVY

5.15.6 Prosthetics and Orthotics Students' Perspective of Blended Learning in Thailand: A Focus Group Interview

Manunchaya Samala, Pattaraporn Kongsatan, Wisavaporn Niamsang

Sirindhorn School of Prosthetics and Orthotics, Faculty of Medicine Siriraj Hospital, Bangkok, Thailand

BACKGROUND
Across 1.5 billion students in 191 nations were affected by COVID-19 in 2019, which had an impact on educational systems all over the world.[1] In order to teach the curriculum effectively during the COVID-19 pandemic, the curriculum was shifted from face-to-face to blended learning.[2] Online and onsite instruction are combined to create blended learning.[3] Prosthetics and orthotics schools require technical practice and theory (Standard for ISPO Education)[4], have been forced to offer an innovative and flexible curriculum.

AIM
This phenomenological study aimed to explore the perspectives of prosthetics and orthotics students toward blended learning in Thailand.

METHOD
A qualitative design using focus group semi-structured interviews was conducted on January 2022 via Google Meet platform. Focus group interviews with a total of 23 undergraduate students were performed. The participants were selected in a purposive sampling approach. Third-year prosthetics and orthotics undergraduate students were invited to participate according to their prior participation in online and onsite courses. The focus group interviews were audio-recorded and transcribed verbatim. The interviews were analysed with qualitative content analysis using NVivo. The data were reported using the Consolidated criteria for reporting qualitative research (COREQ) checklist.[5]

RESULTS
Twenty-three participants were included, of whom the majority were female (n = 17), with a median age of 21 years (aged 20-23 years old). Four Themes and 17 subthemes that emerged from the thematic analysis were identified (Fig.1): Theme One. Advantages and disadvantages, 62.7% of the advantages reported time management, recorded video, and accessibility, whereas the disadvantages reported were concentration, health, and cost., Theme Two. Course management, with the majority of students prioritizing study material (19.12%), followed by study schedule (17.65%) and class activity (15.44%), Theme Three. Infrastructure, the study environment, the Internet, and devices were noted as subthemes. Theme Four. Students' self-evaluation, the majority of student report was about their attitudes. Students' perspectives toward blended learning are both negative and positive depending on the issue and each student's surroundings.

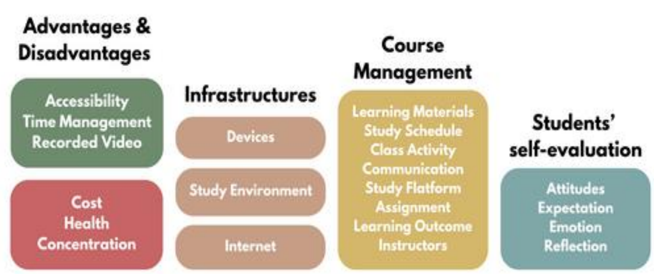

Figure 1. Themes of blended learning from thematic analysis.

DISCUSSION AND CONCLUSION
The finding of this study gives insight into the implementation of conducting blended learning. The result can help them create a curriculum or course and plan group discussions surrounding different topics. If blended learning continues, several downsides, including health and cost, should be more of a worry. Essential infrastructure such as Internet, devices, and study environment must be addressed in order to deliver the best practice to students. Educators can use this finding to improve Prosthetics and Orthotics education.

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Free paper session: Prosthetics: Lower limb - Simulation and theory

5.16.1 A modular open-source platform for lower limb prosthetic control and locomotion decoding (LocoD)

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BACKGROUND
Powered prosthetic legs for those with a transfemoral amputation use information from non-biological sensors such as Inertial Measurements Units (IMUs) and loadcells for control. There is currently no commercial device that uses electromyographic signals (EMG) as a control input. In the absence of any open-source software to record and process EMG signals during gait to accelerate research in prosthetic control, we developed an open-source modular software platform for recording and processing EMG and non-biological sensor data to decode motor volition.

AIM
Develop a modular and open-source platform (LocoD) to record and process EMG signals during gait, in which we can then statistically compare the accuracy of classifying locomotion modes using three different configurations of sensors (EMG, IMU, or EMG + IMU).

METHOD
LocoD was developed in MATLAB, and here we validated it in a study with able-bodied participants. We recorded signals while participants were moving between different terrains such as stairs and ramps. Features extracted from filtered signals were passed through a mode-specific classifier which classified windows in two gait phases, heel contact, and toe-off. For each new window, and based on the previously predicted windows, the classifier predicts either continuation of the current locomotion mode (walking, ramp-ascent, ramp-descent, stair-ascent, stair-descent) or transition to another locomotion mode. In the end, we used LocoD to compare the accuracy of the predicted locomotion modes in the three different configurations of sensors.

RESULTS
We used a signed rank test to compare the accuracies of the locomotion mode prediction for every different configuration of sensors. Results align with the literature, showing that using EMG+IMU is significantly better than using EMG or IMU alone (p-value <0,01). In this study, we also showed that LocoD could be used to record and process signals with the possibility to change and modify algorithms at any level, due to its modular architecture.

DISCUSSION AND CONCLUSION
The results confirmed that LocoD was able to use EMG in addition to non-biological sensors to improve the accuracy of predicting locomotion modes. LocoD as an open source and modular platform can therefore facilitate research in the next generation of lower limb active prosthetics and ultimately allow users to have a more natural control. The next step will be testing LocoD in real-time with participants with transfemoral amputation.

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5.16.2 A novel method for monitoring longitudinal post-amputation changes in lower limb residuum volume

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BACKGROUND

Residuum volume in lower limb amputees reduces in the postoperative phase, leading to challenges when fitting prostheses. Several measurement systems have been used to quantify these changes[1,2], but it remains unclear when the residuum stabilises for different categories of amputees. A new open source package[3] (AmpScan), is available for the analysis of 3D scans of residua, which could provide more accurate information regarding acute (within day) and chronic (over weeks and months) changes in residuum volume.

AIM

The aim of this study was to use AmpScan to analyse shape and volume changes in the residua of a diverse sample of lower limb amputees.

METHOD

20 lower limb amputees participated in the study (17 males and 3 females, 15 transtibial -TT and 5 transfemoral - TF), who had an amputation between 6-10 weeks earlier (age 52.9 ± 11.4 years, height 1.7 ± 0.1 m, mass 87.9 ± 30.4 kg). Their residua were monitored monthly for 9 months, using a previously validated 3D scanner (Artec Eva)[1,2]. In the first and last month of monitoring, participants were scanned twice a day with a minimum of 4 hours between measurements. The 3D scans were processed using AmpScan to extract volume and shape parameters and to graphically visualise the residuum changes.

RESULTS

Preliminary results revealed a consistent reduction of the residuum volume across the different amputee groups (-25% for TT and -13% for TF, 48 weeks after amputation). In terms of residuum shape changes, the [AmpScan] tool allows quantification of the perimeters of the cross-sectional areas of the residuum and the sagittal plane width over the length of the residuum (Fig 1). These changes are not constant along the length of the residuum, and most of them occur 40-80% proximal to the distal end of the residuum (Fig 1). Within-day measurements of residuum volume revealed small changes of ~2% of the original volume, which represents an increase in volume between the first and second scan.

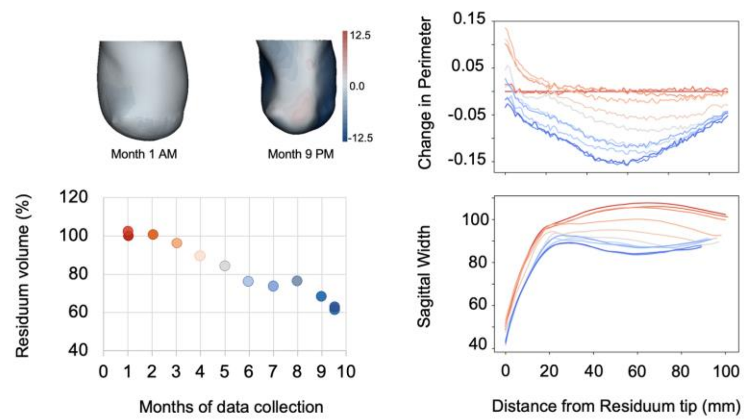

Figure 1: Left images: Residuum 3D representation for one TT traumatic amputee and volume changes over time. Right images: Residuum shape changes (perimeters and sagittal plane width, in mm), where different colours represent different monitoring times

DISCUSSION AND CONCLUSION

The combined use of a 3D scanner and AmpScan proved to be efficient to calculate and visualise residuum volume and shape changes in different amputee populations. Preliminary results show that the residuum volume and shape stabilises 6-7 months post-operatively. Small within-the-day fluctuations are still present after this time. These results have the potential to support clinicians in designing personalised fitting solutions for prosthetic rehabilitation.

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ACKNOWLEDGEMENTS: Funders: CAMERA, RCUK Centre for the Analysis of Motion, Entertainment Research and Application, EP/M023281/1. RAEng, RF/130.

5.16.3 The effect of microprocessor controlled exo-prosthetic knees on limited community ambulators: systematic review and meta-analysis, 2023 update

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BACKGROUND

The clinical benefits of microprocessor-controlled prosthetic knees (MPK) in unlimited community ambulators are well-established. A systematic review in limited community ambulators published in 2014 found benefits in safety, function and perception in a limited number of studies[1]. In the meantime, the topic received continued scientific attention and the body of evidence increased significantly in quality and quantity.

AIM

This work provides an update of a systematic review and a meta-analysis of all published data [1].

METHOD

Literature search was conducted in nine scientific data bases. Search terms related to MPK, transfemoral amputation, MFCL-2 and low mobility. Rating followed the recommendations of the American Academy of Orthotics and Prosthetics. Inclusion required the studies to comprise quantitative and analysable information on low mobility subjects allowing a direct comparison to non-MPKs. Outcomes were categorized whether they favour the use of MPK, non-MPK or were inconclusive. Mean differences (MD) or standardized mean differences (SMD) were calculated with 95% CIs. Selected effect sizes for SDMs were calculated using Heges `g. Conclusions were based on a random effects model only.

RESULTS

Thirteen research projects presented in 15 publications were identified. Overall validity was “high” in nine studies, “moderate” in three and “low” in one. The literature described a total of 2,366 patients, with 704 classified as limited community ambulators.

The use of MPKs in limited community ambulators led to a reduction in falls (SMD g:-0.59;95%CI[-0.85,-0.32;I^2=0%]), fear of falling (SMD g:1.2;95%CI[0.55,1.85;I^2=80%]), risk of falling as indicated by the TUG (SMD g:-0.45, 95%CI[-0.87,-0.02;I^2=0%]), an improvement in mobility grade (0.51;95%CI[0.47,0.55]), self-selected walking speed (SMD g:0.47;95%CI[0.14,0.81;I^2=0%]), and patient-reported ambulation (MD9.32;95%CI[3.61,15.02;I^2=7%]), and utility (MD7.76;95%CI[2.05-13.47;I^2=0%]). Other outcomes exhibited trends in favour of MPK use or remained insensitive. No outcome was identified favouring non-MPKs.

DISCUSSION AND CONCLUSION

The results of this updated systematic review and meta-analysis suggest that limited community ambulators may experience reduced falls and fear of falling, improve mobility grade and patient-reported of ambulation and utility. The availability of meaningful clinical evidence has increased significantly. Trial fittings of limited community ambulators with MPKs may be considered a means to identify specific responders. Further research to study the specific needs and characteristics of that population may be considered.

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5.16.4 Mechanical response customization by finite element analysis of a prosthetic foot made with continuous fiber reinforcement additive manufacturing

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BACKGROUND

The most advanced and functional prosthetic feet are cost-prohibitive for many patients in less developed countries [1]. This research implements finite element analysis (FEA) for the design iteration of the ergoFoot, a dynamic prosthetic foot produced with continuous fiber reinforcement additive manufacturing. The combination of these technologies streamlines decision-making during the development process, reducing costs and tailoring the mechanical response of the foot to the functional needs of the patient [2].

AIM

To evaluate the relationship between the ergoFoot geometry and its stiffness through FEA, determining the design specifications that would allow matching the mechanical response to the patient's functional needs.

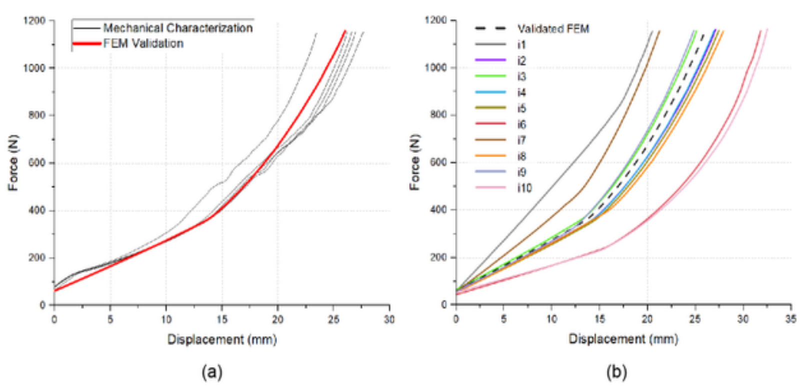
METHOD

The study was performed in three stages. First, the eFoot base design was characterized by compressive pseudo-dynamic mechanical testing following the standards ISO-10328, ISO-22675, and the AOPA's Prosthetic foot Project testing guideline. Then, the finite element model was developed and validated using the mechanical testing results as a reference. Finally, the iterative design process was developed by doing controlled design modifications to the base design and evaluating them through FEA. Then, ten design modifications were simulated to measure three stiffness values (initial, final, and component stiffness), the maximum displacement or deformation, and the Von-Misses peak stress.

RESULTS

The finite element model was validated with less than 5% variations concerning mechanical testing results. In addition, the force-displacement curves described a very similar behaviour (Figure 1a). As shown in Figure 1b, all the design modifications evaluated affected the mechanical response. It was possible to reduce the stiffness by 45.1% and increase it by 111.06%. With the design specifications from i1 and i7 will be possible to manufacture more rigid feet adequate for less demanding functional levels such as K0 and K1. In contrast, the i6 and i10 modifications would make a more dynamic device suitable for the more demanding functional levels such as K3 and K4. All the design modifications evaluated serve as a design input to adjust the ergoFoot mechanical response.

Figure 1. Mechanical characterization versus finite element model validation (a). Design iterations versus FEM(b).



DISCUSSION AND CONCLUSION

The results evidenced a successful implementation of FEA to redesign the ergoFoot. It is possible to adjust the stiffness and maximum deformation with precise and controlled modifications. These design specifications provided the starting point for the ergoFoot tailored prescription, possibly adapting its mechanical response to the patient's functional needs. The presented methodology also establishes the basis for evaluating other materials combinations and new design modifications.

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5.16.5 MRI measured muscle volume and fat fraction adaptation in patients with transfemoral bone-anchored prostheses: Preliminary 6-month analysis and results

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BACKGROUND

Around 2150 major leg amputations are performed per year with 20% non-vascular/diabetic causes. Hip abductor muscles undergo atrophy and strength loss after transfemoral amputation (TFA). Gait is influenced by reduced hip muscle strength and usage of socket-prostheses. Supposedly 48% of lower extremity amputations use a socket-prosthesis, 34%-63% experience socket-related problems. Patients with socket-related problems qualify for osseointegration implant (OI) surgery. The new method of walking and loading might reverse hip abductor muscle atrophy and fatty degeneration.

AIM

We aim to show an increase in hip abductor muscle volume and decreased fat fraction of the residual limb after OI surgery in transfemoral amputation patients. We suspect a more functional usage of the hip muscles resulting in muscle hypertrophy.

METHOD

7 patients were included in this prospective one-year follow-up before-after cohort study. This part of the study encompasses the 6-month measurements. MRI scans were made before OI surgery, six months, and twelve months after OI surgery. T1-weighted and Dixon sequence images were made. Using the T1-weighted images, segmentations were created of the hip abductor muscles gluteus maximus/medius/minimus, tensor fasciae latae, and piriformis. These segmentations were registered over the Dixon images to calculate the fat fraction (FF) of the hip abductor muscles. Wilcoxon signed-rank tests were executed to assess the differences between the baseline and 6-month measurements for the sound and residual limb (n=7).

RESULTS

Sound limb muscles showed no statistically significant difference after 6-months. Most hip abductor muscles of the residual limb showed statistically significant increases in muscle volume after 6-months OI implant usage (cm3) presented as Median (Q1-Q3): gluteus maximus baseline 659.1 (550.8-785.6) and 6-months 683.2 (575.6-823.3) p=0.028, gluteus medius baseline 241.6 (191.8-267.4) to 6-months 257.4 (192.4-291.6) p=0.043, gluteus minimus baseline 53.9 (39.2-64.5) to 6-months 61.9 (55.9-72.2) p=0.018, piriformis baseline 16.5 (10.3-22.5) to 6-months 20.4 (14.1-27.5) p=0.018. Fat fraction (%) only decreased in the gluteus minimus of the residual limb from baseline 9.5 (7.1-16.7) to 6-months 8.2 (7.3-11.2) p=0.043.

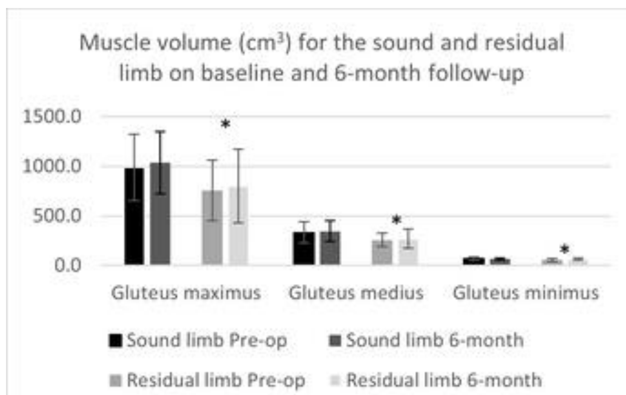

Figure 1 Residual limb shows an increase in muscle volume of the gluteus muscle group. Each muscle shows 4 columns, 2 for the sound limb (left) and 2 for the residual limb (right). * Shows statistically significant differences.

DISCUSSION AND CONCLUSION

This study is the first to analyse the hip abductor muscle volume and fat fraction changes after osseointegration surgery in transfemoral amputation patients. An increase in muscle volume of the residual limb was observed, suggesting a specific and expeditious effect of the OI surgery on the hip abductor muscles. Completion of the 12-month follow-up measurements analysis is necessary for more valid conclusions. Methods to minimize the number of excluded patients are being explored.

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5.16.6 openlimb: an Open Source Transtibial Residual Limb Model for Simulation and Design

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BACKGROUND

Computer aided design and manufacturing (CAD/CAM) may enable evidence-based socket design through data science methods by leveraging prior CAD/CAM records [1] or when matched with simulation for socket fit prediction [2]. However, few researchers have access to the required volumetric medical imaging data, and there is cost, inconvenience, and risk associated with putting our relatively small community of eligible participants through CT or MRI scanning.

AIM

To produce an 'openlimb' open-access Statistical Shape Model (SSM), describing a population of residual limb shapes in a general manner, that can be published and shared with other researchers whilst preserving the security of the underlying imaging data.

METHOD

An SSM was generated using 11 MRI scans of transtibial residual limbs collected with ethical approval and written consent (Figure left). Scans were segmented (ScanIP, Synopsis Inc) to describe the skin surface and bones, exported as .stl meshes, and size-normalised to intact tibia length, estimated using the person's height [3]. Meshes were aligned by the residual tibia and registered (Figure middle top). Finally, the mean vertex locations were calculated (Figure middle bottom), and Principal Component Analysis (PCA) was used to extract the dataset's variation (Figure right).

RESULTS

Principal modes of variation represented independent changes in the length and profile of both bone and soft tissues. Synthetic individuals around the mean shape were created by selecting characteristics from these modes of variation. This model is only preliminary, as it is trained upon a limited population of residual limbs with similar morphology and ethnicity. Assumptions cannot be made about how it will represent limbs outside the training dataset. In a Leave-One-Out cross-validation test, the mean shape was reconstructed with root-mean-squared-error (RMSE) of 0.64–2.51mm (median 1.05mm). However, the left-out shapes were reconstructed with higher RMSE (3.27–11.3mm, median 4.8mm), indicating the training dataset must be expanded. However, to provide access and encourage other researchers to contribute their data, following appropriate approvals, this resource has been made publicly available at https://github.com/abel-research/openlimb, open access.

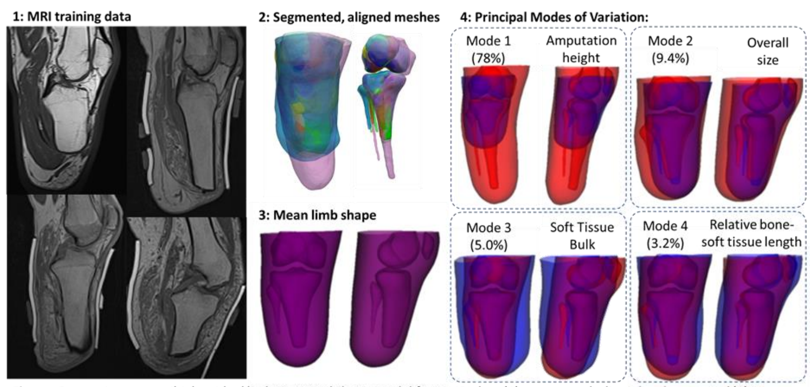

Figure: Generating a transtibial residual limb Statistical Shape Model from MRI data (1), segmented, aligned and registered (2) to produce a mean shape (3) and principal modes of shape variability (4) shown in anterior and lateral views, with associated variance %.

DISCUSSION AND CONCLUSION

Previously SSMs have described the exterior limb surface [1], but this is the first open access residual limb SSM and includes bone geometry. This can provide researchers a wider pool of limb shapes for biomechanical analysis of socket designs and materials and may enable estimation of personalised models to assess socket fit, predicting the bone geometry from external limb shape data. However, the model must be expanded with additional data, and we invite the community to contribute.

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Free paper session: Prosthetics: Upper limb - Grasping

5.17.1 The Use of Eye Tracking to Assess Upper Limb Prosthetic Behaviour: A Scoping Review

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BACKGROUND

Advanced upper limb prostheses aim to restore coordinated hand and arm function. However, this objective can be difficult to quantify as coordinated movements require an intact visuomotor system. Eye tracking is a technology used to measure eye movements and it has only recently been applied to study the visuomotor behaviours of upper limb prosthesis users [1].

AIM

This scoping review aims to characterize the visuomotor behaviours of upper limb prosthesis users, to summarize the eye tracking metrics used to describe prosthetic behaviour, and to identify gaps in the literature and potential areas for future research.

METHOD

Medline, Embase, PsycInfo, ProQuest and Google Scholar were searched for academic literature. The included literature involved the use of an upper limb prosthetic device to perform an experimental task, while eye tracking data were collected to quantify behaviour. Title and abstract screening were performed, followed by a full-text review of the identified literature. Data on the level of amputation, type of prosthetic device, type of eye tracker, primary eye metrics, secondary outcome metrics, experimental task, aims, and key findings were extracted and tabulated to understand the ways in which eye tracking has been used to evaluate upper limb prosthesis use.

RESULTS

Eighteen studies were included. Studies utilized participants with and without amputation and involved various prosthetic devices and experimental tasks. To describe visuomotor behaviours, number of fixations, gaze sequence, percent fixation, eye latencies, and target locking strategy were recorded. The reviewed articles consistently demonstrated that prosthesis users spent more time fixating the hand and less time fixating the target when manipulating objects, and their gaze switched between the hand and the target [1-4]. There was also a delay for the eyes to disengage from the current target and shift to the next target [2,4]. Novel control, sensory feedback, and training interventions were shown to modulate visuomotor behaviours to reduce the visual demand of prosthetic use [4-6]. Pupil dilation and fixation duration were other eye tracking metrics identified in preliminary studies to evaluate cognitive load [7,8] and sense of agency [9], respectively.

DISCUSSION AND CONCLUSION

A distinctive visuomotor behaviour was identified for upper limb prosthesis users despite differences in experimental protocols and devices across research studies. Eye tracking provided a quantitative assessment of human behaviour and was sensitive to novel interventions. Future work should investigate the relationship between skill in using a prosthesis and gaze behaviour. Additional studies are also needed to determine the validity of using eye metrics to assess cognitive load and sense of agency.

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5.17.2 Prediction of grasping movements as a function of neurofunctional representations

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BACKGROUND

Myoelectric upper-limb prostheses can be controlled arbitrarily to a certain degree. However, intuitive, flowing and merging natural grasping movements are still not possible. Part of this control problem is a timely inadequate signal generation and processing. In contrast, synergistic hand postures are encoded at a cortical level [1] and neurofunctional activation is already present during the grasping planning [2]; i.e., before the actual movement execution.

AIM

The present’s study aim is to prove whether it is in principle possible to distinguish different grasps in time to possibly use neurofunctional representations (NR) for a more intuitive prosthetic control.

METHOD

EEGs of subjects S1-S13 performing 16 grasps considering prosthetic hand postures were captured (Fig#1a). Data sorted into grasping taxonomies served to train classification models on features from different signal spectra at different epochs before initial hand movements. For a prosthetic application target subject fine-tunings were evaluated using pre-trainings with selected subject data, resulting in adaptation scenarios A-D (A = adaptation of hyper-parameters S1-S11 without pre-training; B = pre-training using S1-S11 without hyper-parameter adaptions during fine-tuning for S12 or S13; C = like scenario B but with hyper-parameter adaptions during fine-tuning for S12 or S13; D = like scenario C but using only S13 for pre-training and S12 for fine-tuning).

RESULTS

A support vector machine algorithm with spatial covariance matrices as EEG signal descriptors based on Riemannian geometry (TS_SVM) without pre-training showed the highest balanced accuracy with a mean of up to 0.91 ± 0.05 SD over all applied classifiers when discriminating five grasping categories according to the Cutkosky taxonomy [3] during a long epoch E_L = 1500ms (Figs#1b-c). Improvement of results by a downstream fine tuning was not observed for any of the classifiers. No significant accuracy differences were observed when comparing different frequency spectra. Although a shorter and earlier epoch (E_S = 1000ms) lead to accuracy losses of 4-10% for all applied classifiers on average, the classification performances remained significant (p<0.01).

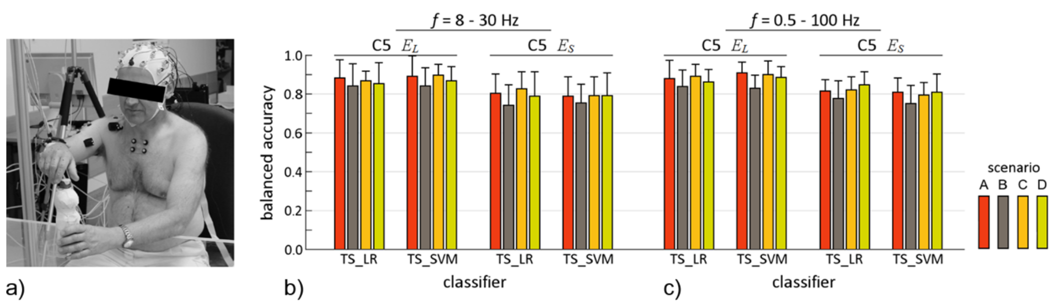

Figure 1: Instrumented subject performing the ADL “unscrewing a bottle” (a); Balanced discrimination accuracy of the classifiers logistic regression in Tangent Space (TS_LR) and support vector machine in Tangent Space (TS_SVM) trained with EEG-data sorted due to 5 grasps of Cutkosky taxonomy (C5) as a function of EEG-signal frequency spectrum of the waking-state (b) and the whole frequency spectrum (c) of long (E_L) and short epochs (E_S). Training scenarios A-D can be taken from the methods section.

DISCUSSION AND CONCLUSION

NR allow highly accurate discrimination of five grasping categories. It is possible to use NR sufficiently in time for prosthetics. Conventional sEMG control could be complemented by EEG control predicting discrete grasping tasks. To enhance desired natural appearances, prosthetic hands could already be kinematically pre-shaped for upcoming grasping tasks. Although NR shortly after first movements would improve discrimination accuracy, results demonstrate decision making is already possible even before actual hand movements. Pre-training seems not to be beneficial in NR control.

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5.17.3 The modulation of muscular synergies as a function of unexpectedly perturbed grasping tasks.

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BACKGROUND

Muscle synergies (MS) are central building blocks for motion production and offer the potential of a more intuitive control compared to conventional pattern recognition methods in upper limb prosthetics since they accompany grasping movements without delay [1]. However, it remains unclear until now to what extent a prosthetic pattern recognition control based on MS is affected by external perturbations.

AIM

The aim of the study is to investigate the modulation of a MS model in the presence of external perturbations.

METHOD

The activity of 12 arm muscles in 15 healthy volunteers was measured using EMG during object manipulation tasks with and without unexpected weight change. The movements of instrumented grasping objects were tracked using a VICON optical system. MS were extracted with a non-negative matrix factorization (NNMF) during different grasping phases and grouped with a k-means cluster analysis. Their reconstruction was then performed once with temporal-fixed and once with spatial-fixed synergy components. A significant drop in reconstruction quality would indicate that activation changes cannot be modulated by the respective unfixed component. Statistically, a Wilcoxon signed-rank and a Wilcoxon rank-sum test were applied.

RESULTS

Independent of the motor correction due to external perturbations, the number of recruited MS remained unchanged for each grasping phase. While there was a significant reduction in the reconstruction quality of perturbation-induced muscle activation in temporal-fixed NNMF, this quality remained unchanged in spatial-fixed NNMF. The temporal modulation of subject-invariant MS significantly depended on the context of the perturbation, whereas the MS activation profiles showed a correlation with the object trajectories.

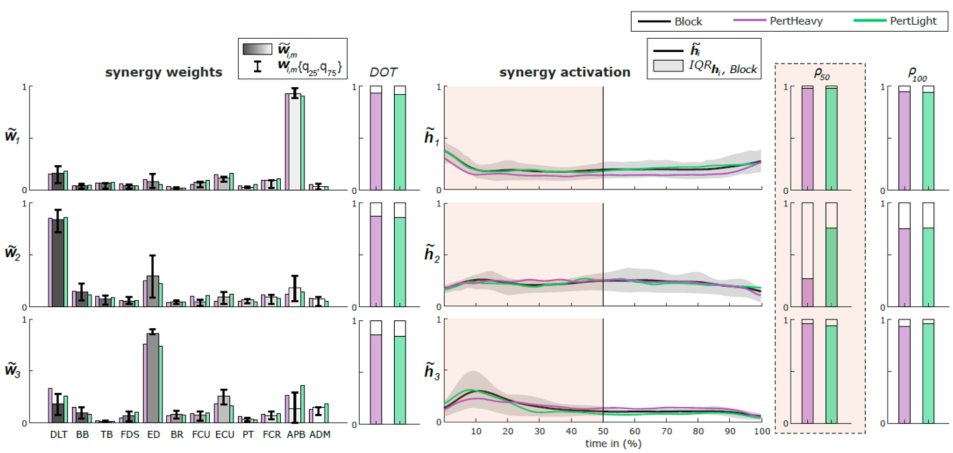

Figure 1: Relative centroids of spatial synergy components from cluster analysis during the manipulation phase with the object (bar graphs, left) and corresponding temporal activations (line graphs, right) for expected (Block, gray), unexpectedly heavy (PertHeavy, purple), and unexpectedly light (PertLight, green) object weights. Spatial (*DOT*) and temporal (ρ) similarity values are shown next to the graph. ρ_{50} is the similarity value for the first 50% of the manipulation phase and ρ_{100} covers the entire grasping movement.

DISCUSSION AND CONCLUSION

MS appear to be modulated by their temporal rather than their spatial components during perturbations. Thus, modulated MS do not affect the pattern recognition of prosthesis control and the classification accuracy should not be changed. The context dependence of modulation may find introduction in prosthetics as a complementary control signal to detect the nature of perturbation. It could be used to automatically correct the prosthetic hand (e.g., a follow-up grasp in case of an unexpectedly heavy object).

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5.17.4 Comparing the Clinical Standard of Care Linear Discriminant Analysis Electromyogram Classification System to Fuzzy C-Means Classification

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BACKGROUND

Currently, the standard of care for electromyogram (EMG) pattern recognition is the Linear Discriminant Analysis (LDA) system. LDA is preferred due to utilizing simple mathematical principles and single posture means for separating datasets. In contrast, Fuzzy C-Means (FCM) systems use multiple centres to spread out across a dataset's space. This approach could be analogous to using a net to catch more points in a given space versus a fishing line to catch points one small area at a time.

AIM

To cover a greater area of a posture in an FCM system with multiple centres and classify more validation data points correctly rather than misclassifying them when a distance is split between two postures' central means in an LDA system.

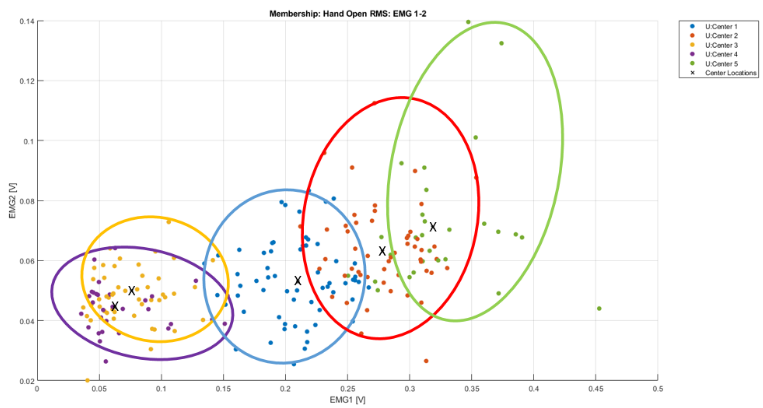
METHOD

We acquired raw EMG data for 11 postures (off, hand close, hand open, thumb abduction, thumb adduction, wrist extension, wrist flexion, wrist pronation, wrist supination, wrist radial deviation, wrist ulnar deviation) for training and validation datasets. Each trial consists of 10 seconds lead in & out time with 5 seconds "ON" and alternating 5 seconds "OFF" for each posture for 10 times. Bandpass filters from 30-480 Hz with notch filters at intervals of 60Hz were then applied. The "ON" sections were extracted and features of root mean square (RMS), zero crossings (ZC), wavelength (WL), and slope sign change (SSC) were calculated. These were then fed into LDA and FCM algorithms.

RESULTS

In contrast to the single mean and distance LDA comparison system, the FCM spreads out multiple cluster centres over the entire area of a posture's feature space [1]. These centres are then converted into linguistic rules through an input membership function. An example rule: RMS feature [EMG 1 (low), EMG 2 (high)] = {hand open}. Therefore, a validation data point will have a degree of truth (DOT) to how close it matches with a rule and the highest DOT will be the classified posture. Preliminary testing may show that while the LDA system has a higher accuracy during the "ON" sections, there is a lack of consistency in going to the "OFF" posture. Meanwhile, the FCM system is able to reliably maintain the "OFF" signal during the rest times.

Figure 1: Multiple FCM centres fit to RMS values [2]



DISCUSSION AND CONCLUSION

Further research must be done to increase the overall accuracy of the FCM algorithm; however, when it does classify to a posture, it guesses more precisely than the LDA system. This in theory should be better for a control system since people would rather have a prosthetic arm at rest than constantly jumping to "wrong" postures. In the future, we would like to apply FCM to create more accurate and natural classification control systems for myoelectric prosthetic hands [1].

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5.17.5 Evaluation of gender differences in hand grasp and motion kinematics for finger prosthetic design, a pilot study

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BACKGROUND

Evaluations of hand grasp frequency during activities of daily life (ADLs) have shown that each individual has different preferences and manipulation strategies [1], one of the possible reasons being biomechanical gender finger differences. Diverse options for finger prosthetics exist in the market with different levels of adaptability and workspace capabilities. However, no standards exist for how finger prosthetic design should meet such criteria and adapt to specific gender needs [2].

AIM

To evaluate gender differences in joint kinematics during motion and selected grasps, to determine functional finger requirements for gender-specific prosthetic design.

METHOD

A full hand marker set developed at the University of Warwick was used to track the right-hand finger motion of 3 male and 3 female participants. Participants performed 3 maximum/minimum movements of all finger joints. Joint maximum/minimum angles and range of motion variables were calculated. Participants used pre-determined objects to execute selected grasps as frequently observed in previous ADL studies [3], namely: medium wrap, power sphere, tip pinch and lateral pinch. Three static trials per grasp were recorded. To evaluate kinematic differences between genders, independently sampled t-tests were performed.

RESULTS

Findings showed gender differences in joint angles during the range of motion trials and grasps ($p<0.05$). Females showed increased finger adduction in the ring and little fingers, as well as increased ring proximal flexion. Conversely, males presented increased little finger distal flexion and thumb interphalangeal extension. Gender differences in joint angles were observed in all grasps except for tip pinch. Males presented larger flexion of the distal joint of the little finger and the metacarpal joint of the middle finger for the medium wrap grasp; similar increased flexion was observed in males for the little finger proximal joint of the power sphere. For the lateral pinch grasp, females showed increased index finger distal flexion and thumb interphalangeal joint extension.

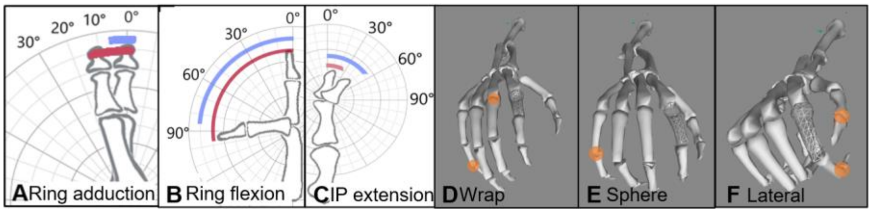

Figure 1. A-C: Kinematic differences between genders (blue: male, red: female). D-F: Joints presenting differences between genders during grasps (orange dots).

DISCUSSION AND CONCLUSION

Differences in adduction between genders might be due to pre-shaping of the fingers during early reach [4]. Differences in middle, ring and little fingers might be due to involuntary movement synergies, as such fingers share flexor tendons. Findings confirm the role of the thumb in precision tasks for each gender. Gender kinematic differences could potentially inform prosthetic design and drive larger cohort studies, determining specialised understanding of gender-specific design needs, leading to improved prosthetic finger dexterity and quality of life.

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Free paper session: Prosthetics: Lower limb - Knees

5.18.2 Development of transfemoral prosthetic knee for safe running

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BACKGROUND

Falls caused by the unintended prosthetic knee flexion are a major barrier to practicing running for transfemoral amputees. However, existing prosthetic knees for running do not have a function to prevent unintended knee flexion during prosthetic stance. In our previous study, we developed a passive knee mechanism that restricts flexion with ground reaction forces (GRFs) [1]. The evaluation experiment indicated that the mechanism requires an appropriate condition of GRFs and cannot completely avoid unintended prosthetic knee flexion.

AIM

The present study aims to propose a new passive prosthetic knee mechanism for running that prevents unintended knee flexion during stance without GRFs.

METHOD

The proposed mechanism was designed to restrict flexion except in the first half of the prosthetic swing. The available time of flexion (pawl motion of the mechanism) is mechanically controlled with a spring and damper to be nearly constant regardless of running speed. We constructed a prototype and conducted a running experiment. An intact participant attached a simulated thigh socket, the prototype knee, and a running-specific prosthesis (1E91, OttoBock) on the right limb. The running motion was recorded with a motion system (MAC3D, Motion Analysis). The pawl motion was recorded with a rotary potentiometer (CP-2FBSJ, Midori precisions). After the practice session, five trials were recorded.

RESULTS

The participant who was a beginner could run without unintended knee flexion in all trials. The running speed was 1.27 ± 0.21 m/s. The results showed that the proposed prosthetic knee functioned as designed. The prosthetic knee flexed in the first half of swing phase and extended in the second half. Then, the prosthetic knee did not flex over the range of the backlash of the mechanism during prosthetic stance. The results of the pawl motion indicated that the flexion restriction of the prosthetic knee was released right before prosthetic leg take-off of the ground and that the pawl restricted knee flexion again before prosthetic leg touch-down of the ground.

DISCUSSION AND CONCLUSION

The proposed mechanism appropriately functioned and prevented an unintended knee flexion during stance in running. The flexion restriction of the prosthetic knee was released for a certain time after the prosthetic leg take-off of the ground. The previous study suggests that the swing time is nearly constant, regardless of the running speed [2]. The present mechanism could accommodate safe running at different speeds preventing an unintended knee flexion.

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5.18.3 Comparative study of gait results in transfemoral amputees: A pilot study using Rehab Impulse Knees

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BACKGROUND

The International Committee of the Red Cross in recent decades has provided, through polypropylene technology, accessible and functional prosthetic devices for people with amputations. For transfemoral amputees, a mechanical monocentric knee with a free axis and manual locking has historically been provided [1]. A couple of years ago the polycentric model was designed and distributed in different countries. However, no formal study including gait analysis has been conducted to assess polycentric knee performance compared to the monocentric model.

AIM

To evaluate gait outcomes for users with unilateral transfemoral amputation following the provision of Rehab Impulse Knees

METHOD

As part of the research project for the MSc Rehabilitation studies in Prosthetics and Orthotics degree at the University of Strathclyde, 12 adults with transfemoral amputation (Age range 18-60 years) previously treated at an ICRC partner center in Colombia decided to participate in the study. Current unilateral users of a transfemoral prosthesis with monocentric Rehab Impulse Knee. Transfemoral users of at least 12 months, independent walking without external aids. New sockets were made and the assembly of the prosthesis, static and dynamic alignment with polycentric and monocentric knee were performed. Three-dimensional gait analysis was developed in a randomized manner. A gait report for each user and tested knee were obtained.

RESULTS

The Polycentric Rehab Impulse Knee provides more symmetry and improves temporal-spatial parameters, as well as kinematics and kinetics in the sagittal plane compared with the Monocentric Rehab Impulse Knee (Fig.1). This pilot study suggests that unilateral transfemoral using the Polycentric Rehab Impulse Knee improve their gait pattern and biomechanical factors and gets a better Gait Profile Score (GPS) and Gait Deviation Index (GDI) compared when using the monocentric one.

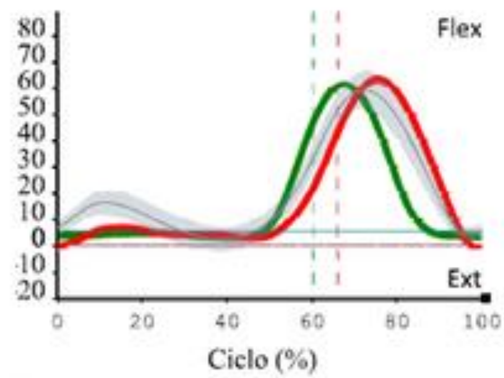

Figure 1. Flex-ext. Knee Polycentric Kinematics

DISCUSSION AND CONCLUSION

This pilot study of an experimental nature was able to evaluate, through 3D gait analysis, the performance and functionality of the Rehab Impulse polycentric knee compared to the monocentric one, demonstrating the biomechanical advantages from the kinetic and kinematic analysis. Factors such as the use of the SACH foot versus a medium energy return foot, as well as the ischial versus quadrilateral socket design, and the possibility of a longitudinal investigation project the future continuity of this study.

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ACKNOWLEDGEMENTS: Physical Rehabilitation Program-Colombia, International Red Cross Committee (ICRC) Department of Biomedical Engineering, University of Strathclyde, SENA -Design and Metrology Centre.

5.18.4 Polycentric prosthetic knees with spring extension assist mechanisms: Design choices can improve gait symmetry in unilateral transfemoral amputees

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BACKGROUND

Extension assist mechanisms in passive prosthetic knees are designed to improve swing phase during gait of transfemoral amputees [1]. In conventional polycentric knees using a four-bar linkage, the extension assist mechanism links one of the bars to the body of the prosthesis. This design introduces a singularity in the delivery of the spring action: past a certain knee flexion angle, the spring pushes towards flexion. A novel polycentric knee design has been created that pushes the knee towards extension.

AIM

This study investigates the effect of different spring extension assist mechanisms in polycentric knees on the walking capacity of unilateral transfemoral amputees (UTF) and their satisfaction with the prosthesis.

METHOD

Gait data were collected from eight UTF traumatic amputees using a 10-camera motion capture system with two force plates. Participants trialled the novel design and a commonly used polycentric knee with a conventional extension assist mechanism, both coupled to a passive foot. They underwent gait analysis and completed SAT-PRO prosthesis satisfaction questionnaires [2] for both prosthetic knees. Comparison analyses were performed between the trial conditions.

RESULTS

Participants were able to walk faster by 0.1m/s ($p=.004$) with the new extension assist design. Investigating gait symmetry, the mean difference between the intact and prosthetic knee peak flexion was 8.9° with the new spring extension assist mechanism, and 19.0° with the conventional mechanism. Overall, participants reported levels of satisfaction of 72% with the new design, and of 65% with the conventional design in the SAT-PRO questionnaires. Participants reported higher scores for functionality, efficiency, durability, and safety with the new extension assist design.

DISCUSSION AND CONCLUSION

The new extension assist mechanism improved the symmetry between the intact and prosthetic knee angles by preventing excessive prosthetic knee flexion in swing. When using the new extension assist, participants did not need to wait for the knee to come back from a position of higher flexion and therefore could walk faster. The improved functionality of the new mechanism is also supported by the findings of the SAT-PRO questionnaires.

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ACKNOWLEDGEMENTS: The funding from the Royal British Legion for Centre for Blast Injury Studies and UK EPSRC is gratefully acknowledged.

Free paper session: Low- and middle-income countries - Healthcare policy and services I

5.19.1 The need for mobility assistive devices in people with lower limb conditions in Nepal

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BACKGROUND
Lower limb conditions (LLCs) can result in pain and mobility limitation, and sufferers may benefit from mobility assistive devices. In Nepal, a large proportion of the population live in remote areas with little access to quality healthcare. The burden and treatment of LLCs is not well known, but it is likely these conditions have profound consequences on individuals and society. It is important to understand the needs of those with LLCs and the challenges of accessing treatment such as devices.

AIM
To investigate the need for mobility assistive devices in people with LLCs across a range of communities and diverse geographical regions in Nepal

METHOD
A three-staged cluster sampling technique was used to select 500 men and women with LLCs (18 and above years) in three selected districts of Nepal. Three districts were selected from each of Nepal's three ecological zones: Mountain (Dolakha), Hill (Lamjung) and Terai (Dang). Screening for an LLC was undertaken on 2,525 households and as targeted, survey interviews were conducted on 500 people with an LLC condition and in-depth interviews (IDIs) on 15 individuals. Surveys included questions to assess LLCs and related issues, such as access to healthcare, treatment, mobility aids, related economic hardship and comorbidities. Data were collected between July and August 2021.

RESULTS
Within the LLC population (n=500), 97% reported a musculoskeletal LLC, 1% amputation, 7% deformity, 30% injury/trauma and 1% wounds. Of those with a given condition who reported using an assistive device, the type of device used is shown in table 1. A total of 82 LLC suffers reported the need for a cane or stick, 34 the need for prosthesis or orthoses, 15 for crutches, 10 for a walking frame, 8 for a wheelchair, and 5 for therapeutic footwear.

Table 1. Type of device used in those with a given condition

	Musculoskeletal	Amputation	Deformity n (%)	Injury/trauma	Wounds
Canes or sticks	201 (83.8)	0 (0.0)	27 (75.0)	43 (65.2)	2 (100)
Crutches	15 (6.3)	4 (100)	7 (19.4)	12 (18.2)	0 (0.0)
Lower limb orthoses	14 (5.8)	0 (0.0)	1 (2.8)	7 (10.6)	0 (0.0)
Walking frame	5 (2.1)	0 (0.0)	1 (2.8)	3 (4.5)	0 (0.0)
Therapeutic footwear	3 (1.3)	0 (0.0)	0 (0.0)	1 (1.5)	0 (0.0)
Wheelchair	2 (0.8)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Total of those using a device	240	4	36	66	2

Of those with lower limb amputation, none had a prosthesis. The reason for this was either the cost of treatment, not knowing where to go for treatment or because of pain/discomfort.

IDIs revealed a heavy reliance on devices, in particular crutches and sticks and the significant challenges faced in getting quality replacements that are appropriate for the given environment.

DISCUSSION AND CONCLUSION
Given the social and economic variation in the country, it is important to understand the needs of those with LLCs. Quantitative findings show the variation in devices used for different conditions. Many LLC sufferers rely on the use of canes, sticks or crutches and a high number report the need for additional devices. Qualitative findings highlight just how dependant LLC sufferers are on mobility assistive devices and the issues faced with accessing quality replacements that are fit for purpose.

ACKNOWLEDGEMENTS: We thank all Nepali participants for their contribution to this study.

5.19.2 Using WHO Training in Assistive Products to expand the scope and reach of Papua New Guinea's National Orthotic Prosthetic Services

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BACKGROUND
The National Orthotics and Prosthetics Service (NOPS) provides prosthetics and orthotics including mobility assistive technology (AT), from a National tertiary centre and via eight satellite clinics around the country. The Service struggles to meet the need, a key barrier to access being distance to services and geographical challenges including limited number of satellite clinics across the country. Many clients also need other types of AT, e.g., for vision or self-care [1].

AIM
To expand the scope and increase access to National AT services by expanding the range of AT provided by NOPS and initiating AT service provision at community level, in partnership with eye care and primary health care services.

METHOD
Between 2019 and 2022, the NOPS team used the World Health Organization's Training in Assistive Products (TAP) online training resource to develop capacity to provide self-care AT (toilet/shower chairs and incontinence products). Using TAP resources, the team supported primary health care managers and mentored staff at 8 primary health care centres to enable them to start to provide walking aids and identify clients with referral needs. In addition, the NOPS team collaborated with the National eye care service to create a referral network to better meet the needs of people in need of more than one type of AT (e.g., for self-care and/or mobility and/or vision).

RESULTS
44 personnel were trained using TAP, including 33 nurses and nurse assistants from 10 primary health care centres (PHC) and 10 orthotic/prosthetic staff from NOPS. These personnel went on to provide over 4000 assistive products, including reading glasses, toilet/shower chairs, absorbent incontinence products and walking aids. Both NOPS and PHC personnel built competence to also provide a basic vision screening service and refer to the eye care service when needs identified. New referral networks were successfully established between NOPS, National Eye Care service and the PHC centres. A successful model of mentoring was also established, whereby NOPS and National Eye Care personnel provided ongoing support to PHC personnel as they developed competence for safe, effective AT provision. Data from interviews and focus groups was very positive and highlighted important learning for future scaling up.

DISCUSSION AND CONCLUSION
TAP enabled easy access to training in AT provision beyond O&P. This allowed NOPS staff to expand their scope and the reach of their service and facilitated new links between services for more integrated patient care. Pressure on tertiary services reduced as a result of services at community-level. The biggest challenge was lack of sustainable AT product supply to meet the need. AT financing and supply chain needs addressing in order for these new services to be sustainable.

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ACKNOWLEDGEMENTS: Technical support: WHO; Financial support: UK aid/German Govt: AT supply: WHO/LDSC; Partners: PNG Eye Care/MOH

5.19.3 Access to assistive technology services for women with disabilities in the General Hospital of Kinshasa

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BACKGROUND

Studies show that different socio-economic and structural factors can limit access to healthcare for women with disabilities. Access to healthcare in general and to physical rehabilitation services and assistive technology is a big facilitator to acquire access to education, the labour market, and to full participation in social life.

Due to their gender, disability, and poverty, women with disabilities frequently experience triple discrimination. Women represent only 38.89% of patients in Kinshasa's rehabilitation facilities, suggesting that there are still ongoing hurdles.

AIM

This study aims at providing a preliminary understanding of the access of women with physical disabilities to the orthopaedic and rehabilitation services.

METHOD

This quantitative analysis is a retrospective study using existing data collected with the Digital Centre Management system in the Functional Rehabilitation Department (DRF) of the General Hospital of Kinshasa. The extraction of the data allowed an analysis disaggregated by gender first, and after by age, and type of service provided. Files that were not complete or treatments that were not finalized were not included. The percentage found was used as a proxy indicator for barriers existence to women obtaining services.

A total of 923 patients with mean age 34.74 benefited from rehabilitation services from May 2021 to August 2022

RESULTS

The common leading age groups were 18-40 years old (n=301, 32.61%) and 40-60 years old (n=299, 32.39%). 36.51% of the adult service users are women. Contrary to adults, children do not exhibit a significant gender access disparity (54.05% boys and 45.95% girls). The biggest gap encountered is for the persons with amputations: 3 out of 4 are males (n=243- 75% of all adult amputees) and 82 are females (25%). Another disparity in access was found among the wheelchair users: 157 service users received wheelchairs, 55 were females (38,5%). When it comes to orthoses, women appear to have more equitable access (48.91% of all orthotic users). These findings show that adult women amputees and wheelchair users experience larger access challenges when seeking out rehabilitation services in DRF.

DISCUSSION AND CONCLUSION

This study allows us to understand that adult women seeking prosthetics and wheelchairs services face the most barriers to access available rehabilitation services in DRFs. However, children and women needing orthotics have a similar access than man. Additional qualitative studies could unable in-depth comprehension of the challenges and lead to improvements in the service.

ACKNOWLEDGEMENTS: Thanks to the International Committee of the Red Cross who support the ongoing work.

5.19.4 Egalitarian public policy in Israeli healthcare

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BACKGROUND

Israel's State Health Insurance Law of 1994, based on principles of justice, equality and mutual aid, established obligatory provision of health insurance to all Israeli citizens. It stipulates the basket of services provided through health insurance funds. A few services are provided directly by the government, including ambulation devices, specifically prosthetics, orthotics and custom-made medical shoes. The Ministry of Health issues a public tender for managing service provision. The Lewis Institute, which secured the tender is the current manager.

AIM

Describe how Israel adheres to egalitarian principles in provision of a scope of devices, tailored to their specific needs and level of function and describe how co-payment is adjusted to income, so that people of low income are exempt.

METHOD

Clinics run by qualified physicians and physiotherapists are dispersed throughout Israel where disabled clients are examined. A detailed prescription stipulating the device to be custom-made, as well as the particular adjustments necessary to support ambulation of the client according to their particular disability is filled out. Prior to arrival at the clinic clients requiring a prosthesis are examined by a physiotherapist who performs an AMP (ambulation mobility prediction) test, so that the prosthesis provided reflects functional status. The client submits the prescription to a technician who fabricates the device. The client returns to the clinic with the device for a final examination. Specific policies will be elaborated during the talk.

RESULTS

The number of clients seen annually according to category (last 3 years). The number of citizens purchasing independently is negligible.

	Total Number of Devices Provided 2019-2021						
	Prosthetics		Orthotics			Shoes	
total no.	clients	devices	clients	devices		clients	devices
2019	906	990	4599	7491		4177	4210
2020	853	928	4274	7173		3055	3067
2021	763	832	4663	7934		3180	3198

DISCUSSION AND CONCLUSION

All citizens, regardless of income, are examined by qualified professionals and receive devices adapted to their functional and ambulatory needs. The maximum co-payment is 25% of cost. Co-payments are adjusted according to income, as well as number of devices needed or number of family members requiring devices. In this manner, the cost burden is minimized. The number of clients who purchase privately is negligible.

Free paper session: Outcome measurements - O&P

5.20.1 Orthotic Patient-Reported Outcomes – Mobility (OPRO-M): An item response theory based outcome measure for assessing mobility in lower limb orthosis users

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BACKGROUND
Patient-reported outcome (PRO) measures can be used to evaluate the effects of orthotic interventions by measuring individuals' perceived mobility in real-world situations. An item bank is a type of PRO instrument that can be administered using computer adaptive testing (CAT) or short forms. A qualitative item review was performed previously to develop a pool of candidate items for measuring mobility in lower limb orthosis users.[1]

AIM
To calibrate items for the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) item bank.

METHOD
Cross-sectional study of English-speaking orthosis users in the United States was conducted. Participants included adults with 6+ months experience using orthoses. Convenience sampling was supplemented with targeted recruitment to ensure representation of specific device types, health conditions, and activity levels. Participants completed an online or paper survey that included candidate OPRO-M items.

Procedures followed established development guidelines.[2] Confirmatory factor analysis (CFA) was performed to assess unidimensionality and items were evaluated for local independence. After removing locally dependent items, a graded response model was fit to the remaining items. Differential item functioning (DIF) by sex, age, or clinical condition was assessed. Short forms were developed for different clinical and research applications.

RESULTS
1036 participants completed the study. Half the participants were female and mean age was 60 years (range: 19-94 years). CFA results supported unidimensionality. A set of 39 items without local dependence was calibrated and included in the final item bank. No significant DIF was identified. 20- and 12-item forms (and corresponding scoring tables) were created for public dissemination (Figure 1). A CAT was also coded for electronic administration.

Instructions: As you answer each question, please think about doing each activity with the devices you normally use. Devices include leg braces, functional electrical stimulation (FES) devices, and walking aids such as canes, sticks, crutches, and walkers.

Choose "unable to do" for situations where you would:
- Need help from another person,
- Need a wheelchair or scooter, or
- Feel unsafe

Try to choose an answer, even if you have never done the activity with your leg brace(s). If you are unable to choose an answer, then you may skip the question.

Mark one box per row.

Are you currently able to...	Without any difficulty	With a little difficulty	With some difficulty	With much difficulty	Unable to do
1. Walk a short distance in your home?	☐ (5)	☐ (4)	☐ (3)	☐ (2)	☐ (1)
2. Take 2 steps backwards?	☐ (5)	☐ (4)	☐ (3)	☐ (2)	☐ (1)
3. Sweep the floor?	☐ (5)	☐ (4)	☐ (3)	☐ (2)	☐ (1)

Figure 1. OPRO-M instructions and example items

DISCUSSION AND CONCLUSION
Results indicated that OPRO-M items were unidimensional, locally independent, and functioned without bias due to characteristics unrelated to mobility. OPRO-M is the first item response theory based item bank developed specifically for evaluating mobility of lower limb orthosis users. OPRO-M may be valuable to clinicians, as the abbreviated forms minimize interruptions to patient care and the items include situations that are likely to be affected by orthotic interventions. OPRO-M instruments are available free-of-charge for clinical and research use at https://uwcorr.washington.edu/measures/.

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5.20.2 Sensitivity to change of patient-reported and performance measures for custom AFO users

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BACKGROUND

Patient-reported outcome measures (PROMs) are not used widely to evaluate the benefits of lower-limb orthoses, reflecting the lack of consensus on what to measure and limited psychometric evidence. 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]; identify instruments to assess care quality [2], and assess orthotists' and physiotherapists' perspectives on quality-of-care [3].

AIM

Aims of this report are to assess sensitivity to change of instruments measuring quality-of-care topics valued by patients and clinicians.

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 the EQ-5D; PROMIS Pain Interference, Physical Function, Participation in Social Roles and Activities, and Satisfaction with Social Roles and Activities short forms; Rivermead Mobility Index; and OPUS Quality-of-Life and Lower Extremity functional status. Staff recruited participants and administered instruments and recorded PROM responses before device delivery, ~1 month after delivery, and 1 month later. Participants provided consent. We calculated descriptive statistics and used generalized linear mixed models to test if measures changed over time. All models assumed an autoregressive (1) covariance structure.

RESULTS

The sample of 31 adults (52% male) had a mean age of 57+/-14 years and body mass index of 28+/-6. Patient impairments necessitating a custom AFO resulted from strokes (35%), neurological conditions (26%), traumatic conditions (13%), and various other conditions (26%). The Table shows estimated means and standard errors for the measures. We observed statistically significant improvement for the EQ-5D total score, PROMIS Physical Function, Rivermead, and OPUS Quality of Life. Gains in PROMIS Participation in Social Roles and Activities, and OPUS lower extremity function approached statistically significant improvements.

DISCUSSION AND CONCLUSION

Results provide evidence of sensitivity to change in four of the nine measures. Had the sample size been larger, we likely would have detected significant improvement in two additional measures. Clinicians may consider these PROMs for evaluating patients' experiences with orthotic services. Findings are specific to custom AFO users; future studies should evaluate measurement properties in other populations. Findings fill a knowledge gap regarding the sensitivity to change of PROMs that are suitable for use with custom AFO users.

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5.20.3 Satisfaction with prosthetic and orthotic services – s Swedish national survey

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BACKGROUND

Careful monitoring of progress toward desired outcomes is an essential component of the prosthetic and orthotic service delivery process [1]. To evaluate outcomes, it is necessary to not only measure functional improvements associated with the provision of specific devices but also the end-user's perceptions of how their needs have been met and their overall level of satisfaction with services.

AIM

This cross-sectional study aimed to evaluate patient satisfaction with prosthetic and orthotic and services in the Swedish context as well as identify factors which have the greatest influence on client satisfaction.

METHOD

Prosthetic and orthotic clinics in Sweden were invited to participate. Every third month questionnaires were sent to a random sample of clients who had received new prostheses or orthoses. Questionnaires were marked with a personalised code and reminders were sent to clients who did not respond after 3-weeks.

The questionnaire comprised of 24 items drawn from validated instruments. Satisfaction with services was measured using OPUS(CSS) [2]. Other items included demographic variables, type of device, frequency of use, perceived health status, quality of life, the extent to which perceived needs were met and comfort of the device.

RESULTS

44 of the total 50 prosthetic and orthotic clinics in Sweden participated in this study with approximately 2000 responses received over a 1-year period. Response rates across clinics varied between 30 and 40% with prosthesis users responding to a greater extent than orthosis users. Most respondents were aged between 65 and 80 years (40%).

Preliminary analysis reveals an average OPUS(CSS) score of 57.2 (SD 19.2) from a highest possible score of 100. No difference in OPUS scores was observed when comparing different types of devices ($p>0.05$) or sex of respondents ($p>0.05$). A significant difference was observed between age groups ($p<0.05$) but this did not exceed the smallest detectable difference (17 points). Clients were most satisfied with the courtesy and respect afforded to them by their clinician and least satisfied with the coordination of services with therapists and doctors.

DISCUSSION AND CONCLUSION

This study represents one the largest studies of client satisfaction within the field of prosthetics and orthotics. Overall results indicate moderate levels of satisfaction with service provision. Average satisfaction scores were similar to those reported for both prosthetic and orthotics users in a smaller study [3], but higher than scores reported for veterans with upper limb amputation [4]. Age, sex and the type of prosthetic or orthotic device did not appear to influence clients' satisfaction with the services they received.

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5.20.4 Outcome measures related to prosthetics and orthotics in Thailand: A scoping review

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BACKGROUND

Outcome measure, the standardized instrument to assess the impact of the intervention, is commonly integrated and researched by various healthcare professionals [1-2]. ISPO has recommended the use of outcome measures in routine clinical practice in prosthetics and orthotics (P&O) [3]. Recently, outcome measures in P&O are widely used and studied worldwide. However, in Thailand, the use of outcome measures in P&O practice and research remains unclear, and the information specific to P&O outcome measures is limited.

AIM

The objectives of this scoping review were to explore and map outcome measures related to P&O in research literature conducted in Thailand; to identify the research gap; and to provide evidence and recommendations for further research and clinical application.

METHOD

This scoping review was underpinned by the 5-stage methodological framework by Arksey and O'Malley [4] and Levac et al. [5], consisting of 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting the data, and 5) collating, summarizing and reporting the results. Twelve Thai and international electronic databases were searched for studies in Thai and English, published from 2010 to 2021. All studies were screened independently by two members, and inclusion/exclusion criteria were applied for the selection of relevant studies. Articles related to outcome measures in P&O and related fields in Thailand were included. Quantitative and qualitative data were extracted, charted, and analysed.

RESULTS

Approximately 900 articles were included in the full-text review. Currently, full-text screening, extracting, charting, and analysing were completed for the included articles published in 2019 - 2021. The preliminary result of 2019-2021 indicated a total of 288 studies. Most of the included studies were conducted in the field of geriatric rehabilitation. The main clinical outcomes of interest in the included studies were pain and disability. The majority of outcome measures used (44%) were performance-based outcome measures, in which TUG, 6MWT, and FTSST were the most commonly used. P&O-specific outcome measures among P&O users were used in 9 studies, with 7 studies in people with lower limb amputation. Fifty-one studies focused on cross-cultural adaptation and psychometric properties of the Thai version of outcome measures. The continuation of the remaining articles from 2010-2018 is currently in progress to finalize the findings.

DISCUSSION AND CONCLUSION

The findings of the preliminary result of 2019-2021 indicated some degree of outcome measure availability related to P&O with the limited use of P&O-specific outcome measures in research conducted in Thailand. Hence, it is considered as research and clinical practice gaps in P&O and denoted for improvement, planning, and application of outcome measures in P&O in Thailand. The more complete data of the articles from 2010-2018 will complement more in-depth and breadth of this scoping review.

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5.20.5 Spanish translation of the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) item bank

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BACKGROUND

The Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) is the first item response theory based item bank developed for lower limb orthosis users.[1] OPRO-M instruments are available for free in English, but are not available for lower limb orthosis users who read other languages. Translation of OPRO-M into other languages such as Spanish will expand access to these promising instruments and allow clinicians and researchers in the United States and Latin America to better assess mobility outcomes in lower limb orthosis users.

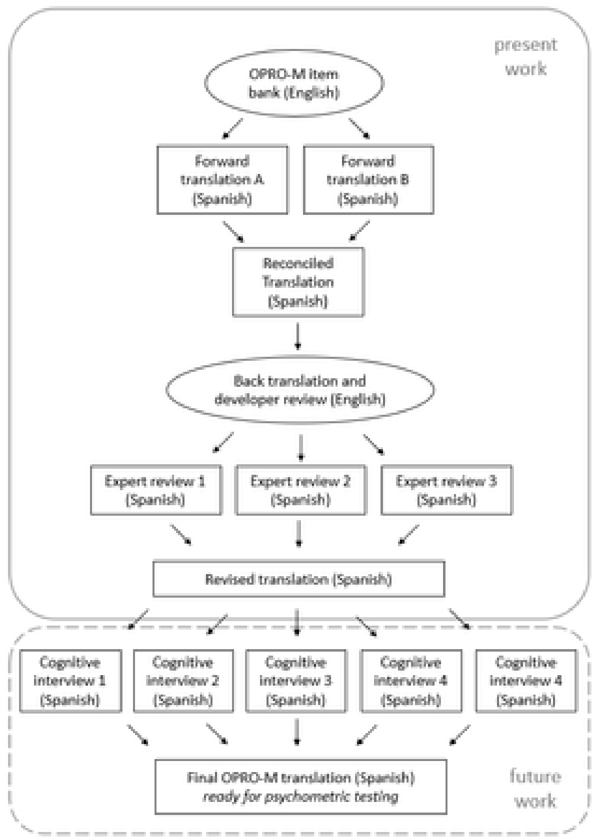
AIM

To perform a formal Spanish translation of the OPRO-M item bank.

METHOD

Formal translation of OPRO-M instructions, items, and response options was performed. Procedures conformed to guidelines for translation of health surveys (Figure 1).[2] The translation was overseen by an experienced coordinator. Two independent forward translations were performed by bilingual medical professionals. Forward translations were reconciled and decisions coded by the translation coordinator using recommended methods.[3] The reconciled translation was back-translated by a native English speaker fluent in Spanish. The back-translation was reviewed by the coordinator and developers; revisions were made as needed. The full translation record was reviewed by three bilingual reviewers from different Spanish-speaking countries. The coordinator and developers reviewed their feedback and revised items as needed.

Figure 1. OPRO-M translation process



RESULTS

The coordinator selected translation A (or revised A) for 25 items and translation B (or revised B) for 8 items. 5 items were translated the same, and 1 item used parts of both translations. The developers approved 34 reconciled translations and requested revisions to 5 items. Feedback from expert reviewers is pending.

DISCUSSION AND CONCLUSION

Access to quality translations of valid and reliable surveys, like OPRO-M, will help facilitate standardization in outcomes measurement around the world. The rigorous translation process resulted in a robust Spanish translation of OPRO-M. OPRO-M instruments can now confidently be administered to both English and Spanish-speaking orthosis users. The linguistic clarity and cultural applicability of the Spanish translation of the OPRO-M item bank will next be assessed via cognitive interviews with target respondents.

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Free paper session: Training and therapy - Training and therapy

5.21.1 Exploring the energy efficaciousness of reciprocating gait orthoses and powered exoskeletons for adults with traumatic paraplegia – a literature review

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BACKGROUND

Although there are numerous physiological, psychological and social benefits associated with the use of reciprocating gait orthoses (RGOs) and powered exoskeletons for ambulation in adults with paraplegia as a result of spinal cord injury (SCI), a major factor contributing to non-adherence is the high energy expenditure associated with their use.(1) A greater understanding of the energy consumption and activity intensity associated with ambulation in these orthotic devices might facilitate further design improvements and augment rehabilitation training.

AIM

This literature review will produce a synthesis of evidence pertaining to energy expenditure while walking with RGOs and powered exoskeletons as prescribed for adults with traumatic paraplegia and explore whether advanced orthotic solutions positively impact energy cost and improve adherence.

METHOD

Population Intervention Comparison Outcome method and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used to search for and report pertinent literature. Search terms including parapleg*, orthos*, RGOs, exoskeletons, energy* connected with Boolean operators AND/OR were used within search engines including SUPrimo Library, PubMed, Web of Science, IEEE Xplore, ProQuest and clinicaltrials.gov website. Inclusion criteria comprised studies reporting energy outcomes with commercially available RGOs and FDA approved exoskeletons involving adults with traumatic paraplegia. Eleven and seven studies pertaining to RGOs and exoskeletons respectively were graded using Scottish Intercollegiate Guidelines Network grading system which was also used to collate levels of evidence and provide grades of recommendations.

RESULTS

Energy outcomes for RGOs and exoskeletons did not differ significantly, despite weight difference between devices. Compared to RGOs, ReWalk and Indego, EksoGT showed the most energy efficient scoring as demonstrated by heartrate response (HR), O2 consumption and O2 cost even with higher levels of SCI. Isocentric RGO (IRGO) showed improved scores with energy parameters including HR and Physiological Cost Index with the introduction of articulated AFOs with dorsiflexion assists lowering metabolic cost with improved velocity. The Louisiana State University RGO showed improved scores with VO2 rate, O2 cost, energy expense and energy cost, with the addition of functional electrical stimulation demonstrating improved cardiac output, although impact on energy remained inconclusive. Respiratory exchange ratio values indicated that RGO walking is a strenuous activity, while metabolic equivalent of task scores demonstrated that walking with exoskeletons is classified as light to moderate activity.

DISCUSSION AND CONCLUSION

Although the level of evidence is low, with insignificant energy score differences between exoskeletons and RGOs, there is an indication that EksoGT is more efficient than other exoskeletons and RGOs. Evidence regarding which RGO is more energy efficient remains inconclusive. Longitudinal studies with larger sample sizes, exploring energy outcomes out with gait laboratories, evaluating the impact of training to increase aerobic capacity, muscle strength and endurance and subgroup analysis based on participant demographics would contribute to evidence-based practice.

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5.21.2 Therapeutic benefits of lower limb prostheses: a systematic review

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BACKGROUND

Enhancing the quality of life of people with a lower limb amputation is critical in prosthetic development and rehabilitation. Yet, no overview is available concerning the impact of passive, quasi-passive and active ankle-foot prostheses on quality of life.

AIM

To systematically review the therapeutic benefits of performing daily activities with passive, quasi-passive and active ankle-foot prostheses in people with a lower limb amputation.

METHOD

We searched the Pubmed, Web of Science, Scopus and Pedro databases, and backward citations until November 3, 2021. Only English-written randomised controlled trials, cross-sectional, cross-over and cohort studies were included when the population comprised individuals with a unilateral transfemoral or transtibial amputation, wearing passive, quasi-passive or active ankle-foot prostheses. The intervention and outcome measures had to include any aspect of quality of life assessed while performing daily activities. We synthesised the participants' characteristics, type of prosthesis, intervention, outcome and main results, and conducted risk of bias assessment using the Cochrane risk of bias tool. This study is registered on PROSPERO, number CRD42021290189.

RESULTS

We identified 4281 records and included 34 studies in total. Results indicate that quasi-passive and active prostheses are favoured over passive prostheses in the short-term. None of the included studies investigated the long-term effects of the prostheses, and none of the studies compared active with quasi-passive prostheses. Among the included studies, quality of life has been evaluated in the short-term using biomechanical (n = 26), physiological (n = 10), performance-related (n = 19) or subjective measures (n = 10). These measures were collected during level walking (n = 34), slope walking (n = 9), standing (n = 2), circuit walking (n = 1), stair climbing (n = 1), standardized clinical tests (n = 1) and rock climbing (n = 1). All studies had a moderate to high risk of bias.

DISCUSSION AND CONCLUSION

Compared to passive ankle-foot prostheses, quasi-passive and active prostheses significantly enhance the quality of life. Although short-term therapeutic benefits have been established favouring more advanced prostheses, outcome measures' discrepancies prevail, and the long-term benefits remain unknown. Investigating these aspects within prosthetic development and evaluation may improve the quality of life of people with a lower limb amputation.

5.21.3 Utilizing novel smart wearable assistive technology to facilitate sensorimotor training of stroke survivors: Towards home/community-based rehabilitation

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BACKGROUND
Stroke survivors often retain a deteriorated motor and sensory function even after rehabilitation in early-stage, causing inconvenience in daily life. The high cost, limited access to, and lack of rehabilitation treatments and resources have further restrained them from receiving the adequate rehabilitation treatment. To address this issue, an affordable and easy-to-get rehabilitation strategy is urged to be developed and investigated.

AIM
To provide an easy-to-get and assistive-technology-based rehabilitation strategy for improving the sensorimotor function of stroke survivors, in an attempt to help relieve the heavy burden of the global rehabilitation system.

METHOD
A home/community-based sensorimotor training strategy has been designed and developed, including a wearable intelligent device for daily monitoring and training of community-dwelling stroke survivors. A total of 22 stroke survivors were then recruited to complete ten sensorimotor training sessions within 2-3 weeks, each session involved a 60-min sensorimotor training. Participants were randomly assigned into two groups, one for training with the system on and another one for training with the system off. The questionnaires, kinematics and kinetic analysis, and position sense threshold were used to evaluate the short-term and long-term effectiveness of this newly developed sensorimotor training strategy in community-dwelling stroke survivors.

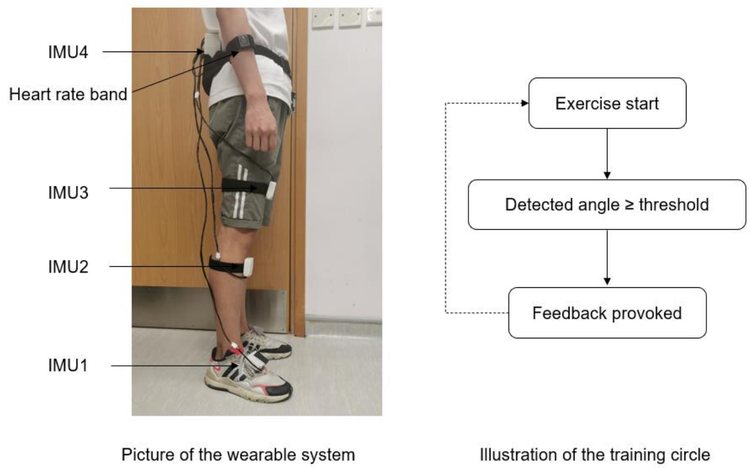

Figure 1. Illustration of the system and the training circle

RESULTS
The development of the wearable sensorimotor training system was completed, including: 1) four Inertial Measurement Units (IMU) to evaluate and monitor the lower-limb sensorimotor function and training progress of stroke survivors, when performing daily physical exercises; and 2) an Android-based mobile app and user-interface (UI) installed on a smart phone to provide the individualized feedback/reminders and improve the training outcomes of stroke survivors (Figure 1). The validity of the system and the feasibility of the strategy has been confirmed.

DISCUSSION AND CONCLUSION
This study provided a novel rehabilitation strategy/approach for the lower-limb sensorimotor training of stroke survivors, by utilizing the novel smart wearable assistive technology. It is expected that the positive results of this study could provide more evidence regarding the feasibility and effectiveness of such rehabilitation strategy in short-term and long-term. We will also continue such efforts and investigate the effectiveness of the developed system on stroke survivors in home-/community-based settings.

5.21.4 Phantom motor imaginary treatment reverted the decision to perform euthanasia due to phantom limb pain: a case study

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BACKGROUND
Phantom limb pain (PLP) is a debilitating and common condition suffered by people after amputation that directly affects a person's quality of life (QoL). PLP can lead to depression, increase in anxiety, and even suicide or euthanasia. A recent randomized clinical trial (RCT) used Phantom Motor Imaginary (PMI) as a control treatment for treating PLP [1]. A case study was initiated to deeply investigate a participant with severe PLP who became pain-free after PMI treatment.

AIM
To explore the perception and subjective experience of a person with chronic PLP, his journey, and the impact of PLP and the Phantom Motor Imagery (PMI) treatment had on his life.

METHOD
A 68-year-old male with a transfemoral amputation and chronic PLP was included in the PMI group at PLP RCT(1). PMI consisted of imagining the movement of the phantom limb guided by virtual reality (1). Eighteen assessment visits were done at the trial to measure PLP intensity, intrusion of PLP in sleep, and QoL (1). After one month’s follow-up (FU), the participant decided to leave the RCT due to an increase in PLP and was provided with the PMI software at home to intensify the training. After six months of home training, the assessments and a semi-structured interview were applied to explore the participant's perspective about his PLP journey.

RESULTS
Before the PMI treatment, the participant had arranged euthanasia to end the suffering, depression, and insomnia that PLP brought to his life. He stated: “I was done with it”. During the RCT, PLP decreased from 8 to 0 on the Visual Analog Scale, and hope in life returned until the one-month FU when the PLP increased to 5 and euthanasia was reconsidered. However, during the PMI home training, the PLP disappeared. He said: “Now I am completely pain-free. As reborn”. The participant reported an increase in QoL from 3 to 9 on a scale were 10 represents the best QoL. He no longer experienced intrusion of PLP in sleep, expressed hope for the future, and had no more thoughts about euthanasia.

DISCUSSION AND CONCLUSION
PLP can lead a person to consider euthanasia. PMI helped one person to decrease PLP and returned the desire to live by increasing his QoL. PMI is possible to perform in a home environment and might be a solution to reduce chronic PLP. However, larger studies about amputees' PLP journey and PMI must be performed to draw any conclusions for the population.

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Free paper session: Prosthetics: Lower limb - Osseointegration outcomes

5.22.1 Have surgery and implant modifications been associated with a reduction of soft-tissue complications in transfemoral bone-anchored prostheses?

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BACKGROUND
The most frequently occurring adverse events in individuals with a transfemoral amputation treated with a bone-anchored prosthesis are soft tissue infections and stoma-related complications. These soft tissue complications are believed to be influenced by surgical technique and implant design, but little is known about the effect of changes to treatment on these events.

AIM
To assess the result of surgery and implant modifications on the incidence of soft tissue infections and stoma-related complications in individuals who received a press-fit bone-anchored prosthesis, depending on implant design and surgical technique.

METHOD
Individuals with a transfemoral amputation experiencing socket-related problems were treated with 2-stage osseointegration surgery between 2009 and 2018. Between 2009-2013 treatment occurred using a conventional surgical technique and a Cobalt-chrome-molybedenum implant. Between 2015-2018 treatment occurred using an adapted surgical technique, resulting in a more shallow stoma, and a titanium alloy implant was used. The period between 2013-2015 was a transitional period and was excluded from the analysis, also to keep groups comparable. A standardized 2-year follow-up was used. Outcomes studies were (1) soft tissue infections and stoma-related complications (hypergranulation/keloid formation, stoma redundant tissue), and (2) bone or implant infection, aseptic loosening, implant stem breakage, periprosthetic fracture and death.

RESULTS
Patients treated with the adapted surgical technique and titanium implant (group 2) experienced fewer soft tissue infections (13 vs 76 events, absolute risk 0.16 (95% CI 0.09-0.31) vs 0.84 (95% CI 0.56-1.25); $p < 0.01$), which were treated with less invasive measures, and fewer events of stoma redundant tissue (0 vs 5 events, absolute risk 0 vs 0.06 (95% CI 0.03-0.14)); than patients treated in group 1. This is contrasted by an increased incidence of surgical site infections, occurring between surgical stages 1 and 2, after implementation of treatment changes (group 1 vs group 2: 1 vs 11 events: absolute risk 0.01 (95% CI 0.00-0.08) vs 0.14 (95% CI 0.08-0.25); $p = 0.02$). Patients in group 2 did not experience potentially disastrous complications, while bone infections did occur (6 events, 8% (3/40) of patients) in group 1.

DISCUSSION AND CONCLUSION
Ongoing treatment adaptations to surgical technique, implant design, as well as learning curve and experience, have resulted in a decrease of incidence and severity of soft tissue infections and stoma redundant tissue; contrasted by an increase in surgical site infections prior to stoma formation. Furthermore, potentially disastrous complications were infrequent in this 2-year follow-up period. Therefore, we advise surgeons to aim for a more shallow stoma with a stable soft tissue envelope.

5.22.2 Safety and effectiveness of the bone anchoring device for artificial limbs in Individuals with transtibial amputation: a two-year follow-up study

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BACKGROUND

We describe safety and effectiveness of patients with a transtibial amputation treated with the Bone Anchoring Device for Artificial Limbs (BADAL X) with a 2-year follow-up.

AIM

The aim of this two-year follow-up study was to present the safety and effectiveness of the BADAL X in patients with a transtibial amputation.

METHOD

All individuals with a transtibial amputation who were treated with the BADAL X in our center (Radboud University Medical Center, the Netherlands) between March 2015 and March 2020 were eligible for this study.

The BADAL X was considered to be safe when device failure (implant loosening and/or breakage requiring revision surgery) occurred in less than 10% of cases, and/or soft tissue events requiring surgical treatment occurred in less than 15% of cases, within the first two-years after implantation.

Performance and quality of life were evaluated using the Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) Prosthetic Use Score (PUS) and Global Score (GS).

RESULTS

Sixty-one individuals were included of which 45 (74%) were male. Mean age at implantation was 53.6-years. There was 1 patient with a bilateral amputation. In total 62 tibia osseointegration implants were implanted. The number of secondary surgical events reported were: 2 (3%) patients with septic implant loosening resulting in a transfemoral amputation. There were no implant breakages seen in this cohort. Also, there was no soft tissue events requiring surgical treatment.

The Q-TFA PUS and GS at baseline were median [25th to 75th percentile (PCTL)]: 70.97 [51.61 – 90.32] and 41.67 [25 – 50], respectively. The PUS and GS improved statistically significant to 100 [25 – 100] and 75 [66.7 – 87.5], respectively, at 2-years follow-up (P<0.001).

DISCUSSION AND CONCLUSION

This study suggests that the BADAL X is a safe treatment option in patients with a transtibial amputation suffering from socket-related problems. Further research with longer follow-up is needed to study the safety of the BADAL X in long-term.

5.22.3 Radiological signs of osteoarthritis of hip and knee in lower limb amputees that apply for bone anchored prostheses

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BACKGROUND

In the pre-surgical screening of amputees applying for a Bone-Anchored Prosthesis (BAP) we have seen that quite a few subjects have shown radiological signs of probably disuse osteoarthritis (OA) of the ipsilateral joint immediately proximal to the amputation level. Since with BAP the axial loading of these joints is restored, it is important to know the clinical consequence of the radiological signs of OA and potential progression in time.

AIM

To determine the pre-surgical incidence of hip or knee OA in persons with a lower extremity amputation and to investigate the course of OA after implantation of a BAP.

METHOD

In a single-centre cross-sectional study, all subjects who underwent osseointegration implant (OI) surgery between May 2009 and November 2019 were included. Two independent raters (JM, AW) used the Kellgren-Lawrence (KL) classification to grade the level of OA of the hip or knee of the residual limb on standard radiographs taken before surgery and at 1, 2, and 5-year follow-up. According to the classification grade 2 or higher was defined as OA. Cohens Kappa was used to measure the inter-rater reliability.

RESULTS

Two hundred and twenty-eight subjects were included of which 168 (74%) were male. The mean time between amputation and OI surgery was 14.5-years. One hundred and twenty-six (55%) and 147 (67%) subjects had radiological signs of OA at respectively pre- and in average 3.1-years post-OI surgery. In 177 transfemoral amputees 101(57%) and 120 (68%) had radiological signs hip OA respectively pre- and 3.7-years post-OI surgery. In 51 transtibial amputees respectively 25 (49%) and 27 (53%) had radiological signs of knee OA at pre-, and 1.2-years post-BAP surgery. One patient underwent hip resurfacing surgery because of severe hip OA. Inter-rater Cohens Kappa was 0.56 (considered as moderate) with a percent agreement of 78%.

DISCUSSION AND CONCLUSION

In this study it is shown that radiological signs of OA are a common incidental finding in the pre-OI surgical diagnostics and in time it appears that the number of subjects with radiological signs of OA slightly increases. However, it is not known whether these radiological signs of AO have any clinical consequences. Further research is needed to evaluate the relation between radiologic signs and clinical symptoms.

5.22.4 Examining the complication and re-operation rates after osseointegrated 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.

AIM

In addition to commonly anticipated complications including fractures, surgical debridements or revisions, this study has identified several significant events in which a patient may require to be readmitted and go through additional surgery.

METHOD

A detailed analysis has been performed on all osseointegration surgeries performed by the Osseointegration Group of Australia and its affiliates since 2010. The majority of surgeries took place in Australia, the United States, the Middle East as well as in Europe. All events leading to a re-admission 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

Over 800 surgeries have been identified with a minimum 12-month follow-up time and included in this study. These included tibial, femoral and humeral, radial-ulnar and transpelvic osseointegration cases. The majority of these were performed using a single stage protocol. While general complications such as infection and soft tissue refashioning are common, serious events such as revision and fracture are rare. Interestingly, the rate of debridements and soft-tissue refashions were found to be higher among patients who were operated using a two-stage surgery. Among all cases, there were a total of 399 re-operation events recorded which occurred among 163 patients, indicating a high recurrence rate among the same patients. We recorded a total of 112 washouts, 93 neurectomies, 117 soft tissue refashions, 53 implant revisions and 24 periprosthetic fracture fixations.

DISCUSSION AND CONCLUSION

Many events leading to readmission after the primary surgery may not necessarily be graded as a complication of the osseointegration technique. This study has identified several addition possible reasons in which an osseointegration patient may need to be re-admitted into hospital for additional surgery. It was identified that through the implementation of improved surgical techniques and rehabilitation protocols, the rate of several of these re-operation events can be largely reduced, thus improving the overall outcomes of patients undergoing osseointegration surgery.

5.22.5 Removal of press-fit transtibial osseointegration implants

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BACKGROUND

Approximately 2,000 osseointegration procedures have been performed worldwide as of 2020, more than half of which have been performed by the Osseointegration Group of Australia using a press-fit technique with either ILP or OPL implant designs. Despite the demonstrated clinical benefits, concerns regarding potential complications have slowed its widespread adoption. As more patients are followed for a longer period of time, longitudinal studies have confirmed complication rates are very acceptable, similar to those of total ankle and total elbow replacements.

AIM

Aim this study was to investigate the complications and technical issues associated with transtibial osseointegration implant removal. The focus here will be on the press-fit ILP and OPL implants, including the indications for removal and patient outcomes following removal.

METHOD

A review of our osseointegration registry between November 2010 and March 2022 was performed. Inclusion criteria were patients who have undergone removal of a transtibial osseointegration implant due to any cause. Selected patients either had a follow-up of at least two years or had their index osseointegration surgery at least two years prior to when the study was performed. Patients who have had osseointegration at other anatomic levels, and patients who underwent simultaneous total knee replacement with transtibial osseointegration were excluded from the registry search.

RESULTS

A total of 148 transtibial osseointegration procedures performed, with 97 (65.5%) males and 51 (34.5%) females. The average of patients is 50.4 years (range 16.8-87.9, SD 14.1). In the study cohort of 22 cases requiring implant removals, 12 (54.5%) were male and 10 (45.5%) were female. The average age at first stage osseointegration procedure in this cohort is 51.3 (range 37.4-82.6, SD 10.7) and average BMI 30.3 (range 21.9-40.9, SD 5.8). Although men comprised the majority of removals, women had a greater relative risk (Fisher exact test p=0.032). The average duration from time of STOI to removal was 2.6 years (range 0.1-6.8, SD 1.9) within this 11.5 year follow-up period. The most frequent indication was infection (54.6%, n=12) followed equally by pain (13.6%, n=3), aseptic loosening (13.6%, n=3) and implant fracture (13.6%, n=3), and lastly failure to integrate (4.6%, n=1).

DISCUSSION AND CONCLUSION

Of the 22 removals, 12 were reimplanted at the same anatomical level. 11 of these cases currently wear their prosthetic legs for more than 13 hours daily. 1 case was recently reimplanted. Of the patients who were not reimplanted, few returned to wearing traditional socket prosthesis successfully and 3 cases are currently awaiting transtibial osseointegration reimplantation. 1 patient was deceased. 1 patient was lost to follow-up.

5.22.6 Patients' preferences for osseointegration after lower extremity amputation, a discrete choice experiment in The Netherlands (PREFER1)

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BACKGROUND
The rising popularity and utilization of osseointegration (OI) in developed countries in lower extremity amputees with socket-related issues has led to increasing interest in the measurement of functional outcomes and improvements in quality of life. However, none of these assessed the value of the different characteristics of OI treatment from the patient's preferences perspective, nor the relationship between these characteristics.

AIM
This study determined (i) the relative importance of specific characteristics of OI, (ii) the quality-of-life trade-offs (WTQ) patients are willing to make and (iii) the willingness to pay (WTP) for given levels.

METHOD
We conducted a multicentre prospective Discrete Choice Experiment (DCE) at the two only tertiary academic referral centres in The Netherlands to offer OI. Mixed method sessions with all health practitioners of OI teams, experienced patients with OI, and eligible patients for OI were conducted to determine the essential and important attributes with corresponding levels for the DCE survey. The survey was pre-tested on conversance, improved to reduce the cognitive and time burden and optimized for a Bayesian D-efficient design (n=20). To determine the relative importance of the attributes and corresponding levels, and to estimate the WTQ and WTP with assumed linearity a multinominal logistic regression was utilized.

RESULTS
Between January and October 2022, 74 patients completed the survey, which had OI therapy between 2017 and 2022. Most common (mode) age group was 40-49 years. 72% were male and the mean year of amputation was 2006 (SD 17) with transfemoral amputation as the most common type (n = 50 (67%)). Quality of life (QOL) was the most important attribute (31%) followed by long term complications and the price attribute (both 23%). Opting not for OI had the most negative preference, and patients would even prefer a decrease of 1 QOL point with OI (from one to ten QOL-points). Participants found long-term complications less preferable than short-term complications. Participants were willing to pay €12,160. – per QOL-point improvement. Implant removal would lead to loss of 3.3 QOL-points and be compensated by €40,200. –.

DISCUSSION AND CONCLUSION
This study summarized patient preferences for OI treatment, provided WTQ and WTP estimates for QOL, short- and long-term complications and implant durability with OI. The outcomes of this study can be utilized by OI teams during shared decision-making for OI eligibility and information sessions on the perceived value of OI treatment elements by OI patients. Furthermore, the study outcomes can be used by policymakers and health managers to evaluate OI as treatment option.

Free paper session: Prosthetics: Lower limb - Various topics

5.23.1 Development and alpha testing of a patient shared decision aid for prosthesis design after lower limb amputation

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BACKGROUND

Lower limb amputation (LLA) is a chronic health condition that introduces a lifetime of complex healthcare decision-making, including multiple decisions associated with the design and maintenance of a prosthesis. Several options for prosthesis design exist, but decisions about prosthesis design do not always reflect a prosthesis user's needs, values, and preferences.

AIM

The purpose was to develop a patient decision aid (PDA) prototype to guide prosthetists and new prosthesis users in making prosthesis design decisions for the first prosthesis after LLA, and to assess the PDA prototype's usability, accuracy, and comprehensibility.

METHOD

We used an iterative user-centred approach to develop a PDA, including a qualitative needs assessment with 38 prosthetists and 17 new prosthesis users, and alpha testing with steering groups of 5 prosthetic professionals and 6 experienced prosthesis users. Alpha testing included qualitative semi-structured interviews reviewing the PDA for general feedback, and quantitative ratings of usability, accuracy, and comprehensibility on a 10-point Likert scale. The PDA development process was guided by the steps outlined in the International Patient Decision Aid Standards (IPDAS) [1], and content of the PDA was guided by both the IPDAS and the Patient Roadmaps for Chronic Illness Model [2].

RESULTS

Three steering group meetings and two rounds of revisions resulted in a PDA that included six sections based on four identified decisional needs of end users, including: 1) acknowledging complexity in communication, 2) clarifying values, 3) recognizing the role of experience to inform preferences, and 4) understanding the prosthetic journey. Sections of the PDA include: 1) Amputation and Early Recovery, 2) Communication, 3) Values, 4) Prosthesis Design, 5) Preferences, and 6) the Prosthetic Journey (Figure 1). The PDA's usability, accuracy, and comprehensibility were rated as 9.2, 9.6, and 9.6 out of 10 respectively by prosthetic professionals, and 9.4, 9.6, and 9.6 out of 10, respectively by prosthesis users.

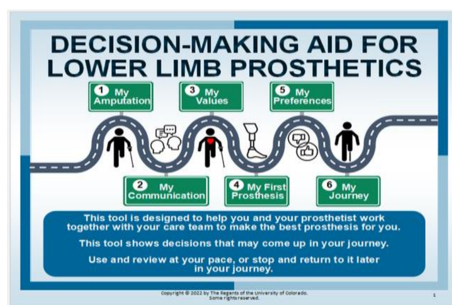

Figure 1. Final patient decision aid for prosthesis design.

DISCUSSION AND CONCLUSION

A standardized, iterative method was used to develop a PDA for use by new lower limb prosthesis users and prosthetists when considering prosthesis design decisions. The PDA incorporated guidance by relevant stakeholders and was rated favourably, emphasizing a need for shared decision-making support in prosthesis design. The resulting PDA is designed to advance shared decision-making by supporting new prosthesis users and prosthetists in making prosthetic design decisions.

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5.23.2 Innovative adaptive socket technology for prosthesis users with pelvic amputations

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BACKGROUND
Prosthetic fitting of users with pelvic amputations is a major challenge for orthopaedic technology as well as for the user. Novel process and manufacturing techniques bring significantly improved usage characteristics and increase the quality of care for users.

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 lecture presents different fitting options for prosthetic fitting after amputation in the pelvic region. It is shown that the use of individual silicone interface as skin protection and as a compressing medium to prepare the residual limb/abdomen for the prosthesis socket plays a major role, especially for active prosthesis users. The silicone pants can have different designs.

The prosthesis socket in carbon pre-preg technique, can be implemented in a two-piece design with dorsal closure technique and also in a two-piece design with dorsal semi-elastic intermediate piece and ventral closure technique. The advantages and disadvantages of both systems will be discussed in the lecture.

RESULTS
The conventional design of a classic pelvic cage in cast resin technique, possibly with a flexible inner socket, has almost completely given way to the socket techniques described in our company. The fit results achieved are convincing due to a reduced residual limb socket pseudarthrosis, due to an optimized loading situation on the skin surface, due to the good cleaning possibilities 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 consider the presented socket systems to be in a special position compared to conventional systems. The outcome of the restoration is excellent. These systems are faced with increased effort in fabrication, a high degree of expertise, necessary operating equipment for the implementation of the manual tasks and thus higher costs compared to the conventional socket systems.

5.23.3 Assessing non-steady state metabolics during a short walking interval for individuals with transtibial amputation

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BACKGROUND

Measuring metabolic parameters during a 6-minute steady state walk is the most commonly accepted method for assessing energy expenditure. However, there are limitations to implementing this method including the requirement to walk at a constant speed for 6 continuous minutes. This may be particularly difficult for individuals with limited mobility, such as those with lower limb amputation. Blokland et al. 2021 have shown that steady state results may be estimated from shorter periods of walking by including recovery time.

AIM

The goal of this study was to determine if oxygen consumption during a 2-minute constant speed walk plus recovery correlates with oxygen consumption during the last 2 minutes of a 6-minute steady state walk, in individuals with transtibial amputation.

METHOD

Individuals with unilateral transtibial amputation were recruited. Participants self-selected a treadmill walking speed to be representative of how they would walk in their everyday life. A Cosmed K5 system was used to measure oxygen consumption ($\dot{V}O_2$) during 2 minutes seated rest, 2 minutes walking at the pre-selected speed, 10 minutes seated rest, and 6 minutes walking at the same pre-selected speed. Total $\dot{V}O_2$ for the 2-minute walk plus recovery was calculated similarly to Blokland et al. 2021 and steady state $\dot{V}O_2$ was calculated from minutes 4-6 of the 6-minute walk. Pearson's r was calculated for the relationship between total $\dot{V}O_2$ and steady state $\dot{V}O_2$.

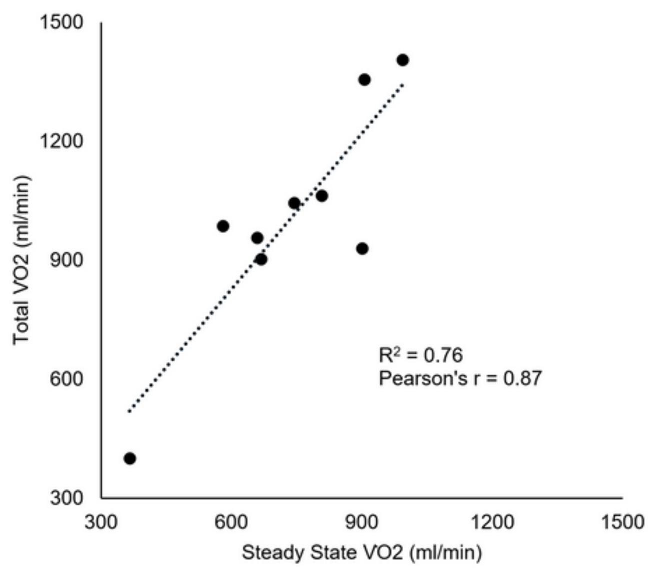

Figure 1: Total $\dot{V}O_2$ (ml/min) for a 2-minute walk plus recovery vs. steady state $\dot{V}O_2$ (ml/min) for minutes 4-6 of a 6 minute walk at the same speed.

RESULTS

Nine participants (age: 52.8 ± 13.2 years; 7 male, 2 female; time since amputation: 16.7 ± 16.1 years) provided informed consent and completed the study. Total $\dot{V}O_2$ showed a strong positive correlation with steady stated $\dot{V}O_2$, Pearson's r = 0.87 (Figure 1).

DISCUSSION AND CONCLUSION

These results indicate that measuring total $\dot{V}O_2$ for 2 minutes of walking plus recovery may be sufficient to assess energy expenditure. This may be particularly useful for those who cannot walk for 6 continuous minutes. Limitations of this study include a small sample size and data collection from only one self-selected constant speed. Further investigation into short duration, non-steady state metabolic parameters may lead to development of outcome measures more suitable for individuals with lower limb amputation.

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ACKNOWLEDGEMENTS: Supported by NIDILRR RERC 90REGE0003 and NIH R01 HD079428- 02.

5.23.4 Front and side mounted approaches for a powered hip joint

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BACKGROUND
People with hip level amputation often have difficulty walking with prostheses and less than 50% use a prosthesis in everyday life. Microprocessor-controlled and powered joints have improved lower limb amputee mobility; however, powered or microprocessor-controlled devices are not available for hip-level amputations. A power hip prosthesis would help restore a more natural gait and be better able to adapt to the walking environment and stumbles.

AIM
Create and evaluate powered hip joints that can be attached anterior or lateral to the pelvis.

METHOD
Two powered hip joints were designed, simulated, and prototyped. Both joints used the Össur Power Knee motor and utilized pulley-based transmission to transfer motor torque to the hip. Since the motor, battery, and electronics are located in the thigh, both anterior and lateral joint locations were enabled. Following successful design simulation and prototyping, ISO 15032 standard loads were applied to prototypes to evaluate the ability to safely function, based on a 100 kg user. A proof-of-concept test was completed by walking with the two joints using a hip prosthesis simulator [1].

Figure 1. Side mounted power hip joint (left) and joint mounted on prosthesis simulator (right).

RESULTS
Both front mounting and lateral mounting joints successfully passed ISO 15032 proof and ultimate tests. The front mounted design was lighter (3.9 kg) than the lateral mounted design (5.1 kg). Walking was achieved with both approaches.

DISCUSSION AND CONCLUSION
Powered moments at the hip should provide a great improvement in hip amputee mobility. This research has demonstrated that both anterior and lateral mounted prosthesis have potential for walking and should withstand everyday loads. Even as first prototypes, both joints were less than 5.2 kg. Future testing with HD amputees will help determine which design approach is preferred.

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ACKNOWLEDGEMENTS: This project was funded by MITACS and Ossur. Hossein Gholizadeh provided prosthetist contributions.

5.23.5 The effect of the amputee's body mass index on the functional status upon admission to rehabilitation: a retrospective audit

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BACKGROUND

Most lower limb amputations are directly or indirectly related to an unhealthy lifestyle: diet, smoking, and excessive alcohol consumption. As a result, when admitted to rehabilitation, many patients are obese and, therefore limited in functional mobility. Despite known allometric inaccuracies, body mass index (BMI; a measurement obtained by dividing a person's weight by the square of the person's height) is still the most commonly used method for obesity classification.

AIM

To analyse the effect of the obesity stages on the functional status upon admission, using an adjusted BMI, a Six-Minute Walk Test (6MWT), and a measurement of the functional status of lower-limb amputees without the use of a prosthesis (AMPnoPRO).

METHOD

We included inpatients who had been admitted to Rehabilitation Department for Patients after Amputation at the University Rehabilitation Institute in Ljubljana between March 2021 and May 2022. Based on the adjusted BMI, according to the level of amputation, the patients were divided into five classes, from normal body weight to extreme obesity (class III). Mean 6MWT and AMPnoPRO values were compared using one-way ANOVA. Levene's test was used to assess the equality of variances.

RESULTS

One-hundred-eight patients (aged 47-91, mean 71 years; 71% men) walked on average 98 m (SD 94 m) in 6 minutes and scored an average of 21 points (SD 14 points) on AMPnoPRO. One patient had a foot amputation, 51 had a below-knee amputation, 35 had an above-knee amputation, and 12 had bilateral amputation (a combination of below-knee, above-knee, and foot amputation). They belonged to five classes: 25 had BMI in the normal weight range, 33 were overweight, 31 had class I obesity, 14 had class II obesity and 5 had class III obesity. There were no significant differences in the 6MWT ($p= 0.797$) and AMPnoPRO ($p= 0.374$) between the groups according to the adjusted BMI.

DISCUSSION AND CONCLUSION

High BMI does not seem to have a significant effect on inpatients' functional status (AMPnoPRO and 6MWT). Based on the results of our and similar studies 1, high BMI should not be a deciding factor as to whether a patient is entitled to rehabilitation and fitted with a prosthesis. Nevertheless, the correlation between obesity and comorbidities that affect the rehabilitation outcome remains significant. Integration of nutritional interventions in rehabilitation programs should be considered in all amputees with an increased BMI.2

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5.23.6 The qualitative experience of a hydraulic self-aligning prosthetic ankle-foot for older adults with a transtibial amputation categorised as “K2 users”

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BACKGROUND

In the UK, many patients with a transtibial amputation, who are categorised as having “limited community mobility” (K2 users), are prescribed a standard ankle-foot which does not self-align to sloped surfaces. This can make walking more difficult and uncomfortable and may stop patients from using their prosthesis. Self-aligning ankle-feet are seldom prescribed to K2 users on the NHS because their effectiveness for this patient group has not been demonstrated and they are more costly.

AIM

The aim of this qualitative study was to explore the experience of a self-aligning ankle-foot for older adults categorised as K2 users. Understanding patients’ experience is important for the design of clinical trials and prosthetic prescription.

METHOD

Ten male participants with a non-traumatic transtibial amputation (age range 53-86 years) were purposively recruited from the STEPFORWARD randomised controlled feasibility trial intervention group (ISRCTN15043643). All were established prosthesis users >1 year and replaced their standard ankle-foot with a hydraulic self-aligning ankle-foot (Avalon K2, Blatchford, UK) for at least 12 weeks as part of the trial. They completed semi-structured interviews about their experience of the new self-aligning ankle-foot compared to their standard ankle-foot, including the fitting, adjustments and impact on daily living. A thematic analysis was undertaken to search for common themes running through the conversations.

RESULTS

Four themes were identified about the experience of the self-aligning ankle-foot: adapting; mobility; benefits and drawbacks. Most participants stated that the self-aligning ankle-foot afforded them improved mobility compared to their standard foot and they adapted within a couple of weeks: “*the flexibility took a bit to getting used to*”. Several participants reported important differences on slopes: “*I walk down a short maximum steepness hill and before I used to walk down like a crab...And now I walk down like a gentleman and that is the difference*”. Some participants’ mobility was limited by their age. Several reported benefits related to experiencing less pain, having greater movement and confidence and being able to wear their prosthesis for longer. The main drawback was that some participants reported feeling “*wobbly*” on the self-aligning ankle-foot.

DISCUSSION AND CONCLUSION

Overall, participants were largely positive about their experience of a self-aligning ankle-foot compared to their standard ankle-foot. They reported less pain, better mobility and ability to do more than previously, although this was relative to their own perceived ‘starting point’. Some participants placed a lot of emphasis on how the new ankle-foot could make a difference to their mobility and quality-of-life. The findings support a robust clinical evaluation of the effectiveness and cost-effectiveness of a self-aligning ankle-foot for K2 users.

ACKNOWLEDGEMENTS: This paper presents independent research funded by the NIHR under its Research for Patient Benefit Programme (Grant Reference Number PB-PG-0816-20029).

Free paper session: Rehabilitation medicine and surgery - Various topics

5.24.1 Hand function and independent donning of lower limb prosthesis

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BACKGROUND

In our previous study (1) we found out that people with lower limb loss (LLL) had decreased grip strength and dexterity. They need functional hands not only for the usual daily activities, but also for transfers, propelling wheelchair and walking with walking aids. It is not clear how hand function influences the ability to independent don their prosthesis.

AIM

The aim of our study was to find out whether independent donning of a prosthesis depends on hand function, mainly grip strength and dexterity, and whether there are differences between different sockets designs and suspension systems in this respect.

METHOD

All patients admitted for primary rehabilitation after trans-tibial (TT) and trans-femoral (TF) amputation to our institute in 2020 and 2021 were included into study. At admission and before discharge we measured grip strength with Jamar digital dynamometer and hand dexterity with Nine Hole Peg Test. All the participants were included into a comprehensive rehabilitation program and fitted with prosthesis based on cardiorespiratory function, Amputee Mobility Predictor no-prosthesis score, range of motion of joints of lower limbs, muscle strength of lower limbs and results on the Montreal Cognitive Assessment Procedure. Functional Independence measure (FIM) was used for assessing functioning. The study was approved by the Medical Ethics Committee of our institute.

RESULTS

We included 149 patients (112 men) after TT and 90 (55 men) after TF amputation, 68 and 71 years old on average, respectively (SD TT 11 years, TF 10 years). The main cause of amputation was diabetes in those after TT amputation (84) and peripheral vascular disease in those after TF amputation (52 patients). In patients after TT and TF amputation, we observed statistically significantly lower grip strength and dexterity of both hands among those who were not fitted with a prosthesis, with no statistically significant difference between those independently donning prosthesis and those not able to do that. After TT amputation, patients fitted with roll-on liner had lower grip strength then those fitted with foam liner on average. After TF amputation, those fitted with skin-fit suction had higher grip strength than those fitted with roll-on liner on average.

DISCUSSION AND CONCLUSION

It appears that grip strength is more important than dexterity for rehabilitation of patients after LLL, especially for selection of socket type and suspension system for both amputation levels. Neither grip strength nor dexterity appear to influence independent donning of a prosthesis.

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5.24.2 Prosthetist and Orthotists taking hands with the multi-disciplinary team: A Way to step up and be involved.

Mariette Deist

ISPO, Pretoria, South Africa. SAOPA, Pretoria, South Africa. HPCSA, Pretoria, South Africa

BACKGROUND

ISPO has challenges with retaining old members and getting new members on board. ISPO is claiming that we are multi-disciplinary, however, the efforts of reaching other professionals are not very clear. The chair and vice chair of the membership committee will put forward some suggestions for stepping up to bring professionals together. The strategies have been discussed in the committee and the idea is to motivate ISPO members to "step up" to assist with this task.

AIM

Presenting strategies how to involve more multidisciplinary members within each National Membership Society (NMS) to make ISPO stronger where the persons that using assistive devices benefit the most.

METHOD

The membership committee had meetings once a month for the past two years with the aim of growing numbers. The presidents of various NMS'e were contacted and a list was made of the challenges and ideas received. A short survey was done parallel within one NMS where the multidisciplinary team was approached. Qualitative questions were asked to determine the relationship that they have with the Prosthetist and Orthotist and if they were willing to be more involved in a "team setup".

RESULTS

Challenges such as COVID, finances, and international support was raised by the presidents. Timing of the membership and the benefits was a main focus. New ideas were discussed at the committee level.

The audience that was reached through the small survey consisted of physio's, occupational therapists, orthopaedic surgeons, biokinetisists and psychologists. A question was asked rating the essentiality of orthoses and prostheses. Out of 10, the average was 9. Another question was asked if they would want to be involved with any research project with the P&O. There was a 100% positive response. Each was asked if they had some idea of a topic or field of research and 80% could provide us with a topic that related to their field of study.

DISCUSSION AND CONCLUSION

The challenges that ISPO faced has been noted, discussed and debated. Where possible, solutions were provided and a new strategy from the membership committee grew out of it.

ISPO members need to "step up" and be more involved in the activities of our multi-disciplinary team members. The important role that they are playing needs to be showcased. A few practical ways and ideas to grow ISPO will be shown and discussed to encourage participation.

ACKNOWLEDGEMENTS: Membership committee; Executive Board; Support from head-office ISPO

5.24.3 Effects of a full body electro-stimulation garment in subjects with cerebral palsy, multiple sclerosis, and stroke on spastic movement disorder

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BACKGROUND
Impairments, disease, or injuries to the central nervous system as induced e.g., by stroke, multiple sclerosis (MS) or cerebral palsy (CP) may inflict spastic movement disorder (SMD) [1]. The manifestation of symptoms results from alterations of supraspinal and peripheral input signals to segmental interneuron processing. Substitution of missing input by peripheral afferent input by electrical stimuli has been identified as a promising modality [2,3].

AIM
Electrical stimulation provided by a 58-electrode full body garment [4] was investigated in an observatory setting during trial fitting.

METHOD
Subjects were required to be walkers and cognitively able to follow instructions. Testees were assessed prior to stimulation wearing the suit (T0), after a one-hour stimulation (T1) and after four weeks of use (T2).

RESULTS
Data from 72 testees were retrieved. Age averages 36.6 (19.8) ys with 44 females. The cohort spans infantile cerebral paresis (N=29), multiple sclerosis (N=23) and stroke (N=20) as leading etiologies. Data were stratified for analysis by etiology and BBS Score <45 indicating an increased risk of falling.

Effects sizes (Cohen`s d) indicating improvement were in CP: Berg Balance Scale (BBS) 1.64***, Timed up and Go (TUG) 0.29*, Functional Gait Assessment (FGA) 1.59***, 10 meter walk test (10mWT) 0.76(t), Wolf Motor Function Test (WMFT) 1.0***, Euroqol Quality of Life questionnaire (EQ5D5L) 0.5*, Pain (derived from EQ5D5L) 1.28***; in MS: BBS 1.83***, TUG 0.83***, FGA 1.28**, 10mWT 0.93*, EQ5D5L 1.11**, Pain 0.78** and Stroke: BBS 1,28**, TUG 0,78**, FGA 0.89, 10mWT 0.92**, WMFT 0.71, EQ5D5L 1.26* and pain 0.78* where significance levels are indicated by *: p<0.05, **: p<0.01, *** p<0.001, (t): p<0.1.

DISCUSSION AND CONCLUSION
Individualized multi-site transcutaneous electrical stimulation increases ambulation related skills in subjects with SMD stemming from CP, MS and stroke. These results show effects on static and dynamic balance, fall risk, mobility, upper extremity improvement as well as an overall increase in health utility and a reduction in spasticity related pain. Effects are immediate as well as sustained. The results may excel individual trial fittings as well as inform controlled trials that are most clearly warranted.

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5.24.4 Known racial/ethnic disparities in lower limb amputation rates in the U.S. persist into functional recovery after amputation

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BACKGROUND
Lower limb amputation (LLA) is one of the costliest, debilitating and potentially preventable chronic conditions affecting American society. Persons of color (Black, Hispanic, Native American people) and those from disadvantaged backgrounds are at increased risk of LLA, likely due to the prevalence of chronic diseases like diabetes in underserved populations. There is a dearth of amputation research inclusive of minority populations, and no study has directly examined factors that may affect prosthetic mobility in persons of color (POC).

AIM
The purpose of this research was to measure prosthetic mobility in a diverse group of people with dysvascular LLA and investigate disparities in functioning.

METHOD
This cross-sectional study enrolled 56 English or Spanish-speaking adults with dysvascular LLA. Participants were recruited through prosthetic clinics in metropolitan locations based in Florida, Nevada, and Utah. Participants completed the PLUS-M™ and PROMIS Ability to Participate surveys to assess perceived mobility and community reintegration and were administered surveys to assess barriers or facilitators to recovery. Research personnel administered Component Timed-Up-and-Go test (cTUG) and 2-minute walk tests to assess capacity for mobility. Statistical analyses were administered to examine group differences between racial minority and white participants, and between males and females. Hedges' g effect size was calculated to indicate practical significance of differences.

RESULTS
Thirty-one participants were categorized as non-Hispanic White and 25 as POC, 22 participants (39.2%) were female. Participants of color were younger than non-Hispanic White participants and exhibited lower scores on all measures of prosthetic mobility, activity participation and self-efficacy (Table 1). When the data was examined by sex, females with dysvascular LLA performed significantly worse than males on all measures of prosthetic mobility, accompanied by medium to very large effect sizes (Table 1). Overall, females of color exhibited the worst scores on outcomes despite having the youngest average age. Correlations between capacity for prosthetic mobility and participation in activities were stronger in POC (cTUG: -0.64 vs -0.47, p<.001; 2 MWT: 0.54 vs 0.30, p<.001).

Table 1. Comparisons based on race/ethnicity and sex

Variable	Non-Hispanic Whites (n=31) Mean (SD) {range}	POC (n=25) Mean (SD) {range}	P value	Hedges' g effect size
Age (years)	63.9 (9.2) {42.2-78.5}	58.6 (9.8) {38.9-77.8}	0.04*	0.56
cTUG (sec)	17.9 (8.5) {9.2-39.3}	22.8 (11.3) {8.5-48.3}	0.05*	0.50
2MWT distance (m)	79.5 (28.2) {27.0-131.1}	64.2 (35.3) {12-156.7}	0.07	0.48
PLUS-M	47.9 (10.8) {30-71.4}	47.2 (11.7) {21.8-71.4}	0.82	0.06
PROMIS Self-efficacy	45.8 (9.5) {31.2-60.7}	44.7 (9.9) {31.2-60.7}	0.70	0.11
PROMIS Ability to Participate	46.7 (11.5) {25.9-65.4}	44.7 (9.0) {25.9-65.4}	0.48	0.19
	Males (n=34) Mean (SD) {range}	Females (n=22) Mean (SD) {range}		
Age (years)	62.1 (9.2) {43.6-77.8}	60.7 (10.8) {38.9-78.5}	0.6	0.14
cTUG (sec)	17.3 (8.5) {8.5-46.4}	24.4 (11.1) {10.8-48.3}	0.008*	0.74
2MWT distance (m)	85.2 (29.7) {24-156.7}	53.4 (26.2) {12-112.1}	<.001*	1.12
PLUS-M	50.1 (10.5) {32.2-71.4}	43.6 (11.2) {21.8-64.5}	0.03*	0.60
PROMIS Self-efficacy	45.9 (9.8) {32.3-60.7}	44.5 (9.7) {31.2-60.7}	0.5	0.14
PROMIS Ability to Participate	45.7 (9.6) {25.9-65.4}	46.0 (11.8) {25.9-65.4}	0.9	0.03

Effect size: small = 0.2, medium = 0.5, large = 0.8, and very large =1.3.

DISCUSSION AND CONCLUSION
This is the first study to examine prosthetic outcomes focused on collecting performance-based data in a diverse sample of people with LLA. Despite sample size limitations, our results indicate that disparities in prosthetic functioning are evident by race/ethnicity. Furthermore, females are exhibiting consistently poorer scores on outcomes after LLA. In conclusion, these results provide the foundation for future research in a larger diverse sample of people with LLA to further investigate factors that may be influencing prosthetic outcome disparities.

ACKNOWLEDGEMENTS: Research was supported by the NIMHD (U54MD012393), Florida International University RCMI and AOPA (EBP-043021).

5.24.5 Grip strength and hand dexterity in patients with lower limb loss

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BACKGROUND

People with lower limb loss (LLL) need good grip strength and hand dexterity for activities of daily living as well as for transfers, walking with walking aids and donning their prosthesis. In spite of this, we did not find any study investigating hand grip and dexterity in this patient group.

AIM

The aim of study was to determine the grip strength and dexterity in patients with LLL admitted for primary rehabilitation after amputation. The secondary objective was to determine whether diabetes influences hand function, and if an occupational therapy program improves them.

METHOD

All patients admitted for primary rehabilitation after LLL to our institute in 2020 were included into the study. As part of our rehabilitation programme, we measured grip strength with Jamar digital dynamometer and hand dexterity with Nine Hole Peg Test at admission and before discharge. The OT programme included individual meaningful activities that might also improve grip strength and hand dexterity. The study was approved by the Medical Ethics Committee of our institute.

RESULTS

We included 118 patients (82 men), 68 years old on average (SD 12 years, range from 38 to 91 years). The main cause of amputation was diabetes (60 patients), followed by peripheral vascular disease (48 patients); the majority of patients (78) had trans-tibial amputation. At admission, we observed lower grip strength and worse dexterity than the norms for healthy subjects in all age groups. There was no statistically significant difference in grip strength either in dominant or in non-dominant hand between patients with and without diabetes, either at admission or at discharge. The patients with diabetes had worse dexterity of both hands on average than those without it at admission, whereas at discharge the differences disappeared. The OT programme resulted in significant improvement in grip strength and hand dexterity of both hands.

DISCUSSION AND CONCLUSION

In our study we found that both grip strength and hand dexterity in patients with LLL are decreased compared to the healthy population, more so in patients amputated due to diabetes. The main limitation of our study is that we did not analyse the influence of grip strength and hand dexterity on performance of daily activities, which we will do in the future. The OT program improves both, so it is important that it is a part of rehabilitation program.

Free paper session: Prosthetics: Lower limb - Socket function

5.25.1 Subischial vs Ischial Containment Sockets: a multicentre randomized cross-over trial to assess comfort and mobility in ecologic daily life situations.

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BACKGROUND

Transfemoral prosthetic socket is the interface between the residual limb of people with above-knee amputation and their prosthesis. It is a key element for comfort and mobility. Recently, NUPOC developed a new socket design with a trimline distal to the ischium: the subischial socket (NU-Flex) [1]. A clinical investigation showed improved comfort [2], but no distinction was made between specific situations, such as sitting, standing or walking, despite lower limb amputees spending most of their time sitting or lying [3].

AIM

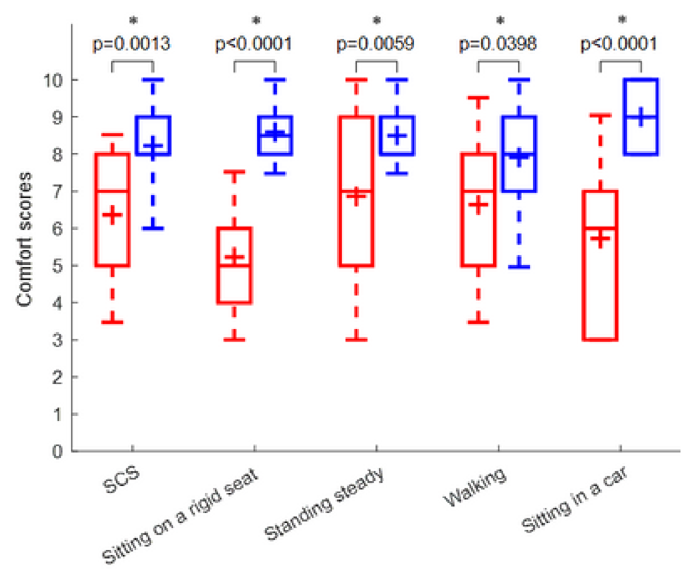
This clinical trial aimed to compare above-knee socket designs, ischial containment vs subischial, assessing comfort, including situations of daily living; and evaluating mobility capacity.

METHOD

The trial was registered and approved by an Ethics Committee. Persons with transfemoral amputation, equipped with a definitive ischial containment socket, were recruited by 10 investigator sites. After providing written informed consent, participants got a new subischial socket. Evaluations were randomly run after wearing each socket for at least two weeks. Outcome measures were (i) to assess comfort: Socket Comfort Score (SCS) at 2 weeks, Comfort scores specific to four daily situations (sitting on a rigid seat, standing steady, walking, sitting in a car); and (ii) to assess mobility capacity: PLUS-M12 questionnaire, the distance measured at the two-minute walk test (2MWT).

RESULTS

25 subjects were enrolled. 22 participants completed the study with full (n=21) or partial (n=1) data. We got a wide range of activity level (CIF d4600 to d4608), etiology, and age (32 to 79 yo). With subischial sockets, comfort scores were significantly improved * in all situations. The best improvements are about seated positions, the mean differences being greater than the minimum detectable change (MDC 90% CI) [4]. The T-score calculated from PLUS-M12 is significantly improved with subischial sockets (p=0.04). No significant difference was detected with the 2MWT.



DISCUSSION AND CONCLUSION

Socket Comfort Scores obtained here are quite similar to NUPOC results [2]. Going into deeper details to understand this comfort improvement through four specific questions revealed the critical situations are seated positions. Subischial sockets seem to provide a very good solution, compared to classical devices.

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5.25.2 Manual vs. Digital: a feasibility study on the manufacturing of lower limb prosthetic sockets

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BACKGROUND
Digital technology has been long employed in the medical industry, but some areas are still underdeveloped. Prosthetic socket manufacturing is experiencing a revolution by shifting towards digital manufacturing techniques. However, globally, clinicians still prefer manual methods as there is no sufficient evidence of satisfactory outcome measures, and the learning curve is steep.

AIM
To explore the feasibility of analysing differences in digital vs. manual socket manufacturing through comparing geometric differences, patient experience and socket comfort score.

METHOD
Adult inpatients with below-knee amputation who needed a preparatory prosthesis to ambulate were recruited. Ethics approval was gained through Joint West Park – Toronto Grace Research Ethics Board. Two sockets were 3D printed (FDM, Stratasys) for each participant through: (1) hand-casting and manual modification, then hand-held 3D scanning to obtain the printable socket model; and (2) scanning the residuum then digital modification and printing. The final socket file geometries were compared. Two preparatory prostheses were aligned identically and fitted. Socket Comfort Scores (SCS) were quantified. Patient experience was measured using a questionnaire. Feasibility data were collected to measure procedure implementation fidelity to inform a future larger study.

RESULTS
Nine participants with trans-tibial amputation were recruited in total. Geometry analysis results are presented in figure & table. Vertical distance from the distal end of the residual limb to the patellar tendon showed that the 70% of manual sockets were taller than the digital. Half of the participants chose digital socket over manually; there was no significant difference. Mean SCS was 8.1/10 on day one fitting. 80% of the participants followed intended protocol, no participants dropped out, and only one adverse event was reported.

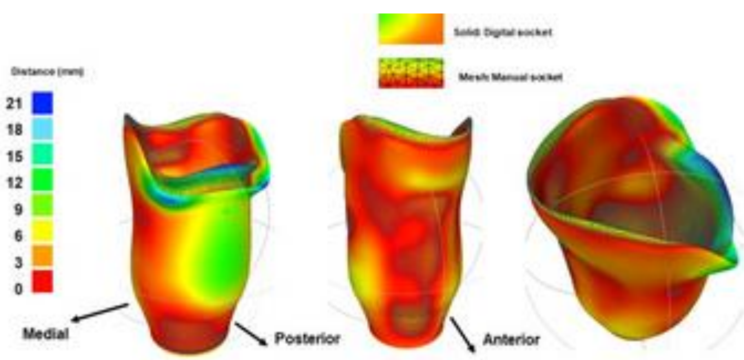

Figure: Manual & digital sockets comparison for participant WPHC01.

	Vertical distance from distal end to patellar tendon (mm)		Difference (mm)
	Manual	Digital	
WPHC01	188.728	174.442	14.286
WPHC02	190.297	186.637	3.66
WPHC03	209.390	198.896	10.494
WPHC04	163.167	159.633	3.534
WPHC05	190.97	194.853	-3.883
WPHC06	117.736	118.392	-0.656
WPHC07	125.891	134.23	-8.339
WPHC08	167.894	164.188	3.706
WPHC09	210.233	202.181	8.052

DISCUSSION AND CONCLUSION
Overall, the participants equally chose digital and manual sockets, and in 50% of the cases the participants reported similar comfort scores with both sockets; thus, randomly chose one socket to be used for their prosthetic rehab. Even though we found geometrical differences in the sockets, it seemed that the participants experienced similar comfort. Overall, the study feasibility was shown successful, and a larger study will be conducted on a larger sample and more relevant outcome measures.

5.25.3 Perspiration and lower limb suspension: hybrid dynamic air exchange versus as-P prescribed versus perforated liner

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BACKGROUND

Accumulation of perspiration inside a prosthesis can led to an insecure adherence, limiting the mobility of individuals with lower limb amputation. One approach to address perspiration suspension problems is an elastomer liner with small perforations (PERF) that allow perspiration to exude into the interstitial space between the liner and the socket. Another uses a novel vacuum technology to expel perspiration into a distal chamber (DAE-RED).

AIM

Compare DAE-RED, as-prescribed prosthesis (RX), and PERF outcomes in laboratory conditions that produce profuse perspiration and, in the home, work, and community environments using a cross-over experimental design.

METHOD

Subjects were randomized to PERF or DAE-RED to wear in their home, community, and work environments. After two weeks, skin hydration and transepidermal water loss (Courage & Khazaka, GER) were measured along with the Socket Comfort Score [1]. In a 35° C and 50% relative humidity chamber, subjects acclimated for 30 minutes then treadmill walked for 30 minutes at self-selected speed. After resting for 30 minutes at 20° C and 30% relative humidity, perspiration and liner slippage were measured. Subjects then wore their RX for two weeks, after which the procedures above were repeated. Finally, the subject wore the remaining study prosthesis for two weeks and the procedures repeated.

RESULTS

Eight individuals with transtibial amputations provided informed consent to participate in this institutional review board-approved protocol (91±11 kg, 1.75±0.08 m, 47±15 years; 6 trauma, 1 diabetic, 1 infection). Results are shown in the Table.

Table. Perspiration, liner slippage, and skin health metrics (mean ± std. dev.).

	DAE-RED	Rx	Perf
Perspiration residual limb (g)	2.0±1.9	1.3±1.4	0.5±0.6
Perspiration contralateral limb (g)	0.7±0.6	0.6±0.4	0.5±0.4
Liner slippage (mm)	3±5	15±15	6±7
Skin hydration residual limb (arbitrary units)	18±2	21±2	26±2
Skin hydration contralateral limb (arbitrary units)	25±2	23±2	29±2
Transepidermal water loss residual limb (g/h/m2)	12±0	13±0	9±0
Transepidermal water loss contralateral limb (g/h/m2)	6±0	6±0	7±0
Socket Comfort Score (0:10 scale)	7±1	8±1	7±2

DISCUSSION AND CONCLUSION

In a hot and humid environment, the PERF accumulated the least perspiration while the DAE-RED provided better adherence (less slippage). Contralateral limb perspiration remained relatively constant, suggesting repeatable test conditions. In the field, skin hydration was very dry (<30) for all three study prostheses but maintained barrier function as indicated by the low transepidermal water loss (<15; healthy skin). All three were reasonably comfortable to wear.

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5.25.4 Ventilating liner and socket suspension interface reduces humidity on transfemoral amputee's residual limb

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BACKGROUND

Sweat accumulation on the residual limb inside a roll-on silicone liner is a common problem for prosthetic users that may affect quality of life [1]. Residual limb skin perspiration is a side-effect of occlusive gel liners and interfaces connecting the residual limb to the rest of the prosthesis [2]. Skin perspiration is often the root cause of many residual limb skin problems and suspension issues that may cause near-falls or falls.

AIM

The aim was to evaluate the efficacy of a ventilating socket and liner interface (intervention) in reducing humidity build-up on an amputee's residual limb compared to a conventional suspension interface (control).

METHOD

The study design was a randomized controlled crossover. High active individuals with transfemoral amputation, current Direct Socket, and Seal-In Silicone liner users were recruited and fitted to the ventilating liner and socket interface. After a minimum of two weeks, subjects were randomized into two groups and scheduled for two measurement sessions of relative humidity using sensors (MSR Data Logger, Switzerland). Measurements were conducted on two separate days, same time of the day. During the measurement sessions, participants conducted activities in a heated and humidity-controlled room. Additional outcome measures were the patient's perceived perspiration, stability, suspension, and comfort.

RESULTS

Nine TF amputees completed the entire protocol procedures. Relative humidity (rH%) inside the liner was plotted for all participants on both interfaces. The area under the curve (AUC) was calculated over the same time for all subjects. A generalized linear model was used to compare the two suspension solutions. The model tested the ability to predict AUC, given liner and socket solution, and controlling for baseline relative humidity. The model confirmed that the AUC was statistically significantly smaller when wearing the intervention interface ($p<0.0001$). Using the ventilating solution, participants reported significantly less sweat on their residual limbs ($p=0.04$, paired t-test). Non-inferiority was shown between solutions regarding patient-perceived stability, suspension, and comfort.

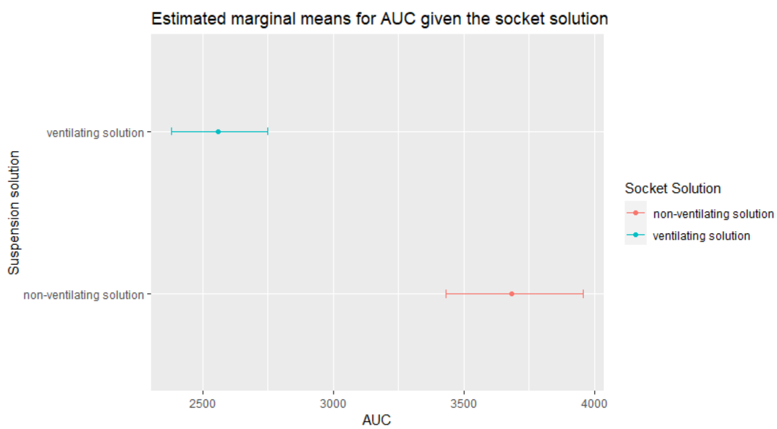

Figure 1: Area under the curve (AUC) for relative humidity comparing ventilating suspension solution and non-ventilating suspension solution.

DISCUSSION AND CONCLUSION

A lower overall humidity (AUC) level for the intervention indicates that the ventilating interface allows humidity to escape from the skin and out of the liner and socket. The participants also experienced the ventilating effect and reported less sweat wearing the intervention interface. The study results confirm the performance of the ventilating suspension interface in reducing humidity build-up within the liner.

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ACKNOWLEDGEMENTS The investigation was funded by Össur Iceland ehf.

5.25.5 Developing a repeatable methodology for humidity measurements within a prosthetic interface

Margrét Sól Ragnarsdóttir, Jóna Valgerður Kristjánsdóttir, Sigurður Hannesson, Rowan Cain

Össur, Reykjavik, Iceland

BACKGROUND

Sweat and humidity within a prosthesis is a common problem amongst prosthetic users leading to suspension and skin health issues [1]. To analyse effectiveness of potential prosthetic solutions, it is important to have objective and reliable tools to evaluate the interface solutions. An evaluation method is needed that can be reliably performed using commercially available equipment and applicable to use with any socket and liner interface.

AIM

The objective was to develop a reliable and accurate methodology for objectively measuring humidity within a prosthetic liner and socket interface.

METHOD

Data is collected on each interface under investigation on separate days at the same time of day. Relative humidity (RH) and temperature sensors (MSR Datalogger, Switzerland) are applied on the skin on the prosthetic and sound side. The procedure starts with a period where the subject dons the liner and socket with resting intervals to investigate the effect of donning on the humidity. Then the subject walks (self-selected speed) on a treadmill in a heated room, followed by rest, a four-step-square-test (FSST), and stair walking. Actions are taken to minimize intra-subject variability to effectively evaluate the difference between interface systems.

RESULTS

This methodology was used in a study where nine TF amputees completed full protocol procedures. RH on the skin was plotted and area under curve (AUC) calculated from liner don to exit hot room as the primary outcome to evaluate the performance of each interface during instigation of perspiration in a single value. Comparison of AUC between interface solutions for each subject proved to be a good comparator, showing significant difference between the interfaces under investigation. Temperature difference between systems was not significant, which is a precondition for direct comparison of RH. No user reported discomfort due to the sensors.

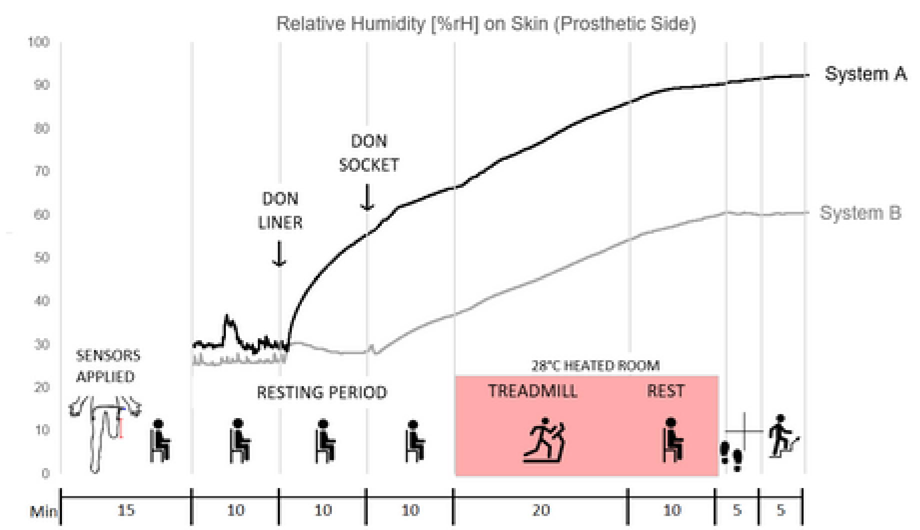

Figure 1. Schematic diagram of the measurement protocol along with RH data from one subject on two interface systems during the protocol

DISCUSSION AND CONCLUSION

This work describes a procedure suitable for assessing perspiration in liner and socket interfaces of individuals of any activity level, in a controlled way using commercially available equipment. New solutions for mitigating sweat within a prosthesis are emerging. Having a robust, reliable, accurate, and objective method for evaluating if the solution alleviates the problem is beneficial to both prosthetic designers and clinicians while selecting devices for their patients.

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ACKNOWLEDGEMENTS The investigation was funded by Össur Iceland ehf.

Free paper session: Paediatrics - Upper limb

5.26.1 Comparison of compensation strategies for an active elbow support in healthy subjects, an exploratory pilot study

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BACKGROUND
There is a need for active arm supports in people with progressive muscle weakness such as Duchenne Muscular Dystrophy (DMD) to support functional arm movements during daily activities. Arm supports can increase the quality of live by retaining independent task execution and social participation. This study serves as an exploratory pilot study in the development of a full arm support for daily use in boys and men with DMD (Brooke Scale >3).

AIM
To develop 4 different high level control strategies (*modelled-based*, *hybrid-based*, *measured-based*, and *personalized-based*) and compares the compensation efficacy and preferences in an elbow support with healthy male subjects.

METHOD
The study exists out of 2 sessions with 12 healthy male subjects: 1) measurement of the passive interaction forces around the elbow joint in both horizontal and vertical workspace (*relaxation*-task) 2) comparison of the compensation strategies in vertical workspace (*position*-task). The passive interaction forces were measured with a force-torque sensor at the sleeve interface and the compensation support was provided by the newly developed series elastic actuator at the elbow joint. The compensation efficacy was determined by surface electromyography (sEMG) and interaction forces at the sleeve during a target position tracking task. Moreover, NASA-Task-Load-Index and personal preferences were collected in session 2.

RESULTS
Out of the 12 participants (aged 24 to 35 years), 4 preferred the *modelled-based* (weight compensation only based on kinematic model), 4 preferred *measured-based* (all passive forces measured in session 1), 3 preferred *personalized-based* (model of gravity and joint impedance fit to the passive forces measured in session 1), and 1 *hybrid-based* (kinematic gravity model with measured joint impedance) compensation strategy. The experiments are finalized and the sEMG and interaction forces are currently analysed to examine the compensation efficiency, expected end 2022.

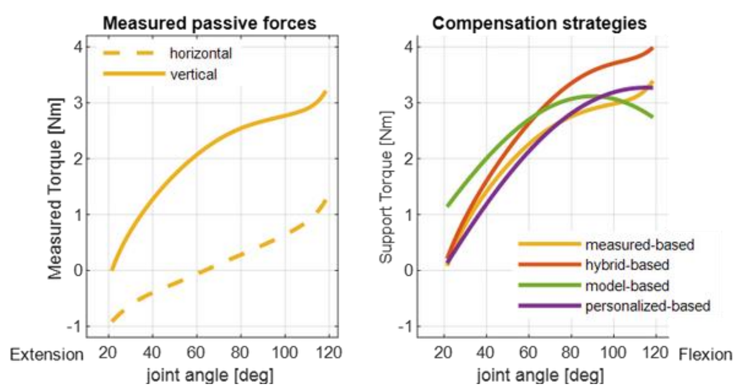

Figure 1. Left graph shows an example of the measured passive forces in the horizontal and vertical workspace measured in a single subject. Right graph shows the different support torque profiles applied in the active elbow support for the same subject. *Note*: Measured-based curve is based on measurement in vertical workspace plus weight component of support interface.

DISCUSSION AND CONCLUSION
The passive forces measured in the horizontal workspace are considered as joint impedance and seem to play a substantial role in the vertical workspace. Suggesting, the compensation strategy should account for joint impedance, especially in populations such as DMD with elevated muscle stiffness. However, 4 out of 12 participants preferred the conventional modelled-based strategy, not taking the joint impedance into account. The sEMG and interaction forces are expected to give more insight in the compensation efficiency between the different strategies.

ACKNOWLEDGEMENTS This work is part of the Wearable Robotics program (P16-05), (partly) funded by the Dutch Research Council (NWO), The Netherlands.

5.26.2 Design requirements for upper extremity support for home use in people with severely impaired arm function in Duchenne Muscular Dystrophy

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BACKGROUND
Optimizing orthotics to real user needs is a basic challenge in our field. A variety of upper extremity supports is available for people with severe muscle weakness, such as Duchenne Muscular Dystrophy (DMD). Unfortunately, the rate of disuse of these products is high due to multiple reasons, among which mismatch between the specific user needs and design requirements. Moreover, in the more advanced disease stages (>Brooke scale 3), there seem to be no suitable wearable arm supports (i.e., motorized).

AIM
This paper aims to 1) provide clinical guidance to match the technology to patient needs, and within this framework 2) formulate functional and technical design requirements for the development of an active exoskeleton for people with DMD Brooke 4.

METHOD
A clinical meaningful classification was developed based on available literature over the past 1.5 years and data from the Dutch Dystrophinopathy Database (DDD) was reused. The DDD is the Dutch national register for Duchenne and Becker muscular dystrophy, in which natural history data is collected. For boys and men with DMD Brooke scale 4 the functional level was elaborated: the muscle force/torque, active and passive range of motion, reachable workspace, and performance of upper limb (PUL) scores. From these, technical design requirements were formulated to restore arm function to achievable levels, aligned with the needs of the user.

RESULTS
Figure 1 gives a summary of the classes per Brooke scale with comprehensive descriptions of characteristics. Elaborating on DMD patients with Brooke 4, their range of motion is limited to what they can reach with elbow and wrist movements. As a results of increased muscle stiffness, their joint impedance around the elbow and shoulder is elevated. The muscle strength of their arm muscles varies between 3-25 N (i.e., 0.8-9 Nm of torque). Intuitive force-based support with active weight and joint impedance compensation is expected to best match their needs. Both the shoulder and elbow should be supported and there are important safety considerations that are specific to this population.

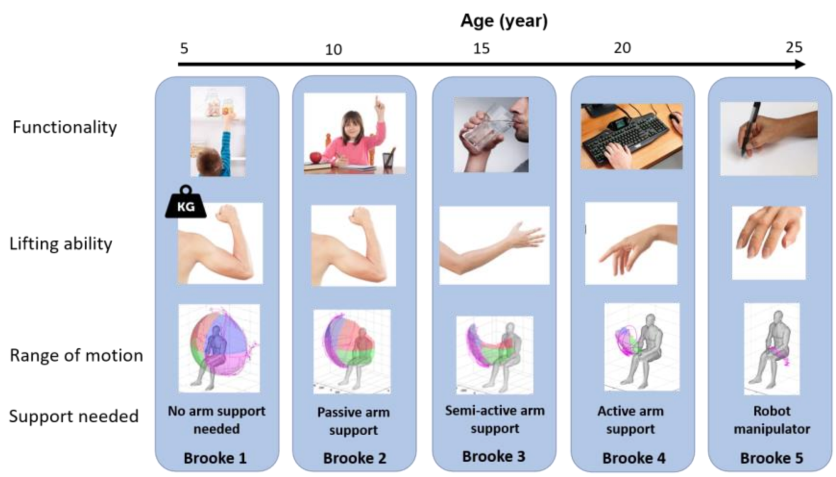

Figure 1. Natural arm function in DMD

DISCUSSION AND CONCLUSION
This paper can be used to make the prescription and further development of arm supports more user centred. It is important to closely match target population to design requirements in order to prevent non-use. Active arm supports with weight and joint impedance compensation are expected to best match the needs of boys and men with DMD Brooke Scale 4. In addition, (and beyond our scheme) it is important to also consider the (personal and environmental) barriers that could result in non-use.

ACKNOWLEDGEMENTS We would like to thank the Duchenne Centre Netherlands (DCN). This work is part of Wearable Robotics (P16-05) funded by NWO.

5.26.3 Problems in the use of prosthesis in children with congenital upper limb deficiency in social participation situations

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BACKGROUND
When children with congenital upper limb deficiency bring and use their prosthesis to social activities such as nursery schools, kindergartens, and elementary schools, there are advantages such as making it easier for them to perform tasks and so that their operating skills can take root. However, the current situation has not been clarified, such as the actual use of prosthesis in social participation situations, the understanding and perception of their surroundings including schoolteachers and other staff.

AIM
The aim of this study was to clarify the situation and problems of wearing a prosthetic hand in social participation situations of children with upper limb deficiency.

METHOD
The subjects were the children with upper limb deficiency visiting our outpatient clinics, and their nursery school teachers, and kindergarten and elementary school teachers. The children and their parents were informed about the survey by the doctors and occupational therapists during their regular visits to the clinic, after obtaining consent the school teachers were asked to cooperate in the web-based survey. The survey asked whether the children were using the upper limb prosthesis, how often and how long they wore them, the situations in which they used them, any problems they experienced. This study is conducted with permission from the Ethics Committee.

RESULTS
Responses were obtained from 24 teachers at 13 facilities where children attend. Twenty-two of the 24 respondents indicated that their child brings the prosthetic hand to school. The types of prosthesis brought were passive prostheses for 16, myoelectric prostheses for 15, and activity-specific prosthetic for gymnastics for one. About 82% indicated that the children wear their prosthesis almost every day. Eight of the 22 respondents reported that their children had problems of donning and using their prosthesis. Specifically, 7 reported difficulties of donning and doffing their prosthesis, 5 reported problems with handling, maintenance, and breakdowns of prosthetic hands that are expensive or precision instruments, and 1 reported problems with ensuring that the child had enough time to use the prosthesis. The results are shown in the table below.

Table

Difficulty of donning and doffing the prosthesis
・Difficulty in doffing the myoelectric prosthesis ・Child cries or doesn't want to wear their prosthesis ・The prosthesis is too small to wear, as the child grows ・Unable to wear a prosthesis because it's uncomfortable with stuffiness and heat ・Unable to remove prosthesis
Problems with handling, maintenance, and breakdowns of the prosthetics
・Must be careful with water and dust-proofing ・A specific teacher assists with the wearing because the prosthesis must not be broken ・Unknown cause of myoelectric prosthesis immobility ・Need to keep learning as prosthesis changes as it grows
Problems with ensuring that the child had enough time to use the prosthesis
・Limited the situation of using prosthesis and short time wearing them

DISCUSSION AND CONCLUSION
The collaboration of teachers is essential for children to use the prosthetics in social participation situations. The results of this survey showed that teachers are collaborative and positive about their children's use of prosthetics. On the other hand, this has led teachers to various difficulties. Providing sufficient and appropriate information on how to deal with these problems will lead to comfortable prosthetic use at the facility for both the child and the teacher.

ACKNOWLEDGEMENTS We would like to thank all the children, their parents, caregivers, and teachers who contributed to this study.

5.26.4 FIRST prosthesis – a new concept prosthesis for the initial treatment of children with congenital malformations of the upper extremities

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BACKGROUND
In the provision of prostheses for children with congenital malformations of the upper extremities, both the teaching opinions and the experiences from everyday care vary significantly with regard to the point in time of the first prosthetic fitting. While the experience with passive initial prostheses is modest to bad, the purpose and the resulting goals of this initial prosthesis are absolutely understandable and desirable.

AIM
The FIRST concept stands for First, Integrative, Rehabilitative and Situation-oriented Training prostheses. It is a concept prosthesis that is used in the early fitting phase of children. The FIRST prosthesis was conceptually adapted to the age-appropriate development [1] of the child.

METHOD
The first prosthesis consists of a partially flexible (thermoplastic) or elastic (silicone) inner socket. Due to its material properties, this can be reshaped (thermoplastic) or stretched (silicone). This inner socket is also responsible for the bedding comfort of the malformed extremity. With the integration of 3D printing methods [2], a multifunctional adapter with different tools could be integrated into this prosthesis. Tools that the child handles very early on depend on the situation and can change independently. The number and type of tools are increasingly expanded and built up based on the development of the child and is therefore a good step towards a first myoelectric prosthesis.

RESULTS
Last year, 22 children with congenital malformations of the upper extremities were fitted with this concept prosthesis. The mean age at the time of initial care was 28 months, with the youngest child being 9 months and the oldest being 69 months. The children started with 3 age-dependent tools, which were expanded to up to 6 tools as they grew older. As part of the initial treatment, all children received therapeutic support to learn how to operate and use the tools. In comparison to the traditional passive initial prosthesis, a significantly more active perception and use of the prosthesis in everyday life can be seen after this short fitting phase.

DISCUSSION AND CONCLUSION
The FIRST prosthesis concept starts exactly where traditional passive first prosthesis concepts fail in everyday life: the interest and attention of the child. Such a fitting concept only has a chance of successful fitting if this is ensured. With the FIRST concept, a playful and changing approach with a corresponding variety of uses was deliberately chosen, since this is exactly where traditional prostheses failed.

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ACKNOWLEDGEMENTS Special thanks to the POHLIG Upper-X-prosthetics-Team and POHLIG Therapy-Team for the successful implementation of this new approach.

5.26.5 A literature review: Paediatrics congenital transverse deficiency (peromelia) of the upper limb and advanced prosthesis use and abandonment.

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BACKGROUND
Paediatric congenital transverse deficiency or Peromelia refers to congenital absence or malformation of the extremities. The appearance of the arm is like an amputated stump. According to reviewed literature, a congenital limb deficiency may influence psychosocial domains of quality of life. It is doubtful that currently available prostheses fulfil these aims since abandonment rates range from 35% to 45% in the paediatric population.

AIM
To investigate the reasons for prosthesis rejection in congenital transverse deficiency (Peromelia).

METHOD
A wide literature search updated to March 2015 has been performed from the following databases: PubMed, Google Scholar, and Cochrane Database of Systematic Reviews to obtain comprehensive information about Peromelia, focusing on current recommendations for the prosthetic management of Peromelia (e.g. prosthetic fitting, stump lengthening). This study summarizes the current literature which focused on the etiology, pathogenesis, and specific treatment algorithms for children with Peromelia. Current studies stated that children with trans-radial or trans-humeral Peromelia should preferably be fitted with passive /cosmetic prostheses at the age between 6 to 24 months, followed by myoelectric prosthetics at 2 to 4 years.

RESULTS
There were many recorded reasons for rejection or partial rejection, and for each child, there were usually several contributory reasons. When these were grouped together and all the different appliances were considered, it was found that the commonest cause for rejection was the mechanical inefficiency of the prostheses. The next most common cause of rejection was the child's preference for using his or her own residual limbs. In relatively few cases, the lack of cooperation of parents or children was a major reason for rejection. The provision of prostheses for children with upper limb deficiency starts at an early age. However, the optimal age for prosthetic fitting is still controversial. Many authors believe that early fitting can enhance and increase physical skills and decrease prosthesis rejection time.

DISCUSSION AND CONCLUSION
The principal reasons for rejection of a prosthesis are lack of function, including some cases in which the device impaired function, and lack of comfort. Moreover, further studies are still required to improve sensory feedback and also focus on the development of new upper limb prosthetic microprocessors in electronic components for the paediatric population, which provide several new benefits. More research needs to be directed towards conferring sensibility to the prosthetic user.

Free paper session: Low- and middle-income countries - Healthcare policy and services II

5.27.1 The changing needs for prosthetics services: learning from digital centre management data

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BACKGROUND
Development and delivery of prosthetic services relies on quality data describing population needs in specific contexts. However, most existing data come from High-Income Countries or small geographic areas [1-3], which are not commonly comparable across services and locations. There are also few longitudinal studies that investigate multiple countries or assess service user demographics in detail [4] and the dynamics of prosthetics service user demographics are under-reported across all income contexts.

AIM
To provide insights into the characteristics of people accessing Cambodian prosthetic services, evaluating how their needs have changed over time and forecasting future service requirements.

METHOD
Using digital patient records for three Cambodian prosthetic clinics [Phnom Penh (Urban), Sihanoukville and Kampong Chhnang (Rural)], we investigated trends over three decades in birth year, sex, year and reason for limb absence, and prosthesis type. We extracted cross-sections in 2005 and 2019 indicating how the population accessing prosthetics services has changed. The dataset contained 50,144 entries between December 1992 and December 2019, representing clinical contacts for 7,117 individuals, 2,820 of whom were classified as ‘active’ (having had at least one appointment in the last 7 years).

RESULTS
Temporal trends aligned with Cambodia’s socio-political history. The predominant reason for limb absence was weapon trauma during and following conflict (77% overall, neglecting missing data), but non-communicable disease (NCD) and road accidents were most common since 2000. Transtibial remained the most prevalent amputation level (65% overall) but transfemoral amputation had higher incidence in road traffic accidents (46% vs 43%). The most common age at amputation was 20-29yrs for all reasons except congenital conditions (0-9yrs), animal bite (10-19yrs), and illness, which showed increasing incidence with age, with 45% of individuals aged over 50yrs stating this reason for amputation. Both transfemoral and older-aged groups experience particular rehabilitation challenges. The high proportion of individuals with amputation due to 'unspecified disease' may indicate an under-estimate of diabetic and vascular disease. The impact of comorbidities will accentuate these figures.

DISCUSSION AND CONCLUSION
The study presents a description of Cambodian prosthetics service user populations, and their changing demographics over time, based upon standardised, routinely collected data across multiple clinics. Similar analysis of data from services run by other providers and in other countries would give researchers, service providers, policymakers and industry insights into future challenges, and enable them to develop appropriate technologies and adaptive service access models which maintain closer alignment with prosthetic limb users’ changing needs.

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5.27.2 Estimation of unmet needs of assistive devices in Rawat, Islamabad, Pakistan

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BACKGROUND

Disability and unmet need of assistive devices is a serious public health concern. Fifteen percent of the world's population is living with disability, among them about 3.8% people between 15 to 65 years have marked functional limitations. [1] Pakistan Bureau of Statistics shows that 3,286,630 persons are living with disabilities in Pakistan. [5] Current knowledge is that the provision of Assistive devices is insufficient in Pakistan. There is a great necessity to address unmet needs of assistive devices among people with disabilities.

AIM

Provision of assistive technology devices in Pakistan is insufficient. This study assessed unmet need of assistive technology in Rawat, Pakistan.

METHOD

A descriptive cross-sectional study was conducted in Rawat, which is a town situated 30.9 km away from Islamabad with a population of 17,860. Rawat was selected deliberately as a study area because of its low socioeconomic status. A survey was conducted using the WHO Rapid Assistive Technology Need Assessment Tool. 32 different types of assistive devices were addressed in the questionnaire including 18 different devices used for physical functional limitations, 2 for auditory disabilities, 6 for visual limitations, 1 for speech limitations and 2 for intellectual disabilities. Printed data collection tools were provided to female health workers to complete the data from study population selected by systematic random sampling.

RESULTS

75 households were selected, representing 350 people. 180 (51.42%) were females and 170 (48.5%) were males of different age groups. 85 (24.28%) people needed assistive devices for different type of functional limitations. Out of those 85 (24.28%) only 15 (4.3%) people were using assistive devices, whereas 70 (20%) people were not using any assistive devices.

DISCUSSION AND CONCLUSION

Current findings of the study suggest that policy and service delivery systems for AT in Pakistan may not be reaching all people who need assistive devices. Research data shows that each disability group has substantial unmet demand for AT. Efforts should be made to improve access to AT.

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ACKNOWLEDGEMENTS I am honored to express my gratitude to my Supervisor Dr. Shahzad Ali Khan for his guidance and support.

5.27.3 Macro-environmental analysis of prosthetic and orthotic services in Cambodia: political, economic, social, technological, environmental, and legal (PESTEL) factors

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BACKGROUND
The World Health Organisation estimates that over one billion people globally experience a disability, of whom 2-4% experience a significant loss of physical functioning. Physical rehabilitation services in Cambodia were developed in the early 1990s as an emergency response to landmine victims and have been generously supported by international aid through various non-governmental organisations. These physical rehabilitation services in Cambodia have historically been free-of-charge. There is a significant reduction in financial income from international aid to continue providing free care.

AIM
This study aimed to analyse facilitators and barriers including strengths, weaknesses, past and present business situations at a macroenvironment level with the use of Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) factors on prosthetic and orthotic services in Cambodia.

METHOD
The analysis is made with the use of 8 steps, the recommendations of best practices for document analysis, by Ardu (2019) and the integration of PESTEL factors: 1. Name of document; 2. What type of document is it?; 3. When was it produced?; 4. Why does this document exist (purpose)?; 5. Who produced the document?; 6. What kinds of information can we get from the document?; 7. What did this document mean to people during that time (audience)?; 8. What does the document tell us about the time period? Interpretation: Which aspects of the document directly or indirectly address the question, and what do the selected relevant considering the context?

RESULTS
27 legal documents with direct involvement to prosthetic and orthotic services and another 25 other related studies and assessment related to physical rehabilitation in Cambodia were included in this analysis. A catastrophic expenditure coverage on assistive devices and individualised rehabilitation service will be a burden to the government and public finance responsibility. For social protection for people with disabilities (PWDs), government actions on the protection of economic security, and promotion of an enabling environment for economic security for PWDs should be founded. The other considerations on discount goods and services for PWDs have not yet been discussed in a public policy forum. A cash transfer programme for the disability benefit arrangement in five provinces between 2019 and 2021 has proven to be a new action for disability support service. Cambodia may require disability service reform to improve multiple approaches to enhance service quality, accessibility, and sustainability.

DISCUSSION AND CONCLUSION
The main findings affirm that there is a world-class prosthetic and orthotic service in Cambodia. The service financing requires cross-cutting cooperation, interdisciplinary inputs, government strategies, and support for the investment toward entrepreneurship for long-term sustainability and impacts of services. Stakeholder engagement and participatory development contribute to a successful framework for sustainability. The principles of co-design, co-creation, and co-ownership of a long-term vision for inclusive and sustainable financing strategies post-international aid with mutually beneficial, respected, and productive for the targeted beneficiaries.

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5.27.4 Exploring attitudes and perceptions of stakeholders on social enterprise supporting sustainability of prosthetic and orthotic service financing in Cambodia

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BACKGROUND
The foundation of this interest is based on the evolution of funding availability toward sustainable financing strategies for prosthetic and orthotic services. Along multi models funding, the rehabilitation workforce could be built and continuously develop to respond to the need and demands of the country from multiple sources of funding to enhance service quality, accessibility, and sustainability. This research explores whether social enterprise is a feasible model to support financial sustainability for prosthetic and orthotic (PO) services in Cambodia.

AIM
The study aims to explore specific contextual and cultural settings focusing on the exact problems, priorities, abilities, perceptions, attitudes, and potential solutions exclusive to the long-term sustainability of prosthetic and orthotic service financing in Cambodia.

METHOD
The study employs a qualitative research method with the use of semi-structured interviews. The semi-structured interviews were made with 20 key stakeholders in physical rehabilitation, health, social protection, social security fund, health, economy and finance, and user organisations in Cambodia between February and September 2022. The semi-structured interview was chosen over other qualitative research methods (i.e. focus group discussion or structured interview) for it allows flexibility in the topic of discussion, and independent discussion without being influenced by the authority, power, or nomination of other people in the interview.

RESULTS
It was found that Social Enterprise could be a model contributing to the sustainability of PO service financing in Cambodia. However, pluralistic models with considerations on disability service system strengthening, rehabilitation workforce integration, disability and rehabilitation information system, changes of disability service-seeking behaviours, policy framework on PO service delivery, cost-effectiveness, and impact assessment on the current model of PO service financing. The advancement of National Social Security scheme and the National Social Protection scheme for vulnerable groups are deemed to be possibilities influencing both public and private insurance. System thinking, system reforms, and system approach have to be embedded in all legal requirements, policies, guidelines, and practices for diversified sources of funding. The development and revolutions for innovations, responsive, resilient, timing, effective, and sustainable financing strategies with diversified funding sources from global, national, and local communities are required for Cambodia.

DISCUSSION AND CONCLUSION
The inefficiency of the PO service financing mechanism in Cambodia has resulted from a focus on the extreme expectations, either government or international aid support, that are not realistic and achievable. Yet, Cambodia has proven to be successful in the delivery of mixed methods of healthcare financing models in the last two decades. This study embraced the present contributing factors both perceptions and attitudes of key stakeholders in the future sustainability of PO service financing in Cambodia.

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5.27.5 Lived experiences of prosthesis and orthosis users in Cambodia: a qualitative study

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BACKGROUND
It is likely that provision of prosthetic and orthotic devices leads to an improvement in many diverse aspects of a user's life. While improvement in mobility and functioning have been well documented, there is limited research focusing upon the effects that prosthetic and orthotic devices may have on other aspects of a person's life, including daily living [1], psychological outcomes [2], and participation [3].

AIM
The aim of this qualitative study was to explore the life experience of people who use lower-limb prosthetic or orthotic devices in Cambodia.

METHOD
Fifteen participants were recruited from urban and rural prosthetic and orthotic clinics run by the same non-governmental organisation in Cambodia. All participated in individual, semi-structured interviews. Questions were based on five domains from the WHO Disability Assessment Schedule (WHODAS 2.0). Interviews were transcribed verbatim and analysed using a thematic analysis approach.

RESULTS
Three main themes representing life as a prosthesis or orthosis user in Cambodia were identified. These included 1) a more positive outlook with an assistive device, 2) assistive devices reduce barriers but do not eliminate them, and 3) disability creates social exclusion while assistive devices facilitate inclusion. Main themes and sub-themes are presented in figure 1.

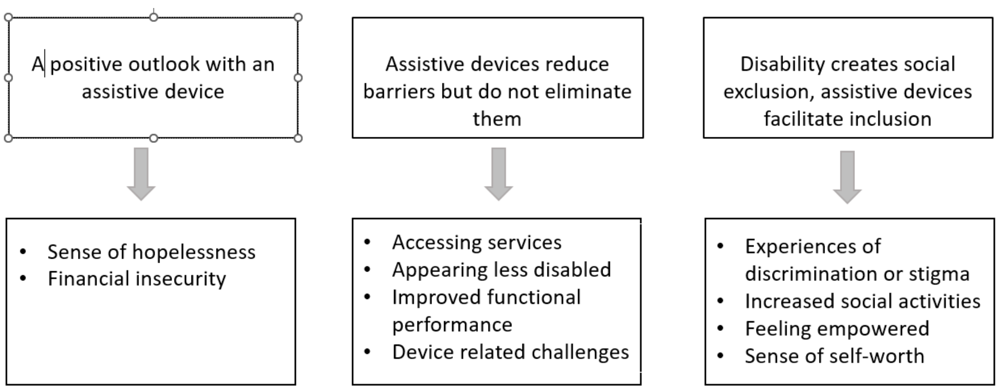

Figure 1. Main themes and sub-themes representing life as a prosthesis or orthosis user in Cambodia

DISCUSSION AND CONCLUSION
Findings reflected many important areas related to exclusion of persons with disability. These have been highlighted in previous work [4] and involve difficulties gaining employment, the experience of social exclusion and discrimination. Prosthetic and orthotic devices were identified to facilitate inclusion, positively affecting participation in social activities, empowering participants and improving their sense of self-worth.

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ACKNOWLEDGEMENTS This work was financed by a grant from the Swedish International Development Cooperation Agency

Free paper session: Prosthetics: Lower limb - Physical activity

5.28.1 Correlation between physical activity and knee osteoarthritis outcomes in people with lower-limb amputations

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BACKGROUND

Individuals with a unilateral lower limb amputation (LLA) have a higher prevalence of knee osteoarthritis (OA) and are at a higher risk of developing intact limb OA than the non-amputee population [1]. In non-amputees, regular exercise and physical activity have been shown to improve functional performance and quality of life (QoL), and therefore play a critical role in knee OA management [2]. However, in individuals with LLA, the association between physical activity and knee OA outcomes remains unknown.

AIM

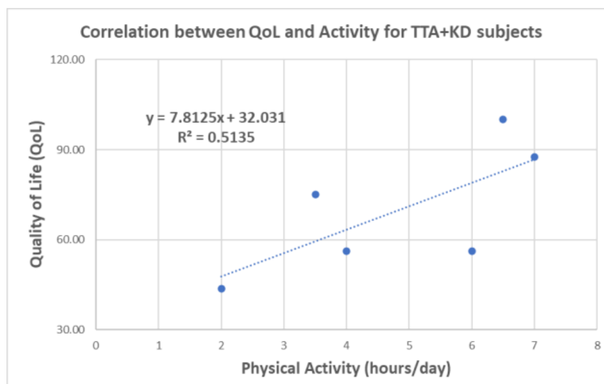
To determine the effects of physical activity on knee OA outcomes of pain, OA symptoms, difficulty with functional activities of daily living as well as sports/recreational activities and QoL.

METHOD

Eleven individuals with a unilateral lower limb amputation participated in the study [4 transtibial amputation (TTA); 2 knee disarticulation amputation (KD) and 5 transfemoral amputation (TFA)]. Subjects completed questionnaires for demographics, amputation history, prosthesis use (hours/day), physical activity (standing/walking in hours/day) and the Knee Osteoarthritis Outcomes Score (KOOS). Correlation coefficients between each of the 5 subscales of KOOS and prosthesis use, as well as KOOS and physical activity were calculated. For data analysis, TTA and KD subjects were grouped together. A correlation coefficient > 0.7 was considered as a strong correlation and $p<0.1$ was considered significant due to the small sample size.

RESULTS

The mean age of the TTA+KD group was 52.5±7 years, while that of the TFA group was 46±15 years. The mean activity for the TTA+KD group and TFAs was 4.8±1.9 hours/day and 3.8±2.7 hours/day, respectively. For the TTA+KD group, there was a strong positive correlation between physical activity and knee-related QoL ($r = 0.71$; $p<0.1$) (Figure 1) as well as between physical activity and function during sports/recreation ($r = 0.88$; $p<0.1$). Prosthesis use had a poor correlation with all KOOS subscales in both TTA+KD subjects as well as TFA subjects.



DISCUSSION AND CONCLUSION

Results indicate that greater physical activity is associated with a higher QoL and lesser difficulty with sports/recreational activities, in individuals with TTA and KD amputations. While a correlation does not imply causation, results suggest a trend for improved OA outcomes with higher physical activity in TTA and KD patients. Data were inconclusive for TFA subjects due to high variability between subjects. This is an ongoing study, and a greater sample size would increase generalizability of the results.

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5.28.2 Quantifying step counts in new prosthetic users following inpatient rehabilitation

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BACKGROUND
People with lower limb amputation face challenges to regain their previous physical activity level. Wong's [1] recent scoping review found people walking with lower limb prostheses have significantly lower activity levels compared to the 10,000 steps generally recommended or the 6000 steps common in people with diabetes, however found no data along the recovery continuum. It is unknown if people walking with a new lower limb prosthesis increase their activity after they leave inpatient rehabilitation and return home.

AIM
To measure changes in daily step count in new lower limb prosthetic users at time of discharge from inpatient rehabilitation, and in the 12-week period post discharge into the community.

METHOD
All patients 18 years or older, who underwent first major (transtibial or higher) unilateral lower limb amputation and were prescribed their first prosthesis during inpatient rehabilitation, were identified. Participants wore an activPAL activity monitor for seven days to measure step count at four time points (one week prior to discharge from inpatient rehabilitation (T0), and at 2 (T1), 6 (T2), and 12 weeks (T3) post discharge from inpatient rehabilitation. Repeated measures ANOVA was performed to track step count over time.

RESULTS
Ten participants (90% male, 90% trans-tibial amputation level, 90% dysvascular aetiology) completed the study. Mean (SD) steps per day increased from 961 (514) at T0, to 1360 (1821) at T1, 1692 (2697) at T2 and 2245 (3007) at T3.

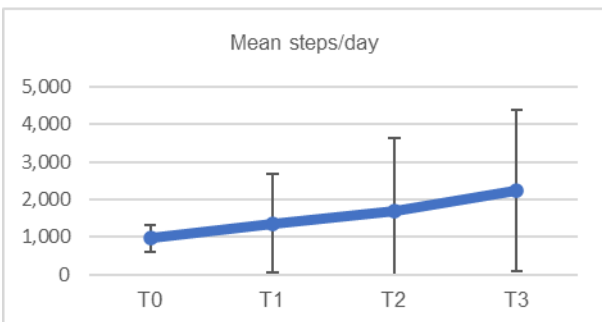

Figure 1. Comparison of steps per day

DISCUSSION AND CONCLUSION
Participants in this study took significantly fewer daily steps than previous studies (Wong 2021) and recommended activity levels, however these participants were new prosthetic users.

These results demonstrate that new unilateral lower limb prosthetic users are not very active when they leave hospital post inpatient rehabilitation. However, their activity gradually increases over the first three months that they are back at home.

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5.28.3 One-year analysis of demographics, clinical characteristics, and functional mobility level of bilateral lower limb amputees

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BACKGROUND
Bilateral (BL) amputation is complex and can take significant rehabilitation resources. For increased objectivity in the provision of care decisions, information about the population of bilateral amputation should be analyzed. In Latvia, there is significantly limited information available about the amputee population in the country. In prior research, data was used to analyze the population of general lower limb amputation patients who received prosthetic limbs in Latvia [1]. In this research, data was used to analyze the bilateral amputee population.

AIM
This study aims to analyze amputation characteristics and demographics of patients in Latvia with acquired bilateral amputation who received prosthetics from the National Assistive Device system in Latvia in 2019.

METHOD
Quantitative retrospective design. Data was collected from the National Assistive Device system in Latvia from the year 2019 patient information forms. Analyzed data: age, gender, amputation level, cause of amputation, mobility level (Bilateral amputee mobility predictor [2]), and use of assistive devices (AD), including use of lower limb prosthetics. Performed data analysis: descriptive statistics.

RESULTS
In Latvia, 45 BL (n=4 female) prostheses were received. The mean age was 58.62 years (SD 13 years). Bilateral amputation levels were: transtibial (TT) (n=22), transfemoral (TF) amputation (n=6), TT/TF combination (n=6), and 11 mixed amputation levels. Cause of amputation was trauma (n=32), vascular (n=12), and congenital (n=1). Mobility levels for BL amputees were: K1 (n=11), K2 (n=19), K3 (n=14), K4(n=0) cases. The most often used AD was a wheelchair (n=18, 8 patients were without prostheses and 10 were prosthetic users), crutches (n=10), cane (n=6), walking frame (n=1), and electrical wheelchair (n=1). In 9 (20%) cases, patients did not use any AD for ambulation in addition to the prostheses (from that TT amputation n=4). For bilateral TT amputees (n=22) in 9 cases, patients mostly used wheelchairs for ambulation, crutches (n=4), cane (n=3), walking frame (n=1), and scooter (n=1).

DISCUSSION AND CONCLUSION
Data from this study is important for understanding bilateral amputee profiles in the Latvian population. Research data showed that in Latvia patients with bilateral amputations most likely are men and with amputations caused by trauma. Despite receiving prosthetic treatment, patients still prefer to use wheelchairs in everyday life. Unfortunately, none of the bilateral patients reached the highest mobility level (K4 level). Further research is necessary to determine descriptors of the bilateral amputee population and rehabilitation outcomes in Latvia.

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5.28.4 AMPREDICT PROsthetics: predicting prosthesis mobility to aid in prosthesis prescription and rehabilitation planning

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BACKGROUND
The ability to ambulate after lower limb amputation is associated with higher levels of function and independence via improved self-care and mobility, quality of life, and employment success. The current paradigm for prescription of a lower limb prosthesis (LLP) is largely driven by “K-levels” which rely on clinicians to estimate future mobility based upon their clinical experience. Clinicians have expressed a significant lack of confidence in this system and their own ability to predict a LLP candidate’s future mobility.

AIM
To develop and validate a patient-specific multivariable prediction model that utilizes readily available predictors to predict 12-month mobility at the time of prosthesis prescription to assist in selecting a prosthesis that will match future demands and rehabilitation planning.

METHOD
Mixed-methods cohort study that identified patients retrospectively through a large U.S. Veteran’s Affairs (VA) dataset then prospectively collected their patient reported mobility. Veterans who underwent an incident transtibial or transfemoral amputation for chronic limb threatening ischemia and received a qualifying definitive LLP between March 1, 2018, and November 30, 2020 were approached through phone calls and mailings. A machine learning methodology was used for variable selection to predict four categories of mobility for the same patient: wheelchair, household, basic community, or advanced community using the Amputee Single Item Mobility Measure. The final model was validated internally with bootstrap sampling. As a sensitivity analysis, 10-fold cross validation was also performed.

RESULTS
Three hundred and fifty patients meeting study criteria agreed to participate. A total of 72 individuals (20.2%) reported AMPSIMM scores indicating wheelchair mobility, 63 (17.6%) household ambulation, 110 (30.8%) basic community ambulation, and 112 (31.4%) advanced community ambulation. Among transtibial amputees, this distribution was 52 (19.5%), 41 (15.4%), 73 (27.4%), and 100 (37.6%), respectively. Among transfemoral amputees, 20 (22.0%), 22 (24.2%), 37 (40.7%), and 12 (13.2%), respectively. The final model included 23 predictors across a wide range of domains including amputation level, time to prescription, age, body mass index, marital status, several comorbidities and mental health diagnoses and prior revascularization. The model effectively discriminated household ambulation from basic community ambulation and from advanced community ambulation – levels of key clinical importance when estimating future prosthesis demands.

DISCUSSION AND CONCLUSION
We have successfully developed the AMPREDICT PRO prediction model to be applied at the time of prosthesis prescription using predictors available in the medical record. This model will meet the perceived clinical need for assistance in determining future prosthesis mobility and the appropriate LLP to accomplish these goals. A more accurate prediction of mobility will assist the rehabilitation team in formulating appropriate rehabilitation goals and will improve the shaping of patient expectations.

5.28.5 50-Yard Dash and Biodex testing results in children affected by bilateral lower extremities Hemimelia

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BACKGROUND

Fibular and Tibial hemimelia are congenital limb deficiencies where the bone is partially or entirely missing resulting in shorter leg(s) and malfunctioning joint(s). In approximately 30% of cases, children are affected bilaterally and a common treatment is a bilateral amputation increasing their daily life potential.

AIM

This study aimed to evaluate the strength and running performance of adolescents affected with hemimelia that have undergone bilateral amputation in early childhood. A secondary goal was to analyse the association between self-reported function via a questionnaire and physical performance.

METHOD

11 participants (3 females,15.8±2.2 years) diagnosed with bilateral tibial and/or fibular hemimelia enrolled in a prospective IRB-approved research study. All amputations were recorded to have happened before they reached 2 years of age (16.0±21.9 months) and were either Symes or Transtibial amputations. Patients using their prostheses for at least a 12-week period prior to testing, completed the Pediatric Outcome Data Collection Instrument (PODCI) questionnaires, including Sports/Physical Functioning (SPF) and Global Functioning (GF) Scores. Participants were asked to perform bilateral isokinetic hip strength testing and a 50-yard dash. Mann-Whitney-U tests were performed to identify significant group differences, and Wilcoxon signed-ranks tests were performed to identify side-to-side differences in strength.

RESULTS

<u>SPF scores</u> varied between 44.7 to 90.2. Median was computed to 65.3 and used to divide *HIGH* (n=6) and *LOW* (n=3) SPF-Groups. Specifically, group strength significantly differed in **right hip Flexion** (p=0.020) and **extension** (p=0.020). (Table 1). <u>GF scores</u> varied between 60.5 to 81.4, and median was 74.0, used to create *HIGH* (n=5) *LOW* (n=4) GF-groups.

PODCI (Normative scores)		**Strength Testing** (Range of Motion Average normalized to Body Weight)															
		HIP FLEXION				HIP EXTENSION				HIP ABDUCTION				HIP ADDUCTION			
		Side-to-Side difference p=0.005				Side-to-Side difference p<0.001				Side-to-Side difference p=0.213				Side-to-Side difference p=0.520			
		LEFT		RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT		RIGHT	
SPF *Median* 65.3	**Average Scores**																
	HIGH: 90.2	76.0	p=0.180	**48.0**	p=0.020	64.3	p=0.297	**79.5**	p=0.020	55.4	p=0.101	61.5	p=0.710	71.2	p=0.18	66.8	p=0.710
	LOW: 44.7	36.5		**20.2**		102.9		**28.5**		27.6		41.3		52.6		39.4	
GF *Median* 74.0	HIGH: 81.4	87.3	p=0.053	**55.7**	p=0.014	114.4	p=0.830	**87.9**	p=0.014	**65.7**	p=0.021	**73.9**	p=0.014	75.6	p=0.149	**85.7**	p=0.027
	LOW: 60.5	35.1		**22.0**		62.5		**32.6**		**33.6**		**30.8**		48.6		**33.2**	
Hip Deficit (limb difference) in GF Group (%)		% -0.38±0.29				% -0.74±0.72				% 0.18±0.37				**% -0.15±0.51 (p=0.021)**			

Table1.1 Strength testing versus PODCI results (grey boxes represent significant results)

PODCI (Normative scores)		**50-yard dash** **Average Velocity** (yard/sec)	
SPF *Median 72.2*	**Average Scores**		
	HIGH: 89.0	**4.8**	p=0.018
	LOW: 54.2	**2.3**	
GF *Median* 74.0	HIGH: 79.8	**5.2**	p=0.047
	LOW: 67.4	**2.8**	

Table1.2 50-yard dash versus SPF results (grey boxes represent significant results)

A significant difference in hip strength between *HIGH*- and *LOW* GF-groups was found, specifically, in **right flexion** (p=0.014), **extension** (p=0.014), **adduction** (p=0.027), and **bilateral abduction** (Left p=0.021, Right p=0.014). Hip **Adduction strength deficit** was also noted to be significant (p=0.021). <u>Side-to-side differences</u> in **both hip flexion** (p=0.005) and **extension** (p<0.001) strength were observed. <u>50-yard dash velocity</u> exhibited differences in the *Sports/Physical Functioning (SPF) scores in HIGH* (n=5) versus *LOW* (n=6) groups (p=0.018), as well as *Global Functioning (GF)* scores in *HIGH* (n=5) vs *LOW* (n=5) groups (p=0.047) (Table 1.2)

DISCUSSION AND CONCLUSION

Both SPF- and GF-related differences in strength and 50-yard dash performance indicate that self-reported function via the PODCI is a good indicator of physical performance in bilateral hemimelia pediatric amputees. To the author's knowledge, this is the first time that Pediatric Outcome Data Collection Instrument (PODCI) SPF- and GF- domains were compared to isokinetic strength and 50-yard dash testings in bilateral hemimelia children.

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Free paper session: Prosthetics: Upper limb -Various topics

5.29.1 Gamified exercises and surface electromyography for rehabilitation in individuals with upper limb impairment

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BACKGROUND

Life-changing neurological injuries lead to devastating impacts on patients' function, independence, and quality of life. Individuals with spinal cord, traumatic brain, and peripheral nerve injuries, or stroke frequently experience severe muscle weakness and require rehabilitation to maximize strength and functional recovery. Standard therapy is not fully initiated until muscles are strong enough to achieve visible movement, resulting in delayed therapy and missing the critical window for recovery that may never be regained.

AIM

Our aim was to develop an interactive therapeutic gaming platform using surface electromyography (sEMG) to provide individuals with upper limb impairment with a biofeedback-based therapeutic option, sensitive enough to use soon after injury and simple enough to use at home.

METHOD

A highly sensitive, low-cost sensor measured electrical signals generated during muscle activation via noninvasive electrodes placed on the skin surface overlying the muscle of interest. A mobile app was designed to provide visual confirmation of muscle activity even if no visible muscle or limb movement was present. The mobile app translated the raw sEMG signals into input for gameplay. Because each patient's exercise and therapy needs are different due to injury type and varying strength, endurance, and muscle activation control, these parameters for the exercise game can be customized for each patient.

RESULTS

An exercise game in a mobile app was developed that requires the user to break plates using a slingshot and a ball (Figure 1). The ball is flung to break the plates when the user activates their muscle as measured by the sEMG sensor. Different exercise types were created that focus on muscle bursts (quick repetitions) and holds (endurance). The exercises can be customized to the number of sets, number of target plates (repetitions), and duration of muscle activation required to activate the slingshot. Through this exergaming option, the users were engaged and motivated during the exercises by providing biofeedback and a gamified approach to rehabilitation.

Figure 1. sEMG exercise game

DISCUSSION AND CONCLUSION

Motivation and interest are essential in maintaining adherence to therapeutic interventions over the long course of recovery, and adherence to standard rehabilitation therapy is generally poor. Therapeutic gaming at home with a low-cost sEMG sensor and mobile app can encourage individuals to complete their rehabilitation and have better outcomes [1].

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5.29.2 Outcomes of upper limb press fit osseointegration

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BACKGROUND
Upper extremity amputations are associated with the most severe traumatic injuries. Bilateral upper extremity amputations are rare and are often the result of blast injuries. Osseointegrated (OI) reconstruction of the upper limbs is an option for amputees who are unable to use prosthetics due to socket-related problems, by directly attaching the prosthesis to the skeletal residuum.

AIM
Our aim was to study the indications and outcomes following osseointegrated reconstruction in upper limb amputees.

METHOD
A retrospective review of our osseointegration registry identifying patients who have undergone an upper limb osseointegration reconstruction from 2014 - 2019. Analysis was performed of their causes of amputations, preoperative and postoperative outcomes, and complications.

RESULTS
A total of 24 patients underwent 26 upper limb osseointegrated reconstructions. Two patients had bilateral OI, 23 transhumeral and 3 transradial amputations, average age of 50 years (range of 20-67 years). This study cohort had 22 male and 2 female patients. Twenty-five and these patients had single stage and 1 patient had two stage OI reconstruction. All 24 patients had amputations related to trauma - 16 were acute traumatic amputations, and the other 8 were all secondary to trauma; blast injury in 4 patients, electrocution and brachial plexus injuries in 2 patients each. 12 patients sustained military blast, combat related, or military service-related traumatic injuries and surgery was generally performed on humanitarian grounds. The average length of follow up was 1.9 years (range of 6 months to 6 years). Major complications: mortality - 0; deep infection necessitating removal of implant – 1

DISCUSSION AND CONCLUSION
We identified 26 osseointegrated reconstructions performed for upper limb amputations. Acute traumatic amputation was the main cause in 16 patients. Two patients had bilateral surgeries. Single case of loosening related to deep infection required explant. We recommend the use of this novel technology (osseointegration) in selected patients after upper limb amputations, for those amputees unable to use a prosthetic limb due to socket – residuum interface problems.

5.29.3 Evaluating the reliability of a shape capturing process for transradial residual limb using a non-contact scanner

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BACKGROUND
Advancements in digital imaging technologies hold the potential to transform prosthetic and orthotic practices. Non-contact optical scanners can capture the shape of the residual limb quickly, accurately, and reliably. However, their suitability in clinical practice, particularly for the transradial (below-elbow) residual limb, is unknown.

AIM
This project aimed to evaluate the reliability of an optical scanner-based shape capture process for transradial residual limbs related to volumetric measurements and shape assessment in a clinical setting.

METHOD
A dedicated setup for digitally shape capturing transradial residual limbs was developed, addressing challenges with scanning of small residual limb size and aspects such as positioning and patient movement. Two observers performed three measurements each on 15 participants with transradial-level limb absence. Interclass correlation coefficients (ICC) were calculated to assess intra- and inter-rater reliability of the digital scanning process in terms of volumetric measurements, as well as the overall Medial-Lateral and Anterior-Posterior measurement of each scanned model. A threshold of ICC > 0.90 was selected for the level of reliability. In addition, Bland–Altman plots were used to assess the agreement between observers.

RESULTS
Overall, the developed shape capture process was found to be highly repeatable. The assessment of reliability showed high levels of intra- and inter-rater reliability on volume measurements, with all ICCs ranging from 0.998 to 0.999. Bland–Altman plots of the reliability analysis demonstrated good agreement within and between observers. Regarding the shape measurement, there were high levels of intra- and inter-rater reliability on the overall M-L measurement of the residuum model, with all ICCs ranging from 0.991 to 0.996. ICCs for the overall A-P measurement of the model ranged from 0.918 to 0.946, but their 95% CIs ranged between 0.832 and 0.980, that is, the lower bound of the CIs was lower than the selected threshold.

DISCUSSION AND CONCLUSION
This paper uniquely evaluated the reliability of a digital shape capture process for transradial residual limbs based on direct scans of the limb. The results indicate that transradial limb scans can be acquired reliably, and on par with static models. This study demonstrated the feasibility of using non-contact scanners for the quantification of the shape and volume of transradial residual limbs, and possibly for the design and fabrication of prosthetic sockets and devices.

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5.29.4 Prosthetic care for upper limb amputees at the CRAORF in Mopti.

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BACKGROUND
Mali is now affected by regular attacks and other security incidents led by unidentified armed groups, particularly in the center and north of the country, which lead to a large number of people with disabilities. The determinants of a good social reintegration of these people are not yet clearly established, but one part would be the prosthetisation of upper limb amputees.

AIM
Evaluate the quality of the prosthetisation of amputees fitted with the upper limb prosthesis at the Regional Center for Orthopedic Equipment and Functional Rehabilitation (CRAORF) in Mopti; evaluate their satisfaction according to the expectations indicated on the prescription and identify the determinants of this social reintegration.

METHOD
This is a study, using open and closed structure questionnaires, on the prosthetic care of upper limb amputees received at the CRAORF, all ages, of 30 beneficiaries of the orthopaedic reintegration package (PRP / CICR) residing in central and northern Mali.

RESULTS
In this study, a strong representation of the male sex over the female sex was observed (89%/11%). In addition, a high number of subjects with a level of trans-brachial amputation was observed. Regarding the distribution according to the causes of amputation, our results show that most amputations are traumatic causes, directly and/or indirectly linked to conflicts (armed, inter-ethnic, etc.).

DISCUSSION AND CONCLUSION
A better understanding of the factors underlying the prosthetisation of upper limb amputees remains the key to better oriented interventions in their favour.

ACKNOWLEDGEMENTS: Regional Center for Orthopedic Equipment and Functional Rehabilitation of Mopti (CRAORF); International Committee of the Red Cross, Mali

5.29.5 Rehabilitation after upper limb amputation: toward the development of guidelines

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BACKGROUND
One in seven or 15% of the world's population live with a disability [1]. Upper limb loss has been reported to range from 1.2 to 4.4 per 10 000 people to 11.6 per 100 000 [2, 3]. Rehabilitation guidelines ensures that an amputee's needs on all levels are taken into consideration whilst allowing a consistent approach from surgery through to lifelong skills. Currently there is no clinical guideline available that specifically addresses treatment for upper limb loss rehabilitation.

AIM
Provide a cohesive clinical guideline for upper limb amputation that ensures clinicians and users to experience safe and effective standard rehabilitation pathway to support their individual rehabilitation.

METHOD
A literature review was undertaken as part of the OneHand Project funded by the European Union's Horizon 2020 research and innovation programme. We reviewed evidence-based as well as grey literature. An expert panel consisting of therapists and amputees globally provided feedback while the guidelines were formulated.

RESULTS
As a result of the literature review and expert feedback, the guidelines have been separated into key phases that include acute or postsurgical, subacute or pre-prosthetic training, basic prosthetic training and advanced long-term rehabilitation or ongoing care. These phases outline key personnel to be involved at each stage, as well as key elements that will ideally be included for each phase. Alongside these guidelines are key resources to support the amputee along their rehabilitation journey. These include frequently asked questions (FAQs) for upper limb amputees and regularly used rehabilitation exercises for each level of upper limb amputation.

DISCUSSION AND CONCLUSION
The next phase of development of these guidelines will be to engage more widely with all stakeholders including the ISPO communities of interest. We anticipate that this final stage of the preparation will ensure that these guidelines can be utilised by rehabilitation teams both in low income to high income countries to encourage safe and efficient access to services globally.

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Free paper session: Telehealth and mobile services

5.30.1 Consumer experiences and satisfaction with orthotic/prosthetic telehealth services – a qualitative and quantitative pilot study

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BACKGROUND
Telehealth is one innovative model of service delivery that may help improve access given the growing demand for orthotic/prosthetic (O&P) services. Telehealth has been widely used in recent years to minimise the transmission of SARS-CoV-2 (COVID-19). There is limited evidence about which O&P services were provided via telehealth, to whom, and what the consumer experience and satisfaction was with those services.

AIM
To describe the population receiving O&P services via telehealth in Australia, the types of services provided, and the consumer experience and satisfaction.

METHOD
Participants were O&P users ≥ 18 years of age (adult subgroup) or parent/guardian of children O&P < 18 years of age (parent/guardian subgroup). Participants were convenience sampled following a recent O&P telehealth service. An online survey included: demographic questions, Telehealth Usability Questionnaire (TUQ) [1], and Orthotic Prosthetic Users Survey – Satisfaction with Services Module (OPUS-SSM) [2]. Survey respondents were invited to participate in a semi-structured interview to learn more about their experience and satisfaction. Demographic data were analysed using descriptive statistics. OPUS-SS and TUQ data were analysed according to the instrument’s instructions. An inductive approach was used to identify themes describing the consumer experiences and satisfaction.

RESULTS
Most participants (12 adult subgroup, 3 parent/guardian subgroup) were female (60%) adults between 30-59 years of age (59%) who lived in major cities (40%) or inner-regional centres (47%). Most participants chose telehealth given the distance to the O&P service (40%), irrespective of whether they lived in metropolitan cities or regional areas. Most telehealth services were for routine- (27%) or unscheduled-reviews (40%). Based on the TUQ, participants were satisfied with the telehealth system (5.9/7) given its usefulness (6.1/7), ease of use (6.0/7), effectiveness (5.8/7), and reliability (4.5/7). Participants were highly satisfied with the orthotic/prosthetic services they received (OPUS-SSM T-score = 74.6±23.3). Satisfaction was underpinned by high-quality interpersonal interactions, agency and control over the choice to use telehealth, and a high degree of health literacy.

DISCUSSION AND CONCLUSION
While O&P users were highly satisfied with the telehealth mode, technical issues affected reliability and detracted from the user experience. Many of these issues could be addressed with thoughtful planning that included scheduling appointments. Interviews highlighted the importance of high-quality interpersonal communication, agency and control over the decision to use telehealth, and a degree of health literacy from a lived experience of using an orthosis/prosthesis.

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5.30.2 Exploration of the barriers and facilitators influencing use of telehealth for orthotic/prosthetic services in the United Stated of America.

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BACKGROUND
Telehealth may help meet the growing demand for orthotic/prosthetic (O&P) services; particularly for underserved communities. While telehealth is often synonymous with video conferencing, there are many modes including: phone calls, emails, text messages, photo sharing. Understanding of the complex barriers and facilitators that influence the use of telehealth is important to improve access to O&P services via telehealth, and the effectiveness of those services.

AIM
To explore the orthotist/prosthetist's perspective of the barriers and facilitators influencing use of telehealth in the United States of America (USA).

METHOD
Participants were certified orthotists and/or prosthetists who were purposefully sampled through the American Board for Certification in Orthotics, Prosthetics & Pedorthics. In-depth, semi-structured interviews explored the services being provided using telehealth, and the barriers and facilitators influencing use of telehealth in the USA. Data describing participant and service demographics were summarised using descriptive statistics appropriate to the data type. Interviews were transcribed verbatim and analysed using an inductive approach to derive themes that were supported by illustrative first-person quotes.

RESULTS
Participants (n=30, 16M:14F, mean age 47.7 years) had an average of 19.8 years of experience and were employed at a diverse range of service providers across the USA. Services were delivered using a range of telehealth modes including: video, phone call, text messages, emails and postal services. Of these modes, video conferencing was used for the most diverse range of clinical activities: multi-disciplinary consultations, trouble-shooting, routine follow-up, accessing specialist support, and preliminary screening. Barriers to providing O&P services using telehealth included: poor phone/internet connection and lack of access to technology; lack of capability or support; and the impact of poor-quality systems, communication, attitude, and patient knowledge of healthcare. Facilitators to using telehealth to provide O&P services included: excellent communication and interpersonal skills; a patient-focused attitude; and recognition of the benefit of telehealth services to those involved.

DISCUSSION AND CONCLUSION
The barriers and facilitators to telehealth can be considered on a spectrum from 'essential' through to 'value-adds'. For example, it is essential that people have access to the necessary technology and a reliable phone/internet connection. At the other end of the spectrum, a satisfactory O&P service delivered by telehealth can become exceptional in the presence of value-adds such as excellent communication and interpersonal skills, a patient-focused attitude, and a genuine belief in the benefits of a telehealth service.

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5.30.3 Do UK prosthetists and orthotists have adequate guidelines and training to provide telehealth patient consultations?

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BACKGROUND
The COVID-19 pandemic caused a rapid transition to remote consultations and services may have been unprepared for telehealth implementation. The UK National Health Service (NHS) was undergoing digital transformation prior to the pandemic, but the transformation was slow. Healthcare systems needed to develop policies and training to move to a new model of care delivery, however, some of these requirements may have been bypassed during the pandemic.

AIM
The aim of this study was to explore the UK prosthetic and orthotic services' organisational telehealth readiness, focusing on guideline implementation and staff training, through the perspectives of NHS prosthetists and orthotists.

METHOD
A cross-sectional online survey exploring available telehealth guidelines and staff training was distributed among prosthetists and orthotists and prosthetic and orthotic service managers between May and June 2021. The survey covered questions related to telehealth implementation, financial, and technical considerations and was developed based on the findings of our previous scoping review [1]. This study focuses on the survey sections related to available telehealth guidelines for clinicians and telehealth consultation training for clinicians. Data were analysed using SPSS. After classifying participants based on their role (clinician or manager), descriptive statistics were computed for the two groups. All variables were presented as frequencies and corresponding percentages.

RESULTS
Responses were received from 51 orthotists and 4 prosthetists. A breakdown of the types of consultations for which telehealth was used is provided in Figure 1. Most clinicians (91%) who responded were using telehealth consultations. Just over half of the clinicians (52%) stated that their service had implemented telehealth guidelines, with the guidelines predominantly produced by their NHS trust (37%) or their professional body (23%). Regarding the quality of the guidelines, some respondents stated that they had areas of ambiguity (33%) and that they lacked detail in certain areas (24%). Most clinicians reported that they had not received training in all telehealth aspects listed and many considered training on how to deal with an emergency during a telehealth consultation (67%) and how to conduct a risk assessment (45%) was needed.

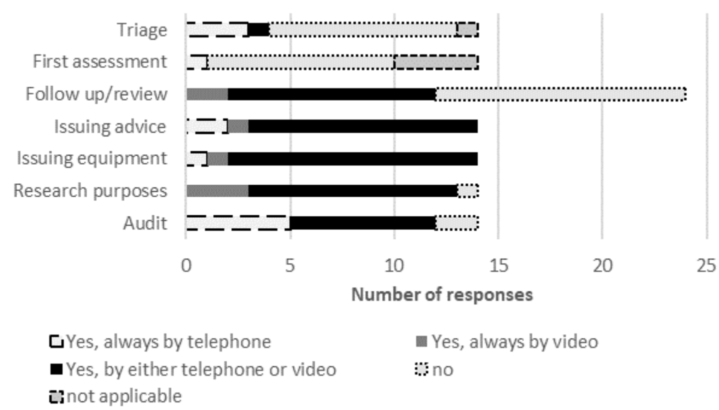

Figure 1. Types of consultations for which telehealth was used.

DISCUSSION AND CONCLUSION
The areas of the most ambiguity/lack of information identified were how the clinician is protected from litigation should a telehealth consultation go wrong and how to deal with an emergency during a telehealth consultation. Nationally accepted guidelines for telehealth consultations are needed, with collaboration required between the NHS and professional bodies. Training should include not only technical but also practical skills in telehealth consultations.

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ACKNOWLEDGEMENTS The project was funded by Public Health England (PHE) through the British Association of Prosthetists and Orthotists (BAPO) (reference: 6719098).

5.30.4 Prediction of the functionality and step activity of transtibial and transfemoral amputees via telehealth: a preliminary study

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BACKGROUND

The rise of the COVID-19 pandemic and social distancing measures have hindered routine hospital check-ups for patients, revealing the need for telehealth development. Individuals with lower limb amputation are one of the most influenced groups in this pandemic. After long-term inactivity, the prostheses may become unfit for their residual limbs and mobility will be lost gradually. Therefore, simple tools enabling clinicians to remotely assess patients' functionality and physical activity are crucial.

AIM

To predict the functionality and step activity of transtibial and transfemoral amputees using easily obtainable patient-reported outcome measurements to identify patients with higher risks of losing independence and walking ability under conditions where face-to-face contact is impracticable.

METHOD

We obtained data on questionnaires (PHQ9, SF36, PEQ), demographics, 6-minute walk test (6MWT), and step activity for at least 25 days from 22 amputees (13 transfemoral and 9 transtibial) between October 2021 and August 2022. Among 22 participants, 15 are males and 7 are females (mean ± standard deviation: age 54.9 ± 9.7 years, body mass 72.1 ± 15.3 kg, height 168.7 ± 9.3 cm). Multi-linear regressions were conducted to predict the results of 6MWT and step activity respectively by questionnaires and demographic data using SPSS. All variables were tested on assumptions and violated variables were excluded.

RESULTS

After the exclusion of invalid variables, only specific parts of SF36 and PEQ contributed to the prediction model. The goodness of fit (adjusted R^2) of step per day (SPD) and 6MWT prediction model was 0.909 and 0.863 respectively. Predictors encompassed emotional perspectives, physical health status, and mental well-being. As shown in Table 1 and 2, common significant predictors of SPD and 6MWT included 'Role limitation due to physical health' (SPD: β = -0.412, P =0.053; 6MWT: β = -0.877, P < 0.001), 'Frustration' (SPD: β = -1.795, P < 0.001; 6MWT: β = -1.538, P < 0.001), and 'Wellbeing' (SPD: β = 0.896, P = 0.011; 6MWT: β = -2.017, P = 0.001).

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	-1676.265	1651.756		-1.015	.344		
SF36-Role limitation due to physical health	-20.764	8.950	-.412	-2.320	.053	.206	4.851
SF36-Role limitation due to emotional problem	-56.934	10.092	-1.144	-5.642	.001	.158	6.317
SF36-Emotional wellbeing	-51.018	26.778	-.521	-1.905	.098	.087	11.479
SF36-Social functioning	41.132	20.620	.457	1.995	.086	.124	8.070
SF36-Pain	73.574	11.952	1.001	6.156	.000	.246	4.061
SF36-General Health	32.312	15.895	.319	2.033	.082	.264	3.792
SF36-Energy fatigue	112.018	34.935	1.161	3.206	.015	.050	20.128
PEQ-Appearance	-45.583	20.541	-.546	-2.219	.062	.107	9.306
PEQ-Frustration	-124.263	19.745	-1.795	-6.293	.000	.080	12.506
PEQ-Wellbeing	58.479	16.940	.896	3.452	.011	.097	10.355
PEQ-Tansfers	70.043	27.917	.607	2.509	.040	.111	8.997
PEQ-Utility	47.425	26.909	.562	1.762	.121	.064	15.598
PEQ-Social burden	-20.912	11.849	-.246	-1.765	.121	.335	2.983
PEQ-Ambulation	-34.999	27.804	-.404	-1.259	.248	.063	15.822
a. Dependent Variable: Step per day							

Table 1. Results of daily step activity prediction model.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-298.980	76.119		-3.928	.004
PEQ-Ambulation	2.122	.556	.534	3.819	.005
PEQ-Frustration	-4.882	.730	-1.538	-6.691	.000
PEQ-Perceived_response	6.387	1.036	1.587	6.164	.000
PEQ-Residue limb health	-2.502	.488	-.553	-5.122	.001
PEQ-Sounds	2.936	.570	.993	5.146	.001
PEQ-Wellbeing	-6.037	1.123	-2.017	-5.376	.001
SF36-Physical function	4.400	.490	1.243	8.974	.000
SF36-Role limitation due to physical health	-2.026	.309	-.877	-6.556	.000
SF36-Role limitation due to emotional problem	-1.675	.378	-.734	-4.434	.002
SF36-Emotional wellbeing	2.382	.676	.530	3.525	.008
SF36-Social functioning	1.497	.609	.363	2.459	.039
SF36-General health	4.028	.627	.868	6.426	.000
SF36-Health change	2.337	.507	.612	4.608	.002
a. Dependent Variable: 6MWT					

Table 2. Results of 6MWT prediction model.

DISCUSSION AND CONCLUSION

The 6MWT and step activity, which indicate ambulation endurance and physical activity level, may be accurately predicted by the scores of specific sections of SF36 and PEQ such as 'Frustration' and 'Wellbeing'. Even amid situations where face-to-face check-ups are not allowed, medical institutions may still monitor the physical and mental health of patients and predict their functionality by regularly collecting questionnaire data. Interventions should be given to high-risk groups before the patients lose ambulation ability permanently.

Free paper session: Prosthetics: Lower limb - Osseointegration gait and biomechanics

5.31.1 Transfemoral bone-anchored prostheses: load applied on osseointegrated implant by state-of-the-art knees

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BACKGROUND

Efficacy and safety of surgical implantation of osseointegrated fixations are confounded by the fitting of bone-anchored prostheses (BAP) during rehabilitation and beyond [1]. Microprocessor-controlled knees are commonly prescribed as they can increase stability and walking capacity, attenuate excessive daily loading and reduce risks of falls [2]. Evidence confirming the biomechanical advantages of state-of-the-art components is emerging [3, 4]. A deeper understanding of loading profile applied by BAP fitted with several state-of-the-art components during daily activities is needed.

AIM

This study (A) presents the load profile applied by transfemoral BAP fitted with the Power Knee (ÖSSUR), and (B) compares the loading boundaries applied by Power Knee, Total Knee (ÖSSUR) and Rheo Knee (ÖSSUR) during daily activities and a fall.

METHOD

This cross-sectional cohort study included 20 participants fitted with a press-fit transfemoral osseointegrated implant (4F/16M, 59±14 yrs, 1.74±0.10 m, 89.04±17.20 kg). Loading datasets were measured with the tri-axial transducer (iPecsLab, RTC Electronics, USA) fitted between the implant and the knee unit.

RESULTS

We analysed 2,155 steps. The cadence ranged between 33±8 and 48±11 strides/min. The resultants and the components of the average absolute maximum of forces and moments applied on and around the long, anteroposterior and mediolateral axes of the implant across all activities were 99±10%BW, 98±10%BW, 18±6%BW, and 9±3%BW as well as 5.5±1.4%BWm, 0.9±0.3%BWm, 3.1±1.1%BWm, and 4.6±1.7%BWm, respectively. The resultant loading boundaries for the forces and moments applied by Power Knee were comparable to those applied by Total Knee and Rheo Knee during daily activities and noticeably smaller to those applied during a fall (Figure 1). The outcomes suggest that the BAP considered can restore ambulation safely and effectively whilst applying relevant loads at the interface with the osseointegrated implant.

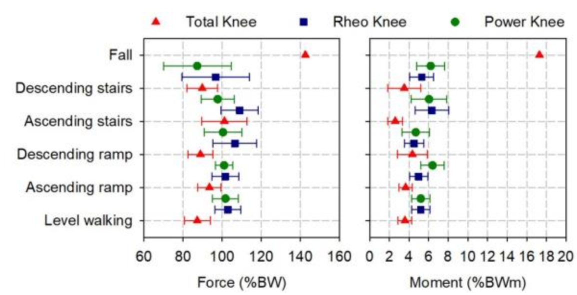

Figure 1: Overview resultants of loading boundaries.

DISCUSSION AND CONCLUSION

New benchmark loading data applied by transfemoral BAP fitted with selected state-of-the-art components were shared. This study contributed to systematic recording, analysis, and reporting of ecological prosthetic loading profiles applied by lower limb BAP. Furthermore, this work contributed to closing the evidence gaps between prescription and biomechanical benefits of state-of-the-art BAP components. Hopefully, this will contribute to improve safety and efficacy of bionic solutions becoming available to the growing number of individuals with limb loss worldwide.

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ACKNOWLEDGEMENTS This study was founded by ÖSSUR, Iceland in collaboration with APC, and YourResearchProject, Australia.

5.31.2 Margin of safety of load applied by transfemoral bone-anchored prostheses fitted with state-of-the-art components

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BACKGROUND
Transfemoral bone-anchored prostheses (BAP) fitted with microprocessor-controlled knees (MPKs) can contribute to increase efficacy and safety of osseointegrated implants (e.g., auto adaptive stance and swing control, stumble recovery, push off functions) [1]. Preliminary studies showed that loading boundaries applied by BAP fitted with selected basic and state-of-the-art components during standardized daily activities were significantly smaller than the ones applied during a fall [2-4]. There is a need for more quantitative evaluations of the safety of BAP fitted with state-of-the-art components.

AIM
This study tested the hypothesis that the regular load applied of osseointegrated implant by BAP fitted with Power Knee (ÖSSUR, Iceland) have a margin of safety unlikely to compromise healthy bone/implant coupling.

METHOD
Twenty participants fitted with a press-fit transfemoral osseointegrated implant participated in this study (4F/16M, 59±14 yrs, 1.74±0.10 m, 89.04±17.20 kg). Loading boundaries were measured during walking, ascending and descending ramp and stairs at self-selected pace with the tri-axial transducer (iPecsLab, RTC Electronics, USA). Maximum loads were conservatively extracted from a study reporting internal constraints applied on femur of able-bodied during running [5]. Factor (FoS) and margin (MoS) of safety were calculated for forces (F) and moments (M) applied on long (LG), anteroposterior (AP) and mediolateral (ML) axes expressed as percentage of bodyweight (BW). A MoS≥3 was deemed unlikely to compromise the integrity of bone/implant coupling.

RESULTS
The overall minimum and maximum load applied on the implant across all activities (2,155 steps) ranged between -305 N and 1,258 N or -32 %BW and 147 %BW on FLG, -331 N and 224 N or -47 %BW and 25 %BW on FAP and -47 N and 234 N or -6 %BW and 21 %BW on FML as well as -17 Nm and 19 Nm or -2.2 %BWm and 2.0 %BWm on MLG, -74 Nm and 20 Nm or -6.6 %BWm and 2.0 %BWm on MAP-82 Nm and 91 Nm or -10.3 %BWm and 9.9 %BWm on MML, respectively. As detailed in Table 1, the MoS across all forces and moments ranged between 3.78 and 17.62.

Table 1: Factor of safety ([High impact load / absolute maximum load measured across all activities]-1) of load applied by Power Knee.

	Edwards et al (2008)		Power Knee		
	Mean	SD	Mean	SD	MoS
FLG (%BW)	984.00	67.00	98.35	10.01	9.00
FAP (%BW)	103.00	9.00	17.94	5.80	4.74
FML (%BW)	152.00	16.00	8.76	3.41	16.35
MLG (%BWm)	16.00	1.00	0.86	0.34	17.61
MAP (%BWm)	31.00	2.00	3.09	1.07	9.03
MML (%BWm)	22.00	3.00	4.60	1.66	3.78

DISCUSSION AND CONCLUSION
The MoF>3 of the loads confirmed the hypothesis that the regular daily usage of the BAP considered could hardly be held responsible for mechanical damages, let alone catastrophic failures, of healthy bone/implant coupling. More work is needed to assess the MoF considering the load required to create periprosthetic fractures and breakage of implant's parts. This work was a worthwhile contribution toward innovative designs of bone/implant interfaces and bionic components capable of tolerating high impact activities currently contraindicated.

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ACKNOWLEDGEMENTS This study was founded by ÖSSUR, Iceland in collaboration with APC, and YourResearchProject, Australia.

5.31.3 Comparison of two treatment options: socket fitting and transcutaneous osseointegrated prosthesis systems for transfemoral amputees

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BACKGROUND

The standard treatment for patients with transfemoral amputation is still the conventional socket. The socket causes problems during wear, such as skin irritation and pressure ulcers, in nearly half of the patients, especially in short stumps [1, 2]. Transcutaneous osseointegrated prosthesis systems (TOPS) have been an alternative for almost 30 years now when indicated.

AIM

The aim of this study was to compare the two treatment options for transfemoral amputees with regard to gait pattern, development of osteoarthritis in the hip joint and patient satisfaction.

METHOD

A total of thirty-seven unilateral transfemoral amputees (17 socket, 20 TOPS) were included. A motion analysis was performed with the subjects at a self-selected speed in the plane. In addition, the Six Minute Walk Test (6MWT) and Timed Up & Go (TUG) were conducted. An MRI of the lower extremity was done on the same day of the examination. The questionnaires SF36 and Q-TFA were used to assess the mobility and satisfaction of the subjects.

RESULTS

Radiological evaluation of the MRI scan revealed signs of osteoarthritis in the contralateral hip joint in 50% and in 59% of the TOPS and socket-supplied subjects, respectively. On the amputated side, osteoarthritis was evident in 65% of the TOPS-supplied subjects and in 88% of the socket-supplied subjects. In the questionnaires SF36 and Q-TFA used, no significant difference was found in any of the subscores or sum scores between the two groups. We also saw no significant difference in the two tests 6MWT and TUG. Only in the temporary gait parameter step width we found a significant difference ($p=0.001$). The step width in TOPS was 0.24±0.04m and in the socket group 0.19±0.04m.

DISCUSSION AND CONCLUSION

The propagated advantages due to the direct coupling of the prosthesis with TOPS compared to the socket could not be shown in this study. We have found only few differences in the studied parameters. Mobile patients with a good socket fitting are on a similar high level regarding their mobility and quality of life. However, there were large individual differences within the groups, so that the outcome does not appear to be primarily dependent on the type of treatment.

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ACKNOWLEDGEMENTS This study was financed by the Deutsche Forschungsgemeinschaft (DFG- WE4827/3-1)

5.31.4 Cortical rhythm changes when walking with a transfemoral prosthesis; differences between socket suspended or bone-anchored

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BACKGROUND

After transfemoral amputation (TFA), patients must adapt to walking with a socket-suspended prosthesis (SSP). Previous research [1] demonstrated that initial adaptation to walking with a prosthesis is reflected in changes of cortical rhythms in the frontal-central and parietal cortex. However it is unclear whether these altered cortical activation patterns persist in experienced prosthetic walkers and if so, whether different suspensions (SSP or bone-anchored prosthesis (BAP)) may influence these activation patterns.

AIM

To identify differences in cortical rhythms between able-bodied (AB) persons and persons with TFA, and between persons using an SSP and persons using an BAP during walking.

METHOD

Highly-active AB, and experienced transfemoral SSP- and BAP-users were recruited. Participants walked at their preferred speed on a treadmill (200 steps), while high-density EEG was recorded (128 channels). Independent component analysis was used to separate brain- and non-brain-related independent components in the EEG. The activity of the brain related components was segmented into gait cycles and analysed in the time-frequency domain to reveal relative enhancement or suppression of intrinsic cortical rhythms. Preliminary result regarding the frontal-central and parietal cortex will be discussed below.

RESULTS

We included 18 AB persons (age: 55±10years) 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). Preliminary results of the frontal-central cortex show decreased beta power in the TFA group before heel strikes. The power decreases around heel strike with the prosthetic limb (HsP) seem more prominently present in BAP than SSP users. Further, just before HsP decreased theta and alpha power is shown for TFA and decreased beta power ifor AB. In the parietal cortex, the TFA group and AB groups both show a decrease in theta and beta power around heel strike. For SSP users, this power decrease can mainly be found around heel strike with the intact limb, whereas in the BAP users this is mainly observed around HsP.

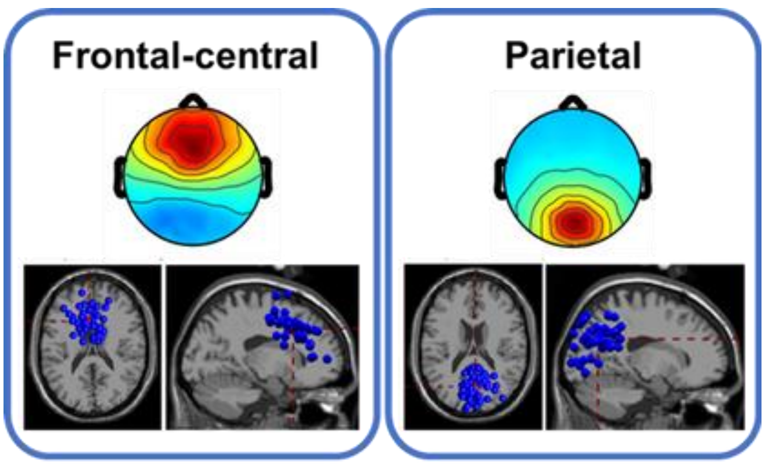

Figure 1: Scalp projections en dipole locations of the frontal-central and parietal cluster.

DISCUSSION AND CONCLUSION

These preliminary results suggest increased cognitive top-down control and sensorimotor integration in people with TFA. This seems to be more focused around the prosthetic heel strike for BAP and more around intact heel strike for SSP. Final analyses will be available at the time of the conference.

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ACKNOWLEDGEMENTS The work was supported by ERC-H2020 Project MyLeg (#780871).

5.31.5 Comparison of Cognitive Load in Prosthesis Users with a Transfemoral Bone-anchored versus a socket-suspended prosthesis

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BACKGROUND
When compared to people using a socket-suspended prosthesis, persons using a bone-anchored device experience an increased feeling of their prosthesis being part of their body [1]. Moreover, an improved ability to detect vibrations through the bone-anchored prosthesis as compared to the socket-suspended device have been reported [2]. It is not clear if these benefits are associated with a decrease in cognitive load during walking.

AIM
To compare cognitive load in level walking for trans-femoral prosthesis users with a bone-anchored prosthesis versus a socket-suspended device.

METHOD
This cross-sectional study involved 16 persons with a unilateral transfemoral amputation. Eight used a bone-anchored prosthesis (1 woman, 7 men, mean age 52 years) and were matched in relation to sex, age and height with 8 people who used a socket-suspended device. Both groups used microprocessor-controlled prosthetic knees (MPK). Functional near-infrared spectroscopy (fNIRS) was used to estimate cognitive load by measuring the relative concentration of oxygenated haemoglobin (oxyHb) in the dorso-lateral pre-frontal cortex of the brain during level walking. Temporospatial gait variables were also recorded.

RESULTS
Figure 1 presents average oxyHb data for both groups. As can be seen on this graph, no group had consistently higher or lower levels of oxyHb. This suggests that there is little difference in cognitive load when comparing the group with bone-anchored prostheses and the group with socket-suspended prostheses during level walking. Temporospatial data suggests however that the group with bone-anchored prostheses walked significantly faster than those with a socket-suspended prosthesis ($p<0.05$).

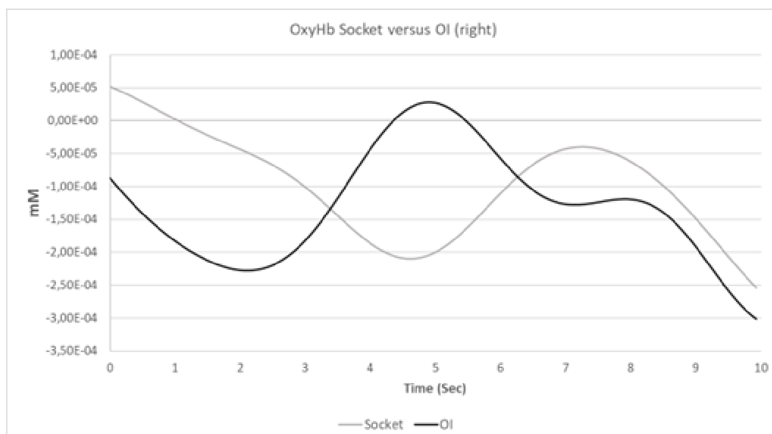

Figure 1. Mean oxyHb for the group using bone anchored prostheses (black) versus socket-suspended prostheses (grey)

DISCUSSION AND CONCLUSION
Results revealed similar patterns of brain activity in persons with a bone-anchored prosthesis and those with a socket-suspended prostheses during level walking. Given that previous results, using identical methods, have demonstrated significant differences in transfemoral prosthesis users fitted with an MPK versus non-MPK(3) it is likely that choice of prosthetic componentry may have a greater effect on cognitive load than the suspension mechanism used.

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5.31.6 Osseointegration promotes activity in amputees with socket-related issues: a retrospective, case series with continuous monitoring of daily activity

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BACKGROUND

Following lower extremity amputation, patients can opt for a bone-anchored prosthetic limb if socket-related complications are experienced with standard care. Knowledge on functional outcomes of patients with osseointegration (OI) with socket-related problems is increasing, however little is known about the objective quantity of activity of daily living of patients with OI. Data on continuous monitoring of activity in daily living of the patient's own environment are collected to measure out of clinic change with OI.

AIM

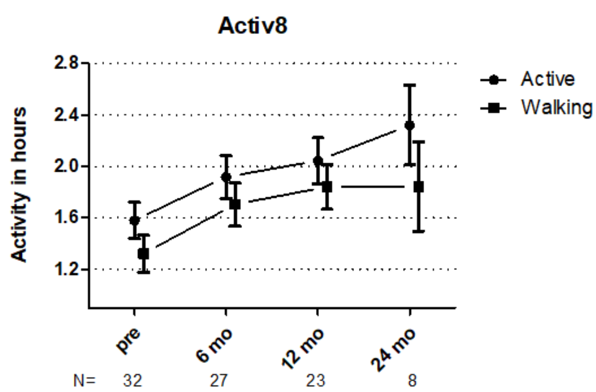
The primary aim was to measure activity of daily living in patients without OI and with OI over time. The secondary aim was to measure the mobility and walking ability over time.

METHOD

All patients aged between 18 and 99 years who underwent surgery for a transfemoral or transtibial OI between September 11, 2017, and February 11, 2021, were included in this retrospective case series. Activity of daily living was measured through a continuous recording with an activity monitor (Activ8) in hours (h) without OI, and at six, 12, and 24 months with OI. Furthermore, mobility was assessed by the Timed Up and Go test (TUG) in seconds (s) and walking ability by the 6 Minutes Walk Test (6MWT) in meters (m) at the same follow-up moments.

RESULTS

Informed consent was obtained from 47 of 56 persons with OI. The median age at baseline was 59 (P25-P75 51-64) years, and 36 (77%) were males. Median daily total activity without OI was 1.68h (P25-P75 1.02-2.09) per day and increased to 1.95h (P25-P75 1.24-2.39) at six months, 1.97h (P25-P75 1.34-2.65) at 12 months and 2.37h (P25-P75 1.80-2.50) at 24 months (Figure 1). Median daily walking time increased from 1.29h (P25-P75 0.74-1.92) without OI to 1.76h (P25-P75 1.06-2.14) at six months, to 1.70h (P25-P75 1.14-2.42) at 12 months and 1.70h (P25-P75 1.23-2.05) at 24 months. TUG decreased from a median of 11.66s (P25-P75 9.04-14.17) without OI to 9.23s (P25-P75 7.69-12.50) at 24 months. The 6MWT increased from a mean of 278m (SD 99) without OI to 323m (SD 65) at 24 months.



DISCUSSION AND CONCLUSION

Osseointegration has a positive effect on the activities of daily living, mobility level, and walking ability for patients with socket-related problems. These results indicate that patients could walk faster, more frequently, rise faster from a chair, and be more active, with OI than when wearing a socket prosthesis in less than two-year follow-up. Clinicians are encouraged to advise patients suffering from (severe) socket complaints to consider osseointegration for functional improvement in activities of daily living.

Free paper session: Low- and middle-income countries - Device fabrication and testing

5.32.1 investigation on the outcome of recycled gypsum in limb modelling

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BACKGROUND

Recycled gypsum in limb modelling is geared towards cost effective management of hospital resources, reducing hospital cost expenditure, and cost reduction of Prosthetics and Orthotics rehabilitation care involving Plaster of Paris (POP) bandages. A hollow replica of body segments and POP mould 3-dimensional solid impressions of body segments. POP materials purchasing cost continually escalates due to economic downturn and foreign exchange rate in Nigeria. Annually, average of POP powder expended at National Orthopaedic Hospital Igbobi Lagos is worth millions of Naira.

AIM

Recycling saturated gypsum in form of POP cast for limb modelling back to the Hemi-hydrated gypsum state for successful reuse for limb modelling consecutively, making use of shavings and crumplings of positive cast at cast modification room.

METHOD

Collection of samples of shavings of saturated gypsum positive cast limb models; initial weighing of samples pre-drying; oven drying; variations of duration of oven drying; weighing of samples post-drying; reuse testing and outcome of oven dried samples.

RESULTS

Oven dried hydrated gypsum samples dried at 223ºC two and half hours (sample "B") readily complied to reuse for limb modelling test for formation of Plaster of Paris positive cast within same stipulated time as commercial Plaster of Paris. Samples dried at 223ºC for five and half hours (sample "C") showed better improved limb modelling characteristics only discoloration of initial white appearance to a grey coloration. Comparison of expelled water of varied duration of oven drying of samples at 233ºC was conducted. The percentage of expelled water by mass is approximately 31% for both two and half, and five and half duration of oven drying. A hand compression grip exertion on samples show sample "C" to be hardest; sample "B" least hard of the three samples and sample "A" commercial Plaster of Paris of reference standard hardness.

DISCUSSION AND CONCLUSION

Oven dried hydrated gypsum samples dried at 223ºc for two and half hours readily complied to reuse for limb modelling test for formation of Plaster of Paris positive cast within same stipulated time as commercial Plaster of Paris. This is in agreement with Shangali, Shiyo, & Nagels (2020), who stated that under controlled conditions of grinding size, heating temperature, time and contamination avoidance, used Plaster of Paris continual recycling and reuse is achievable, and recycled products stronger and workable.

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5.32.2 A multimethod transdisciplinary approach towards prosthetic design

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BACKGROUND

There are approximately 31.6 million lower-limb amputees (LLAs), worldwide. Sociocultural, economic, and demographic variability affect product availability and user preferences and needs; effective prosthetic design must take this variability into account. This can be done by using data obtained through published literature, medical/prosthetic and orthotic centre records, fieldwork, and/or analysis of broken prosthetics. Each method reveals unique information about sociocultural, economic, and demographic variability, but methods are rarely used in tandem.

AIM

Using northern Sri Lanka as a case study, develop a framework for combining information from these different methods for the improvement of prosthetic design. In particular, focus on the design of locally manufactured prosthetic feet.

METHOD

First, a statistical analysis of an anonymized database from the largest P&O centre in northern Sri Lanka to identify local amputee trends (n = 3,665 patients). Second, a literature review of published amputee data from countries involved in a conflict with 25,000+ deaths since 1945 and machine learning was used to identify global patterns in LLA data. Third, a wear analysis on broken SACH prosthetic feet (n = 27) from northern Sri Lanka to identify how they are failing. Finally, an ethnographic study in northern Sri Lanka consisting of surveys, interviews, and observations of LLAs to identify what people want, and how they use their prosthetics.

RESULTS

The database analysis revealed that most amputees in northern Sri Lanka were transtibial amputees, and <90% suffered from lower limb loss. This is largely consistent with other studies in the literature. Both the database and literature pointed towards gender gaps in P&O provisioning, as the vast majority of reported amputees were males. Prosthetic foot failure analysis revealed excessive wear under the end of the keel and around the edge of the foot, being particularly high at the heel and under the toes: these failure mechanisms are not captured by the ISO 10328 prosthetic standards. Ethnography revealed issues with prosthetic function (e.g., difficulties in carrying heavy loads) and ways in which prosthetics are failing to get individuals back to pre-amputation activities (e.g., farming, walking on the beach).

DISCUSSION AND CONCLUSION

Each method provided unique data about the needs of the local amputee population. Amputee needs can vary drastically, but in a somewhat predictable way. Global indicators are useful, but local data is needed. There is large variation in how prosthetics are used, that are reflected in amputee desires. Amputee desires can vary dramatically, based on gender, occupation, and area they live. Combining multiple fields (anthroengineering, prosthetics, data science) has helped create design criteria for northern Sri Lankan prosthetic feet.

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5.32.3 Measuring Current Usage of Silicone Gel Liners and Potential Impact provided by Access to a Low-Cost Option in LMICs

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BACKGROUND
In April 2022 Operation Namaste launched a research effort to gather data to guide distribution planning and funding development for the 'Namaste Liner' and 'Namaste Limb Solutions'; the low-cost silicone prosthetic liner and DIY manufacturing package developed by Operation Namaste. This survey, designed to quantify the current availability of silicone gel liners in the developing world and estimate the potential impact of a low-cost version, is a key element of that market research.

AIM
To gather data to guide distribution planning and funding development for the low-cost silicone prosthetic liner and DIY manufacturing package developed by Operation Namaste by gaining a better understanding of patient and clinician needs.

METHOD
An online survey was distributed to members of the International Society for Prosthetics and Orthotics, and to subscribers of the OandP-L forum. The survey sample base included over 3,000 prosthetics and orthotics industry professionals who deliver care in 80 countries across the Americas, Europe, Africa & Middle East, Asia and Oceania. This survey was designed to gather feedback from practitioners who provide prosthetic devices in the developing world – specifically those serving patients who struggle to pay for basic prosthetic care. The 12-question survey was delivered to prospective respondents via email link. We received responses from 102 prosthetic clinicians representing their experience providing a lower-limb prosthesis to 27,000+ financially disadvantaged amputees annually.

RESULTS
Survey respondents verified that access to silicone gel liners for amputees in the developing world is very limited with only 20% of amputees currently using a silicone/gel liner on average, and 45% of respondents indicated that less than 10% of their patients benefit from this basic prosthetic component; cost was the most common obstacle. Survey participants said the current cost of providing a silicone liner in the communities they serve averages $352 USD. For a component requiring frequent replacement, this cost is prohibitive for low-income patients according to 89% of responding clinicians. With regard to the potential impact of a ~$50 silicone liner, 90% of survey respondents said availability at that price would increase the number of patients to whom they could provide one.

See Full Results Here: www.operationnamaste.org/post/results-of-our-prosthetic-liner-survey

DISCUSSION AND CONCLUSION
Expanded distribution of the elastomeric prosthetic liner would increase the number of amputees who would benefit from it, including allowing financially disadvantaged amputees to enjoy community life and the results support investment in delivery of a low cost liner. The 39% increase in the likelihood of patients returning to work is projected to generate a 5:1 return on investment based on the incremental income potential. Global Report on Assistive Technology noted the 'ripple effects' of reduced costs and income generating capacity of family caregivers.

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5.32.4 User Requirements and Testing Protocols for a Prosthetic Knee for Global Use

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BACKGROUND
User requirements for an appropriate prosthetic knee have been generated previously for resource constrained settings [1,2]. However, those have not highlighted specific requirements appropriate for a global market such as kneeling/squatting, fast walking, and compatibility with different fitment systems. Despite proven clinical and user advantages, through knee (TK) amputation surgery is seldom used due to a lack of suitable prosthetic designs [3,4]. To increase TK prescription, prosthetic knees should include this use case, necessitating additional requirements, including cosmesis.

AIM
The aim of this study was to establish requirements and suitable testing protocols for prosthetic knees for a global market to increase functionality of device designs for above knee and TK amputees.

METHOD
User requirements were generated using semi-structured amputee interviews in Cambodia, expert interviews and a literature study, and reviewed against global standards [5]. The user and laboratory testing protocols were designed and selected to demonstrate outcomes according to these requirements using the three principles and nine ethical considerations of the ISPO/ERN position paper on conducting clinical research studies in low- and middle-income countries [6].

RESULTS
The key additional user requirements are in Table 1. Novel requirements which were identified are full (165°) range of motion (ROM) for kneeling/squatting, safety during fast walking, and compatibility with the ICRC polypropylene system. Cosmetic requirements (particularly for TK amputees) which were identified were minimal thigh lengthening, and no shank shortening (important for sitting symmetry). Tests of note which were identified included compatibility tests with the ICRC and pyramid systems, ROM testing with a socket, kneeling testing, fast walking testing, and cosmetic checks. The standard ISO10328 prosthetic strength and fatigue tests were recommended for testing durability and strength.

Table 1. Key additional user requirements for an appropriate through knee or above knee prosthesis

Stable standing even for uneven ground, with foot contact at any point
Strength of device up to maximum loads for maximum patient mass and three years of use
Features for natural, safe walking for a range of speeds, such as extension assist and end of swing damping
Ability to fully bend the knee to full range of motion (165°) to kneel or squat on heels
Anatomic cosmesis that doesn't lengthen the thigh or shorten the shin excessively when sitting
Compatibility with ICRC PP and pyramid attachment systems for through knee and above knee sockets
Compatible with standard diameter pylon interface (30mm diameter), including length adjustment
Product can easily be fit/removed and serviced in a bicycle/wheelchair workshop in field settings
Resistant to field temperatures, sunlight, humidity, water, mud, and salt.

DISCUSSION AND CONCLUSION
The user requirements generation yielded novel requirements which are particular to low- and middle-income countries and TK amputees. These requirements demonstrate that prosthetics designed for high income countries may not be suitable in terms of both cost and functionality for these settings. These requirements required novel tests, such as for example kneeling/squatting tests with amputees, cosmetic checks and fitment compatibility tests.

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5.32.5 Difference between Laminated Sockets and 3d Printed sockets: A Qualitative Study

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BACKGROUND

3D-printing is revolutionizing the Orthotics and Prosthetics industry in a diverse way. Its applications can be seen not only in Orthotics but in the Prosthetic industry too. They are competing with laminated sockets by saving fabrication time, hence decreasing the patient's wait time for the final fitment. Previous literature has discussed a lot about their durability but less is discussed on the patient feedback on the 3d printed sockets.

AIM

The current study aims to analyze the drawbacks of 3d printed prosthetic sockets on the basis of patient feedback using a qualitative approach and biomechanical considerations.

METHOD

The study was conducted by 3d scanning the stump of 10 secondary transtibial healthy stump patients, having a stump length between 10-15cms. The sockets were then 3d printed through the scanned data to produce the final sockets. On the contrary, manual casting was also done to fabricate the final laminated prosthetic sockets for the same patients. The material used for 3d printing the sockets was PLA Pro 1.75mm with a socket thickness of 5mm and the other one was fabricated through the use of resin of hardener to produce a 5mm thickness socket. Both the sockets were assembled with the same type of suspension, structural components and prosthetic foot.

RESULTS

The feedback stated that the patients were much more confident and comfortable with the laminated socket in comparison to the 3d printed ones. It also reflected that the gait was much more normal in the laminated socket type. The patients stated that they felt more confident and independent while walking with the laminated socket. They felt hesitant and cautious while walking with the 3d printed ones.

DISCUSSION AND CONCLUSION

The gait analysis of the patients was analysed during the first trial and later on, after 30 minutes the PEQ was taken. The PEQ for both socket types were recorded and compared. There could be several factors affecting the study but the patient's psychology and habitualness of using laminated sockets for several years could be a major reason for the above-stated result.

Free paper session: Orthotics: Lower limb - AFO neuromuscular disease and stroke

5.33.1 Ankle-Foot Orthoses for Improving Walking in Calf Muscle Weakness due to Neuromuscular Disorders: A Cochrane Systematic Review and Meta-Analysis

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BACKGROUND

Calf muscle weakness is a common symptom in neuromuscular disorders (NMD), which can cause walking problems like falls, pain and fatigue. To improve walking, the mainstay of treatment is the provision of ankle-foot-orthoses (AFOs). However, an up-to-date overview of the effectiveness of AFOs to improve walking in adults with calf muscle weakness is missing. In order to support clinical decision-making and guide AFO selection in NMD, we reviewed current evidence.

AIM

To review the evidence for effects of AFOs for improving walking in calf muscle weakness due to NMD in comparison to no intervention.

METHOD

For this Cochrane review, we searched six databases on 20 August 2021 for RCTs and non-randomized studies that examined effects of AFOs in adults with calf muscle weakness caused by NMD compared to no intervention (i.e. shoes-only). We used the methodological procedures as described in the Cochrane Handbook [1]. We summarized findings for the primary outcome (objectively measured walking effort) and secondary outcomes (perceived walking effort, walking speed, balance performance, use, satisfaction and adverse events). Where possible, we synthesized effects in meta-analyses grouped according to AFO material. We used the GRADE approach to rate the certainty of the evidence.

RESULTS

We included 9 non-randomized studies (175 participants, sample sizes from 8 to 37 participants) that examined custom-made or prefabricated AFOs of carbon, polypropylene, silicone, or elastic materials. For carbon AFOs, we found low-quality evidence for a reduction in walking energy cost of 0.86 J/kg/m (95%CI; -1.33 to -0.39; 2 studies), and an increase in walking speed of 0.19 m/s (95%CI; 0.11 to 0.27; 4 studies) compared to shoes-only, and moderate-quality evidence for a beneficial effect on satisfaction while walking. For polypropylene AFOs, (very) low-quality evidence showed no effects on perceived walking effort (1 study), walking speed (2 studies), and balance performance (1 study). For silicone AFOs, low-quality evidence showed no effect on perceived walking effort (1 study). For elastic AFOs, low-quality evidence showed no effect on walking speed (1 study).

DISCUSSION AND CONCLUSION

The available evidence for AFOs to improve walking in people with calf muscle weakness originates from a few small non-randomized studies of overall low quality with heterogeneity in intervention characteristics and outcome assessment, which highlights the need for well-designed studies. Evidence indicates that carbon AFOs may reduce walking effort, increase walking speed, and enhance satisfaction, while polypropylene, silicone, and elastic AFOs might not improve perceived walking effort, walking speed, and balance.

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5.33.2 Specialised Orthotic Care to Improve Functioning in Adults with Neuromuscular Disorders: Results of a Prospective Randomised Open-label Blinded End-point Study

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BACKGROUND

People suffering from leg muscle weakness caused by neuromuscular disorders (NMDs) are often provided with leg orthoses to reduce walking problems. However, evidence for the effectiveness of ankle-foot orthoses and knee-ankle-foot orthoses to improve walking ability is scarce. In 2012, the Dutch multidisciplinary guideline for the prescription of leg orthoses in NMD was published to standardize the provision of orthotics in this population. We propose that guideline-based orthotic care in a multidisciplinary expert setting may improve treatment outcomes.

AIM

To assess the effects of specialised orthotic care on functioning in adults with leg muscle weakness due to NMD compared to usual orthotic care.

METHOD

In our currently ongoing prospective randomised open-label blinded end-point study, we included adults with calf and/or quadriceps muscle weakness due to NMD who experienced walking problems and were indicated for a (new) leg orthosis. After inclusion, participants were randomly assigned to specialised orthotic care (intervention) or usual orthotic care (control). The primary endpoints, measured at baseline and at 3 and 6 months follow-up, include gross walking energy cost (J/kg/m) assessed during a 6-minute walk test and achievement of personal goals, measured with the Goal Attainment Scale (GAS). Secondary endpoints include comfortable walking speed, gait biomechanics, stability, physical functioning, falls and fear of falling, perceived fatigue and satisfaction.

RESULTS

From May 2019 to February 2022, we screened 71 adults with various NMD. Sixty-one participants (40 males) with a mean (SD) age of 61.6 (12.6) met the inclusion criteria and performed the baseline measurements. At baseline, 46 subjects (75%) already used (high) orthopaedic shoes or a leg orthosis. At this moment, 49 participants have completed the follow-up measurements. We expect the last measurement in the beginning of February 2023. Results on primary and secondary outcomes will follow then.

DISCUSSION AND CONCLUSION

After we finish data collection in February 2023, we will be able to present the results during the ISPO 19th World Congress. Insights into effectiveness of specialised orthotic care in NMD could lead to a better quality of orthotic care, improving overall functioning of adults with NMD in daily living.

5.33.3 A Comparison Between Ankle-Foot Orthosis Lateral Flare and Ankle-Foot Orthosis with Shoe Modification on Stability in Stroke Patients

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BACKGROUND

Stability plays a crucial role in performing daily activities. However, stroke survivors struggle with balance. Fortunately, modifications to the rigid ankle-foot orthosis (AFO), such as tuning with a rigid AFO or a lateral flare with shoe modification offer medial-lateral stability. However, in southeast Asia countries, indoor use of shoes is not typical and is even restricted in some settings.

AIM

To compare the effect of a rigid ankle-foot orthosis with lateral flare (Intervention I1) and lateral shoe modification with a rigid ankle-foot orthosis (Intervention I2) on stability and patient satisfaction in patients who had experienced stroke.

METHOD

Seven participants who had experienced stroke were recruited (mean age 59.57 ± 7.37 years; 7 male, 5 hemorrhagic and 2 ischemic stroke) and were assessed using biomechanical outcome measurement. The study was approved by the Siriraj Institutional Review Board (SIRB). Static and dynamic stability under three conditions were evaluated: a rigid ankle-foot orthosis with lateral flare (I1), rigid AFO with lateral shoe modification (I2), and barefoot.

RESULTS

The results of participant satisfaction using the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) were 4.32 (I1) and 3.87 (I2). Static and dynamic stability results are detailed in Table 1.

Table 1. Data for static and dynamic stability under three conditions

Test	Parameters	Barefoot Mean± SD	I1 Mean± SD	I2 Mean± SD	p-value
Static stability	Symmetry index(%)	21.86 ± 21.79	11.14 ± 18.77	18.29 ± 29.4	0.56
	MLCoP displacement (mm)	1.21 ± 0.13	1.31 ± 0.59	1.18 ± 0.16	0.15
Dynamic stability	Step length (m)	0.29 ± 0.13	0.36 ± 0.13	0.32 ± 0.12	0.101
	Stride width (m)	0.21 ± 0.03	0.22 ± 0.03	0.24 ± 0.05	0.367
	Walking speed (m/s)	0.40 ± 0.21	0.47 ± 0.24	0.39 ± 0.21	0.156
	MLCoP displacement (mm)	39.91 ± 16.46	32.13 ± 8.59	37.64 ± 8.59	0.778
	ML CoP velocity (m/s)	0.71 ± 0.26	0.38 ± 0.13	0.63 ± 1.23	0.028 *

* m: meter, mm: millimeter, m/s: meter per second

DISCUSSION AND CONCLUSION

In static stability test, the study found better symmetry index was obtained in I1. The I2 showed less static mediolateral CoP displacement. In dynamic stability, clear stability improvements were obtained in I1. Moreover, participants were better satisfied with the I1 than the I2. Future investigations with larger participants must be performed.

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5.33.4 Effect of posterior leaf spring and carbon composite ankle foot orthosis on gait and functional mobility of hemiparetic stroke patients

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BACKGROUND
Stroke is the most prevalent clinical disease of the cerebral blood vessels leading to death or long-term disability. About 2/3 of survivors achieve independent walking function but continue to have difficulty walking and remain at high risk of falls due to imbalance. Different orthoses are used to treat gait impairment. Ankle Foot Orthoses (AFOs) are among the orthoses commonly used to improve gait in hemiplegic stroke survivors.

AIM
This study aimed to assess and compare the effect of PLS-AFO and C-AFO on functional mobility, walking speed and satisfaction among hemiplegic stroke survivors.

METHOD
Twenty-seven hemiplegic ambulatory stroke survivors who had completed a rehabilitation program and were already using AFO were included in the study. Subjects were randomly assigned either PLS-AFO or C-AFO, and assessment was done with and without AFO. Functional mobility, walking speed and satisfaction were assessed using the Timed Up and Go (TUG) test, the 10-meters walking test (10MWT), and the Orthotics and Prosthetics Users' Survey (OPUS) questionnaires, respectively.

RESULTS
The two types of AFO improved functional mobility. PLS-AFO and C-AFO reduced TUG time by 4.4 seconds (10.5%) and 7 seconds (22.4%), respectively. Walking speed increased during the self-selected walking speed in both AFO users by 0.1m/s (33.4%) and 0.5m/s (40%) for PLS-AFO and C-AFO, respectively. Similarly, an increase in fast walking speed was observed in PLS-AFO and C-AFO users by 0.05m/s (12.5%) and 0.01m/s (1.42%), respectively. Participants were satisfied with both AFOs regarding weight, fitting and comfort (>90%). Satisfaction with the durability while using PLS-AFO and C-AFO were 73% and 92%, respectively. Free from irritation and skin abrasion with PLS-AFO and C-AFO were 81.8% and 85.7%, respectively. Pain was reported by 8.1% of PLS-AFO users as compared to 28.6% of C-AFO users.

DISCUSSION AND CONCLUSION
The study showed that C-AFO and PLS-AFO can improve the walking ability of hemiplegic stroke survivors, including walking speed and functional mobility. C-AFO has shown the ability to provide a better self-selected walking speed, while PLS-AFO was slightly better in fast waking speed. Both AFOs provided a high level of user satisfaction. Pain reported with C-AFO suggests the need to redesign. A future study of the AFO users grouped in different levels of walking speeds should be considered.

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5.33.5 From science into daily clinical practice: Implementation of early AFO-provision in the rehabilitation after stroke

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BACKGROUND
In a randomized controlled trial (RCT), resulting in a PhD-thesis [1], we showed that early provision of ankle-foot orthoses (AFOs) after stroke has substantial short-term functional benefits compared to delayed AFO-provision, without negative effects on muscle-disuse. To ensure the uptake of these scientific results into daily clinical practice of our rehabilitation centre, we conducted a structured implementation by means of a consultation hour to facilitate early AFO-provision after stroke. The process and results will be presented in this contribution.

AIM
Implementation of early AFO-provision in the rehabilitation after stroke in daily clinical practice.

METHOD
Based on the results of the RCT, Roessingh Centre for Rehabilitation, Enschede, the Netherlands, wanted to implement the scientific results into clinical practice and facilitate early AFO-provision after stroke. Clinicians and management were involved in the process of setting-up a new workflow. The former way of working regarding AFO-provision post-stroke was identified and new plans were assessed, taking into account the results of the RCT. In an iterative process a new weekly multidisciplinary consultation hour was set-up, including a specialized physical therapist, orthotist and, if needed, a rehabilitation physician. A 6-months pilot was conducted and afterwards all involved clinicians and management were included to evaluate the new workflow.

RESULTS
Within the new workflow, stroke patients admitted for inpatient rehabilitation care are screened for AFO-indication on the day of admittance. In case of AFO-indication, a physical examination is planned, followed by a consultation hour 2-3 weeks after admittance. Within this hour, the gait pattern is observed and various AFO-types are available to assess effects. In case of AFO-indication, provision follows in the next week. Standard evaluation of the effect is planned 2-3 weeks after provision. Evaluation of the 6-months pilot revealed that on average 3 consults per week were planned and consults were performed 23 days after admittance. 87% of the referred patients were provided with an AFO. Clinicians were enthusiastic about this new set-up. The possibility of easy referral early in the rehabilitation post-stroke, together with multidisciplinary assessment of the need for, and type of AFO, were highly valued.

DISCUSSION AND CONCLUSION
Evaluations of the pilot period revealed that clinicians were enthusiastic about the multidisciplinary consultation hour. Points of improvement that were mentioned mainly focussed on the communication about the trajectory after AFO-provision. Based on the results of the pilot, early referral for AFO-indication post-stroke appears to be feasible. Currently, the new consultation hour is implemented in the usual daily clinical practice of Roessingh. Suggestions for improvements during the pilot were incorporated and continuous evaluation is performed.

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5.33.6 Effect of stiffness-optimized ankle-foot orthoses on gait stability in people with neuromuscular diseases and bilateral calf muscle weakness

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BACKGROUND

Calf muscle weakness in people with neuromuscular diseases is a common symptom and negatively impacts gait stability and walking energy cost [1]. Recently, it has been shown that stiffness optimized ankle foot orthoses (AFOs) reduce the energy cost of walking compared to conventional AFOs [2]. However, it is unknown whether stiffness optimized AFOs improve gait stability as well.

AIM

We aimed to compare gait stability, quantified as gait variability and the margins of stability, in people with bilateral calf muscle weakness walking with shoes only, conventional AFOs, and stiffness-optimized AFOs.

METHOD

We included ten participants from the PROOF-AFO trial [2] who had bilateral calf muscle weakness and walked without a walking aid (e.g. cane, stick). Participants walked at comfortable speed in three conditions: 1) walking with shoes-only, and 2) with the conventional AFO at baseline, and 3) walking with the individually stiffness-optimized AFO after 3 months of use. For each condition, we assessed step length variability, step width variability, and the mediolateral and anteroposterior margins of stability (ML_MoS and AP_MoS) as measures for gait stability using 3D gait analyses. Differences between conditions were assessed with Generalized Estimating Equations. To correct for the effect of walking speed, this outcome was included as covariate.

RESULTS

No significant effects of stiffness-optimized AFOs were found on gait stability measures compared with conventional AFOs (Table 1). Both conventional and stiffness-optimized AFOs increased ML_MoS compared to shoes only (Wald=12.6, P=0.002), however no difference in ML_MoS was found between conventional and optimized AFOs.

Table 1. Gait stability measures

	Shoes	Conventional orthosis	Optimized orthosis	Wald	p	Pairwise comparison
Walking speed (m/s)	0.86 (0.74-1.02)	1.05 (0.97-1.14)	1.14 (1.07-1.21)	16.3	<0.001	S-C# S-O# C-O*
Step width variability (cm)	3.73 (3.09-4.38)	3.36 (2.74-3.97)	3.24 (2.66-3.81)	2.17	0.34	
Step length variability (cm)	3.5 (2.7-4.4)	3.2 (2.7-3.6)	3.7 (3.0-4.4)	4.35	0.114	
ML_MoS (m)	0.049 (0.043-0.053)	0.059 (0.051-0.067)	0.061 (0.053-0.069)	12.6	0.002	S-C* S-O#
AP_MoS (m)	0.17 (0.15-0.18)	0.16 (0.14-0.17)	0.16 (0.15-0.18)	1.69	0.43	

All measures are in mean (95% confidence interval)

*p<0.05 #p<0.001

S=shoes only, C=conventional orthosis, O=optimized orthosis

DISCUSSION AND CONCLUSION

The utilization of AFOs while walking improved mediolateral gait stability independent of gait speed in people with bilateral calf muscle weakness. However, stiffness-optimization of the AFO did not further improve this. The AFOs were optimized for walking energy cost, not for stability which requires other mechanisms such as ankle strategy and foot placement. Therefore, gait stability parameters should also be considered when optimizing AFOs to improve gait pattern in people with bilateral calf muscle weakness.

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Free paper session: Education - Education II

5.34.1 Embedding Global Citizenship Competence into the Prosthetics & Orthotics Curriculum through the Virtual International Collaborative Learning Activity

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BACKGROUND
With rapid evolving of globalization, universities would endeavour global citizenship education for preparing their graduates to this Volatile, Uncertain, Complex, and Ambiguous (VUCA) world [1]. Some scholars have demonstrated that incorporating internationalized curriculum model fosters personal transformation and global citizenship in terms of understanding local and global health issues [2-4]. This study highlights a virtual international collaborative learning activity as a tool for global citizenship education in prosthetics and orthotics (P&O) education.

AIM
The study aimed to assess the perceptions and experiences of P&O students from different cultural backgrounds toward global citizenship through an international learning activity.

METHOD
A validated global citizenship instrument was used to examine the development of global citizenship for students of two universities participating in a virtual learning activity. It included P&O educational elements as well as cultural components. Twenty-four undergraduate P&O students (17 from Hong Kong, and 7 from Thailand) responded to a pre- and post-survey embedding 27 Likert-scale questions. Students' perceptions on different dimensions of global citizenship including social responsibility, global competence, and sustainable development goals (SDG) were assessed. The study also examined the experience and development of the students as they learned to become global citizens.

RESULTS
Upon conducting this study, the internal consistency (reliability) of survey in sub-domains of global competence and SDG was satisfactory (Cronbach alpha coefficient > 0.8). The analysis of responses of total number of students (n=24) by using the Wilcoxon Signed Ranks to pre- and post-survey indicated an overall significant change ($p < 0.05$) in the respondents' interest and appreciation towards two sub-domains of global competence (intercultural communication and global knowledge) as it reflected in the following three questions: "I often adapt my communication style to other people's cultural background.", "I feel comfortable expressing my views regarding a pressing global problem in front of group of people.", and "I am able to write an opinion letter to a local media source expressing my concerns over global inequalities and issues."

DISCUSSION AND CONCLUSION
The results of this study revealed a positive trend in the responses of the P&O students from two universities regarding global citizenship in some respects upon completion of the virtual learning activity. This preliminary study could potentially provide a new perspective about embedding global citizenship attributes into P&O curriculum to empower the graduates not only on required clinical and research skills but also to become responsible about global issues and be active promoters of sustainable and open-minded societies.

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ACKNOWLEDGEMENTS This study was funded by the University Grants Committee Funding Scheme for Teaching and Learning Related Projects [PolyU10/Teaching and Learning/2016-2019].

5.34.2 Educational programmes about electronics in orthotics and prosthetics bachelor's degree

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BACKGROUND
The need to have professionals in the area of orthotics and prosthetics has led UNAM to create a study programme at the undergraduate level. During its design and planning, engineering subjects were included, such is the case of those related to applied electronics, knowledge with which the student will be guided towards the generation of biomechatronic orthoses and prostheses, as well as other auxiliary devices in rehabilitation.

AIM
Emphasize the importance of including the electronic area in the orthotics and prosthetics study plans and programmes during the degree.

METHOD
In the study programme of the bachelor's in Orthotics and Prosthetics, four subjects related to electronics are: 1) Circuit Analysis, 2) Basic Electronics, 3) Digital Circuits and 4) Amplification and filtering of biomedical signals. This project focuses on creating practice manuals for each subject, ensuring that all units of knowledge are covered and help meet the objectives of the current syllabi. Also, small "projects" within the manuals, which is an innovation to this type of academic product since the students achieve a greater retention of the information because they integrate concepts of two or more isolated practices, seeking to be projects oriented to the needs of orthotists and prosthetists.

RESULTS
So far, four practice manuals have been designed with which the subjects have been taught following the order of the proposed activities and the students have managed to integrate the knowledge into their career as a multidisciplinary section. Projects have been achieved with the help of applied electronics, on the one hand, there is a KAFO with automatic unlocking of the knee during walking, the substitution of proprioceptive feedback was studied, and the development of a didactic model of the spinal cord (project transversal that involved three subjects). More labs and projects are expected as students progress to more advanced semesters and topics, such as spinal orthoses.

DISCUSSION AND CONCLUSION
The bachelor's degree in orthotics and prosthetics has the responsibility of providing transdisciplinary education, which implies studying in depth the topics of the areas involved to link them through examples, activities, practices and projects applied to orthoprosthetic devices.

The study of this area opens up the possibility of updating, modernizing and revolutionizing orthoprosthetic practice, as well as favouring the study of a postgraduate degree in both the engineering area and the medical sciences.

ACKNOWLEDGEMENTS: Author thanks to UNAM-DGAPA that through PAPIME PE102022 this work was made.

5.34.3 Abstract Title: Using Curriculum Mapping to Facilitate Programme Self-assessment and Support the Accreditation Process

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BACKGROUND

A professional learning community (PLC) of Brother Tarcisius Prosthetics and Orthotics Training College (BTPOTC) and University of Washington (UW) instructors has collaborated on various projects since 2017. PLC conversations raised questions about potential gaps and redundancies between BTPOTC curriculum and ISPO Standards. To support program review efforts, curriculum mapping was selected as a structured process to facilitate programme assessment [1], document and align content across the programme, and identify gaps [2].

AIM

This project used collaborative curriculum mapping processes to support programme assessment and restructuring of the BTPOTC education programme to meet the ISPO Education Standards.

METHOD

From August 2021-March 2022, we mapped the BTPOTC curriculum to the ISPO Standard I Evidence of Compliance categories. To begin, an Excel template was created [3]. ISPO categories were listed on separate sheets with corresponding subcategories in separate columns. Each sheet listed the BTPOTC courses chronologically in rows to create a matrix. To map the curriculum, first we discussed the ISPO subcategory and documented our interpretation. Next, PLC members identified where the content occurred within the BTPOTC curriculum and designated the developmental level as introduced, reinforced, mastered, or assessed. Throughout, we focused on content alignment across the programme.

RESULTS

To date, 33 BTPOTC courses have been considered against six of the 12 Evidence of Compliance categories. Through shared interpretation, a comprehensive understanding of each category was achieved, which facilitated curriculum restructuring. The curriculum mapping helped to realign ten theoretical courses with five core practical courses which ensured that theory courses containing prerequisite knowledge needed for teaching subsequent courses were taught at the appropriate time. Identification of developmental levels within the 33 courses helped in the revision of the course objectives for ten courses and facilitated removal of redundant introduction of topics in multiple courses providing time to build on student prior knowledge (Table 1).

Table 1. Examples of identified outcomes of the mapping process

Outcome of mapping process	**Example of revision**
Realigned core courses	Knee biomechanics moved from semester 4 to 3 to align with P&O practical content.
Revised course objectives to reflect appropriate level	*Before:* Alignment of transtibial and transfemoral prosthesis. *Revised:* Apply mechanical principles to align transtibial and transfemoral prostheses to match the needs of users
Eliminated re-introduction of topics	Gait cycle introduced in first year and reinforced in second year.

DISCUSSION AND CONCLUSION

Collaborative curriculum mapping provided a structured process and visual tool to support programme assessment and realignment of course content. Theoretical coursework, now taught at appropriate times, allows BTPOTC tutors and students to easily draw relevant connections between theory and practice. Challenges to the mapping process included internet connectivity, time commitment, and coordination of schedules. Other educational programmes could use a similar process to align content and improve student learning.

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5.34.4 Identifying interprofessional rehabilitation education opportunities through comparative review of competencies and standards

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BACKGROUND

Rehab 2030 established the need to strengthen and integrate Prosthetists/Orthotists (POs) into health systems worldwide. Multidisciplinary courses with opportunities for interprofessional education (IPE) make this a possibility by promising more effective and efficient education through shared resources and improved awareness of the role of POs. Nevertheless, opportunities for multidisciplinary learning are still limited, particularly in low-resourced settings. Improved understanding of education competencies and standards across rehabilitation professions can help identify new opportunities for IPE.

AIM

To identify opportunities for interprofessional education (IPE) across rehabilitation professions.

METHOD

International competencies, standards of practice (SOP), and standards of education for PO, Occupational Therapy (OT), Physiotherapy (PT) and Speech Language Pathology (SLP) were assessed. To compare and contrast the entry-level competencies, each profession's SOPs were mapped to the domains, competencies, and activities of the WHO Rehabilitation Competency Framework (RCF). A comprehensive course list for each of the common competencies was created. University curricula from 63 rehabilitation programs representing the 4 professions across 28 countries were then compared to the course list. The 10 courses with the highest frequency count amongst university curricula were identified as opportunities for multi-disciplinary education, where students can learn alongside each other.

RESULTS

Ten common roles of the rehabilitation professional were identified within the five competency domains of the RCF; Expert: Knowledge, Expert: Skills, Expert: Activities, Professional, Communicator, Collaborator, Teacher, Manager, Leader and Scholar (Figure 1). The outcome of the curricular mapping process of the 63 programs was a comprehensive course list. The ten courses with the highest frequency count across the rehabilitation professions were: Clinical Reasoning, Professional Behaviours, Screening, Examination, and Evaluation, Communication (professional), Business and Practice Management, Inter-professional Practice and Teamwork, Applied Evidence Based Practice, Assistive/ Adaptive Technology- Adaptive Equipment and Devices, Documentation and Digital Literacy, Teaching and Learning.

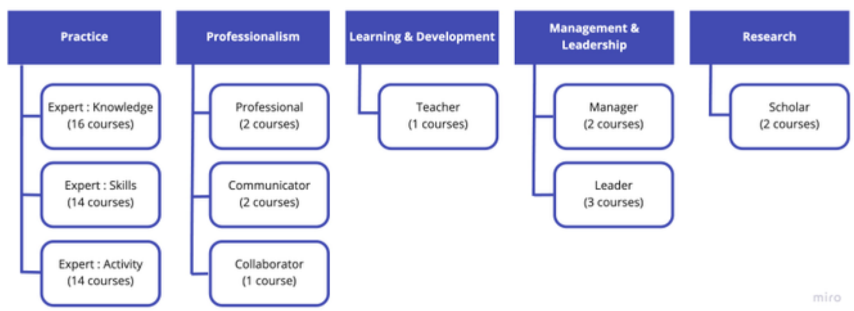

Figure 1. Number of courses mapped for each competency domain within the RCF

DISCUSSION AND CONCLUSION

Identifying opportunities for IPE across PO, PT, OT and SLP is an important step towards strengthening the rehabilitation sector and improving integration into health systems worldwide, particularly in low-resourced settings. The common knowledge and skills identified as the foundation of the ten common courses provides an opportunity to practice IPE core competencies and improve resource efficiencies in rehabilitation education while ensuring PO have the ability to work within an interprofessional team both in clinical practice and beyond.

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ACKNOWLEDGEMENTS Physiopedia’s interdisciplinary ReLAB-HS team for diligently assessing the data and guiding the mapping process.

5.34.5 The Prosthetic and Orthotic Instructors' Perception on Usability in Blended Learning during the Covid-19 Pandemic in Thailand

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BACKGROUND

Due to COVID-19, face-to-face classroom learning is disrupted around the globe [1]. As a result, most of the country would rapidly migrate to blended learning in the 2020–2021 academic year [2]. "Blended learning" is defined as combining online and face-to-face instruction [3]. Clinical and practical sessions are examined as a majority of curricular activities [4], which cannot be replaced by online learning. With the restrictions and limitations, the Prosthetics and Orthotics curriculum adopts blended learning as a teaching model during the new normal.

AIM

This study aimed to investigate instructors' perceptions of the usability of blended learning in the Prosthetics and Orthotics field during the COVID-19 pandemic in Thailand.

METHOD

A qualitative study was conducted through individual structured interviews via face-to-face or online platforms between November 2021 and January 2022. Twenty Sirindhorn School of Prosthetics and Orthotics instructors were recruited for participant-structured interviews exploring instructors' perspectives in terms of effectiveness, efficiency, satisfaction, user experience, and accessibility of blended learning as five major aspects [5]. The interviews were audio-recorded, transcribed, and Spielberg's 3-step process of intuiting, analysing, and describing was used to thematically analyse [6].

RESULTS

Twenty SSPO lecturers (*Male 6; Female 14; aged 24-49 years*) completed one-to-one interviews. Five major aspects were determined for the usability of blended learning. A sub-theme originated from Concept Map,[5] and an inductive sub-theme was developed and emerged. Various perspectives on usability in blended learning were reported by lecturers (Fig.1). 54.4% of the interviewees revealed an effectiveness report, followed by efficiency (17.5%), accessibility (17.1%), satisfaction (8.4%), and user experience (2.6%). Most lecturers would prioritize course content and course material (31.0%) in terms of effectiveness and time management (48.9%) is the most influence the efficiency of blended learning. Nevertheless, the devices and applications (42.5%) are the greatest impacts on accessibility. Although the perspective/attitude 'before/after' of lecturers has various perspectives, 58.3% of the interviewees reported satisfaction with blended learning.

Fig. 1 Sunburst graphic for the sub-themes generated from the deductive findings of the thematic analysis

DISCUSSION AND CONCLUSION

The findings shed light on the usability that explains instructors' blended learning experience during the COVID-19 pandemic. Discussion and recommendations for blended online learning were also concluded from the study. Instructors and policymakers may bring the recommendation to make better decisions that ultimately could lead to better achievement and improvement over time.

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5.34.6 Knowledge translation in prosthetic and orthotics: A course development, implementation, and outcome evaluation in postgraduate prosthetics and orthotics education

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BACKGROUND

Recently, knowledge translation (KT) has gained international healthcare policy and research attention [1-3]. There is a need for the development of knowledge and skill in KT, particularly in post-secondary education curricula [4]. The Master of Science in Prosthetics and Orthotics at Mahidol University offered a course entitled "Knowledge Translation in Prosthetics and Orthotics" with an aim to enhance the learning experience in KT following outcome-based education. Course development, management, and outcomes were explored and discussed in this study.

AIM

To describe the approach and content of "Knowledge Translation in Prosthetics and Orthotics"; to describe and discuss course development, implementation, and outcome evaluation; and to share reflections and learning experiences of postgraduate students and educators.

METHOD

The compulsory one-credit course, "Knowledge Translation in Prosthetics and Orthotics", was designed and embedded into a revised MSc in PO curriculum. This course was first launched in 2021 as a synchronous online course due to the pandemic. Course development utilized outcome-based education [6], and curriculum mapping [7] with the constructive alignment of learning outcomes. Constructivism, active learning, and learner-centred pedagogies include problem/project-based learning [8], collaborative learning, small group discussion, student reflection, and various activities/assignments. Various online platforms were used based on different purposes. Summative/formative assessments and feedback were included formally and informally throughout the course. Course evaluations were conducted mid-course and at course completion.

RESULTS

Course development focusing on learning outcomes and key learning elements was comprehensively addressed, which contributed to course content, teaching strategies, learning experiences, and evaluation strategies. The class size ranged from 5-10 Thai and international students with prosthetics/orthotics and healthcare backgrounds. Despite similarities in professional background, students had different experiences and diverse interests. Therefore, the main project was formulated by focusing on students' interests. Initially, students developed 2-3 KT issues of interest and subsequently selected and sustained one issue/topic throughout the course. The core course content was delivered in 12 sessions through interactive lectures, various class activities, assignments, and a KT proposal. Evaluation strategies were effectively utilized throughout the course. This course was effectively planned and implemented as reflected in student achievement of learning outcomes, student feedback, and course evaluation, including student engagement and participation in the classes/activities.

DISCUSSION AND CONCLUSION

Course design and applied pedagogies enhanced meaningful learning experiences, problem-solving skills, and independent and critical thinking skills for a diversity of students. Students who participated in this course were uniquely positioned in the field to be future knowledge translators and thus greatly benefited from the course. Students indicated the potential application of KT in their future clinical/practical practice despite the limitation of actual implementation and evaluation of their KT project due to time limitations.

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Free paper session: Prosthetics: Lower limb - Ankle & foot

5.35.1 Benefits of a Microprocessor-Controlled Prosthetic Foot on Steeper Slopes

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BACKGROUND

Energy storage and return (ESR) feet are prescribed for persons with a lower-limb amputation to restore lost mobility. However, due to the limited adaptability of their rigid ankles and springs, situations like walking on slopes or uneven ground remain challenging tasks. Previous studies reported benefits of a microprocessor-controlled foot (MPF) with very limited range of motion (ROM) on shallow slopes of 5° only [1,2].

AIM

To investigate in more detail the effects of a MPF with larger ROM on the gait on steeper slopes.

METHOD

Seven persons each with a unilateral transtibial amputation (TTA) and unilateral transfemoral amputation (TFA) as well as ten able-bodied subjects participated. Participants were studied while using a commercially available MPF and their prescribed standard ESR feet. The MPF generates hydraulic plantar- and dorsiflexion resistances, offers instant terrain adaptation and a ROM of 14° dorsiflexion and 22° plantarflexion. The study investigated participants ascending and descending a 10° slope. Kinematic and kinetic data were recorded with a motion capture system. Biomechanical parameters, in particular leg joint angles, shank orientation and external joint moments of the prosthetics side were calculated. A Wilcoxon signed rank test was used to test for differences between feet.

RESULTS

Prosthetic foot- and subject group-dependent joint angle and moment characteristics were found for both situations. The MPF showed a larger and situation-dependent ankle ROM compared to the standard feet. Furthermore, it remained in a dorsiflexed position during swing.
While ascending, the MPF adapted the dorsiflexion moment and reduced the knee extension moment. At vertical shank orientation, it significantly reduced the knee extension moment by 26% for TFA and 49% for TTA compared to the standard feet ($p<0.05$). For descending, differences between feet in the biomechanical knee characteristics were found for the TTA group, but not for the TFA group. At the vertical shank angle during slope descent, TTA demonstrated a behavior of the ankle moment similar as able-bodied controls when using the MPF.

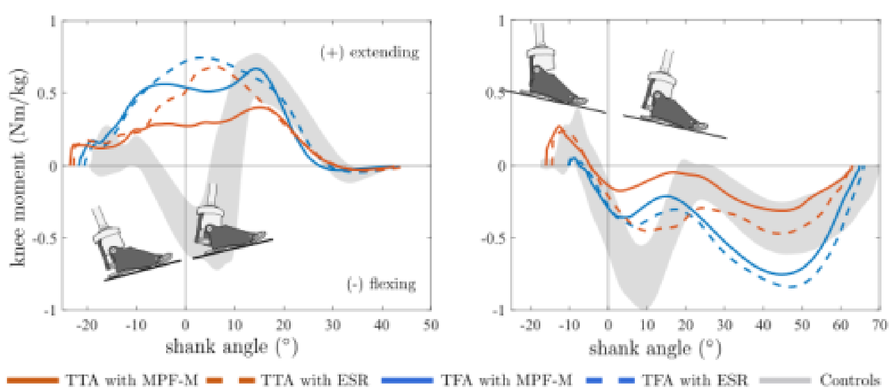

Fig.1 Knee moment as function of the shank angle.

DISCUSSION AND CONCLUSION

The studied MPF facilitated walking on slopes by adapting instantaneously to inclinations and enabling a larger ankle ROM and, thus, easing the forward rotation of the leg over the prosthetic foot. It reduces the moments acting on the residual knee of TTA compared to the prescribed ESR feet. The effect size is amputation-level dependent. Moreover, for TFA, the prosthetic knee seems to be more important for slope descent than the foot.

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5.35.2 High-Level Mobility of Trans-Tibial Prosthesis Users Wearing Commercial and sPace Energy-Storing Prosthetic Feet

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BACKGROUND

Lower limb amputation is a global public health issue. Much work has been done to enhance the function of prosthetic technologies. The energy storage and return (ESR) prosthetic feet improve the gait and satisfaction of users compared to traditional non-energy-storing feet. An ability to traverse across uneven terrain is another hallmark feature of ESR feet. However, improvements in accessibility to design and testing, as well as manufacturing technologies have led to the development of locally designed ESR foot called sPace.

AIM

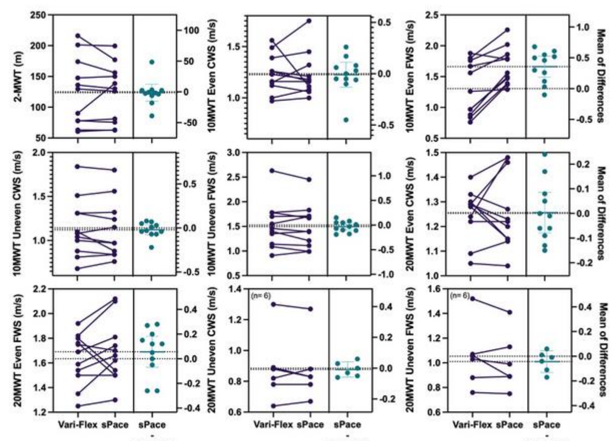
To investigate the functional outcomes of users provided with a commercial ESR Vari-Flex foot (Össur) and the locally designed sPace foot and to examine the free-living physical activity of users wearing their own Solid Ankle Cushion Heel (SACH) or single-axis foot and the sPace.

METHOD

This study was approved by the Siriraj Hospital, Faculty of Medicine Institutional Review Board (IRB 593/2560) with each participant signing an informed consent form before participation. All participants performed the Amputee Mobility Predictor to make certain functional activity level was at least a K3 (high-activity). Eleven individuals with unilateral trans-tibial amputation participated. Participants were randomly allocated to be fit with either sPace and Vari-Flex foot and completed; ten and twenty-meter walk tests (10/20MWT) at comfortable and fast walking speeds (CWS/FWS), Two-Minute Walk Test (2MWT) and Comprehensive High-Level Activity Mobility Predictor (CHAMP). A subgroup was provided with a pedometer to record 7-day steps on their own foot and later sPace.

RESULTS

Results from even terrain 10MWT CWS and FWS showed non-inferiority was met with a mean difference of 0.01 m/s, and a mean difference of 0.40 m/s respectively. Uneven terrain 10MWT CWS mean difference was 0.03 m/s. However, uneven terrain 10MWT FWS did not achieve non-inferiority, mean difference of 0.05 m/s. Results from even terrain 20MWT CWS and FWS achieved non-inferiority, with mean differences of 0.01 m/s and mean differences of 0.02 m/s for CWS and FWS respectively. Uneven terrain 20MWT CWS and FWS did not achieve non-inferiority with mean differences of 0.008 (m/s) and mean difference of 0.04 (m/s). The 2-MWT saw a difference of 1.82 m, however, this result did not satisfy non-inferiority testing. Figure 1 provides a panel overview of differences seen in participants wearing the two study feet.



DISCUSSION AND CONCLUSION

This study measured the differences in performance-based outcome measures in trans-tibial prosthesis users wearing a local and commercial ESR prosthetic foot. There were no clear differences between the prosthetic feet across various measures of mobility, high-level mobility and activity. The sPace foot performed well in a battery of high-level mobility outcome measures. Taken together, these data suggest the potential use of the sPace prosthetic foot for limb-different persons in low-income countries.

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5.35.3 Scoping review of the published evidence on commercially available powered prosthetic ankle-foot components

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BACKGROUND
Powered prosthetic ankle-foot (PwrAF) components have been available for about a decade. However, acceptance by prosthetists and healthcare payers are still very limited. Early studies had shown benefits in faster walking speed and metabolic energy consumption. However, later studies could not or only partially confirm these results. Therefore, a scoping review of the existing literature on commercially available PwrAF was conducted to identify proven patient benefits and potential research gaps.

AIM
The aim of this study was to scope the existing body of evidence for proven patient benefits and evidence gaps for commercially available powered prosthetic ankle-foot components.

METHOD
A literature search with search terms pertaining to PwrAF for persons with transtibial amputations (TTA) was performed in 4 literature databases and archives of several medical and prosthetic and orthotic journals. Identified publications were screened for pertinence by title and abstract review first. Papers with unclear pertinence were reviewed as full texts. Methodological quality of pertinent publications was assessed using both the criteria of a previous Cochrane review on prosthetic feet [1] and the criteria of the American Academy of Orthotists and Prosthetists (AAOP, [2]). Findings of publications with sufficient methodological quality were extracted and are presented descriptively.

RESULTS
The literature search yielded 628 publications. After removal of non-pertaining articles and publications on prototypes not commercially available, 29 publications remained for full-text review, with 23 having sufficient methodological quality to be included in this review.

Undisputed benefits of commercially available PwrAF were improved prosthetic ankle power (3), unloading of the sound knee, reduced sound, residual knee, and low-back pain (4), and gait stability on level ground and slopes. Conflicting results were found for self-selected walking speed (SSWS), metabolic energy consumption, and patient-reported mobility outcomes. No improvements have been reported in performance-based outcome measures other than SSWS.

Several studies reported that, depending on the outcome measure(s) assessed, only 35-50% of participants benefited from a PwrAF. However, information on characteristics of responders is still sparse and requires further research.

DISCUSSION AND CONCLUSION
Persons with unilateral TTA may benefit from PwrAF through reduced knee and/or low-back pain. Selected patients may benefit through faster self-selected walking speed and/or reduced metabolic energy consumption during overground and/or slope walking. Evidence suggests that the adaptation of neuromuscular control to the power delivered by a PwrAF may not be intuitive for many potential users. Further research is needed to better characterize responders and/or develop a device-specific training program.

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5.35.4 Vulcanized Rubber Single Axis foot

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BACKGROUND

In Cambodia, patients who need the prosthetic foot have limited choices for their prescribed prosthetic foot. Only Solid Ankle Cushion Heel (SACH) foot is prescribed for every client in all physical rehabilitation Centers. So far, the single axis foot has not been produced locally to meet the needs where the price of an imported single axis foot cannot be afforded by most Cambodian people with disabilities and the imported single axis foot does not last long with Cambodia's climate.

AIM

To explore possibilities in producing local, affordable, and durable single axis to meet some patients' needs. We expect that the new foot design will last at least for one year.

METHOD

The idea of developing vulcanized single axis was evolved from a modified volcanized SACH foot attached with Chinese ankle axis adapter. That modified vulcanized rubber single axis foot was tested with two patients for one year. The result of that modified single foot worked well. The proper moulded vulcanized rubber single axis foot was recommended. Through the Cambodian Association of Prosthetists and Orthotists (KhAPO), a proposal was requested to ISPO Norway to sponsor development of proper foot mould and foot keel to produce a vulcanized rubber single axis foot. An aluminium mould was ordered and feet samples were produced and tested, followed up and interviewed every 3 months up to 12 months.

RESULTS

Only three testing samples were able to collect the feedback. Those three model patients were happy with the tested feet compared with their previous prescribed SACH feet. Within one year, the client can walk with that vulcanized single axis foot without any problem. Participants feel more confident and faster to walk with that tested foot compared with the SACH foot. They also feel more stable and easier to walk on uneven terrain. From P&O's point of view, that tested foot does improve gait pattern compared with SACH foot. In terms of maintenance, there is not any broken point found in that tested foot, but the mechanical axis is required to be lubricated every 5-6 months to prevent rust, whereas with the prescribed SACH foot this is not required.

Photos from the left: (1) Cambodian SACH foot, (2)SACH foot is cut out for single axis adapter, (3) plantar flexion bumper and single axis adapter, (4)assembly single axis, (5)testing single axis foot, and(6) walking with single axis foot

Photos from the left top : (1)discussion with local mold maker, (2)mold of vulcanized single axis foot, (3) meeting foot producer at National Rehab center, (4)Draft of positive mold (5) Produce foot and attached with ankle axis, (5) participant 1, (6) participant 2, and participant 3 fitted with the tested foot.

DISCUSSION AND CONCLUSION

Comparing with the vulcanized rubber SACH foot, it is clearly found that the patient got several benefits from that tested foot. The tested feet are more durable compared with imported polyurethane single axis foot. Regarding to the cost, if it is made in mass production, the vulcanized rubber single axis foot will be cheaper than imported single axis foot. To help patients' needs with their environment and availabilities, the investment should be done to produce that kind of foot.

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ACKNOWLEDGEMENTS KhAPO express gratitude to ISPO Norway, patient, staff of Exceed Worldwide for sponsoring, participating, and giving advice in this research.

5.35.5 The Effects of Foot Size and Footshell on the Mechanical Characteristics of Carbon Fiber Prosthetic Feet

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BACKGROUND

Prosthetic components are selected according to the patient's size and mobility, being the prosthetic foot one of the most important. It is difficult to provide pediatric patients with appropriate prosthetic feet, as they change foot size rapidly and are candidates for higher mobility components, which are usually expensive. An adjustable, dynamic response, prosthetic foot could offer a solution. To develop it, mechanical characteristics for high mobility feet must me established.

AIM

To test carbon fiber prosthetic feet to determine the effects of their size and the use of a cosmetic footshell on its mechanical response, looking forward to establishing their relevance on prosthetic feet.

METHOD

Heel, Keel and Midstance tests were applied on 2 same model prosthetic feet according to the AOPA's Foot Project methodology [1]. Load was applied at a 200N/s loading rate, with 75N for Initial load and a maximum of 1.6 times the load for which each prosthetic foot was designed. Tests were applied with and without footshell in prosthetic feet sizes 22 and 26. Only steps 5, 6, 11, 12, 17, 18, 23 and 24 were considered for analysis. Energy return, maximum displacement, lineal and rotational stiffness were calculated.

RESULTS

Table 1 shows the results for both prosthetic feet. Lineal Stiffness in the size 22 foot was significantly lower than in the size 26 foot, both in the heel and the keel, with and without footshell. The amount of energy returned decreased when tests were made using the footshell, up to 16.57% in the heel, and up to 31.96% in the keel. Maximum displacement was found to increase by using the footshell. Rotational stiffness on the keel of the size 26 foot was up to 50% higher than on the size 22 foot, while this same parameter on the heel was 57% higher while testing feet in both conditions.

Table 1. Mechanical properties of two commercial prosthetic feet in size 26 and 22.

	Size 26 Foot						Size 22 Foot					
	Heel Test	Heel Test with Footshell	Keel Test	Keel Test with Footshell	Midstance test	Midstance Test with Footshell	Heel Test	Heel Test with Footshell	Keel Test	Keel Test with Footshell	Midstance test	Midstance Test with Footshell
Lineal Stiffness (N/mm)	**84.29**	**58.33**	**56.34**	**39.75**	**352.12**	**236.68**	**55.61**	**47.97**	**37.84**	**27.22**	**253.26**	**209.88**
Energy return (%)	**87.30**	**74.06**	**88.20**	**56.24**	**91.97**	**89.44**	**94.72**	**78.15**	**89.64**	**66.03**	**93.06**	**91.45**
Rotational Stiffness (Nm/°)	**5.34**	**4.87**	**28.4**	**25.8**	-	-	**2.31**	**3.17**	**14.25**	**14.26**	-	-
Maximum displace-ment (mm)	**18.13**	**26.73**	**27.9**	**41.4**	**4.28**	**6.71**	**14.2**	**17.85**	**21.7**	**30.57**	**314**	**3.88**

DISCUSSION AND CONCLUSION

Both foot size and footshell seem to have significant impact on prosthetic feet mechanical characteristics, being the energy return one of the most affected, which seems to decrease while using a footshell, as this also modifies the effective lever length. It must be considered that various commercial feet use different footshells lengths for same-size carbon fiber feet. Further tests must be done using various sizes and feet models.

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ACKNOWLEDGEMENTS This project is funded by the National Ministry of Science and Technology CONACYT (FSSS01-C-2018-1, A3-47048).

5.35.6 Can Hydraulic Ankles Improve Outcome Measures and Satisfaction Scores for Low Activity Trans-femoral Amputees?

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BACKGROUND

Microprocessor knee (MPK) funding has been available in the UK since 2017, for K3 activity level amputees. It is well regarded that advanced technology, including MPKs [1] and hydraulic ankles [2] provide a benefit for K2 and K3 lower limb amputees. The weight of MPK knees often make them unsuitable for lower activity (K1) users, however it is likely that this population group would also benefit from advanced technology to improve gait.

AIM

By using the Seattle Prosthesis Evaluation Questionnaire (PEQ), to establish if low activity trans-femoral locked knee users can benefit from the use of hydraulic ankles.

METHOD

Ten established trans-femoral K1 activity level patients using semi-automatic knee lock (SAKL) were asked to evaluate their existing prosthetic foot using the PEQ, before commencing a trial of the Avalon hydraulic ankle. Following a period of four weeks with the Avalon, the PEQ was completed in order to establish whether any improvements had been made. Video analysis was done for reference to determine changes in gait pattern. Timed up and go and two minute walk tests (2MWT) were carried out to compare the feet.

RESULTS

Across five of the six scoring groups, there were improvements with the Avalon foot, in particular ambulation and gait satisfaction. There was a trend during the two minute walk tests for the Avalon to increase walking speed. Although difficult to score, the observation by the researchers was that the gait pattern was improved with the Avalon.

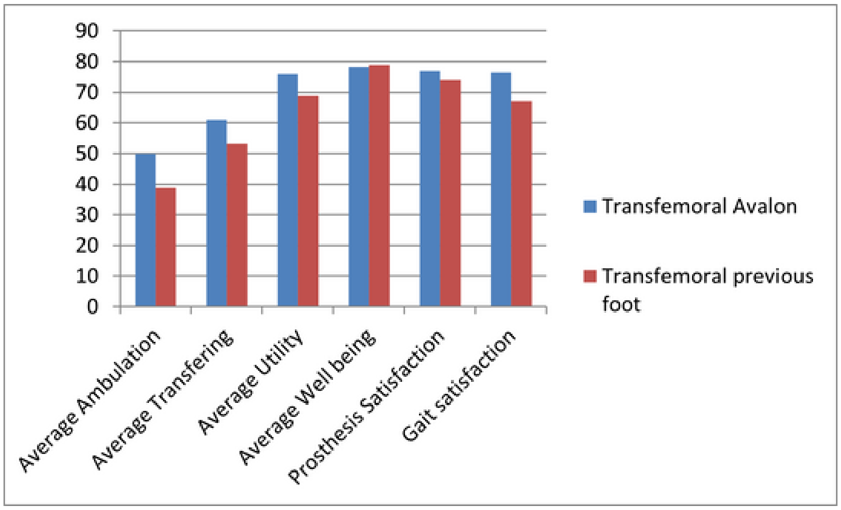

Figure 1. Avalon v previous foot for trans-femoral amputees

DISCUSSION AND CONCLUSION

It was thought that the stability from the ankle plantarflexing at initial contact provided improved sensory feedback and an added sense of security when scoring for the ambulation. The key component of gait satisfaction came from the Avalon dorsiflexing, therefore giving an increase in ground clearance for swing. It is likely this was the main factor for improved 2MWT. K1 amputees benefit from hydraulic ankles and further studies, including gait analysis should be completed.

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Free paper session: Prosthetics: Upper limb - Partial hand

5.36.1 Hand Surgeon Understanding of Partial Hand Prostheses: Results of a National Survey Study

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BACKGROUND
Partial hand (PH) amputations are injuries that negatively impact individuals and communities. PH prostheses mitigate the burdens of living with an amputation, especially when reconstruction alone cannot restore form or function. Hand surgeons may be unfamiliar with these newer devices as the prosthetic field advances and many surgeons work independently without the support of a multidisciplinary team. Assessing surgeon awareness of the modern PH prostheses and measuring the degree of collaboration within a multidisciplinary team may help improve amputee rehabilitation.

AIM
To share the results of a nationwide study in the USA of surgeons understanding of PH prosthetic rehabilitation. To make suggestions as to what steps can be taken to further educate surgeons to improve patient outcomes.

METHOD
A nationally distributed survey was distributed within the USA to hand surgeon members of the American Association of Hand Surgery with the intent of assessing surgeon familiarity with PH prosthetic devices and their clinical applications. Secondary aims explored degree of collaboration with prosthetists, therapists, and physical medicine and rehabilitation physicians. Survey items utilized Likert 5-point scales, rank order, multiple choice, and yes/no question formats. Responses were compared by training background (orthopaedic or plastic surgery) and by years of experience (10 years in practice) using independent t-tests. Demographic and clinical decision-making questions were reported as proportions and/or were reassigned into a binary format for Fisher's exact analyses.

RESULTS
Activity-specific prostheses were popular answer choices. Body-powered and passive functional devices were underutilized responses for digital and transdigital amputations. Myoelectric devices were frequently listed as options for digital and transdigital amputations. Plastic trained surgeons were more likely to list toe-to-hand transfers as treatment options for multilevel digital amputations ($p=0.03$) and transmetacarpal amputations ($p=0.02$). Senior surgeons were less likely to suggest treatment for partial thumb amputations ($p=0.02$). Cost and insurances were identified as barriers to prosthesis utilization. Perceived barriers were not influenced by years of experience ($p=0.95$ and $p=0.83$, respectively) or training ($p=0.96$ and $p=0.59$, respectively). The majority of surgeons denied working within a multidisciplinary team (76.2%) or consulting with a prosthetist prior to revisional surgeries (71.4%). Plastic trained surgeons were more likely to highly rank the importance of having a prosthetist present during amputee rehabilitation than orthopaedic trained surgeons ($p=0.02$).

DISCUSSION AND CONCLUSION
PH educational initiatives are needed on a national level for hand surgeons. Most surgeons don't work within multidisciplinary teams. Encouraging participation in such teams may mitigate these findings and improve amputee care.

Traumatic PH amputations impair independence and identity. PH prosthetic devices are available and functional, and have the potential to mitigate challenges faced by PH amputees. This study shows that surgeons are not familiar with these newer prostheses. Expanding surgeon knowledge and encouraging multidisciplinary collaboration may enhance amputee care.

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5.36.2 Case Study: A Bi-directional Ratcheting Thumb Rail Prosthesis

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BACKGROUND

The thumb is essential in grasp formation and production of grip strengths for ADLs [1]. Loss of the thumb represents a 40% reduction in hand function [1]. The thumb has five DOF: three flexion, an adduction, and a rotation degree of freedom [2]. Critically, flexion only makes up 25% of the thumb's function [3]. We present a novel bi-directional adduction rail which adds adduction and rotation DOF to the Point Thumb. We also present a case study and report preliminary outcome measures data.

AIM

To demonstrate functional outcome of a novel new prosthetic component for individuals with thumb amputation to assist in restoration of functional grasp.

METHOD

Subject is a 43 y/o female w/ right thumb amputation at CMC joint post MVA. Initially fit with a custom silicone restoration and then fit with a static Point Thumb attached to a socket/frame. The patient utilized the static Point Thumb for one year and found a high degree of function for opposition grasp. A similar socket and frame design were utilized with the adduction rail and compared to her original prosthesis. The adduction rail was positioned to allow for opposition grasp as well as lateral key grasp. An HTV silicone socket was utilized for the interface and a laminated frame was utilized to secure the adduction rail.

RESULTS

The patient found immediate benefits from the adduction rail. Positioning the thumb laterally allowed for a flat palm which gave her the ability to push off the floor and hold a plate. She was also able to achieve a cylindrical grasp allowing her to hold a pen. The CAPPFUL outcome measure was evaluated for this patient and a 3.41% improvement in overall score was found relative to the static mounting of the Point Thumb. In addition, a 9.09% reduction in maladaptive compensatory movements was achieved. Overall, the patient was very pleased with the increased function found with manipulation of the thumb in multiple positions along the adduction rail.

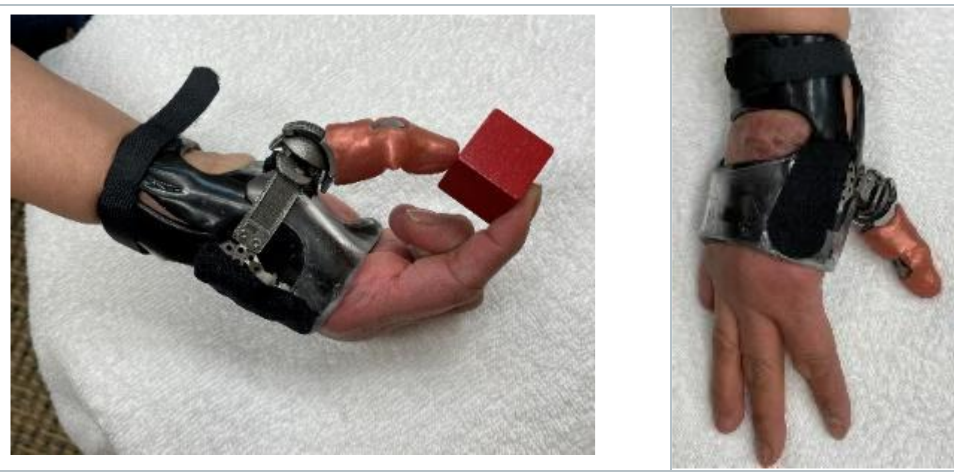

Figure 1: (Left) Prosthesis used in opposition. (Right) Prosthesis used in flat hand posture.

DISCUSSION AND CONCLUSION

The prototype adduction rail system allows for a robust thumb prosthesis that provides for flexion, extension, adduction, and rotation of the thumb. The use of the adduction rail and Point Thumb allowed the patient to achieve their functional goals. Clinical outcome measures showed a reduction in maladaptive compensatory movements as well as an improvement in overall performance of the device relative to a static thumb prosthesis. This shows the importance of adding additional degrees of freedom to prosthetic thumbs.

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5.36.3 Investigating Experiences of Clinicians Working With Partial Hand Prosthetics

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BACKGROUND

Amputation of the wrist, palm or fingers of the upper limb is defined as partial hand amputation [1]. People with this condition may have difficulty carrying out tasks and activities, so they may benefit from using a prosthetic device. Others may use a prosthetic device for cosmetic reasons. While prosthetic technology is advancing, there are many people who choose not to use a device, abandon their device, or do not have device options available to them [2].

AIM

The objectives of the study were to survey experiences of partial hand prosthetics from the perspective of the workforce who develop, assess or prescribe them.

METHOD

An online survey was designed on Qualtrics to gain knowledge around the experiences of people who work with partial hand prosthetics. Survey questions included a selection of multiple choice, Likert-type scale, closed and open ended. Participants identified which devices and outcome measurement tools they had heard of and/or used. Participants were also asked about decision making processes and factors involved in device prescription. They rated factors of importance when assessing outcomes in the partial hand prosthesis user population. Analysis of data was carried out on Qualtrics.

RESULTS

In total, responses from 14 participants were collected. User satisfaction and comfort are most important when assessing outcomes. The most commonly used device amongst participants was cosmetic (93%) followed by opposition plate (64%). The majority of participants (79%) stated that they work with colleagues on decisions related to device prescription. The majority (79%) loan test units to users prior to prescription. Participants used a range of outcome measurements. A key theme in results was the impact of funding, and all participants stated that funding influences the range of partial hand devices available for them to work with. Common concerns were the cost of devices on the market and managing user expectations.

DISCUSSION AND CONCLUSION

Multiple stakeholders are involved in prescribing partial hand prosthetics. A range of factors such as funding, cost, user satisfaction and comfort must be taken into consideration when prescribing partial hands. Loaning test units is a beneficial and commonly implemented practice. There are no specified outcome measures designed or recommended for assessment of this population.

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ACKNOWLEDGEMENTS This work was supported by the UK EPSRC grant EP/S02249X/1 for the CDT in Prosthetics and Orthotics.

5.36.4 Six-week use of a wearable soft robotic glove assisting ADL: interim results on hand function of an ongoing clinical study

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BACKGROUND
Various patient populations (e.g., trauma, orthopaedic, spinal cord injured) frequently experience difficulties in performing activities of daily living (ADL) due to declined hand function. Assistive technology can contribute to functional independence by supporting ADL. The soft-robotic glove Carbonhand [Bioservo Technologies AB, Sweden] supports the grip of its user by assisting finger flexion. It is an assist-as-needed device, requiring an active contribution of the user. Prolonged use of such smart assistive technology in the home situation may turn ADL into therapy.

AIM
To examine whether six-week use of an assistive soft-robotic glove during ADL at home results in a therapeutic effect in handgrip strength and dexterity.

METHOD
An ongoing multicentre uncontrolled intervention study is performed, with three pre-assessments (averaged) and two post-intervention assessments after one (post) and four weeks (follow-up). Sixty-three patients with chronic decreased hand grip strength (wide variety of disorders) are included, recruited by eight Dutch clinical centres. Patients use CarbonHand during ADL at home during six weeks. Outcome measures (selection from assessment battery) include maximal grip strength using the Jamar hand dynamometer and the Jebsen-Taylor hand function test (JTHFT), measuring functional performance of the hand during seven unilateral hand skill tasks related to ADL. Tests were performed without using the glove. Appropriate statistical tests were used to analyse whether outcome measures changed over time.

RESULTS
Forty-nine subjects are included in the analysis so far, while the last subjects are currently finalizing their participation. Grip strength increased with 2.1 (±4.3) kg from pre to post ($p=0.001$), and this improvement was maintained between post to follow-up. JTHFT total score improved pre to post and pre to follow-up with 16 seconds ($p=0.000$) and again this improvement was maintained between post to follow-up. In addition, performance of six of the seven JTHFT subcategories improved, again mostly between pre to post, with the improvement maintained or further improved between post to follow-up. The task that did not improve after glove use was “stacking checkers”, a relatively fine motor task that requires the ability to feel where the checkers are and if they will slip between gloved fingers, for instance.

Figure 1: CarbonHand glove

DISCUSSION AND CONCLUSION
Current interim-results are promising for finding modest therapeutic (clinical) effects of using a soft-robotic glove as assistive aid during ADL for six weeks at home. Persistent improvements at follow-up suggest learned non-use was counteracted. If so, this would open up new opportunities for extending rehabilitation into peoples’ homes after discharge, while also providing direct support to object handling during ADL. Smart soft-robotic gloves can turn everyday activities into high-dose, high functional and task-specific training integrated in people’s daily life.

ACKNOWLEDGEMENTS We acknowledge Clinical Trial Service BV for study monitoring according to GCP for clinical studies with medical devices (ISO 14155).

Free paper session: Gait and balance - Sensors and classification

5.37.1 Low-Cost Wearable Sensors for Augmenting Observational Gait Analyses in Lower Limb Prosthesis Users

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BACKGROUND
Lower limb prosthesis users depend on “good gait” [1] for sustained mobility. While convenient, observational gait analyses depend on the clinicians’ expertise and are only moderately reliable [2]. Advanced technologies like gait mats and motion capture systems offer objective information on gait quality, but are expensive, require expert operation, and do not provide in-socket measurements. Therefore, they have remained research tools and are rarely used for day-to-day gait rehabilitation.

AIM
In this study, we aimed to develop and evaluate a low-cost and easy-to-use wearable gait and in-socket sensing system that can augment clinical expertise in gait assessment and training.

METHOD
The wearable sensing system was designed to meet three main criteria: 1) use inexpensive off-the-shelf sensors; 2) take <5 minutes to don/doff; 3) display gait parameters and in-socket forces on a simple interface. The prototype effectiveness was evaluated within an amputee rehabilitation program. Eight lower-limb prosthesis users (with a variety of amputation levels) and three physiotherapists were recruited. The usability of the sensing system was explored through multiple 30-second walk tests, where either an intervention was evaluated or the effect of using walking aids was examined. Interviews with participants were used to gain insights into the technology usefulness.

RESULTS
The resulting sensing system prototype includes an adjustable shoe cover instrumented with IMUs and force sensors to monitor temporal gait parameters and a thin sock furnished with force sensors at five distal locations (posterior, medial, lateral, anterior, and distal) for in-socket force monitoring. A simple interface displays the measurements and applicable normative data. The prototype cost less than $200, and takes 3-5 minutes to don and 1-2 minutes to doff. Figure 1 presents a schematic of the sensing device and an example comparison of in-socket forces before and after an effective intervention, where higher reliance on the prosthesis led to increased stance symmetry and higher in-socket forces over a longer stance time.

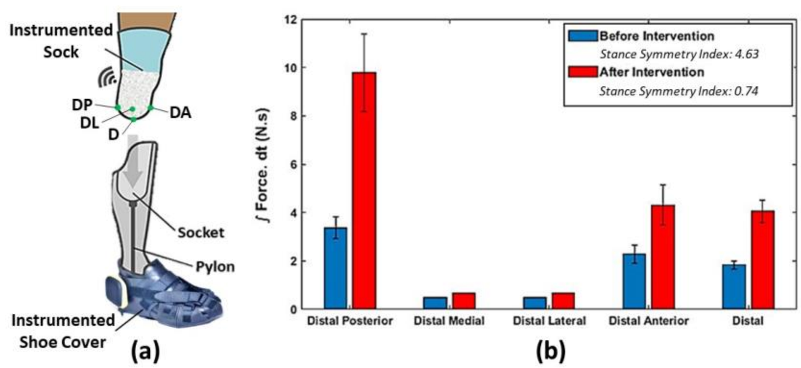

Figure 1. (a) Gait and in-socket sensing system; (b) Example comparison of in-socket forces.

DISCUSSION AND CONCLUSION
The developed sensing system satisfied all design criteria and proved to be a convenient mobile gait lab, augmenting observational gait analyses by quantifying improvements after feedback. The results also confirmed that gait quality affects socket fit and vice versa. All participants expressed interest in reusing the sensing device. Further research is required to assess the technology acceptance for regular use in gait training and socket fit adjustment.

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ACKNOWLEDGEMENTS We would like to acknowledge CARTE at the University of Toronto and The War Amps for their support and funding.

5.37.2 Development of tools for post-Stroke data collection - Validation of novel fabric EMG sensor, with Arduino-driven data collection, on non-affected participants.

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BACKGROUND
Analysis of EMG signals when walking can potentially aid prescription of assistive devices such as Ankle Foot Orthoses (AFOs). In the Post-Stroke community AFOs are commonly prescribed to improve safe ambulation and prevent trips and falls [1]. However, current EMG sensors do not allow for accurate in-brace analysis due to Orthosis design and interaction with the sensors. Additionally, real-world data collection is limited.

AIM
Validation of novel fabric EMG sensor [2] combined with an Arduino-driven sensor, Myoware EMG board and Force Sensitive Resistor (FSR) foot switch (FS) for use with an assistive AFO.

METHOD
Data were collected from a convenience sample of non-affected participants wearing the novel fabric EMG device plus an adjustable AFO (GEO AFO with Triple Action Ankle joint, supplied by Becker Orthopaedic [3]. Spatiotemporal, kinematic and kinetic data were also collected through Vicon using the standard Plug in Gait (PIG) marker placement and modelling. Participants completed a minimum of 8x 5M walks in different AFO constraint configurations. Two different configurations have been reported here: 1) Novel fabric EMG device plus AFO set to 'minimum' ankle joint; 2) Novel fabric EMG device plus AFO set to 900 fixed ankle joint.

RESULTS
Data were gathered from 6 volunteers. 4 male (2 female), average age 26(+/- 4 years). AFO and fabric EMG was worn on the left leg for all participants. Figure 1 shows Arduino data collection device, Myoware board and FSR with fabric EMG reference electrode. FSR foot switch (FS) and EMG data were available for participants 1, 2, 4, 5 and 6. FS data for participant 3 was erroneous due to fault in FSR. EMG data were analysed in post-collection to give output in Volts (V) for comparison to existing published data. Data for each participant showed distinct peaks (n=4 (+/- 2)) for each participant throughout the collected range of 5M walked. FS data indicated distinct periods of contact vs no-contact comparable with stance and swing phases of gait.

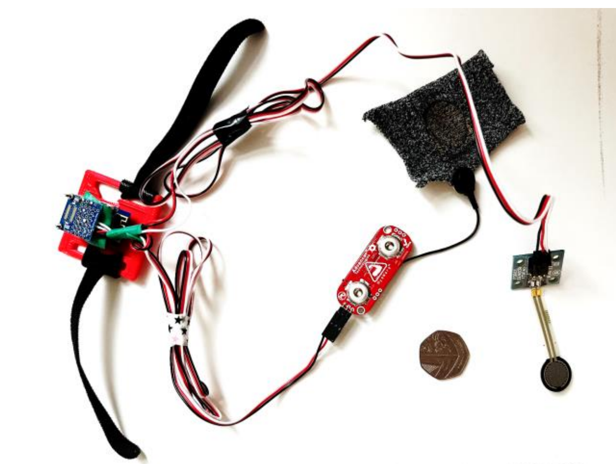

Figure 1 - Arduino, Myoware board, FSR and fabric EMG reference electrode.

DISCUSSION AND CONCLUSION
Timing of muscle activity was appropriate with standard gait cycle events as expected in non-affected participants. Spatiotemporal data showed slight trend towards increased contralateral stride length with the AFO in fixed 900 state. Addition of a forefoot FSR was indicated to improve gait event prediction. Corresponding EMG patterning and FS data indicated potential for the device as an analysis tool for gait.

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5.37.3 Recognising Gait Type from Lower Limb Sensors: Improved Success Using Amplitude Normalisation

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BACKGROUND

Gait is a marker of global health and a method of diagnosing and assessing pathologies [1–4]. Machine learning algorithms can detect activity type and duration using raw acceleration signals [5]. Detecting gait modalities using different sensor attachment sites is essential particularly for applications such sensor integration in lower limb orthotic or prosthetic devices. Discriminating gait modalities using non-intrusive locations e.g. shank, may enhance wearer adherence.

AIM

To explore the effect of normalising acceleration amplitude when using a machine leaning algorithm to discriminate between gait types.

METHOD

A machine learning algorithm combining principal component analysis and discriminant function analysis, alongside a ratio criterion to quantify discrimination quality (Figure) was used to discriminate between three different self-selected walking speeds (slow, normal and fast). Participants (n=35) wore five accelerometers attached at the sacrum and thighs and shanks. Visual inspection of discriminant function clouds revealed that a criterion value smaller than 0.01 determined successful discrimination between cyclical conditions, whilst greater values correspond to unsuccessful gait type recognition. The algorithm processed criterion scores analysing discriminant function scores based on time-series acceleration signals that either did or didn't normalise acceleration amplitudes.

RESULTS

Prior to amplitude normalisation, the algorithm discriminating gait types for the sensor at the sacrum was successfully discriminated the three gait types for 97% of participants, the sensors at the thighs 74% and at the shanks 66%. After normalisation these success rates increased at the sacrum to 100%, thighs 98% and shanks 100%.

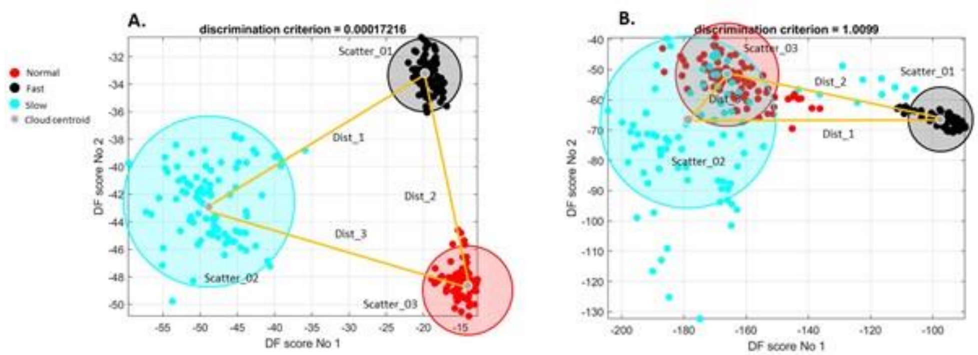

Figure 1.

Scatter = One standard deviation from the centroid of the clouds.

$$\text{Discrimination Criterion} = \left(\frac{\text{scatter}_{01} * \text{scatter}_{02}}{\text{dist}_1 * \text{dist}_2}\right) * \left(\frac{\text{scatter}_{01} * \text{scatter}_{03}}{\text{dist}_1 * \text{dist}_3}\right) * \left(\frac{\text{scatter}_{02} * \text{scatter}_{03}}{\text{dist}_2 * \text{dist}_3}\right)$$

A. Criterion discrimination score below 0.01 threshold exhibiting small standard deviations of feature types, and large distances between centroids.

B. Criterion discrimination criterion score above 0.01 threshold exhibiting large standard deviations of feature types, and small distances between centroids.

DISCUSSION AND CONCLUSION

Results show that normalising acceleration amplitude signals improves success rate in all locations measured. The increased success rates seen particularly at lower limb attachment sites, mean future data collection protocols could attach and/or integrate sensors into prosthetic and orthotic devices. Current results suggest that when using a machine learning algorithm; normalised acceleration amplitude improves gait modality identification success rate in all sensor locations.

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5.37.4 Balance Confidence Classification in Lower Limb Amputees using Step-based Features Calculated from Smartphone Sensor Signals

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BACKGROUND

Lower limb amputees present with inconsistent gait and stability [1]. While fear of falling can prevent people from participating in social activities, excess confidence can increase fall risk [2]. The activities-specific balance confidence scale (ABC) assesses balance confidence during everyday activities (e.g. reaching overhead) with a score of ≥80 considered high confidence [3]. Previous research demonstrated that clinical outcomes can be determined from walk test data [4]. Classification of the ABC score would allow for a more individualized rehabilitation programme.

AIM

To determine if step-based features calculated from smartphone signals collected during a 6-minute walk test (6MWT) can classify the ABC score of lower limb amputees into high confidence and low confidence groups.

METHOD

58 people with lower limb amputation completed a 6MWT along a 20-meter pathway with a smartphone attached to their posterior pelvis. TOHRC Walk Test app [5] collected accelerometer and gyroscope data at 50 Hz. ABC scores and self-reported fall history were collected from each participant. Participants were categorized into two classes, low confidence (<80%) and high confidence (≥80%). Step-based features were calculated using smartphone signals and automatically detected foot strikes [6]. Attribute selection was performed to reduce dimensionality. A random forest classified ABC groups using a 58-fold cross validation. Feature selection and model build were completed using Weka [7].

RESULTS

Approximately 33% of participants (19/58) had an ABC score 80 or greater. Participants were majority male (94.8%) and the level of amputation majority transtibial (96.6%). 248 step-based features were extracted from the smartphone signal data. Feature selection reduced the dataset to 18 step-based features. The random forest correctly classified the balance confidence of 47 of 58 participants (accuracy 81.0%, sensitivity 63.2%, specificity 89.7%).

Table 1. Number of correctly classified and incorrectly classified ABC scores

	Correctly Classified	Incorrectly Classified
≥ 80%	12	7
> 80%	35	4

DISCUSSION AND CONCLUSION

This research demonstrated that step-based features calculated from smartphone signal data can be used to classify lower limb amputees into high and low balance confidence groups after completing a 6MWT. Integration of this model into the TOHRC walk test app would provide balance confidence classification, in addition to other clinical outcomes (e.g. stride parameters, fall risk), after completing a single assessment.

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5.37.5 Development of a Low-Cost Portable IMU System for In-Shoe Foot Motion Analysis

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BACKGROUND
Walking with shoes is common in our daily life. It is difficult to describe three-dimensional foot motions in a shoe or with orthoses in clinical settings. A recently developed Inertial Measurement Unit (IMU) foot motion analysis system may solve this limitation to measure foot motion of shod walking in a hospital corridor.

AIM
To develop a low cost portable IMU system that can measure three-dimensional foot motion of shod walking in clinical settings.

METHOD
The system consisted of six 9-axis IMU wirelings and six control packages. Each wireling was connected to the control package through a cable. Foot switches were used to detect heel strike and toe off. The 1st metatarsus, proximal phalanx and mid-foot of both feet were tracked. One subject with no foot deformities walked in the corridor at self-selected pace with nurse footwears. The data were exported to Excel for Windows where all further data processing and analysis were carried out. Three-dimensional joint rotations were calculated according to the joint co-ordinate system convention from Grood and Suntay.

RESULTS
The patterns of joint rotations were highly consistent between walks for the same subject. Most of the joints data for the left and right foot showed symmetry.

DISCUSSION AND CONCLUSION
This study developed a low cost and portable IMU system to measure three-dimensional foot joint rotations of shod walking in clinical settings. Consistency between subjects will be studied in the future. Future work with this methodology can be used to increase understanding of foot motion in shod activities.

ACKNOWLEDGEMENTS: The research was supported by “the Fundamental Research Funds for Central Public Welfare Research Institutes” 2019CZ-8, 2020CZ-4, 2022CZ-6.

Free paper session: Prosthetics: Lower limb - Socket design

5.38.1 Technique to assess shape captured by two casting approaches

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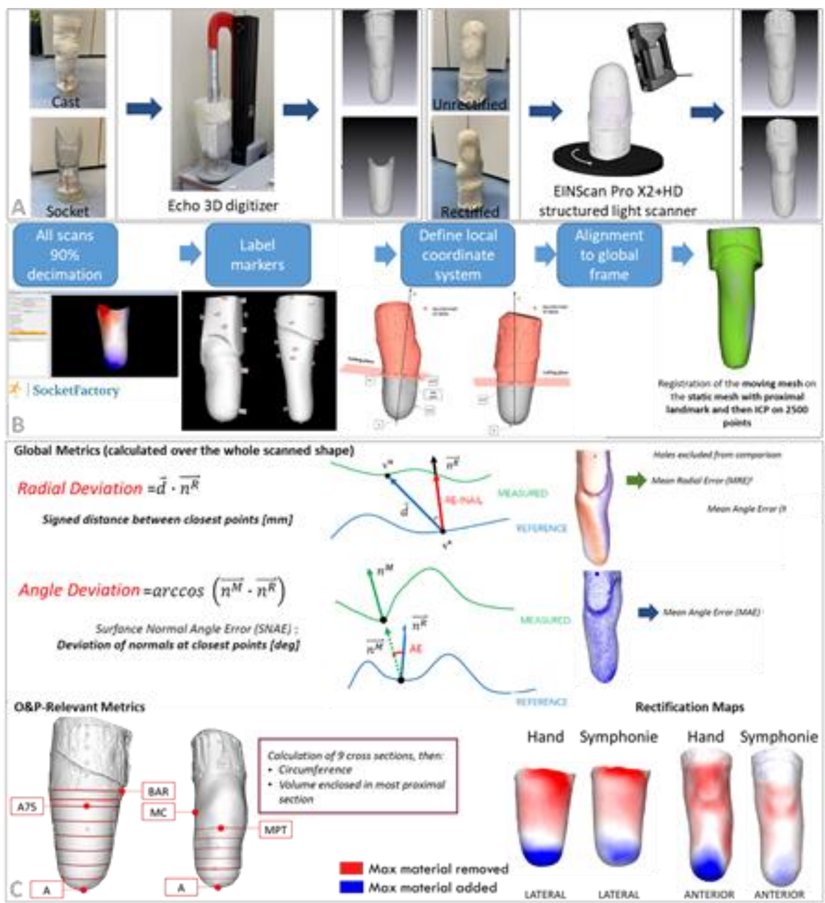
BACKGROUND
Residual limb shape capture is an important step in the fabrication of a prosthetic socket. Hand casting with plaster bandages has long been the conventional approach, however in recent years new shape capture methods using standing hydrostatic pressure casting have been developed. To compare casting approaches, a method of assessing the shape captured in the cast and through the rectification process is needed.

AIM
The aim was to develop a technique to assess the shape captured by two casting approaches: hand casting and casting with the Symphonie Aqua System (Romedis, GmbH, Germany).

METHOD
The analysis technique involved scanning and using markers on a proximal extension to align the cast, pre- and post-rectified positives, and check socket. The EINScan Pro X2+HD structured-light scanner (Shining3D, China) and Echo 3Dv2 digitizer (Rodin4D, France) were used to scan positive and negative shapes, respectively. For mesh processing, we applied 10% decimation, labelled all markers, defined local-coordinate-systems, and aligned the shape to a global frame using purpose-built Python software (SocketFactory). Registration of the moving mesh on the static mesh used landmarks and an iterative-closest-point algorithm. Outcome measures to assess shape difference included global (radial and angle deviations) and O&P-relevant metrics (circumferences at multiple cross-sections and total volume).

RESULTS
Figure 1 illustrates the shape analysis process: A. Digitization. B. Mesh Processing. C. Outcome Measures and Rectification Maps.



DISCUSSION AND CONCLUSION
We are using this shape analysis technique as part of a clinical trial comparing hand casting to Symphonie casting (see rectification maps, Figure 1C). This shape analysis technique may also be used in future as part of machine learning to automate the rectification technique and artificial intelligence supported manufacturing.

ACKNOWLEDGEMENTS: The Residual Limb Shape Capture Group included: D.Anco,[4] I.Annese,[1] L.Ashiku,[3] K.Barrons,[4] M.Bisighini,[1] R.Caldwell,[3] K.Carnahan,[3] J.Cave,[4] F.Ceccarini,[1] K.Falbo,[4] A.Fazzini,[1] S.Gard,[3] F.Giacchi,[1] L.Guiducci,[1] A.Gravely,[4] G.Gregori,[1] J.Looft,[4] C.Mele,[1] G.Migliore,[1] K.Muschler,[4] I.Raileanu,[1] P.Randi,[1] M.G.Santi,[1] N.Walker,[4] K.Yun.[4]

Funded by DOD #W81XWH1910835.

5.38.2 Smart Templates to Inform Personalised Transtibial Prosthetic Socket Design

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BACKGROUND
Transtibial prosthetic sockets are often grouped into patella tendon bearing (PTB) or total surface bearing (TSB) designs, but there are many variations in rectifications used to fit the prosthetic limb to the individual. Prosthetists currently have little objective evidence to assist them as they make socket design choices.

AIM
To compare rectifications made by experienced prosthetists across a range of patient demographics and limb shapes to improve understanding of socket design choices.

METHOD
Residual limb surface scans and CAD/CAM socket designs were analysed for 67 randomly selected individuals registered to a UK prosthetics service, 55 with PTB and 12 with TSB sockets. The residual limb and socket scan pairs were analysed to determine the location and size of rectifications used. Rectification practice was compared between PTB and TSB designs, and across residual limb morphology groups, using statistical limb shape analysis and a Naïve Bayes classifier.

RESULTS
Socket designs varied across a spectrum instead of discrete groups, with most designs showing a hybrid of the PTB and TSB principles. Only the fibula head rectification size was significantly different between PTB and TSB designs. Correlations were observed between the size of specific rectifications (paratibial carves; distal end build-up and cross-section area reduction). The Naïve Bayes classifier predicted socket designs for new virtual patients which were consistent with established PTB and TSB recommendations.

This study demonstrates how we might learn from design records to support education and enhance evidence-based socket design, by defining smart CAD/CAM design templates.

DISCUSSION AND CONCLUSION
We propose that smart templates should be implemented as part of a qualified prosthetist's CAD/CAM workflow and must not be seen to replace their experience-based skill. The method could allow them to focus their time on higher value-added, personalised aspects of socket design, tailoring templates to individuals. Current work is extending the study with a larger dataset, and the feasibility of smart templates will shortly be assessed in a double-blind crossover study, compared to conventional CAD/CAM sockets.

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5.38.3 Effect of Casting Approach on Initial Socket Comfort: Interim Results of Clinical Trial

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BACKGROUND

Prosthetic socket fabrication processes consisting of residual limb shape capture and positive mold rectification affect initial check socket fit. The most prevalent shape capture method involves a non-weight bearing negative wrap with manual manipulation to conform to the residual limb shape. However, it is challenging to accurately capture bony contours and distribute pressure evenly where it can be tolerated. Hence, techniques relying less on manual manipulation, such as standing hydrostatic pressure casting, have been developed.

AIM

The aim was to compare the initial socket comfort of a check socket made from hand casting to standing hydrostatic pressure casting (Symphonie Aqua System, Romedis GmbH, Germany) in persons with lower limb amputation.

METHOD

A 3-site randomized cross-over trial is underway with IRB approval (recruitment goal: 20 TTA + 10 TFA adults/site; total N=90). A single prosthetist/site took each cast randomly by hand or Symphonie, rectified each mold, and fabricated a check socket (TT: total-surface-bearing/TF: subischial/hybrid). Sockets were randomly presented: participants donned each socket, sat for 2-minutes, then stood for 5-minutes. After re-donning socket 1, socket comfort score (SCS)[1] was administered by a blinded-assessor and repeated for socket 2. Prosthetists used a socket-fit-checklist to evaluate fit and make modifications to improve comfort. SCS was administered again/socket and differences between sockets compared before and after modification using paired t-tests (α=0.05).

RESULTS

Performed interim analysis on 48 subjects. For all subjects, comfort before and after modification was slightly but not significantly better for Symphonie. Within sites, results were the same for initial comfort, but final comfort was significantly different at one site with only TT data; other sites had both TT and TF data. Comfort before and after modification was significantly better for Symphonie in TT subjects. Comfort for hand casting was significantly better for TF subjects before modification, with no difference after modification.

Table 1 Mean ± SD socket comfort scores (SCS) (*significant p-values)

SCS	Hand Cast	Symphonie Cast	p-value
Initial (all=48)	6.4±2.3	6.8±1.9	0.1959
Initial (TT=35)	6.2±2.5	7.2±1.8	0.0128*
Initial (TF=13)	7.0±1.8	6.0±2.1	0.0489*
Final (all=48)	7.5±2.0	8.0±1.3	0.0693
Final (TT=35)	7.4±2.1	8.2±1.2	0.0219*
Final (TF=13)	7.6±1.9	7.3±1.4	0.5590

DISCUSSION AND CONCLUSION

Initial results suggest that casting with the Symphonie Aqua System may result in a more comfortable initial socket fit than hand casting for TT but the opposite may be true for TF. However, thus far, we have limited numbers of TF subjects. Results may change as more data is collected.

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ACKNOWLEDGEMENTS: Residual Limb Shape Capture Group includes: D.Anco,[4] I.Annese,[3] L.Ashiku,[2] K.Barrons,[4] M.Bisighini,[3] R.Caldwell,[2] K.Carnahan,[2] J.Cave,[4] F.Ceccarini,[3] K.Falbo,[4] A.Fazzini,[3] S.Gard,[2] F.Giacchi,[3] L.Guiducci,[3] G.Gregori,[3] J.Looft,[4] C.Mele,[3] G.Migliore,[3] K.Muschler,[4] I.Raileanu,[3] P.Randi,[3] M.G.Santi,[3] N.Walker,[4] K.Yun.[4]

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5.38.4 Validation of an affordable prosthetic silicone liner to enable adoption of Total Surface Bearing sockets in resource limited environments

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BACKGROUND

Prosthetic silicone liners improve comfort and skin protection, reduce pain [1,2] and are critical to the use of transtibial total-surface-bearing sockets which bear weight uniformly over the residuum, improving proprioception and comfort [2-5]. Unfortunately, liners are cost-prohibitive in low-to-middle-income countries (LMICs), where patellar-tendon-bearing sockets with PE-lite (expanded-foam) are still the standard care [6]. This standard has a higher prevalence of pain and skin issues [6]: facilitating access to more cost-effective liners could have significant clinical and quality of life benefits for amputees in LMICs.

AIM

This study aims to validate the use of a locally manufacturable and affordable silicone liner in a resource limited environment to enable adoption of total-surface-bearing (TSB) sockets in LMICs.

METHOD

5 transtibial unilateral amputees who were using a patellar-tendon-bearing socket with PE-lite participated in the study and were provided with a new prosthesis (standard TSB socket with affordable liner). Participants performed validated mobility tests [7] for their old and new prosthesis. The mobility tests, recommended by COMPASS [8], consisted of the 2 Minutes Walking Test (2MWT) and Timed Up and Go Test (TUGT). Participants were also asked to complete validated [9] and study-derived self-reported questionnaires for their old prosthesis and at 3-month follow-up.

RESULTS

Participant mobility improved while wearing the TSB socket and liner, with reduced TUGT times (from 10.42 ± 4.65s to 9.47 ± 4.71s), and increased 2MWT distances (from 150 ± 78m to 157 ± 65m). The new prosthesis was found to be more comfortable; there were no problems identified with donning and doffing the liner; and nor were product maintenance or excessive compression issues raised. However, excessive sweating, a common problem of silicone liners, was reported.

DISCUSSION AND CONCLUSION

These preliminary results suggest that this affordable silicone liner may be suitable for use in LMICs as users experienced an increase in mobility and were satisfied with the device overall, although a future, larger sample will further validate this. Further work should also investigate liner longevity. This study indicates that an affordable liner can be successfully and safely used in LMICs, therefore enabling adoption of TSB sockets and helping lower-limb amputees provide for their family and participate in social life.

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5.38.5 Characterizing and estimating prosthetic socket design with digital technologies

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BACKGROUND

Characterizing and estimating prosthetic socket design with digital technologies.

AIM

There are two aims of this research,

(1) characterizing prosthetic socket rectifications.

(2) estimating rectification values between a check socket and a final socket from 3D residual limb shapes with machine learning technology.

METHOD

3D scan of residual limbs is first acquired using a 3D scanner, followed by 3D modeling on our original 3D CAD software to design a socket shape through digital rectifications as a check socket. After fittings with a check socket, we modify a socket shape again on the CAD software. To achieve the first aim, we evaluated rectification parameters from check sockets to final sockets. PCA (Principal Component Analysis) was applied to identify principal parameters. For another aim, we extracted useful features of 3D shape of residual limbs by statistical processes. Then we estimated rectification parameters by machine learning model, LightGBM (Light Gradient Boosting Machine).

RESULTS

We used 6 rectification parameters, (1) compression, (2) depth of patella tendon, (3) depth of tibia, (4) depth of fibula head, (5) depth of distal end of fibula, (6) depth of popliteal fossa. PAC analysis shows that the contribution ratio of the first principal component (PC1) is 0.32 and the second one (PC2) is 0.24. And causal factors for this deviation of PC1 correspond to (a) increase depth of patella tendon, (b) increase depth of popliteal fossa and (c) increase compression rate and PC2 correspond to (a) increase depth of fibula head and (b) decrease compression rate. To estimate rectification parameters (Fig. 1), we reduced the number of features of residual limbs to 50 dimensions. An estimation accuracy of rectification parameters, compression rate as example, is 0.63. The range of compression rate of training data is from -6 to 3%.

DISCUSSION AND CONCLUSION

PCA analysis shows that the causal factors of PC1 correspond to tightening sockets and ones of PC2 correspond to enlargement of sockets. The proposed machine learning model estimates rectification parameters from residual limb shapes. The accuracy is limited, but it can be improved with additional training data and other feature extraction methods. This result suggests that digital technologies and data analysis help rectification processes and provide better fittings of prosthetics.

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Free paper session: Orthotics: Spinal

5.39.1 The effect of Scoliosis brace with vs without opening areas on the treatment of AIS patient: A Single Case Report

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BACKGROUND

Treatment of AIS includes conservative and operative treatment depending on the curve severity and maturity status. In the Boston principles, a window opening is provided in the contralateral area to the corrective force area to maximize the in-brace curve correction and achieve trunk balance. However, to our best knowledge, the difference between with and without an opening area has not been investigated.

AIM

This report aims to study the effects of the scoliosis brace with no opening area (D1) and the scoliosis brace with an opening area (D2) on three factors: in-brace curve reduction, spinal coronal decompensation, and apical vertebral translation.

METHOD

A fourteen-year-old AIS patient with a double major curve, right thoracic (T8) and left lumbar (L2), participated in this study. The D1 was fabricated, fitted, and took an in-brace radiograph first, then the opening areas on the thoracic and lumbar were cut on D1 to be D2 and took the final radiograph. The outcome measurements included thoracic cobb angle (TCA), lumbar cobb angle (LC), coronal decompensation (CD), thoracic apical vertebral translation (TAVT), and lumbar apical vertebral translation (LAVT) were measured in-brace for both designs, while the amount of thoracic and lumbar curve reduction were measured and compared to the baseline (pre-orthosis).

RESULTS

The result of this study has shown that the in-brace curve reduction is improved with the opening on the concave side of both curves, as shown in Table 1. Even though no major change was noticed in other aspects, further brace adjustment has been considered to achieve the optimal alignment. However, patient reported more satisfaction with the opening design, which may have influenced the better compliance of brace wear.

	TCA (degrees)	Thoracic curve reduction (%)	LCA (degrees)	Lumbar curve reduction (%)	CD (cm.)	TAVT (cm.)	LAVT (cm.)
Pre-orthosis	51.33 (R)	N/A	45.33 (L)	N/A	1.99 (L)	0.80 (R)	3.81 (L)
In-brace (D1)	43.33 (R)	15.58%	40.11 (L)	11.51%	0.78 (L)	1.07 (R)	2.90 (L)
In-brace (D2)	36.22 (R)	29.44%	33.33 (L)	26.47%	0.22 (L)	1.21 (R)	2.31 (L)

Table 1. Outcome measurement of the two designs (D1 and D2) and the baseline (Pre-orthosis). The direction was presented as either R (right-sided) or and L (left-sided).

DISCUSSION AND CONCLUSION

The amount of curve reduction improved in D2 compared to D1. One of the causes could be more space in the trunk shifting towards the opening area, which allows the straps to be tightened more. The CD and LAVT were improved in each design. Meanwhile, the TAVT was worsened, which might result from the larger thoracic counter force (from lumbar corrective force) than the thoracic force. Therefore, further brace adjustment should be considered to achieve the optimal alignment.

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5.39.2 Using the Concept of Plane of Maximum Curvature in Orthotic Management of Adolescent Idiopathic Scoliosis: A Pilot Study

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BACKGROUND

Adolescent Idiopathic Scoliosis (AIS) is the most common type of scoliosis combining lateral curvature and axial rotation as a 3D deformity, leading to high risk of progression. The Plane of Maximum Curvature (PMC) is defined as a plane angulated in between the sagittal plane and frontal plane, where a maximum magnitude of curvature can be measured for a specific curve, and the orientation of PMC provides a 3D understanding of the deformity and may improve orthotic design.

AIM

This study aimed to evaluate the outcome of orthotic intervention for AIS designed with the concept of PMC that could provide an evidence-based modification method for effective bracing.

METHOD

Ten female subjects aged 10-14 diagnosed with AIS, with Risser sign 0-2 and moderate scoliosis, were recruited and randomly assigned into 2 groups: Control group using conventional design method; and Test group using PMC design method. The pre-brace orientation of PMC was calculated according to the equation developed by Wu, et al. (2018) with the coronal and sagittal radiographs. The demographic data, Cobb angles measured at the pre-brace and in-brace conditions, and brace wearing compliance tracked using thermosensor were collected for data analyses.

RESULTS

In the demographic data, there was no significant difference between the two groups in age (p=0.262), body height (p=0.474) or weight (p=0.639), or Risser's sign (p=0.881). The coronal Cobb angle at the pre-brace condition was found no significant difference between the two groups (p=0.447). In the modification of spinal brace, the locations of thoracic and lumbar corrective forces in the Control group were 25.5°±2.1° medial and 2.0°±9.9° medial to the orientation of PMC. The in-brace coronal Cobb angle corrections are 4.0°±0.0° and 13°±0.0° in the thoracic curve of the Control group and Test group respectively, and 11.5°±2.1° and 16.0°±3.6° in thoracolumbar or lumbar curves of the Control group and Test group respectively.

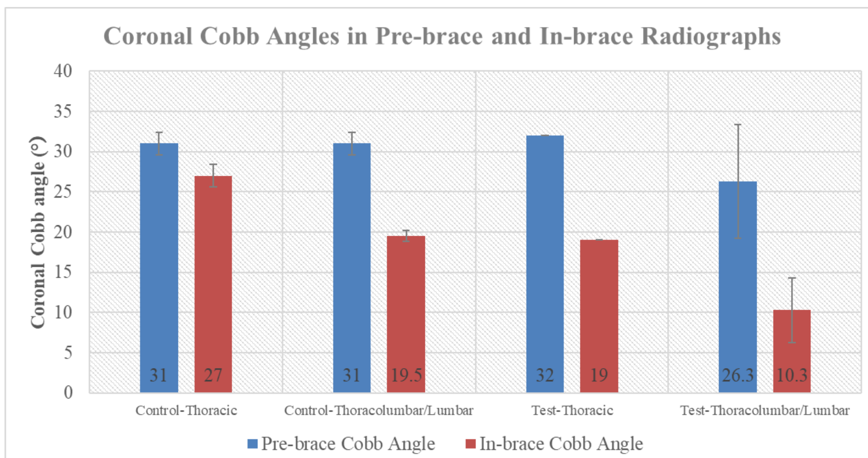

Figure 1. Coronal Cobb Angles in Pre-brace and In-brace Radiographs

DISCUSSION AND CONCLUSION

High correlation was observed between the calculation method and the clinical examination in measurement of coronal Cobb angle. This agreement could assist further verification of equation accuracy and support its application. In the location of thoracic corrective force placement, there is difference between the conventional and PMC methods. The outcome suggested the level of in-brace coronal Cobb angle correction is larger with the application of the concept of PMC. Further study with larger sample sizes is needed for conclusive findings.

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5.39.3 The Effect of Spinal Orthosis Wearing Time on the Spinal Deformity of Patients with Adolescent Idiopathic Scoliosis

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BACKGROUND

The rigid spinal orthosis is generally prescribed to patients with moderate adolescent idiopathic scoliosis (AIS) and growth potential. It is recommended to wear the orthosis 23 hours a day till skeletal maturity [1]. Recent studies reported that higher wearing compliance is associated with a lower failure rate [2]. However, instrumented orthosis wearing time during the whole orthotic treatment period and its impact on the treatment outcome have not been fully investigated.

AIM

This study aimed 1) to assess the orthosis wearing compliance for the whole treatment period, and 2) to compare the outcome of the first and second half of the treatment period under different compliance levels.

METHOD

One hundred and fourteen subjects with AIS of major curve Cobb angle 20°-45°, Risser Sign 0-2, aged 10-14, were selected in this study. Their orthosis wearing compliance during the whole treatment period were recorded and divided into four groups: group A (whole period compliance is < 12h/day); group B (first half compliance is < 12h/day & second half compliance is >= 12h/day); group C (first half compliance is >= 12h/day & second half compliance is < 12h/day); group D (whole period compliance is >= 12h/day). The primary outcome is Cobb angle change between the pre- and post-orthotic treatment.

RESULTS

The results indicated that compliance in the first half, second half, and whole treatment period of the 114 subjects were 15.1 ± 5.9 h/day, 10.8 ± 5.9 h/day, and 12.8 ± 5.5 h/day, respectively. A significant difference was found between the compliance in the first and second half treatment period ($p<0.05$). Only 3 out of 114 subjects fell into group B (Cobb angle increased 8.3°). In addition, the results showed that the treatment outcome of group A (n= 30, Cobb angle increased 7.6°) was significantly different from that of group C (n= 33, Cobb angle increased 0.6 °, $p<0.05$) and group D (n= 48, Cobb angle decreased 2.7°, $p<0.05$). There was no significant difference between groups C and D.

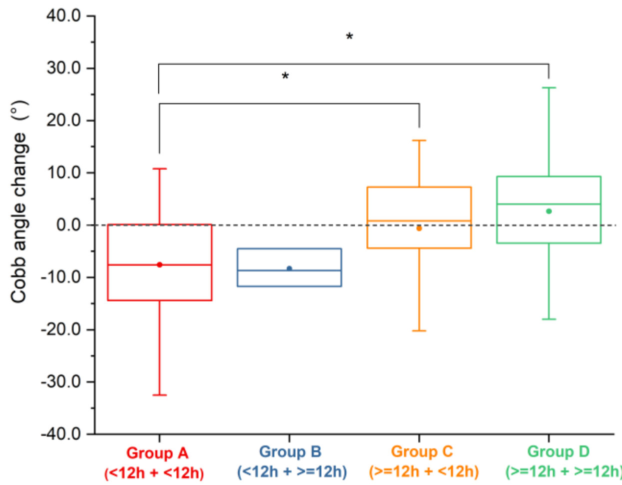

Figure 1. Cobb angle change between pre- and post-treatment under different compliance groups

DISCUSSION AND CONCLUSION

This study revealed that the patient's orthosis wearing time in the first half treatment period is higher than that in the second half treatment period. It is also deserved to note that low compliance, especially during the first half treatment period, could lead to a higher chance of curve progression because the first half treatment period may exactly fall into their growth spurt. Thus, it would be important to have high compliance, especially during such a critical period.

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ACKNOWLEDGEMENTS Special thanks to Mr. Wing Cheung YENG and Mr. Chi Kwan CHAN for their facilitation in data collection.

5.39.4 Patient Characteristics and Clinical Outcomes of Non-School Screening Adolescent Idiopathic Scoliosis Patients at Siriraj Hospital, Thailand: Retrospective Chart Review

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BACKGROUND

Adolescent Idiopathic Scoliosis (AIS), the most common type of scoliosis, is likely to progress over time. Early detection improves treatment outcomes [1], and curve magnitude is considered as an important factor to determine proper treatment. In Thailand, however, there is limited evidence on characteristics of AIS patients at the first diagnosis. Hence, the findings of this study can offer the baseline information about characteristics of AIS patients in Siriraj Hospital, Thailand, emphasizing early detection and promoting the effectiveness of treatment.

AIM

To identify the initial curve magnitude and examine the clinical outcomes of the first scoliosis detection in non-school screening AIS patients at Siriraj Hospital, Thailand.

METHOD

A retrospective chart review of medical records and radiographs of Thai AIS patients aged 10-18 years whom the scoliosis was not detected by the school screening program. The data correction was conducted by the Siriraj Hospital electronic database from January 2017 to December 2021. Genders, age onset, curve pattern, curve location, curve magnitude (Cobb method), curve severity, risser sign, treatment options, and the long-term outcomes within 6-months follow-up which was appointment frequency, curve magnitude as well as the curve progression. Data were extracted and recorded in Microsoft Excel. The descriptive statistics and Intraclass Correlation Coefficient (ICC) were analysed using SPSS version 18.

RESULTS

A total of 172 from 418 charts were included in this study with an average of 14.24 ± 1.90 (range: 10-18) years of age at first scoliosis detection and 135 (78.5%) cases are female. Average of initial curve magnitude was 36.06 ± 18.53 (range: 10-93) degrees, 38.95% and 34.88% were classified as moderate and severe curve respectively. The majority of curve was single pattern (65.9%) and most deformity was located at the thoracic region (52%). Maturity stage of Risser sign (Risser3-5) were found in the majority of samples. 43.41% were suggested for the observation at first detection. During the 6 months follow-up, 58.97% were appointed for the one-time follow-up and the average curve magnitude was 38.50 ± 17.56 (range: 10-90) degrees which progressed from the initial Cobb angle 2.41 ± 7.49 (range: -15-26.5) degrees.

	N	Curve magnitude(Cobb angle)		
		10-19	20-40	Above 40
Gender				
Male	37	13	14	10
Female	135	26	59	50
Average age onset (Year)	14.24	14.7	14.23	13.96
Curve pattern				
Single	111	35	46	30
Double	57	3	26	28
Tripple	3	1	0	2
Curve location				
Thoracic	118	22	47	49
Thoracolumbar	39	10	18	11
Lumbar	69	10	31	28
Lumbosacral	1	0	0	1
Average curve magnitude (Cobb angle)	36.06	14.9	30.59	56.46
Risser sign				
Immatured(Less than Risser 3)	56	9	23	24
Matured(Risser 3-5)	87	19	39	29
Treatment				
Observation	73	37	31	5
Brace	51	0	32	19
Surgery	41	0	6	35
Others	7	1	6	0
Number of follow-up within 6 months				
No follow-up	33	18	10	5
1 Times	80	18	44	18
2 Times	18	2	10	6
3 Times	5	0	2	3
Average curve magnitude within 6 months (Cobb angle)	38.5	17.27	33.64	55.62
Average curve progression within 6 months (Cobb angle)	2.41	1.36	2.61	2.54

DISCUSSION AND CONCLUSION

Previous research reported the curve ranged from 10 to 19 degrees in the screened AIS Thai females aged 11 to 13, as the majority group [2]. Comparing the same age range of non-screened group in our study, indicated ranged from 30 to 39 degrees, and 13 out of 35 patients in this group presented greater than 39 degrees. Additionally, non-screened group presented more severe curve magnitude at first detection, which may differentiate treatment and effectiveness, regarding the SOSORT guideline [3].

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5.39.5 Estimation of the Biomechanical Responses of Scoliotic Spine under Different Loading Conditions via Finite Element Modeling

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BACKGROUND

Adolescent idiopathic Scoliosis (AIS) is a three-dimensional deformity with lateral curvature and axial rotation, which onsets in adolescents for unknown reasons. Cobb angle is generally used to assess spinal deformity, and orthotic treatment is prescribed for Cobb angle over 20° with growth potential [1]. Various Finite Element Methods (FEM) have been developed to estimate both the internal and external mechanical properties of AIS that offer great potential in understanding the biomechanics of AIS and its orthotic treatment.

AIM

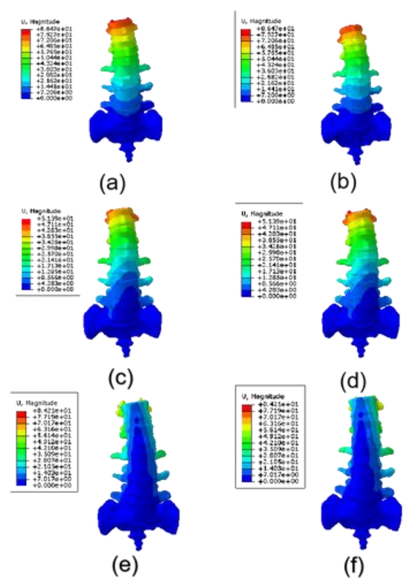
a) To develop a 3-dimensional FE model of the scoliotic spine; b) To simulate the actual loadings on the FE model; & c) To explore the biomechanical responses of the scoliotic spine under different loading conditions including correcting forces.

METHOD

A three-dimensional spine model was reconstructed from the computed tomography (CT) data of a patient with AIS using software named Mimics (version 20.0). The model was smoothed via another software, Geomagic Wrap (version 2021), constructed and assembled using software named Solidworks (version 2017), which included cortical bone, cancellous bone, ribs, sternum, pelvis, ligaments, and muscles. The related mechanical properties of the model were adapted according to the open sources. The established model subsequently meshed in the software named ABAQUS (version 2020). The lumbar spine model was validated under 10Nm moment and compared with the cadaver experiment. The simulation results were analysed with different loading conditions.

RESULTS

The lumbosacral region of the FE model has been completed. The interactions between intervertebral discs and vertebrae were set as 'tie' (no motion), while the friction of facet joints was considered frictionless. Six motions (forward and backward bending, left and right lateral bending, and left and right twisting) were simulated as the figures below, and the range of motion (ROM) was estimated. The correcting forces were applied at the apex of the scoliotic curve with different loading conditions (the force is kept horizontal and moved from posterior to lateral direction with 15° intervals, i.e., from 0° to 45°). The relevant displacement and stress cloud diagrams of the simulation results could be obtained in the ABAQUS (version 2020). The displacement results of the scoliotic curve were observed from the coronal, sagittal, and transverse views to estimate the optimal correcting force.



Displacement cloud diagram of six motions
(a) forward bending (b) backward bending
(c) left bending (d) right bending
(e) left twisting (f) right twisting

DISCUSSION AND CONCLUSION

According to the validation experiment under 10Nm, due to the physiological shape of the scoliotic curve, the ROM of the vertebrae changed. The correcting force moving from posterior to anterior considers all the three-dimensional displacements comprehensively, including the correction outcomes in the coronal view and the sagittal view simultaneously, to avoid flat back or hyperlordosis. This provides a theoretical insight to design much better spinal orthosis effectively.

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ACKNOWLEDGEMENTS Special thanks to the colleagues of Shenzhen University General Hospital for collecting CT data.

5.39.6 Variations and considerations in brace designs for the treatment of adolescent idiopathic scoliosis

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BACKGROUND

As bracing for scoliosis has proven its efficacy, medical professionals are challenged with selecting appropriate brace types. The introduction of varying brace designs and concepts can often present conflicting perspectives on the appropriateness of any treatment approach. The results of the efforts by Negrini et al [1] offer the most extensive and inclusive differentiation of brace designs, yet the resulting consensus can easily mislead readers of less experience.

AIM

The intent of this presentation is to foster a more cohesive understanding of bracing for scoliosis, and to introduce a clearer perspective on how we evaluate our bracing options.

METHOD

We approach this challenge by establishing a sound foundation of knowledge on the basic principles and mechanics of bracing. To further understand the concepts, we consider in generality, the very process that's involved, from patient presentation, through design and fabrication, final delivery, and the subsequent alterations and modifications that may be performed to achieve our intended outcomes. We can then work through our options with knowledge and understanding, discussing the nature, variations, and potential applications of custom bracing for scoliosis.

RESULTS

A custom brace, whether it's, "custom made", "custom fit", or both, is intended to be created and applied specifically for an individual patient. As such, the modifications made at any point in the process, from shape acquisition to final adjustment, dictate the features of that particular orthosis. While "experts" (SOSORT et al [1]) may assign a classification to a particular brace design, that does not make it an appropriate fit for all braces that might share similar names and features, without effectively applying the same features in any meaningful way. In such cases, attempts to classify and/or compare various brace types, can result in inaccurate and misleading categorizations.

Table 5 Classification of the braces currently available and published [18]

Anatomy	Rigidity	Primary action	Primary corrective plane	Construction	Closure	Brace name
TLSO	Very rigid	Detorsion	Frontal & Sagittal	Bivalve	Ventral	ART
		Push-up	Three-dimensional	Bivalve	Ventral	Sforzesco
	Rigid	Bending	Frontal	Monocot	Ventral	Charleston
						Providence
		Detorsion	Three-dimensional	Monocot	Ventral	Chêneau
						Dynamic derotating
						Rigo-Chêneau System
		Push-up	Three-dimensional	Bivalve	Ventral	Sibilla
		Three-point	Frontal	Monocot	Ventral	Wilmington
			Frontal & transverse	Monocot	Dorsal	Boston
			Sagittal	Monocot	Dorsal	TLI
			Three-dimensional	Multisegmented	Ventral	Lyon
	Elastic	Movement	Frontal & transverse	Multisegmented	Lateral	TriaC
			Three-dimensional	Multisegmented	Frontal	Spinecor
CTLSO	Rigid	Elongation	Frontal & sagittal	Multisegmented	Dorsal	Milwaukee
LSO	Rigid	Detorsion	Frontal & transverse	Monocot	Ventral	PASB

Participants in the consensus provided the classification of each brace with this order of priority: (1) the developer, (2) a researcher on that brace, and (3) a Level 1 expert currently using/building that brace

ART Asymmetric rigid three-dimensional; *PASB* progressive action short brace, *TLI* thoracolumbar lordotic intervention; *TriaC* three C, comfort, control, and cosmetics

DISCUSSION AND CONCLUSION

It is the decision making in the design, fabrication, fitting and adjustment, which determine the features of any particular orthoses, and the skill set of the clinician that has the greatest impact on the proper application of all potential components. Most important is the foundational knowledge of customization required, as technical and clinical expertise is highly essential in the effective designing, fitting, and adjusting of any type of brace for scoliosis.

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ACKNOWLEDGEMENTS Spinal Technology, Inc.

Free paper session: Additive manufacturing

5.40.1 3D printed prosthetic arms for the upper limb amputee musician to play Chinese zither and cello

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BACKGROUND
The standard routine for an upper limb amputee is to fit a mechanical or myoelectrical prosthesis to perform daily activities. However, it is uncommon to see upper limb amputees using prostheses to play musical instruments.

AIM
This study aims to introduce three-dimensional (3D) printed prostheses for a left extreme short transradial amputation musician to play the Chinese zither and cello.

METHOD
The subject is a thirty-six-year-old transradial amputation musician who has played Chinese zither since she was a child and lost her left forearm during a car accident in 2019. Two types of transradial prostheses were made for the patient. The first one is made by hand-casting for prototype testing including the socket design, suspension, angle of the prosthetic forearm, and the musical instrument playing device. The second one is the 3D printed musical performance prostheses, based on and upgraded from hand-made prostheses. The 3D prostheses were sketched and designed using Z-brush and Maya software. The final prostheses were 3D printed by a selective laser sintering machine using nylon material.

RESULTS
The patient used the 3D printed functional prosthetic arm to play the cello daily for forty minutes during a period of three months. She also played the Chinese zither daily for forty minutes during a period of one month. After intense training, the patient is able to play the elementary cello melody using the 3D printed upper limb prostheses and achieved stage performance for the Chinese zither. The patient is delighted with the outcome.

DISCUSSION AND CONCLUSION
The lightweight and personalized 3D printed musical performance prostheses is successfully developed for the upper limb amputee musician by employing 3D technology. Nonetheless, it took around six months which is a time-consuming process. The difficulty of directly making a 3D printed prosthesis is the socket design, suspension issue, and the prosthetic elbow angle. The usage of the different software packages enabled the realization of the customized 3D printed functional prosthesis.

5.40.2 Using 3D printable density-graded lattice structures to minimize risk of tissue damage from compression-release stabilized sockets

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BACKGROUND

Pressure, shear, and friction can contribute to soft tissue damage in the residual limb [1,2]. Compression/Release Stabilized (CRS) sockets show evidence of increased control and stabilization of prostheses when compared with full coverage sockets while distributing typically concentrated pressures across the length of residual bone [3,4]. However, the abrupt pressure differential between compression and release areas in current CRS designs may pose a risk for soft tissue damage [5].

AIM

Density-graded lattice structures for use in modified CRS sockets are investigated as a strategy to mitigate risk of soft tissue damage by testing their ability to produce gradual transitions between high- and low-compression areas.

METHOD

Lattice samples were created to address areas of compression (high pressure) and release (low pressure) within a novel cushioned transhumeral CRS style socket. Samples were printed on fused filament fabrication (FFF) 3D printers in flexible thermoplastic polyurethane (TPU). Compression testing was performed on samples using two types of lattice unit cells. Each lattice sample incorporated one of eight possible design changes to alter density. The effect on compressibility as a function of lattice type and density alteration under three loading conditions was recorded. Intermediate lattice structures were developed by gradually tapering lattice density from best performing compression to release values (Figure 1).

RESULTS

Results indicated the widest range of change in compressibility occurred using an offset diamond lattice type paired with blend radius density alterations, producing the only samples meeting low compressibility criteria set for compression areas of the socket. None of the tested samples satisfied the high compressibility criteria set for release areas. The design for future modified CRS socket models was altered to reintroduce open areas for release of compressed soft tissue based on these results with lattice density decreasing significantly toward the opening. Transitional density lattices which taper from the most successful compression lattice densities to the release densities were successfully produced.

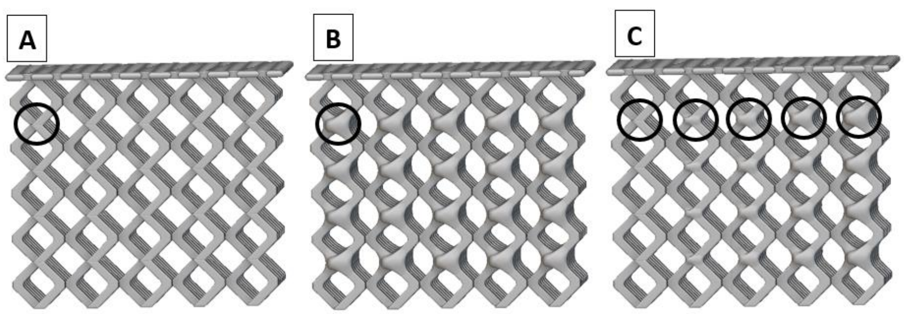

Figure 1. Sample of blend radius settings creating low density (A), high density (B), and transitional density lattice (C).

DISCUSSION AND CONCLUSION

In this study compression thresholds were established based on a functional transhumeral use case rather than thresholds that unequivocally prevent tissue damage. Further research could incorporate working safety ranges given various applied loads, wear time, and patient-specific conditions. Samples were produced that met criteria for areas of compression, but not release. Transitional density lattice structures were successfully produced, offering promise for mitigation of soft tissue damage through minimization of pressure differentials that can exacerbate shear.

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5.40.3 Assembling the pieces: Attaching 3D-printed sockets to lower-limb prostheses

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BACKGROUND

Lower-limb prosthetic socket manufacturing is shifting towards using digital methods, specifically 3D printing. However, structural testing of 3D-printed sockets remains underdeveloped, and the methods and efficacy of securely attaching the socket to the remaining prosthesis are generally unreported [1]. To understand the structural integrity of the socket, it is critical to investigate the strength of its distal connection, since the inherently weak interlayer bonding of the 3D-printed socket is worsened by stress concentrations induced by integrated attachment hardware [2].

AIM

This study aims to evaluate and compare the tensile strength of different standard attachment methods for 3D-printed sockets, and to assess their capacity in withstanding ISO 10328 loading conditions.

METHOD

Custom tensile test coupons were made to obtain the ultimate tensile strength of three connections with standard hardware: an embedded hex-nut, a heat-set insert in a 7.5mm-diameter hole, and a heat-set insert in an 8.0mm-diameter hole. Coupons were fabricated with extrusion-based 3D printing, using PLA material and 100% concentric infill. Tensile testing procedures (other than coupon geometry) were performed according to ASTM Standard D638, and failure loads of the three designs were compared. Experimental results were then compared to those obtained using finite element analysis (FEA) for validation and to assess the hardware's performance in withstanding ISO Standard 10328 loading conditions.

RESULTS

Coupons with heat-set inserts were significantly stronger than those with hex-nuts (Figure 1A) regardless of the heat-set diameter. Coupons with hex-nuts failed catastrophically by delamination at the layer where the printer was paused for inserting the hex-nut (Figure 1C). One 8.0mm-diameter heat-set insert failed by pull-out. The remaining heat-set inserts did not reach failure since the top grip began to plastically deform, causing a load-displacement curve plateau (Figure 1B). FEA simulating ISO 10328 loading conditions (at heel strike for a 150kg person) revealed a maximum delamination stress of 5.27MPa, which is 0.3% greater than the stress withstood by hex-nut embedded coupons, and 45.4% less than that by the 7.5mm-diameter heat-set inserts, confirming the latter's superiority in withstanding ISO 10328 loads.

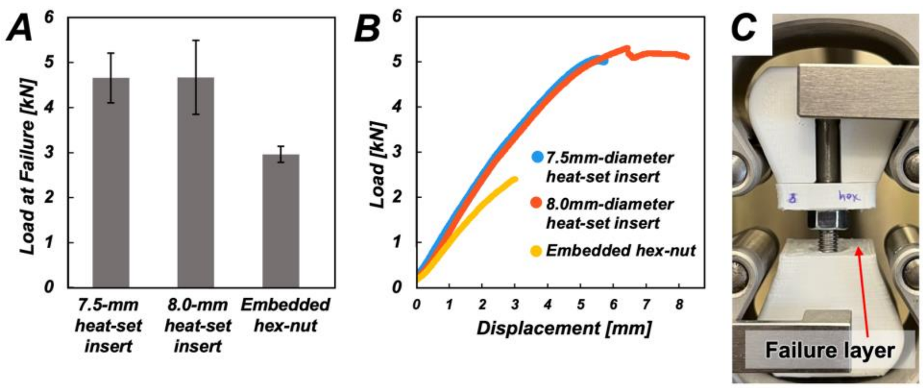

Figure 1. (A) Failure loads, (B) sample load-displacement curves for each design, (C) fractured hex-nut coupon, displaying failure location.

DISCUSSION AND CONCLUSION

Expectedly, heat-set insert designs were strongest, and did not fail by delamination, potentially due to material flowing during heated insertion, altering the coupon's structure from weak interlayer bonds to one with more homogeneous properties. Standard, widely available hardware was used, thus supporting practical clinical implementation. Results may be replicable for other extrusion-based printers, and scalable to full-size sockets, provided 100% infill is used. In conclusion, heat-set inserts may provide a reliable method of directly attaching 3D-printed sockets to prostheses.

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5.40.4 Effect of Distal End Reinforcement on Ultimate Failure Strength of 3D Printed Sockets

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BACKGROUND
3D printed prosthetic sockets (3DS) are a promising solution since 3DS can be manufactured at an affordable cost and quickly delivered to patients. Despite these advantages, 3DS have not been widely used as definitive sockets due to relatively lower strength and durability compared traditionally fabricated sockets [1]. Strengthening the distal interface has been one major recommendation from studies that have tested 3DS for failure [2,3]. However, the effects of distal end reinforcement on ultimate failure are still unknown.

AIM
We sought to examine whether the strength of 3DS can be improved by reinforcing the distal end of the socket.

METHOD
Polyethylene terephthalate glycol (PETG), Polycarbonate (PC), and Polypropylene (PP) filament materials were used to print two versions of 3DS, one with short distal reinforcement (SDR) and a longer version (LDR). Two samples each of traditional laminated socket (LCS) and three samples of thermoplastic sockets (TPS) were also manufactured for comparison. Ultimate failure strength was investigated in accordance with ISO 10328 standards at condition II using an aluminum limb dummy. A settling test, a proof test, and an ultimate test with a loading rate of 100 N/s was performed at P5 load level. A sudden change of force ≥100 N determined failure.

RESULTS
The strength of 3DS varied based on material type (Fig 1). With regard to the SDR, the 3DS made of PP had the highest ultimate force (2373 102 N) in comparison to PC (1735 392 N) and PETG (1587 244 N). During proof testing both PC and PETG sockets started to show premature cracking. The failure force for the LDR sockets made of PP (2502 89.9 N) and PETG (1728 32.6 N) were 3.74% and 8.87% greater than for the SDR, respectively, but only PP passed the proof test. The average ultimate force of PC with LDR was 2612 358 N which represented a substantial increase in ultimate force (50.59%) compared to the SDR.

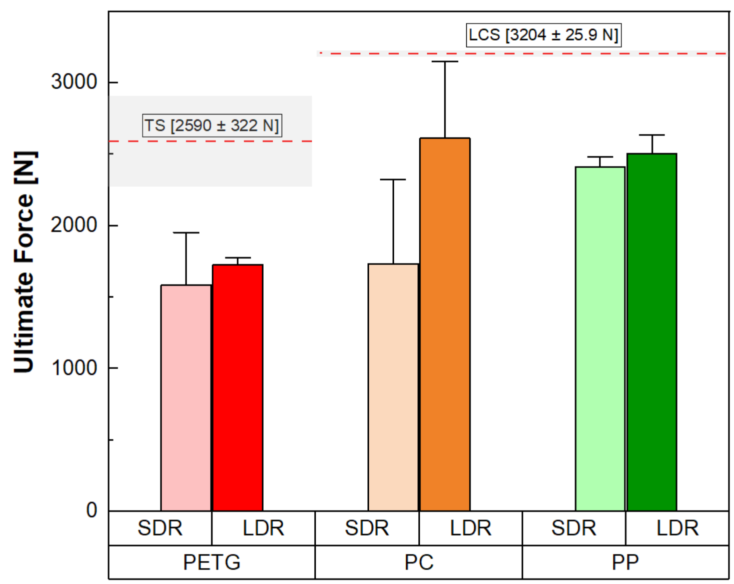

Fig 1. The comparison for ultimate force between 3D printed sockets. The dotted lines indicate the means for TPS and LCS.

DISCUSSION AND CONCLUSION
3DS showed failure of interlayer adhesion, but no crack or crack propagation as observed for LCS and TPS. Modifying the distal end by lengthening and widening the struts (LDR) resulted in greater ultimate failure force for 3DS, but percentage increase varied depending on each material. An extended annealing process for PC combined with LDR design resulted in the greatest strength. Further design iterations are needed to ensure 3DS are fit for clinical use.

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Free paper session: Rehabilitation medicine and surgery - Lower limb amputation

5.41.1 Co-morbidities and functional outcome of primary rehabilitation after lower limb loss

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BACKGROUND
Several factors influence rehabilitation outcome of primary rehabilitation of patients with lower limb loss (LLL), among them co-morbidities [1].

AIM
The aim of our study was to find out which the most frequent co-morbidities of patients with LLL admitted for primary rehabilitation are, and what their influence on rehabilitation outcomes is.

METHOD
All patients admitted for primary rehabilitation after LLL to our institute between March 1, 2021, and June 30 2022 who gave written consent to use their clinical data for research were included into the study. At admission, we checked for all co-morbidities, assessed the patients using BLARt and Amputee Mobility Predictor no-prosthesis score (AMPnoPRO), and set realistic rehabilitation goals together with the patients. They were all included into a comprehensive rehabilitation program. Before discharge, all the patients performed the 6-minute walk test (6MWT), 10m walk test and L-test, and were assessed using the AMPPRO. The study was approved by the Medical Ethics Committee of our institute.

RESULTS
We included 298 patients (212 men, 156 trans-tibial, 101 trans-femoral, 41 bilateral amputation), 69 years old on average (SD 12 years, range 20–91 years). The main cause of amputation was diabetes (136), followed by peripheral vascular disease (PVD, 110 patients). The patients had none to 10 co-morbidities (mean and median 3), the most frequent being diabetes and PVD, followed by stroke (44 patients). The number of comorbidities had low statistically significant correlation with age (0.30), 6MWT (-0.22) and AMPnoPRO (-0.17), and moderate with BLARt (0.46). The patients with heart failure, stroke and PVD walked a statistically significantly shorter distance in 6 minutes on average than those without those diseases, but the difference was on the limit of MCID only for those with PVD. Other diseases were not notably associated with the measured outcomes.

DISCUSSION AND CONCLUSION
Similar to other researchers, we observed that co-morbidities might influence rehabilitation outcome in patients with LLL, especially those with PVD. For other co-morbidities, the number of patients was small, whereby they may not have been referred to rehabilitation due to co-morbidities.

REFERENCES
Similarly to other researchers, we observed that co-morbidities might influence rehabilitation outcome in patients with LLL, especially those with PVD. For other co-morbidities, the number of patients was small, whereby they may not have been referred to rehabilitation due to co-morbidities.

5.41.2 Rehabilitation of a Complex Patient after Transtibial Amputation due to trauma- a Team Approach: A Case Study

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BACKGROUND

This case study will provide the history and rehabilitation of a 49-year-old male patient who underwent complex transtibial amputation surgery due to trauma. He had a background of learning difficulties, longstanding memory loss, history of falls, speech impediment and congenital deformities of both lower limbs requiring multiple surgery. The residual limb had extensive skin grafting, was insensate and was an extremely irregular shape, creating prosthetic/rehab challenges.

AIM

To present a unique case of a patient following trauma and transtibial amputation and to highlight the importance of multidisciplinary team working in achieving a return to walking and function.

METHOD

The patient was admitted to intensive care on 7/12/2020 after having been a pedestrian who was dragged under a lorry for 10 metres. He had severe degloving of his right lower limb and open fractures of his tibia and fibula. He underwent 15 operations between 8/12/2020 and 19/4/2021 for his right lower limb. On 4/1/2021 a pre-amputation consultation was done by the clinical specialist physiotherapist and then underwent a transtibial amputation with pedicled fillet flap on 19/1/2021. A split skin graft/allograft was performed on 4/2/2021 and final residual limb revision surgery/manipulation under anaesthetic of the knee occurred on 19/4/2021.

RESULTS

The patient was discharged to in-patient rehab 17/5/2021 working on independent transfers, increasing muscle strength, joint movement and fitness. He went home (22/6/2021), starting out-patient pre-prosthetic rehab-1/7/2021. Compression therapy started with tubifast (19/3/2021) and a compression sock fitted (20/7/2021). A pneumatic post-amputation mobility aid (early walking aid) was used in physiotherapy (20/7/2021) between bars. Key problems: reduced lower limb strength; reduced range right knee flexion; instability and poor balance (longstanding); poor residual limb skin condition. The patient was seen by the prosthetic multidisciplinary team (4/11/2021)-cast over an Alps3mm easyliner for his prosthesis. A transtibial prosthesis was fitted-16/11/2021.

Outcomes (* indicates clinically meaningful change)				
	Initial 17/2/2022	Discharge 1/6/2022	Residual Limb 8/3/2021	Residual Limb 31/8/2021
SIGAM Score	B	Ca		
Timed Up and Go	70.65	50.35*		
2 Min Timed Walk Test	17.1	27.8		
Locomotor Capabilities Index-5	5	12*		

DISCUSSION AND CONCLUSION

Prosthetic rehabilitation started (18/11/2021) in parallel bars. Due to left foot/ankle deformity/instability an orthotic assessment was undertaken (9/11/2021) and a temporary therapeutic shoe fitted (16/11/2021). A made to measure boot was casted (9/11/2021)- fitted-17/1/2022. Problems: anterior residual limb skin breakdown which required periods of healing/use of silicone discs. He regained the ability with sit to stand from his wheelchair independently and walks with a 4-wheeled walker indoors independently. He was discharged 1/6/2022. Despite an extremely challenging residual limb shape; poor skin and complexities due to pre-existing conditions the patient returned to walking with an aid. This was as a result of interdisciplinary team working closely to assist the patient over 18 months.

ACKNOWLEDGEMENTS Miss C. Boobier (rotational physiotherapist) for initial review of patient notes.
Full therapy/prosthetic MDT for collaborative working with the patient.

5.41.3 Limb Loss and Preservation Registry: Evidence based patient outcomes

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BACKGROUND
There is a significant global burden of disease associated with limb loss and limb preservation. Despite the significant burden there is a paucity of evidence on effective practices and technologies in this population. Published research studies typically rely on administrative data sources, hospital discharge statistics, or small single-centre studies with limited longitudinal follow-up. Little is known about the effectiveness of practices and technologies used following limb loss.

AIM
To advance patient outcomes, the Limb Loss and Preservation Registry (LLPR) has been developed.

METHOD
The LLPR is a centralized multi-stakeholder trusted independent data warehouse designed to collect relevant data and perform analysis to improve the quality of patient care. It stores data in the Google Cloud Platform. Data security meets stringent security requirements for holding protected health information. The LLPR obtains and links data from hospitals, clinicians, and patients to enhance patient-centred clinical decision-making (Figure 1). Data elements reflect characteristics of the individuals, interventions, and outcomes. The LLPR uses a web-based user-interface which allows role-based access to standard reports, ad hoc queries, and embedded analytical business intelligence tools to assess the effectiveness of different care approaches and timing of specific care procedures.

RESULTS
The LLPR currently contains data from 41,000 patients ranging from pediatrics to geriatrics across the nation. Data from both lower extremity and upper extremity amputations are included. Notably, only 13% of the patients do not have at least one comorbidity. The top comorbidities are heart disease, hypertension, and peripheral vascular disorders. The mobility of patients with lower extremity amputations is in the bottom 20% of the general population.

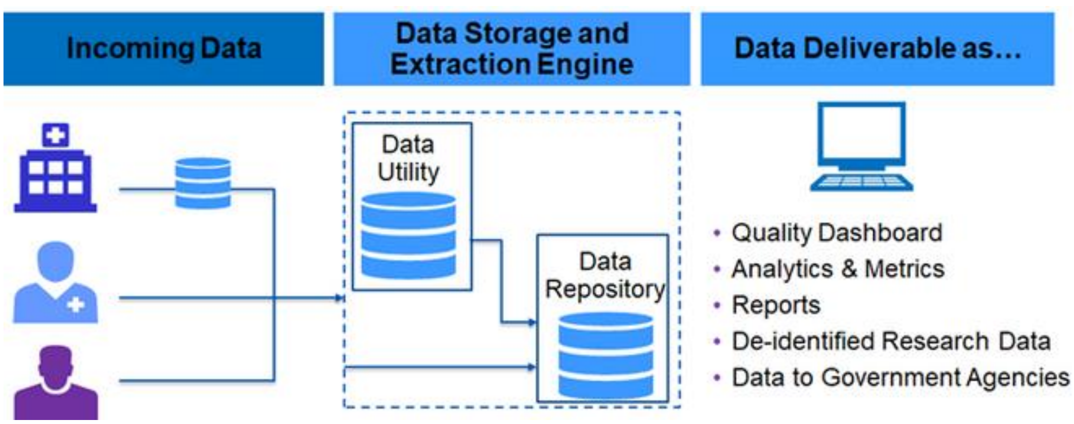

Figure 1. Notional Data Flow Diagram

DISCUSSION AND CONCLUSION
ISPO has recognized the importance of registries by creating the Lower Extremity Amputation Dataset and Consensus of Outcome Measures for Prosthetic and Amputation Services. Registries provide critical data to clinical researchers, hospitals, clinics and individual providers, patients, health-related industries, and national governments. This data can be used to evaluate disparities in access to care, care processes, and care delivery across geographic, demographic, and economic sectors. With data acquired from international registries, marked improvement in patient outcomes can be achieved.

ACKNOWLEDGEMENTS National Institute of Child Health and Human Development contract no. HHSN275201800005I

5.41.4 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

We 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±45% of goal (99±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.

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.

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.

5.41.5 Osseointegration for Diabetic Patients: The Risk of Infection versus the Reward of Mobility

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BACKGROUND

The most common reason for lower extremity amputation worldwide is as management of complications from diabetes mellitus. The typical rehabilitation option for these patients is a traditional socket prosthesis (TSP), but many have trouble with TSP use. Osseointegration has proven beneficial for the majority of patients with TSP dissatisfaction, but diabetes generally has been considered a relatively strong contraindication due to concerns mainly of infection risk.

AIM

Study aimed to evaluate 1) what is the rate of debridement and of implant removal; 2) how does patient prosthesis wear time and mobility change; 3) how does the patient's perception of using a prosthesis change (based on QTFA)?

METHOD

A review of our prospectively collected osseointegration database was performed which identified 13 patients who had transfemoral (9) or transtibial (4) osseointegration from 2013-2018 (all unilateral), who were diabetic, and who were followed for at least two years. The rate and timing of infection requiring debridement or device removal was evaluated. Additionally, the following metrics were compared from their preoperative consultation versus their most recent evaluation: daily prosthesis wear hours, Timed Up and Go (TUG), Six Minute Walk Test (6MWT), QTFA Mobility score, QTFA Problem score, and QTFA Global score.

RESULTS

Thirteen patients had a follow-up of at least two years, for an average of 4.2±1.5 years. One patient died of pre-existing pulmonary fibrosis complications four years after osseointegration. Six patients (46%) required at least one surgical debridement, at an average of 1.3±1.1 years. Three patients (23%) had the implant removed due to aseptic loosening or infection, at an average of 1.9±1.1 years. Three patients did not wear a TSP prior to osseointegration. The other 10 reported wearing the TSP 5.9±7.8 hours daily. Following osseointegration, 11 patients wore their prosthesis, reporting 10.8±5.3 hours (p=0.09). Prior to osseointegration, 4/10 (40%) wore the TSP >8 hours daily, versus 11/13 (85%) after (p=.04). The QTFA Problem score and global score improved, however QTFA mobility scores remained unchanged.

DISCUSSION AND CONCLUSION

The risk of infection requiring debridement or implant removal is relatively high compared to the rates for all-cause osseointegration with a press-fit implant. However, the proportion of patients who were ambulatory significantly improved and was maintained through 2+ years. The QTFA identified the prosthesis-associated problem and global perception of amputee life to have improved. Patients need to be aware that having diabetes may increase their risk of eventual infection and implant removal, but they may achieve mobility improvements.

Posters: Orthotics: Lower limb neurological

6.01 Comparison of effect of ankle foot orthosis forefoot rigidity on knee joint kinematics in children with spastic cerebral palsy.

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BACKGROUND

Children with Cerebral palsy (CP) mostly walk with abnormal gait, such as excessive flexion of knee during stance phase [1]. Ankle foot orthosis are commonly prescribed in such cases in order to improve the gait, which largely depends on the stiffness of orthosis [2]. This change can be achieved by material strength as trimming less or more material [3]. Therefore, trim-line plays a crucial role in altering the biomechanics and function of the orthosis.

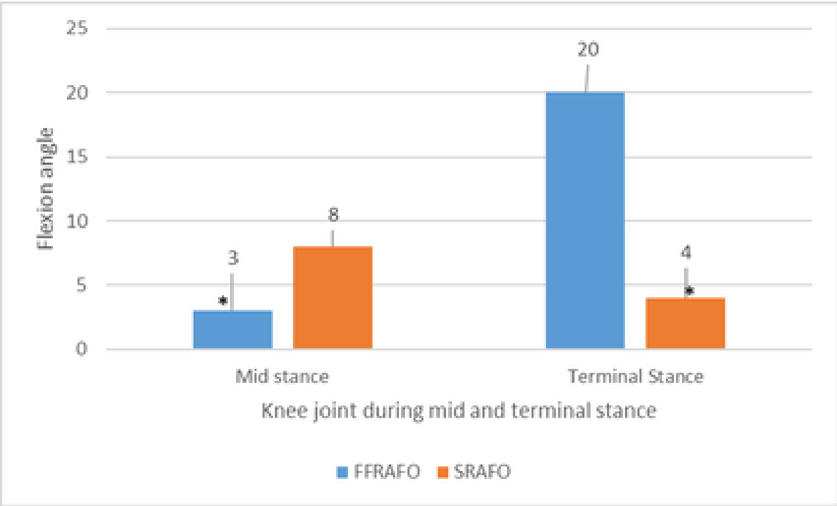
AIM

The aim of this study is to investigate the effect of rigid roll over of Ankle Foot Orthosis (SRAFO) in mid and terminal stance in sagittal plane on knee joint kinematics of children with spastic Cerebral Palsy.

METHOD

10 children with spastic CP, each were prescribed Simple Rigid Ankle Foot Orthosis (SRAFO), and Forefoot Rigid Ankle Foot Orthosis (FFRAFO). The forefoot trim-line of SRAFO was kept 0.5cm proximal to metatarsal heads (free and flexible roll over) whereas the trim-line of FFRAFO cover the metatarsal heads and extend 2 cm distally to it. In order to find its effect on knee joint kinematics, 2-D gait analysis laboratory was used. 6 minutes' walk was done initially with SRAFO and then with FFRAFO. Data was analyzed with 2-sample T-test, statistical software Minitab version 20.

RESULTS



Results demonstrate that in mid stance the FFRAFO could better control the knee joint flexion than SRAFO and they are significantly different (p =0.001). In terminal stance, the rigid fore foot was blocking the forward Progression in FFRAFO and therefore the patients showed early heel rise with excessive knee flexion, where as in SRAFO the patient easily progresses over the free roll over keeping the knee flexion angle normal. In terminal stance FFRAFO and SRAFO were significantly different (0.002) as well. Figure 1 shows comparison of Forefoot Rigid Ankle Foot Orthosis (FFRAFO) and Simple Rigid Ankle Foot Orthosis (SRAFO). In mid stance the FFRAFO has significantly reduced knee flexion moment as compared to SRAFO. During terminal stance there is excessive knee flexion while wearing FFRAFO, while knee flexion is minimized using SRAFO. Asterisks represent that results are significantly different.

DISCUSSION AND CONCLUSION

Careful consideration must be taken while prescribing an AFO, keeping forefoot rigid can provide stability at mid stance but at the same time it limits forward progression which leads to compensatory gait and more energy consumption. Further study should be done to find out the exact trim-line distal to metatarsal heads, which can control the knee flexion and also does not limit forward progression. To conclude, FFRAFO effectively provide stability to knee in mid-stance but restrict forward progression in terminal stance.

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6.02 Problem facing in KAFO users suffering from post-polio paralysis attended at PRSP Peshawar

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BACKGROUND

Poliomyelitis is a common acute viral disease. In many cases a lower neuron paralysis develops in the early days of illness [1]. Polio virus produces weakness and flaccid paralysis of muscles. Such paralysis is called post-polio paralysis [2]. An orthosis designed to control knee and ankle motion extends from the upper portion of the thigh, crossing the knee and ankle known as KAFO (knee ankle foot orthosis). Patient satisfaction is multifaceted and a very challenging outcome to define.

AIM

To identify the problems facing by KAFO users suffering from post-polio paralysis.

METHOD

Study was done through cross sectional survey. Participants were registered polio patients at PRSP Peshawar that had been prescribed KAFO from Jan 2015 to April 2015 (4 Month Duration). The sample size was 25. Sampling was done by convenience sampling technique. The questionnaire was distributed among all the participants of the study. The subjects were asked 22 questions regarding the satisfaction level of KAFO user. The Quebec questionnaire was used.

RESULTS

30 questionnaires were distributed among the registered patients of at PRSP Peshawar; 25 questionnaires were completed.

Patient Satisfaction level in Percentage

(1) Very satisfied : 18.7%
(2) Satisfied : 39.8%
(3) No answer : 19.4%
(4) Dissatisfied : 18.3%
(5) Very Dissatisfied: 3.63%

DISCUSSION AND CONCLUSION

A questionnaire was distributed among the participants of the study. The subjects were asked 22 questions regarding the satisfaction level. The Quebec questionnaire was used for the Malawian study. Overall the patients were quite satisfied with the KAFO. Among the participants: Very satisfied:18.7%, satisfied: 39.8%, No answer: 19.4%, Dissatisfied: 18.3%, Very Dissatisfied: 3.63%. Weight, dimension were areas where the patients were very much satisfied with the assistive device. When it comes to satisfaction, comfort and fitting of the KAFO devices were where the patient was satisfied.

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ACKNOWLEDGEMENTS Thanks to Pakistan institute of prosthetic and orthotic sciences for giving me patient details which helped me in study.

6.03 Functional improvement of lower limb orthotic management in patients with spinal cord injury: A scoping review

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BACKGROUND

Lower limb orthotic interventions are commonly used in spinal cord injury patients during the rehabilitation stage, to support during walking, standing, and balance training [1,2]. Various studies focus on several aspects of functional improvement after injuries in the SCI patient. This scoping review helped to map out the information in the research area and the types of evidence available. Additionally, it provided the future research direction in this area.

AIM

To explore and map the available evidence on functional improvements in spinal cord injury patients during lower limb orthotic management, to identify the research gap and future research direction in this area.

METHOD

This scoping review was conducted using methodological framework by Arksey and O'Malley [3] and Levac et al. [4], including 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting the data, and 5) collating, summarizing, and reporting the results. International electronic databases, including Pubmed, EMBASE, Web of Science, Scopus, ScienceDirect, CINAHL and OVID, were searched for studies in English, published in the past 12 years from 2010 to 2021. Articles related to functional improvements in spinal cord injury patients with the use of lower limb orthotic management were included in this scoping review. The information from the included article was reviewed, extracted, charted, and analysed.

RESULTS

The search resulted in a total of 1,145 articles from 5 databases, and after screening based on inclusion criteria, 95 articles were included for full-text review. From the studies included, there were a total of 2,501 participants, with the majority of injuries at the thoracic level (43.16%). Several orthotic designs were mentioned in the included articles. Outcomes in the functional improvement of lower limb orthotic management were categorized into activity of daily life, gait, balance, energy expenditure, and other outcome measures. The majority of outcome in the included articles was gait parameter which indicated an improvement in walking speed. Additionally, orthoses were reported to reduce pain and falls and improve stability. Despite the findings indicating that lower limb orthoses can improve performance independence and well-being while using orthosis, only a few studies show significant differences before and after using orthosis.

DISCUSSION AND CONCLUSION

More than twenty types of lower limb orthoses were studied in the included articles. The majority of outcomes of interest focusing on functional improvements in spinal cord injury patients under the lower limb orthotics management was gait. Additionally, the finding supported the use of lower limb orthoses in SCI patients and its influence on functional improvements with some recommendations. The gray literature was not included in this study due to the time limitation of the project.

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Posters: Orthotics: Lower limb orthopaedic

6.04 Functional outcome of modified Steenbeek foot abduction brace in the maintenance of corrected CTEV by Ponseti Method

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BACKGROUND
Clubfoot or Congenital Talipes Equino Varus (CTEV) is a fairly common congenital deformity of the foot among newborns. Globally, its incidence varies from 0.39 per 1000 to 6.8 per 1000 [1,2] and is about 2.5 times more common among males [3]. This deformity may occur in isolation (idiopathic) or as a part of other congenital malformations like meningomyelocele, arthrogryposis etc [4].

AIM
To analyze the functional outcome of modified steen beek foot abduction brace in the maintenance of corrected CTEV by Ponseti method

METHOD
It was a descriptive study followed by consecutive case series. 26 patients with corrected CTEV by ponseti method was selected from APPNA Rehabilitation department of Benazir Bhutto hospital. The patients were given modified Steen Beek foot abduction brace (FAB) for the maintenance of correction. Club feet were graded according to Pirani scoring system. Patient were called for routine follow-up to check the maintenance and improvement, compliance via bracing and skin complications. Duration of study was 6 months.

RESULTS
26 patients completed the study. There were 10 (38.5%) females and 16 (61.5%) males. This included 19 (73.1 %) bilateral cases thus making the total number of affected feet 38. There were 7 (26.9%) unilateral cases. The mean age of patients in this study was 5.3 months. The mean initial Pirani score for the 26 patients, 38 right feet were 2.50 and 7 left feet were 2 (out of a maximum possible score of 6). After the use of Steen Beek FAB the final score for right sided feet was found to be 0.19 and for left sided were 0.15 and the mean change in the score was found to be 2.00. The final Pirani's values, when compared to the initial Pirani's scores by paired t-test gave a p value of 0.000, which is significant.

DISCUSSION AND CONCLUSION
It is concluded that the modified Steen Beek FAB is effective in the maintenance of corrected CTEV by ponseti method. The deformity can cause hurdles in life if left untreated, so there should be early diagnosis and proper treatment for CTEV. By using appropriate skin-friendly material we can reduce the skin damage. Proper sizing is important in the fabrication of the appliance. Proper counselling plays an important role in following proper bracing protocol. Self-modification of the brace should be discouraged.

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6.05 Comparing 3D printed thigh brace and conventional fabric harness for exoskeleton orthosis

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BACKGROUND

Thigh brace is a vital part in lower limb exoskeleton orthosis. It makes not only transmit the power from its Motor to the body but also contribute to stabilize the limbs during ambulatory remedial exercises in exoskeleton. Recent study show that improperly designed braces will restrict the performance of exoskeleton orthosis by up to 50%. Also, it can cause unstable gait and adversely affect the gait rehabilitation using an exoskeleton orthosis.

AIM

The aim of this case study is to compare 3D printed personalized thigh brace with conventional strap by analyzing the effect of compensation for the abnormal motion between the limbs and exoskeleton orthosis.

METHOD

One healthy male (age: 31 yrs., height: 169 cm, weight: 75 kg) was participated in the clinical test. Before the main test, the subject walked in the exoskeleton for five minutes to adapt to the orthosis. In the first session, the subject wore the exoskeleton orthosis which has conventional fabric thigh harness. In the second session, the subject wore the exoskeleton which has personalized 3D printed thigh brace. The whole test was conducted 2 times on the 4m long leveled ground condition and attached the Inertial Measurement Unit (IMU) sensor to both legs and orthosis to the thigh part.

RESULTS

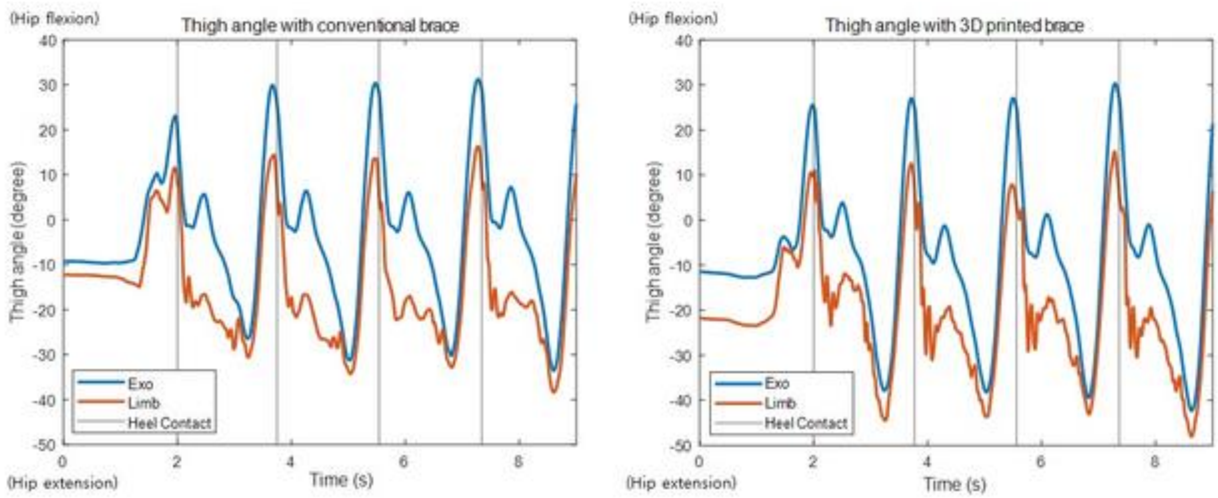

Figure 1. Thigh angle of (L) conventional strap type (R) and 3D printed brace type

Thigh angle pattern shows “M” shape in both conventional strap type and 3D printed brace type. First peak means maximum flexion angle for the heel contact phase. Second peak is second flexion movement after the heel contact phase. In 3D printed brace type, subject’s lower limb showed second flexion more clearly. Rock bottom means maximum thigh extension angle. In case of 3D printed brace type, extension angle shows more clearly.

DISCUSSION AND CONCLUSION

Heel contact impact caused the second flexion peak for absorbing the ground reaction force. Because the 3D printed brace type holds the lower limbs tighter, second peak was shown more clearly. This result affected the extension movement of the thigh for the push off phase; the maximum extension angle showed higher. This result means that the stable absorption by well fitted 3D printed brace makes more powerful push off phase.

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6.06 Adherence of wearing foot orthoses and footwear in people with diabetes mellitus: A systematic review of the literature

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BACKGROUND

Diabetic foot disease is associated with foot deformities, trauma and high plantar pressures that can contribute to the formation of a foot ulcer [1]. Footwear and foot orthoses become essential to prevent foot ulceration. Even the best prescribed device will not be effective if it is not worn by people with diabetes as required. Thus, it is crucial to explore the reasons for adherence and non-adherence to footwear and foot orthoses among people with diabetes.

AIM

To explore the facilitators or barriers influencing adherence to wearing footwear and foot orthoses in people with diabetes mellitus.

METHOD

An electronic search of the literature was conducted from 28 April to 30 April 2022 using keywords or equivalent terms in combination through the following databases: Cochrane Databases, Embase Classic+Embase (Ovid), MEDLINE (ProQuest platform), PubMed, and Web of Science. Additionally, websites of prosthetic and orthotic associations, International Diabetic Federation and World Health Organisation (WHO) were searched. There were no restrictions placed on the year of publication. Searches were restricted to the English language. The reference manager, ENDNOTE desktop version 20, was used to download all the search results for the purpose of screening. All articles were retrieved following PRISMA guidelines.

RESULTS

The search generated 2545 papers; after applying inclusion and exclusion criteria and removing duplicates, nine articles, including quantitative and qualitative research, were reviewed. Physical and psychological variables such as age, gender, duration and type of diabetes, body mass index, footwear design, aesthetics, comfort, protection, imbalance, daily activity limitations, understanding of diabetic foot management, culture, and emotions are factors which have been identified in the included articles. Five adherence domains were identified: patient related factors, footwear related factors, condition related factors, health system related factors, and finally, social, and economic factors as proposed by WHO [2]. Providing indoor footwear, patient education, attractive footwear, and perceived benefits of prescribed footwear appear to be essential aspects of ensuring adherence. The remaining factors (as outlined above) were not linked with adherence or the results are conflicting.

DISCUSSION AND CONCLUSION

The provision of indoor footwear can enhance adherence, considering its significance for social norms. Subjects who have already lacked protective foot sensation have prioritised comfort over protection, demonstrating that they do not understand the purpose of diabetic footwear prescription. Hence, patient education might play an essential role in influencing adherence.

Despite including qualitative and quantitative studies, there are too few articles to reach definitive conclusions; additional research is warranted to determine the variables that influence adherence.

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ACKNOWLEDGEMENTS ICRC Syria Delegation, University of Strathclyde.

6.07 Effect of lateral ankle wedge insole (LAWI) in knee osteoarthritis patients at Alneelain University Faculty of Physiotherapy out-patient clinic 2022

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BACKGROUND

Knee osteoarthritis is generally resulting of put on, tear and progressive loss of cartilage. Treatment for knee osteoarthritis starts with conservative methods and progresses to surgical treatment when conservative therapy fails [1].

Lateral wedge insoles are therapeutic alternatives in moderate to average medial knee osteoarthritis. Its objective is for medial compartment relief to stop expanded loading of the medial joint compartment at some stage in gait [2].

AIM

To determine the effect of lateral ankle wedge in knee osteoarthritis patients on pain and functional activities.

METHOD

This randomized controlled trial was conducted at outpatient clinic of Faculty of Physiotherapy at Alneelain University. 21 patients were selected using predefined inclusion and exclusion criteria and randomly allocated into two groups: Group A (control group) 14 patients they received conventional physiotherapy and group B (experimental group) 7 patients they received conventional physiotherapy plus LAWI. Outcome was recorded at the beginning and at the end of two weeks in term of pain and disability as recorded in Visual Analog Scale (VAS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) respectively. Both groups received 6 physiotherapy sessions.

RESULTS

At the end of two weeks there was statistical significance difference of each group regarding VAS scale and WOMAC questionnaire. There was statistical significance in VAS scale in group A pre and post physiotherapy p value was 0.000. And WOMAC questionnaire of group A pre and post physiotherapy also showed statistical significance (p value 0.00).

Regarding experimental group (B) VAS scale also showed statistical significance in the group pre LAWI and post LAW (P value 0.001). And WOMAC questionnaire of group B also showed statistical significance in pre and post LAW (P value 0.00). And in correlation between two groups regarding VAS and WOMAC also there was statistical significance difference; P value was 0.008 and 0.000 respectively.

DISCUSSION AND CONCLUSION

In a previous study the effectiveness of different treatment approaches in knee pain demonstrate that conventional Physiotherapy is effective on knee pain of osteoarthritis patients [3]. Another long-term study on use of foot insole indicate that there was remarkable improvement in knee pain during walking and also knee adduction moment if the insole used with conventional physiotherapy [3].

Conclusion: LAW insole when added to conventional physiotherapy we can gain good results in pain and functional activities for knee osteoarthritis patients.

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6.08 Limb position adjustment in a digital environment based on a human body avatar for the production of orthotic devices

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BACKGROUND
In the O&P field, 3D technology enables the creation of individualized medical devices that are tailored to perfectly fit the patient's anatomy. After the acquisition of the patient's 3D scan, the data needs to be processed before it can be used to design medical devices. A big challenge in processing the 3D data involves digitally correcting the patient's joint posture to achieve a neutral position that can be used for fitting of a customized orthopedic aid.

AIM
To examine the effectiveness of digital limb alignment for the creation of customized orthotics, which could provide a substantial advantage for patients where casting is not possible, young children or patients with open wounds.

METHOD
Using 3D data from a handheld scanner and digital production tools to create the individualized orthosis, the entire process will be analyzed in the following terms:

1. Overall quality of the treatment (fit, pain reduction etc.)
2. Patient experience
3. Production time
4. Reproducibility
5. Sustainability

To evaluate these metrics, test treatments to create a child's night splint were carried out and the final product, as well as the process itself was inspected closely. A handheld 3D scanner was used along with the Mecuris Solution Platform Software [1]. Patients were asked for their experience and their satisfaction and the result was compared with relevant literature of the topic.

RESULTS
Using a digital process chain for the creation of a child's night splint as an example, we could show that this process, compared with a traditional workflow using plaster casts, achieves the following advantages:

1. Quality of the treatment: Less skin diseases, uneasiness and misalignment of joints [2]
2. Patient experience: Increased patient satisfaction and reduced time spent at the O&P workshop due to 3D scanning instead of plaster casting. Increased customizability due to 3D printing [2]
3. Production time: Saves roughly 3.7 hours of working time [3]
4. Reproducibility: Finely tunable digital tools and the use of templates greatly increased the technician's ability to apply similar treatments [1]
5. Sustainability: Saves an estimated 1.6kg of CO_2 and 1.5kg of waste [3]

DISCUSSION AND CONCLUSION
It could therefore be shown that the advantages of the digital process over manual alignment are significant and benefit not only the patient but also the technician and the industry as a whole. Flexibility of design and more customization options for the patient, reduction in skin irritations and misalignments and a more sustainable production process are only some of the benefits of using a digital limb alignment. Further improvements in key areas are expected to further highlight these benefits [2,3].

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6.09 Influence on body posture by foot orthoses in pronated and supinated feet identified applying Foot Posture Index in young subjects.

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BACKGROUND
The Foot Posture Index is a diagnostic clinical tool to assess foot posture. Postural alterations of the foot can affect the body's static alignment.

The treatment of these alterations is carried out through plantar orthosis, although they are not always done based on the results of the FPI.

Measurements of static body alignment, can be performed with specialized equipment and software, allowing more accurate data to be obtained, thus assessing the impact of the elaborated plantar orthosis on posture.

AIM
To determine if the use of plantar orthosis made for users with a pronated or supinated foot identified from the foot posture index has an effect on posture in the short term.

METHOD
Quantitative – Experimental – Longitudinal

Sampling – Data Collection – Data

Analysis Selection of study subjects: Non-probabilistic sample.

Application of the Foot Posture Index tool to evaluate the study subjects and application of inclusion-exclusion criteria for the development of devices.

Capture and analysis of kinetic and kinematic data subjects with pronated or supinated foot without the use of plantar Orthoses.

Preparation of plantar Orthoses following manufacturing protocol.

Capture and analysis of kinetic and kinematic data from subjects with pronated or supinated feet using elaborate plantar Orthoses.

Data analysis

RESULTS
Work-in-progress: Most of the young subjects evaluated present a pronated foot, which responds with observable changes at the moment of the measurement of the posture, making use in a short time of the orthoses elaborated from the findings with the application of the FPI.

DISCUSSION AND CONCLUSION
Work in progress

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6.10 Repeatability of a bespoke test rig for measuring the stiffness and mediolateral widening at the ankle of rigid ankle-foot orthoses.

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BACKGROUND

Sagittal ankle stiffness, measured in Nm/º, is a key property of ankle-foot orthoses (AFOs), determining resistance to movement and the biomechanical control exerted. Mediolateral widening at the ankle during dorsiflexion, is considered a key mode of AFO failure. Despite recommendations [1], neither are regularly quantified within research, due to the absence of a standardised testing procedure [2]. Therefore, detail on the mechanical properties of the AFOs tested is often vague [1], limiting valid meta-analysis and potential advancements in design.

AIM

To design and verify a test rig capable of measuring the sagittal ankle stiffness and mediolateral widening at the ankle of various sized AFOs, under physiological dorsiflexion loads.

METHOD

Rig Design: Loading the proximal calf of an AFO, with the foot secured to a table, generated a dorsiflexion ankle moment. 14 retro-reflective markers modelled the AFO into shank and foot segments, whilst two markers modelled the pulling cable. 3-dimensional motion tracking [10 opto-electric cameras (Vicon, Oxford)] recorded the sagittal angle between the shank and foot, coronal malleoli widening, sagittal angle between the pulling cable and foot, and transverse shank rotation. Linear regression of the ankle moment versus ankle angle deflection plot, determined sagittal ankle stiffness. ***Repeatability Study:*** One assessor tested two AFOs across two sessions. AFOs were loaded to 14kg in 1kg increments, three times, with 5 seconds intervals.

RESULTS

Table 1 details the inter-trial and inter-session SEM calculated for the four outcome measures[4]. Results of a paired T-test showed only AFO 2 recorded a significant difference (P<0.05) in the stiffness between sessions. Analysis using a one-way ANOVA and Tukey's post-hoc test highlighted a significant change (P<0.001) in sagittal ankle angle, mediolateral widening, sagittal pulling angle and transverse shank movement, with 1kg increments producing significant changes (P<0.001).

Table 1: Inter-trial and Inter-session SEM for the outcome measures, Mean (SD)

Measure	*Inter-trial SEM*	*Inter-session SEM*
Sagittal Ankle Stiffness / Nm/º	0.08	0.49
Mediolateral Widening / mm	0.06(0.05)	0.36(0.29)
Sagittal Pulling Angle / º	0.04(0.02)	0.7(0.1)
Transverse Shank Movement / º	0.03(0.01)	0.86(0.05)

DISCUSSION AND CONCLUSION

Ankle stiffness inter-trial and -session SEM agree with literature [4]. Converting the upper confidence limit of mediolateral widening inter-session error into a percentage of mean malleoli width, results in 0.84%, less than the smallest change (2.2%) presented previously [5]. Despite a significant change in sagittal pulling angle and transverse shank rotation, the maximum recorded was 6.32º and 1.00º respectively, therefore having minimal impact on ankle moments. Consequently, the aims were achieved, facilitating thorough research into AFO design and biomechanical performance.

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Posters: Orthotics: Spinal

6.11 Corrective effects of novel multilayer lumbosacral orthosis for early rehabilitation after spine surgery

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BACKGROUND
Lumbar orthosis is commonly used clinically to relieve pain and improve quality of life in patients with lumbar disease surgery. A new multi-layered lumbosacral orthosis with improved comfort and corrective power was developed at the Veterans Health Service Medical Center to compensate for the shortcomings of wearing conventional orthosis and Cybertech®. The newly developed orthosis does not require a buckle and designed to be easily worn by the patient with both hands by pulling method.

AIM
This study aimed to compare the effectiveness of a conventional lumbosacral orthosis (LSO) and the commonly used, ready-made Cybertech® LSO to that of a novel multilayer, Veterans LSO (V-LSO), through radiographic analysis for early rehabilitation after spine surgery.

METHOD
From March 2019 to November 2019, patients who underwent lumbar degenerative surgery at the Neurosurgery and Orthopedics department were included in this study. According to the time of hospitalization, the conventional LSO, Cybertech® and V-LSO were applied for 6 weeks with randomization. All patients were pre-operatively assessed using the Oswestry Disability Index (ODI) and underwent plain lumbar imaging tests (anteroposterior and lateral views) on the 7th postoperative day. We measured the lumbosacral angle (LSA), frontal imbalance, lumbar lordotic angle (LL), and lumbosacral disc angle (LSDA) with or without the brace. At the 6th postoperative week, a follow-up assessment with the ODI and orthosis questionnaire was conducted.

RESULTS
A total of 90 patients were performed and 11 patients were not included because they did not undergo image test and 1 patient was not visited six weeks after surgery. Differential LSA and LL of the V-LSO group were significantly increased before and after wearing the LSO compared to the conventional groups ($p<0.05$). Also, when the change in LSA toward the reference value was defined as a positive change with LSO, the ratio of the positive change in LSA was significantly different in V-LSO group (conventional: 62.96% vs. Cybertech®: 61.90% vs. V-LSO: 92.86%; $p=0.015$); a similar tendency was observed for LSDA (conventional: 62.96% vs. Cybertech®: 61.90% vs. V-LSO: 92.86%; $p=0.054$).

Fig 1. Three semi-rigid lumbosacral orthoses (LSO)
A : Conventional orthosis, B : Cybertech® spinal brace, C : A newly developed LSO (V-LSO)

DISCUSSION AND CONCLUSION
New V-LSO showed no significant difference in subjective satisfaction. But based on the results of the radiographic findings, it is supposed that the new LSO is effective in correcting lumbar lordosis than the existing LSO after spine surgery.

6.12 Immobilization effect and abdominal pressure of newly-developed lumbosacral spinal orthosis during task performance

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BACKGROUND

Lumbar orthosis is known to have the effect of increasing body cavity pressure by compressing the abdomen, thereby correcting lumbar lordosis, and dispersing the pressure on the spine and intervertebral discs [1,2]. A new multi-layered lumbosacral orthosis with improved comfort and corrective power was developed at the Veterans Health Service Medical Center to compensate for the shortcomings of wearing conventional orthosis and Cybertech®.

AIM

We evaluated the efficacy of a newly developed spinal orthosis (V-LSO) by comparing the stabilizing effect, abdominal pressure, and comfort of 3 different semirigid LSOs (classic LSO, V-LSO, and Cybertech®) during various body movements.

METHOD

Thirty healthy volunteers (23~47 years, 24 males, 6 females) were selected. A dual inclinometer measured the range of motion (ROM) while the participants performed flexion/extension and lateral flexion of the lumbar spine with 3 LSOs. The LSO's pressure on the abdominal surface was measured using 9 pressure sensors while lying, sitting, standing, flexion/extension, lateral flexion, axial rotation, and lifting a box. Comfort and subjective immobilization were analyzed by a questionnaire.

RESULTS

V-LSO had a statistically significant effect on flexion over Cybertech®. No significant differences were noted during extension and lateral flexion between the 3 LSOs. The abdominal pressure showed no significant differences while supine. While sitting, standing, and lifting a box, the mean abdominal pressure for V-LSO were significantly higher than those for Cybertech®. During lumbar flexion, the mean abdominal pressures for classic LSO and V-LSO were significantly higher than that of Cybertech®. For extension, lateral flexion and axial rotation, the abdominal pressure for V-LSO was significantly higher than those of classic LSO and Cybertech®. In the subjective analysis, V-LSO and Cybertech® scored best for comfort.

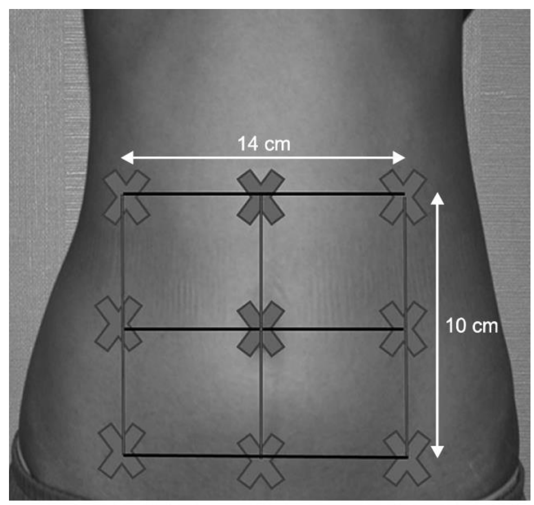

Fig 1. Abdominal pressure sensor placement.
A total of nine sensors were positioned in three rows, three for every 7 cm horizontally and every 5 cm vertically for 14 cm wide.

DISCUSSION AND CONCLUSION

The V-LSO and Cybertech® were more comfortable than the classic LSO, and hence, may have improved compliance with decreased discomfort. V-LSO may be superior to the other LSOs in restricting lumbar movement and increasing intra-abdominal pressure.

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6.13 Functional spinal motion and physical activity in females diagnosed with Adolescent Idiopathic Scoliosis undergoing Thoraco-Lumbar-Sacral Orthosis treatment

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BACKGROUND

Functional spinal mobility is a routine biomechanical way to measure the spine's flexibility while integrating biomechanical principles such as spine evaluation of flexion, extension, or rotation measures. Physical activity represents specific measures of physical activity intensity over a period of time assessed objectively and subjectively. Objective assessment of physical activity can be measured with an activity tracker such as the Step Activity Monitor (SAM) and subjective physical intensity by survey self-reporting physical activity monitoring low to high physical activity intensity.

AIM

There is a need to understand Idiopathic Scoliosis before initiating treatment. We acquired knowledge on pre-bracing spinal mobility and physical activity for AIS females. Our central hypothesis anticipated that females will exhibit functional differences compared to age-and sex-matched typically developing controls

METHOD

Motion capture data collection was conducted using a 14-camera motion capture system (Vicon Motion Systems Ltd, Denver, CO, USA) to collect kinematic data, sampling at 120Hz. 14-mm reflective motion capture markers were placed on bony anatomical landmarks and on the trunk of the patients using double-sided tape. Participants were asked to complete the Hospital for Special Surgery Pediatric–FunctionalActivityBriefScale (HSS Pedi-FABS) survey during the MSL visit. Both groups were invited to wear a StepWatch Activity monitor (SAM version 3) using StepWatch 3.1 software (Modus Health, Edmonds, WA, USA). The sampling rate for the SAM was set to 10-second intervals allowing up to eight days of data to be stored.

RESULTS

Spinal mobility variable of interests:

- Thoracic and lumbar flexion/extension
- Bilateral spinal rotation
- Cervical extension
- Total spine Flexion/ Extension-TotalSpinalSymmetry
- A custom spinal model will be used to compute variables of interest, including joint angles at cervical, thoracic, and lumbar segments of the spine, and total spine angle in all planes. Displacement of trunk, neck, and pelvis angles of all participants in all planes will also be computed.
- A sample size of 26 in each group will be sufficient to detect a large difference effect of spinal mobility and physical activity between AIS patients diagnosed and typically-developing groups and reach 80% of power for this study.
- Regarding our study, to be able to report a large clinical effect size of 0.70, we anticipate a minimum of 10 degrees’ difference in lateral bending range of motion between our two independent groups.

DISCUSSION AND CONCLUSION

We anticipate finding differences between typically developing girls and AIS patients. We expect to see lower spinal peak angles (thoracic, lumbar, cervical, and total spine angle) in the AIS group indicating lower functional mobility. We assume to report limited displacement of the trunk, neck, and pelvis angles of all participants in the AIS group. We also expect to find significantly lower intensity and duration count and lower HSS Pedi-FABS scores in the AIS group compared to the typically developing group.

Posters: Orthotics: Upper limb

6.15 Computed tomography verification of the traction effects in artificial muscle type dynamic traction splints

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BACKGROUND

Darts slow motion (DTM) from radial dorsiflexion to palmar flexion has recently attracted attention as a functional movement of the wrist joint. In addition, as a technique to effectively improve wrist joint contracture, the effectiveness of passive exercise with the wrist joint manually pulled towards the hand has also been reported. We devised a new artificial muscle-type dynamic traction splint (DTSaM) that adds these movements.

AIM

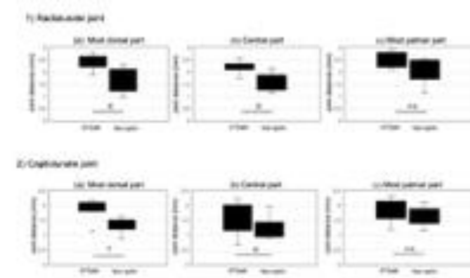
This study examined the traction effect by measuring the interosseous distance and area with and without DTSaM by computed tomography.

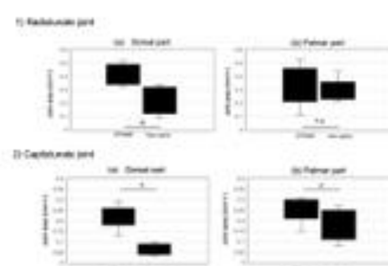
METHOD

The subjects were six healthy men (six fingers) and four healthy women (four fingers) with no history of finger disease (average age 29.4 years). The limbs were fixed with elbow joint extension and the wrist joint in 40° dorsiflexion. The joint fissure distance and joint space between the radiolunate and capitolunate (RL and CL) joints were measured using automatic movement and DTSaM computed tomography (CT). The lateral surface of the target joint was sliced at 0.1mm intervals and the traction forces at the sagittal section of the center point were evaluated. Statistical analyses were performed using Wilcoxon signed-rank tests.

RESULTS

In terms of joint distance, DTSaM showed significant dilation on both the dorsal and central sides of both the RL and CL joints compared to those without orthotic devices ($p > 0.05$) (Figure 1). The area was significantly larger on the dorsal side of both the RL and CL joints ($p > 0.05$) (Figure 2).





DISCUSSION AND CONCLUSION

Traction applied to the wrist joint is effective mainly during dorsiflexion, and the scaphoid bone rotates owing to the dilation of the CL joint, which produces the dorsiflexion effect of the lunate bone [1]. Thus, movement of the CL joint in the dorsiflexion is important. The results of this study suggest that the dilated CL joint makes it possible to approach the dorsiflexion method and that traction may be possible.

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6.16 Customized 3D printed lawn bowl hand orthosis for a quadriplegia

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BACKGROUND

For individuals with disabilities, a sport can be a therapeutic means that promotes social integration as well as strength training. There are few sports that individuals with severe disabilities can play, such as lawn bowling. Nevertheless, lawn bowling is not easy to perform because of the poor ability of such individuals to hold the ball when the hand is severely disabled. Therefore, customized hand orthoses are needed for these patients.

AIM

Recently, the upper limb orthosis which is made with three-dimensional (3D) printer is used for disability because of customization, light and comfort. In this study, 3D printers were made for upper limb braces in three patients with spinal cord injury.

METHOD

After scanning the patient's hand and forearm with a 3D scanner, an orthosis was designed through a CAD (Computer Aided Design) programme. The designed model was printed using a FDM (Fused Deposition Modeling) method.

Each of orthoses were manufactured by PLA (Polylytic acid) and TPU (Thermoplastic Polyurethane). TPU is more flexible and elastic. Wearing each of them, they participated in the lawn ball game for one month and had time to adapt. In order to evaluate the satisfaction and function before and after wearing the orthosis, a self-study was conducted in two areas: the feeling of use and satisfaction evaluation.

RESULTS

The patient was a 49-year-old man with C5 level quadriplegia who was in a state of difficulty holding and supporting objects due to decreased muscle strength in the wrist and fingers. Eight years ago, he had a left upper limb brace at another hospital and participated in the Lawn Bowl Disabled Movement. 20 questionnaires were evaluated for the feeling of use and satisfaction before and after use. There was a trend of continuous increase in the feeling of use and satisfaction with the TPU 3D brace. The other patients were men aged 63 and 66 years with C6 and C7 level quadriplegia and reduced finger strength. They have participated in a lawn bowl exercise, but neither of them had ever used hand orthoses. The feeling of use and satisfaction was higher in TPU compared to PLA.

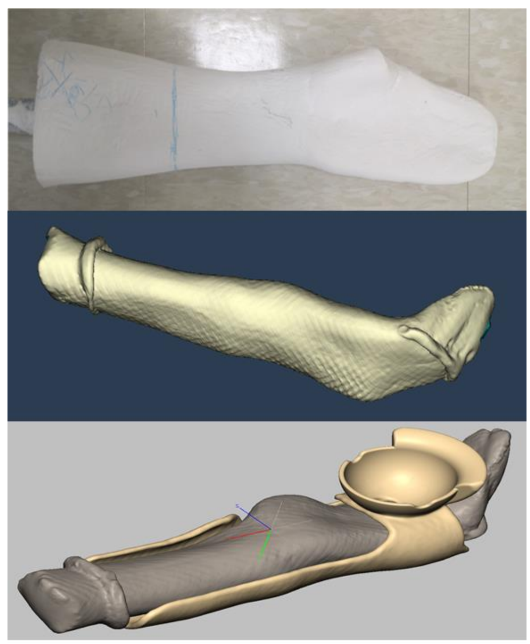

Fig. Scanning of gypsum model and design through modeling

DISCUSSION AND CONCLUSION

A 3D printing is a next-generation technology with modularity compared to traditional technology by allowing production and repair to be tailored to each individual. In addition, it was confirmed that the TPU material is a suitable material compared to PLA as an orthosis for sports events. Through the questionnaire, we confirmed that the hand orthosis made with 3D printing helped the disabled to participate in society and improve their performance, thereby improving the quality of life.

6.17 Application of a 3D-printed writing–typing assistive device in patients with cervical spinal cord Injury

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BACKGROUND

Spinal cord injury, particularly cervical injury, patients cannot perform all the activities of daily living (ADL) due to arm and hand dysfunction. ADL assistive devices can improve the independence of patients with cervical SCI and reduce caregiver burden. However, assistive devices are usually manufactured by ready-made products. Hence, it is difficult to match to the individual characteristics of patients.

AIM

The current study aimed to evaluate the effects of customized 3D-printed writing and typing assistive devices. The purpose of this case series is to demonstrate the effects of a customized 3D-printed writing and typing device in severely disabled patients.

METHOD

Three patients with cervical spinal cord injury who presented with severe hand dysfunction were included in the analysis. The patients' writing and typing abilities were evaluated after using the silicon assistive device made from a 3D-printed frame for 4 weeks. Patient discomfort and issues were evaluated. Customized 3D-printed writing and typing assistive devices were developed. The Korean Western Aphasia Battery (K-WAB), particularly the writing part, and the word practice program of Hangeul were utilized to assess device effects. All patients with cervical spinal cord injuries performed writing or typing using a customized assistive device.

RESULTS

The patient (1) had 0 grade on both hands. Hence, he required assistance from a caregiver in writing his name. Moreover, the patient could not write normally. Thus, evaluation could not be performed. However, after the device was worn, all evaluation items could be performed. The patient did not want to be evaluated because he did not use a computer and did not require a typing aid. The other patients (2, 3) had better typing and writing accuracies based on the word practice program of Hangeul and the K-WAB, respectively. However, patient 3 had increased time, which was associated with the process of adapting to the use of the customized device. Nevertheless, he was highly satisfied with the device.

DISCUSSION AND CONCLUSION

Customized 3D-printed writing and typing devices may improve the writing and typing abilities of patients with severe disabilities, thereby promoting greater satisfaction. We believe that this study will be the cornerstone of research on assistive devices developed using the alternative 3D printing technology of conventional orthosis in patients with cervical SCI who have tetraplegia.

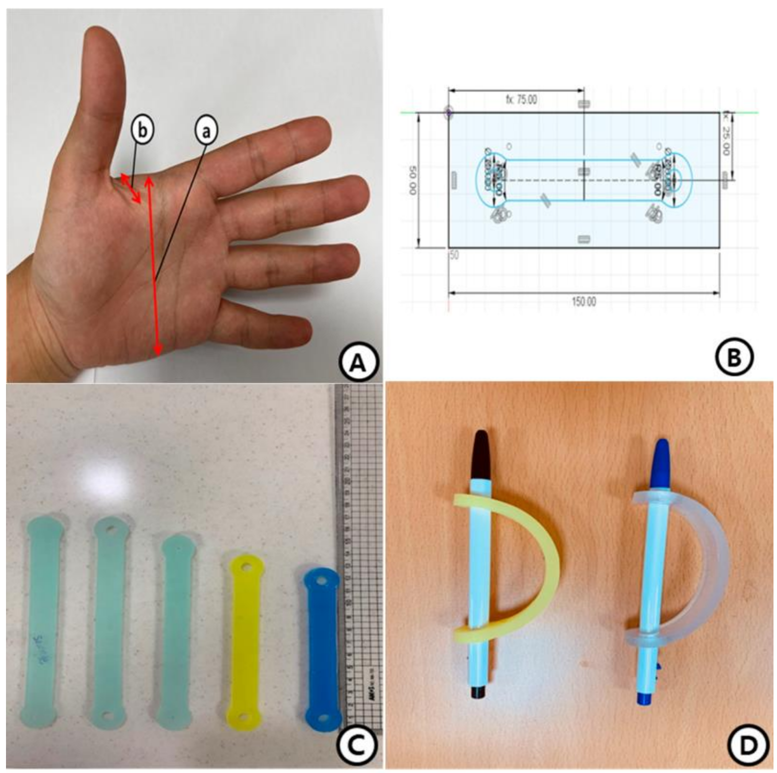

Fig. (A) a. Handbreadth from the MCP joint of the thumb to the MCP joint of the 2nd finger along the surface of the hand. b. Width between the index and little finger. (B) Frame design on the STL file. (C) Five silicon assistive devices according to length. (D) Printing typing and writing integration device.

6.18 The effectiveness of a simplified orthotic torque profile for weight compensation of the hand.

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BACKGROUND

People with Duchenne Muscular Dystrophy (DMD) suffer from progressive muscular weakness and joint contractures. At a certain stage, lifting their hands against gravity becomes challenging and contractures are formed by disuse, reducing the range of motion. By compensating the hand's weight through an orthotic support, the task execution can be improved. However, compensating the weight of the hand is challenging as the required compensation moment depends on the spatial orientation of the forearm.

AIM

This proof of principle study compares a hand orthosis employing a simplified *constant* compensation strategy with the conventional *sinusoidal,* aiming to minimize the required muscular effort to lift the hand against gravity in healthy subjects.

METHOD

Three different compensation torques profiles (*non*, *constant* and *sinusoidal*) were statically applied for 4 wrist positions under 3 forearm orientations in 8 healthy subjects. The *sinusoidal* torque profile can be considered as the theoretically ideal profile, dependent on wrist and forearm orientation. The *constant* torque profile is solely dependent on forearm orientation. Both compensation profiles are compared to *non*, i.e. no compensation. Surface electromyography (sEMG) measurements were taken of the wrist flexor and extensor muscles as measure of the required effort. The results were analyzed using a repeated measures analysis of variance.

RESULTS

The experiments showed a mean significant reduction in extensor muscle activity (anti-gravity) of 51% for *constant* (p<.001) and 46% for sinusoidal (p<.001) compared to no compensation. No significant difference was observed between the constant and sinusoidal profiles. However, on average a significant increase of 50% for constant (p=.012) and 44% for sinusoidal (p=.005) in the flexor muscle activity was observed compared to no compensation. This increase in average activity is mainly caused by the increased activity of the flexor muscles at 50° palmar flexion (Figure 1).

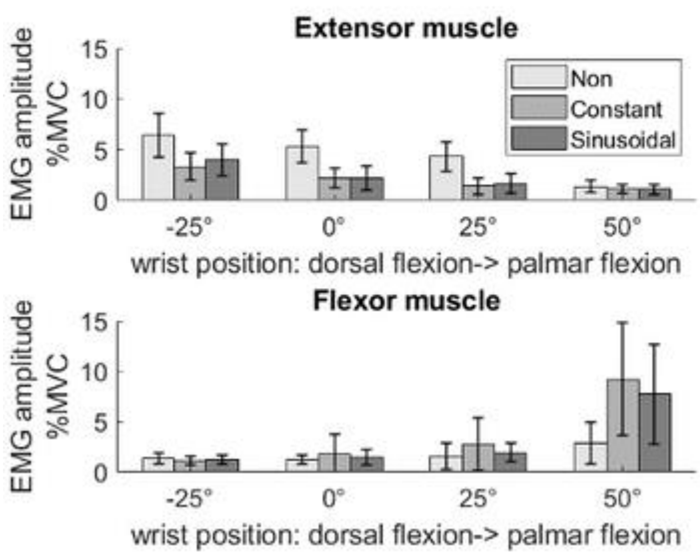

Figure 1. Effect of the different wrist positions on the wrist extensor and flexor muscles activity for different compensation methods, with the forearm in a horizontal pronated position.

DISCUSSION AND CONCLUSION

Constant and sinusoidal compensation behave comparably to reduce muscular efforts over a range of wrist positions and forearm orientations. It is hypothesized that for the ideal compensation profile the increased flexor muscle activity at 50° palmar flexion is caused by the influence of joint impedance for which is not compensated. So, constant torque is a simplified alternative strategy for weight compensation of the hand, but the joint impedance should be accounted for, especially as it is increased in DMD patients.

Posters: Prosthetics: Lower limb transfemoral

6.19 An experimental model of variable diffusivity between the skin and the liner by infrared thermographic analysis: towards personalized liners

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BACKGROUND
A crucial factor in prosthesis abandonment is the use of liners that increases temperature and sweating, which favor skin lesions, especially in zones with higher pressure [1-3]. The temperature increase varies throughout the stump: regions close to muscles are warmer [4]. To determine those areas we used infrared thermography. Thus, some areas require greater thermal diffusion than others in the same individual. The use of personalized liners according to thermal needs might be helpful to improve users' comfort and attachment to prosthetics.

AIM
To obtain an experimental model that describes thermal conductivity between the skin and liner in physiological conditions. Second, to obtain thermal dissipation coefficients in liners with different diffusivity rates that fit the prior model to predict thermal response in skin.

METHOD
In a temperature-controlled room, we obtained thermograms (model E-53, FLIR System, Inc., Wilsonville, OR, USA) of the anterior thigh of 6 healthy participants in basal condition. Later, thermal behaviour between the skin and a liner made of silicon was characterized by placing a sample of the liner on the skin until thermostasis.

We elaborated a sample of liner made of silicon with three different rates of porousness to describe the thermal dissipation by using a hydraulic heater at a constant temperature of 40°C and infrared thermography.

With these data, we obtained a mathematical model to estimate the thermal behaviour in the skin with liners with three different diffusivity rates.

RESULTS
We obtained the equations to describe the thermal pattern in the anterior thigh and the equations that describe thermal elevation as a function of the thermal insulation capacity of liners.

DISCUSSION AND CONCLUSION
Knowing the thermal pattern of the skin of the stump obtained by infrared thermography might be helpful to determine which areas need different degrees of thermal diffusion and to design personalized liners, according to those needs to improve the control of perspiration and thereby improve comfort, which can eventually reduce the development of skin lesions and enhance the adherence to prosthetics, and prognosis of the users.

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6.20 Mechatronic proposal for a self-adjustable transfemoral socket

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BACKGROUND
Lower limb amputations affect a person for life. In particular, transfemoral prostheses are a challenge for prosthetists since the stump can change in volume due to different circumstances of each patient (e.g., weight loss or gain), which means that the user must replace the socket several times.

AIM
This work proposes a mechatronic system coupled to a transfemoral socket to allow it to change its internal volume to automatically adjust to changes in the volume of the stump.

METHOD
The stump mould of a patient with transfemoral amputation was obtained, from which a socket was generated using the thermoforming technique. Before generating the socket, the mould was modified to generate four chambers in each quadrant (anterior, posterior, lateral and medial) where inflatable bags made of silicone (Ecoflex 00-50) will be housed. The bags will be used to adjust the volume of the stump according to the patient's conditions. A mechatronic system was designed and implemented to control the bags inside the socket.

RESULTS
An automated system was obtained to inflate the socket bags, which consisted of 1) a microcontroller, 2) two servo valves, 3) air pump, 4) tubing with unidirectional air valves, 5) battery.

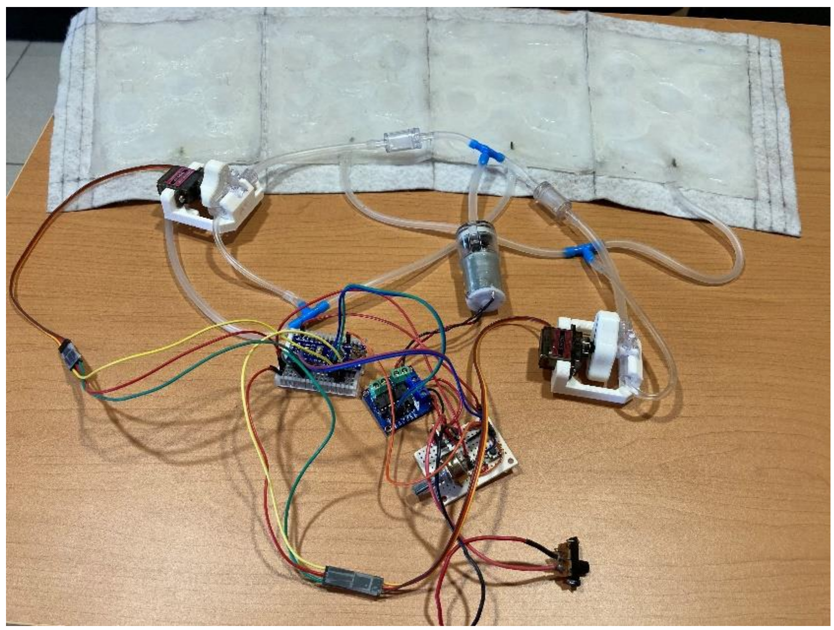

Figure 1 shows the electronic system together with four bags manufactured in silicone.

The bags will inflate automatically through servo valves that control the flow. Depending on the conditions of the patient's stump, the bags inflate and deflate alternately, that is, if the medial and lateral bags are required to inflate, the anterior and posterior bags deflate and vice versa when required. The control algorithm was designed, tested and debugged using the Arduino platform, whose program starts by inflating a pair of bags (front and back) moving the servo valve towards the "fill" position, the air pump is activated for a time to introduce air to these bags.

DISCUSSION AND CONCLUSION
The mechatronic system was obtained for the adjustment of the mediolateral and anteroposterior volume before volumetric changes of the stump, e.g., when the patient sits or stands up through a button and filling the bags with an adjustment knob. As a work in progress, instrumentation with pressure sensors will be added to self-regulate the inflation of the bags. The impact of this research is to improve comfort and safety in the use of the transfemoral prosthesis through the self-adjusting system.

ACKNOWLEDGEMENTS The authors thank UNAM-DGAPA for the support received through the project PAPIIT IT101121 “Self-Adjusting Socket Design”.

6.21 Monocentric and polycentric mechanical knees designed for low-resourced settings: Assessing the end-user satisfaction.

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BACKGROUND
Despite the large number of lower limb amputees living in low- and middle-income countries (LMICs), most of the prosthetic knee joints on the market are primarily designed for high-income countries, therefore being inappropriate for the social, cultural, environmental, and resource-constrained settings of the majority of countries. More recently, a few institutions have endeavoured to develop new prosthetic devices to specifically meet the requirements of amputees in LMICs.

AIM
This study assesses the satisfaction of lower limb amputees in LMICs using mechanical monocentric and polycentric knee joints (MKJ and PKJ) for unilateral transfemoral amputation or knee disarticulation.

METHOD
A total of 35 participants were recruited in Tanzania and Cambodia to trial three different prosthetic knee joints in their own homes for a three-week period each: a long-established conventional monocentric knee joint with no extension assist mechanism (C-MKJ), a recently-introduced conventional polycentric knee joint with standard linkage geometry and extension assist mechanism (C-PKJ), and a novel polycentric knee joint design with a new extension assist mechanism (N-PKJ) collaboratively developed with prosthetists based in LMIC prosthetic clinics. Each participant trialled at least two different knee joints. Two validated questionnaires (SAT-PRO [1] and PEQ [2]) were translated in Khmer and Swahili, and administered to each participant for each knee trialled.

RESULTS
Participants were overall more satisfied with the PKJs than the MKJ. Focussing on the SAT-PRO questionnaire results in the Tanzanian cohort, the C-MKJ averaged a total score of 71%, while the C-PKJ and N-PKJ scored 78% and 88% respectively. Figure 1 shows that participants were more satisfied with the cosmetic appearance of the C-MKJ, but reported it was difficult to clean and felt people responded better to the physical appearance of the PKJs. They also felt safer with the PKJs and thought they worked better than the C-MKJ. Participants reported that the C-PKJ was easier to understand and worked better than the other knees but scored the perceived durability lower.

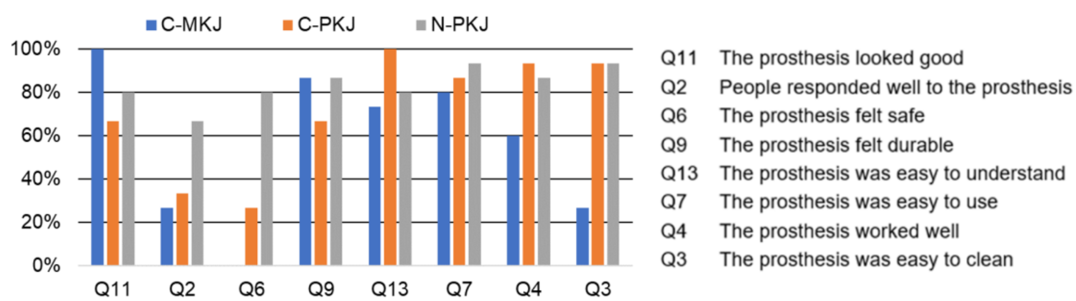

Figure 1: Average SAT-PRO scores of questions where the prosthetic knee is the most likely component to have an impact on the participants' answers.

DISCUSSION AND CONCLUSION
Despite the C-MKJ's better cosmetic appearance, participants preferred PKJs. The continuous collaborative development with prosthetists in LMICs resulted in a N-PKJ that enabled faster walking and allowed higher knee flexion angles for kneeling and squatting, scoring higher than the C-PKJ but being more difficult to understand.

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6.22 Comparative study on social life satisfaction of fresh transfemoral amputees

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BACKGROUND

Individuals who have undergone transfemoral amputation suffer many barriers, be it psychological or physical what determines is how they tackle with this state. The purpose of my study is to compare the satisfaction level of patients with and without prosthesis. To find out how much a patient is satisfied with rehabilitation i.e., satisfaction level of patients with their prosthesis. Often times patients who use a prosthesis are not satisfied with it.

AIM

To find out how much patients are satisfied with their prosthesis.

METHOD

It was a cross sectional correlation study design. These patients were categorized into two groups i.e., Pre-Prosthetic and Post-Prosthetic. Out of 60 participants, 30 were pre-prosthetic and 30 were post-prosthetic patients. These patients were selected from PIPOS rehabilitation service (PRSP) Program, Peshawar. Patients were selected from PRSP Peshawar rehabilitation Centre (PIPOS). Patients were thoroughly accessed for this study before conducting the study and the consent forms were signed by the patients.

We used a questionnaire which has a total of 35 questions starting from patient personal information to their comfort and independence level achieved through Prosthesis.

RESULTS

In this study 60 patients filled in the questionnaire. Out of these 60, 44 were male and 16 were females. Patients selected for the interview were minimum 6 months prosthetic user. It is known that more of the ratio with prosthetic users are satisfied and have a very positive approach towards life. They find least difficulty in performing their daily life activities as well as becoming an active member to the society.

DISCUSSION AND CONCLUSION

It is quite evident for the pre-prosthetic group that the patients who are not independent in their daily life activities have a mean of 2.0 (with none being independent) whereas in the post-prosthetic group patients attained independence with a mean of 1.13. Out of 30 patients, 26 (86.7%) patients have become independent in their ADL whereas only a smaller number of 4 patients (13.3%) patients are not independent despite receiving rehabilitation.

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ACKNOWLEDGEMENTS Cordial thanks go to our parents for their cooperation and good wishes.

6.23 TRIUMPH Hydraulic Prosthetic Knee Joint

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BACKGROUND
TRIUMPH prosthetic knee is designed to offer comfort and self-confidence to amputees. This knee is mainly based upon either a passive concept, with a damping system, or an active computational intelligent design to control knee motion during the stance & swing phase. Most lower extremity amputees are unable to afford modern prosthetic knee joint due to their high cost. In this work, we present the conception, design and development of a low-cost intelligent prosthetic knee joint for transfemoral amputees.

AIM
Millions of transfemoral amputees need advance prosthetic knee joint, yet they can't afford due to high cost so we invented low cost hydraulic prosthetic knee joint in new design with advance technology, control S-N-S in swing and stance phase.

METHOD
The concept of this invention is based on a control system with hydraulic fluid, which only has a limited resistance scope. The cylinder of knee prosthesis controlled by hydraulic fluid with a double- piston damper design usually used to simulate the damper stiffness of the human muscle and tendon. This design is a double-pendulum mechanism with a hinge joint, and the hip joint is a floating pending point of the double-pendulum. To simplify calculation, the damper is invariable within work scope. In this invention the knee prosthesis controlled by a hydraulic damper is proposed based on two rigid bodies with the help of pendulum mechanism and its enlarged needle valve.

RESULTS
The laboratory tests performed showed the feasibility of this design. This invention is to bring the knee joint function select ability still closer to the natural range of motion when ambulating, walking, climbing stairs, cycling, or performing other, different movements. In one embodiment of the present invention, this is a purely hydraulic knee joint prosthesis is created for thigh amputees covering the normal spheres of the wearer in the best way possible. This embodiment is applicable to domestic, occupational, leisure and sporting activities, such as cycling. Functions such as free mobility of the unloaded joint, walking at variable speeds, support of extension initiation—i.e. onset of the swing phase, and definable time dependent resistance to drop off when climbing and descending stairs, as well as ascending or descending ramps and sitting down and standing up and kneeling, are possible.

DISCUSSION AND CONCLUSION
The design concept and the resulting knee prosthesis show promising results concerning prosthesis activation during human walk, there by showing the feasibility of a reduced manufacturing cost compared to the modern prosthesis available on the market. This joint offers a unique approach to facilitating stance phase control, which may be more suitable for young and active individuals. this is beneficial in enabling faster and more normal walking speeds without additional energy costs.

Posters: Prosthetics: Lower limb transtibial

6.24 Effect of different prosthetic feets on the kinematic of transtibial amputee gait

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BACKGROUND
In the past years, there have been numerous advances in the development of prosthetic feet for the amputee [1]. There is little data to support the use of DER feet by amputees for everyday walking. Despite the reported energy storing and releasing properties of the DER feet, previous studies have failed to show differences in kinematic values when comparing DER feet [2]. It is necessary to conduct a study on differences in kinematics of DER feet in patients with trans-tibial amputation.

AIM
To find the effect of different prosthetic feet on the kinematic of transtibial user using gait analysis.

To compare different type of the feet with each other and determine if any trends were demonstrated for producing a more optimal gait.

METHOD
The 2D gait analysis was done and data collected in “Biomechanics Gait Lab” by using active markers. These markers were placed on the anatomical landmarks of the subjects. Participants were advised to walk with comfy cadence; self-selected velocity, under the “Simi Motion Analysis camera system” to measure the gait parameters related to tempura-spatial variables and kinematics.

The stride parameters were measured on a 10-metre-long pathway. The following standard formulae were used to determine cadence and velocity of amputated and intact sides.

Velocity = Stride Length / Stride time & Cadence = Velocity / Step Length

RESULTS
Significant differences were observed in stride length of amputated side while using dynamic plus foot and Trias foot. Dynamic plus foot statically shows greater stride length than trias foot (1.2m v 1.14m). There was no significant difference in average mean of amputated side while using all five types of feet. Statically greater cadence was observed with dynamic plus foot (103.84 steps /min) while lowest Cadence was trias foot (98.92 steps/min). Statically highest velocity was recorded with dynamic plus foot (1m/sec), lowest velocity was with trias foot.(0.92m/sec). The velocity of amputated side show higher result than Trias foot, carbon copy II, flex foot, Seattle foot (1m/sec vs .92,.97,.98,.98) however no significant mean difference was observed with all type of feet on amputated side.

DISCUSSION AND CONCLUSION
In our study we anticipated the Dynamic Plus, Trias foot, Carbon-Copy, Flex foot and Seattle with demonstration of differences in gait parameters. However, we observed that the Dynamic Plus stood distant from the other feet for a few parameters.The findings of our study reveal that amputees using dynamic plus foot shows more near to normal gait patterns compared to other prosthetic feet. Dynamic plus foot demonstrated higher velocity, statically significantly higher cadence and stride length.

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6.25 Effect of Casting Approach on Procedure Time: Interim Results of Clinical Trial

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BACKGROUND

The conventional prosthetic socket fabrication process consists of residual limb shape capture via a non-weight bearing negative wrap, positive plaster mould rectification, and, as needed, check socket modifications. This process requires time to achieve an acceptable socket fit. An alternative approach using a standing hydrostatic pressure cast is supposed to be simpler, requiring less rectification, and possibly less time to achieve an acceptable socket fit [1].

AIM

To compare the time required to cast, rectify, and modify a check socket made from hand casting to standing hydrostatic pressure casting (Symphonie Aqua System, Romedis GmbH, Germany) in persons with lower limb amputation.

METHOD

A 3-site randomized cross-over trial is underway with IRB approval (recruitment goal: 20 TTA + 10 TFA adults/site; total N=90). A single prosthetist/site took each cast randomly by hand or Symphonie, rectified each mould, and fabricated a check socket (TT: total-surface-bearing/TF: subischial/hybrid). Participants were presented the check sockets in random order to ensure blinding. Prosthetists used a socket-fit-checklist to evaluate socket fit and make modifications they deemed necessary to improve comfort. The time required to cast, rectify, and modify each socket was timed. Differences in time for each casting approach were compared using paired t-tests with $\alpha=0.05$.

RESULTS

Performed interim analysis on 48 subjects. Total-time was no different between casting approaches. Casting-time was significantly longer for Symphonie, rectification-time was significantly longer for hand casting, and socket modification-time no different. Results were the same for TT and TF.

Table 1 Mean ± SD timing data (*p-values are significant)

Time (minutes)	Hand Cast	Symphonie Cast	p-value
Total (all=48)	49±17.5	50±11.3	0.6521
Total (TT=35)	51±19.0	51±11.6	0.9812
Total (TF=13)	45±11.0	48±10.2	0.3389
Casting (all=48)	12±5.9	25±6.5	<0.0001*
Casting (TT=35)	12±6.2	26±5.9	<0.0001*
Casting (TF=13)	13±5.0	22±7.0	0.0018*
Rectification (all=48)	28±13.0	18±7.4	<0.0001*
Rectification (TT=35)	29±14.3	17±7.9	<0.0001*
Rectification (TF=13)	24±6.9	19±5.6	0.0062*
Modification (all=48)	9±8.5	8±6.4	0.2597
Modification (TT=35)	10±7.0	9±6.3	0.1922
Modification (TF=13)	7±11.5	7±6.5	0.9170

DISCUSSION AND CONCLUSION

Initial results suggest there is no overall difference in the time required to fabricate and modify a check socket to achieve an acceptably comfortable fit when casting by hand or the Symphonie. Even though some time may be saved given the minimal rectification required for Symphonie casts, the set-up for casting takes more time compared to the set-up required for hand casting. While amputation level does not appear to influence these results, results may change as more data is collected.

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6.26 Evaluation of Functionality in a Group of Unilateral Transtibial Amputated Patients Using the Prosthesis Evaluation Questionnaire (PEQ) Scale.

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BACKGROUND

People with lower limb amputation can perceive their functionality altered for various activities, it is important to understand which of these are the ones that compromise functionality to a greater extent, this allows focusing on an appropriate rehabilitation plan to maintain a good quality of life. Previously, other authors have studied the importance of this type of quality of life assessment in patients with amputation [1].

AIM

To assess the functionality of unilateral transtibial amputees using the PEQ self-report measurement tool [2,3].

METHOD

A descriptive study was conducted in men and women between 18 and 80 years-old, with unilateral transtibial amputation by any cause. A convenience sample was obtained from a data base, obtaining 15 patients that met de inclusion criteria. These patients were phoned, and the study was explained to them, the ones that accepted to participate went to a consult in a rehabilitation centre in Bogotá, Colombia, where the PEQ mobility subscale test was applied. These data were organized in a database and analysed with Office Excel and SPSS statistical program version 24.

RESULTS

The study was done with 15 patients, the PEQ score ranged between 35 and 119 and the average was 78.3 points. The activities that displayed the most difficulty to perform were climbing up the stairs, climbing down the stairs and walking on slippery surfaces. K2 functional level was the most common with 9 (60%) patients. Most of the K2 level patients were classified in the middle category and K3 patients were more in the superior category. Eight patients were in the high and superior categories, with 4 patients in each one. K levels and functionality did have a direct association (p=0.0369).

Table 1. Relation between functional category and level

		Functional category				
		35-56 Low	56-77 Middle	77-98 High	98-119 Superior	Total
Functional level	K2	2	4	3	0	9
	K3	0	1	1	4	6
	Total	2	5	4	4	15

DISCUSSION AND CONCLUSION

The functional level measured with the MFCL score (K levels) correlates directly with the patients' functionality measured with the PEQ. There is no relationship between the amount of time using the last prosthesis, the time since amputation, the level of amputation, the comorbidities, or the cause of amputation with the patients' functionality. The activities that caused the most difficulty for mobility in these patients were climbing up and down the stairs and walking in slippery surfaces.

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6.27 Novel adaptive outer socket system for transtibial amputees using modern material combinations

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BACKGROUND

Between 2010 and 2021, novel adaptive prosthetic socket systems for different amputation heights of the lower extremity have already been developed in the authors' workshops. The combination and composite of elastic and rigid socket components has proven to be successful in the design of the outer socket and allows your users a noticeable increase in wearing comfort.

AIM

The objective of these systems can be summarized as follows:

Maximum comfort during daily use. High adaptability and adaptability to different everyday situations during use, while maintaining stability and control of the prosthesis.

METHOD

Prosthesis users have an increased cognitive and physiological effort in activities of daily living compared to non-impaired people. The longest possible wearing duration of the prosthesis depends on several factors. Optimal residual limb bedding is implemented by using individual elastic silicone interfaces. The prosthesis socket is crafted using a combination of rigid, flexible and elastic components, the specific design of which is always adapted to the residual limb situation.

RESULTS

The lecture presents the different socket designs of this external socket variant. The design variants are presented with regard to the characteristics of the residual limb and the special features of fitting and reworking with this socket system are highlighted. It is shown that the combination of individual interface systems in silicone technology with fiber composites has specific advantages for the user compared to conventional systems and thus leads to a better outcome in everyday use.

DISCUSSION AND CONCLUSION

From the authors' point of view, neither costs nor efforts should be spared in continuing to work on adaptive socket systems in order to be able to offer prosthesis users improved wearing comfort with a targeted rehabilitation process.

The presented systems are confronted with an increased effort in fabrication, a high degree of expertise, necessary operating equipment for the implementation of the manual tasks, and thus higher costs compared to conventional socket systems.

6.28 Effect of prosthetic ankle in bilateral transtibial amputee: compared with microprocessor vs conventional

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BACKGROUND
Prosthetic ankles aim to mimic physiological ankle mobility to enhance ambulation in various environments. A microprocessor-controlled prosthetic ankle (MPA) shows advantages compared to a conventional prosthetic ankle (CPA), and its commercialization has started. Bilateral amputees compared to unilateral amputees have disadvantages in ambulation, as they lack the support of a healthy leg.

AIM
We compared CPA with MPA which is first made in South Korea by gait analysis and through the questionnaire in bilateral transtibial amputee.

METHOD
A 70-year-old man presented with bilateral transtibial amputations secondary to trauma from a Vietnam War bomb. The individual was otherwise in a good physical condition, and his functional K-level was 3. The patients wore an MPA (RoFT Ⓡ, Hugodynamics, South Korea) for 4 weeks. We performed gait analysis on wearing CPA and using MPA after 4 weeks. The patient walked at a selfselected speed 15 times along a 10m walkway. Spatiotemporal, kinematic, and kinetic data of the lower limbs were obtained through gait analysis. The survey was prepared based on the Korean version of the Prosthesis Evaluation Questionnaire (K-PEQ) for the respective compatibility of MPA and CPA.

RESULTS
The spatiotemporal parameters of both sides showed increased swing time and decreased stance time. Likewise, single support time increased, whereas double support time decreased. Among the kinematic parameters, both ankle plantar/dorsiflexion range of motion (ROM) and right knee flexion increased in the stance phase. Moreover, the negative ankle power increased in the early stance phase bilaterally. Increasing stability was observed as single time and swing time increased. Although ankle force did not increase, knee and ankle ROM in the stance phase increased. Further questionnaire-based investigations on satisfaction, mobility, and pain revealed excellent results.

Fig 1. (a) Lower extremities X-ray view with RoFT®. (b, c) The front and side view of participant wearing RoFT®

DISCUSSION AND CONCLUSION
MPA proved helpful for knee and ankle mobility in the bilateral transtibial amputee gait, and patient satisfaction showed good results. Thorough understanding of each prosthesis allows the prescription of a proper device considering the patient's characteristics. We present the first case of applying an MPA developed in South Korea to patients with a rare case of bilateral transtibial amputation.

6.29 Socket interface pressure of the total surface bearing: a pilot study

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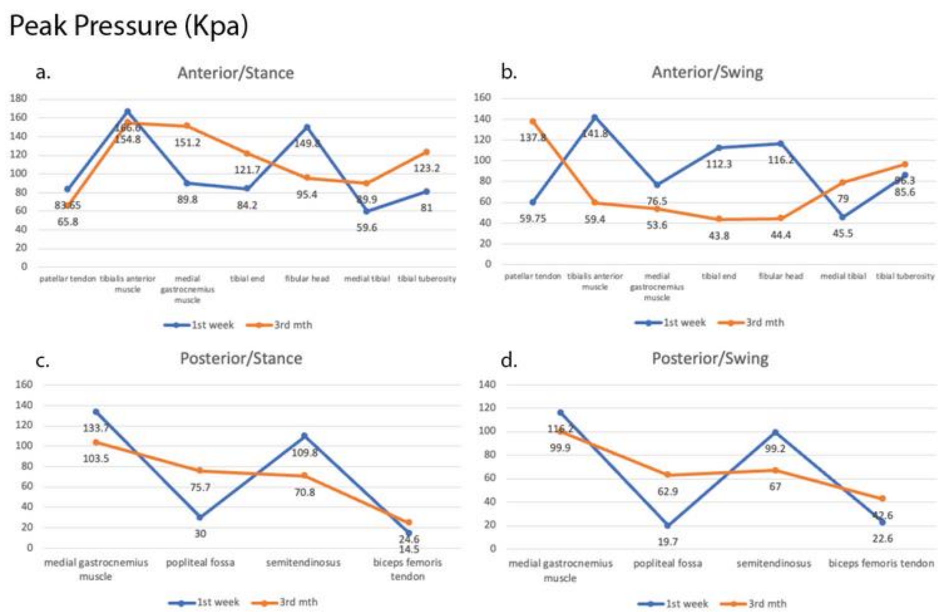
BACKGROUND
To improve the quality of life of amputees, the assistance of prosthetic limbs is very important. The total surface bearing (TSB) was developed, and the method of production is as follows: the residual limb needs to be put on a suitable size silicone sleeve, and the circumference diameter of the residual limb needs to be measured before making the negative model; the target reduction percentage of the circle diameter must be calculated before making positive model.

AIM
The purpose of this study was to observe the changes in pressure bearing capacity after three months of wearing a TSB. It is expected that the TSB can distribute the force to all areas on the residual limb.

METHOD
A female was recruited as a subject (25 years old, 157.5cm, 89.8kg, residual limb length 10.7cm), whose left lower extremity pain for months and found osteosarcoma in 2019. After below knee amputation on 11/15/2019, the subject was arranged left Below Knee prosthesis. After using the F-socket pressure system, the subjects walked 5 times on the GAITRITE gait detection system until the 30-step were obtained and. We cut the pressure sensor pads to better match the load-bearing and decompression parts to be observed, and clearly marked the position. All 30-step data were divided into stance and swing phase and expressed as mean calculated by SPSS 23.0 statistical software.

RESULTS
Figure 1 shows the peak pressure data collected by the subjects walking 30 steps. The maximum occurred in the tibialis anterior muscle during the stance phase, either the first week or the third month. Calculated as a percentage (3rd/1st*100%), in the anterior area, the value in medial gastrocnemius muscle (168.3%) was the largest in the stance phase, and the value in tibialis anterior muscle (41.9%) was the smallest in the swing phase. in the posterior area, the value in popliteal fossa (319.2%) was the largest in the swing phase, and the value in semitendinosus (64.5%) was the smallest in the stance phase.



DISCUSSION AND CONCLUSION
In this experiment, the pressure mainly appeared in the tibialis anterior muscle and fibular head, and this result is similar to the previous study [1]. After three months, overall, the pressure did not decrease significantly, but the pressure remained relatively average in all observed parts, especially the posterior part (Figure1c-1d). The TSB allows the lower limb surface to have a high degree of fit with the bearing, which can be expected to play a role in the average pressure distribution.

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6.30 Longitudinal study of quality of life of persons with lower limb amputation

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BACKGROUND

In considering the consequences of rehabilitation for persons with amputation, it is necessary to evaluate not only the functional aspects but also their quality of life (QOL). However, there are few reports of long-term longitudinal QOL studies. We conducted QOL surveys in persons with lower limb amputation using the Prosthetic Evaluation Questionnaire (PEQ) in 2003 and 2011.

AIM

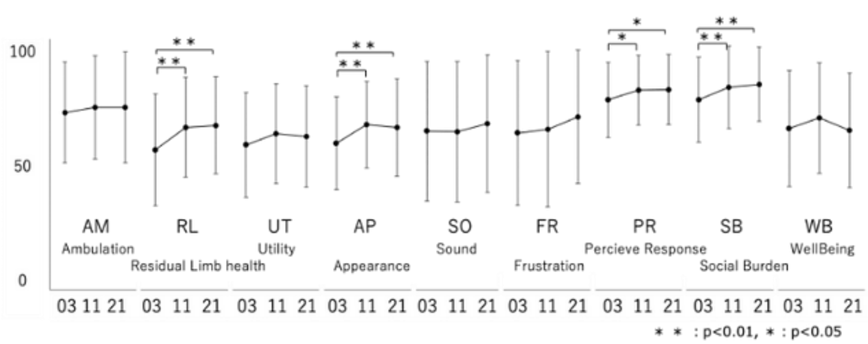
The third QOL survey was conducted 10 years after the second to determine trends in the long-term QOL of persons with lower limb amputation.

METHOD

The subjects were 254 persons with lower limb amputation who underwent prosthesis fabrication at the National Rehabilitation Center for Persons with Disabilities. Questionnaires (the Japanese version) were sent and collected by mail, and the mean scores for each rating scale were calculated according to the method specified by the PEQ and compared with the results of the previous two surveys. Mann-Whitney's U test was used to test for differences, with a significance level of less than 5%. The survey was conducted in 2021.

RESULTS

Responses were obtained from 129 subjects (51% response rate). The basic attributes of the subjects were as follows: gender- 101 males and 29 females; mean age- 62.8 ± 14.8 years; mean age of amputation- 35.9 ± 20.0 years; and causes of amputation- 83 trauma, 44 disease, 1 congenital, and 1 unknown. Compared to previous surveys, the scores on each rating scale showed an upward trend, indicating an improvement in QOL. Scores on the four scales increased significantly compared to the 2003 survey: “residual limb health”, “appearance”, “perceive response”, and “social burden”. (Figure)



In addition, we conducted an attribute analysis of the 57 respondents who were common to the 2011 and 2021 surveys. The most characteristic change in comparison with two surveys was observed in psychological measures: "frustration", “perceive response”, and “social burden”.

DISCUSSION AND CONCLUSION

Over the past 18 years, prosthetic liners have become more widespread in Japan, and prosthetic components have become more sophisticated and multifunctional. Additionally, in 2011, the bid to host the Tokyo Olympics/Paralympics began; the games were held in 2021. As a result, the environment surrounding persons with lower limb amputation changed dramatically, and social recognition of prosthetic legs increased. These are thought to be the factors that influenced the improvement of the QOL of persons with lower limb amputation.

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6.31 Agreement between body composition methods for estimating body fat percentage in lower limb prosthesis users

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BACKGROUND

Body composition is an important index of health. As such, lower limb prosthesis users need reliable methods for assessment of body composition. Although various methods exist to measure body composition, agreement between criterion methods in lower limb prosthesis users is unknown.

AIM

The aim of this study was to assess the agreement of percent body fat measured by BOD POD Air Displacement Plethysmograph (ADP) and dual energy x-ray absorptiometry (DXA) in lower limb prosthesis users.

METHOD

Eleven lower limb prosthesis users (M = 53.22, SD = 13.61) participated in this study. The Texas A&M University Institutional Review Board approved this study and participants provided written informed consent. Body composition was assessed twice, once with and once without prosthesis using both a BOD POD Air Displacement Plethysmograph (ADP) (Cosmed, Italy) and dual energy x-ray absorptiometry (Lunar Prodigy, GE, Boston, MA). Determination of descriptive statistics for percent body fat, as well as agreement and Pearson correlation analyses were performed using SPSS v17 (IBM, Armonk, NY, USA).

RESULTS

Percent body fat for BOD POD with prosthesis was (M= 28.5, SD= 15.6) and DXA with prosthesis was (M= 32.88, SD= 10.5). BOD POD without prosthesis was (M= 33.7, SD= 12.0), and DXA without prosthesis was (M= 32.0, SD= 9.5). Bland Altman plots illustrate agreement between the various methods and with and without prosthesis. BOD POD with prosthesis and without prosthesis evidenced $r=.89$ $p= < 0.001$. BOD POD with prosthesis and DXA with prosthesis showed an $r= .67$ $p= 0.022$. BOD POD without prosthesis and DXA without prosthesis showed an $r= .836$ $p= 0.001$. DXA with prosthesis and DXA without prosthesis showed an $r= .96$ $p = < 0.001$.

DISCUSSION AND CONCLUSION

Percent body fat in lower limb prosthesis users showed good agreement between BOD POD and DXA. With and without prosthesis measurement for both methods also showed a good correlation. Future studies may consider recruiting a larger heterogeneous sample of prosthesis users. The BOD POD is a minimally invasive and valid means for measuring percent body fat in lower limb prosthesis users.

6.32 Relationship between prosthetic suspension method and the shear force between the prosthetic socket and stump

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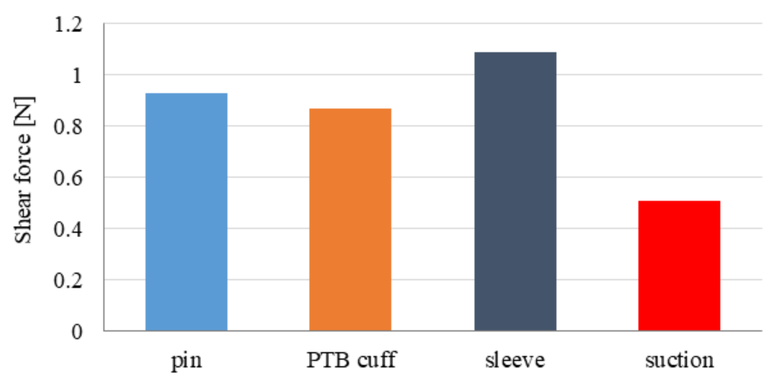
BACKGROUND
Shear force is one of the physical indicators of "misalignment" between the lower prosthesis socket and the stump. In prosthetic suspensions, in which misalignment can occur, suction suspension is recognized by both prosthetists and prosthetic users as the method with the least stump misalignment. However, the effect of different suspension methods on the shear force between the lower prosthetic socket and the stump is not evident.

AIM
This research aimed to compare prosthetic suspension methods using the shear force between the prosthetic socket and the stump as an evaluation indicator.

METHOD
Shear forces between the prosthetic socket and the stump were measured five times during vertical raising of the leg with prosthesis from the ground. We enrolled three lower leg prosthesis users as participants. Two participants with bilateral leg prostheses had both sides measured, and therefore, data for a total of five limbs were obtained. The TSB sockets were fitted to a level that the participants could walk on a daily basis. Four suspension methods were used: pin suspension, PTB cuff belt, sleeve suspension, and suction suspension. A thin shear force sensor was set in contact with the stump and the socket at all times during the measurement.

RESULTS
When the measuring limb is grounded, shear force is generated from the stump sinking into the prosthetic socket, and the value of the shear force transitions in a positive direction. Conversely, when the measuring limb leaves the ground, the prosthesis pulls the stump in the distal direction, and the value of the shear force transitions to the negative direction. The difference between the maximum and minimum shear force for each measurement motion was calculated, and the median value of five measurement motions was used as the evaluation indicator. The highest rated method was suction suspension. The order of the evaluation indicators was the same as that of the user's subjective evaluation.



DISCUSSION AND CONCLUSION
The difference between the maximum and minimum shear forces is lower for suction suspension than for sleeve suspension, confirming that suction suspension reduces the shear force between the socket and the stump. These results are consistent with the general findings. This research provided evidence of the effectiveness of suction suspension through a quantitative comparison of prosthetic suspension methods.

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6.33 Investigating the feasibility of using coconut fibre as a reinforcing material for making lower limb sockets in Ghana

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BACKGROUND
Reinforcement materials can be grouped into four; fibers, particulates, fillers, and flakes. They often enhance the mechanical properties of the matrix and mostly are stiffer and stronger than the matrix. Naturally obtained fibers are considered to be abundant. Most natural fibers are easily found in developing countries and the use of fibers to improve upon the strength and durability of materials is not new. Tensile and fatigue tests have been used to evaluate the mechanical properties of coconut fiber.

AIM
The main aim of this research is to design and fabricate a lower limb prosthetic socket using coconut fiber as a reinforcement material and determine the flexural strength of coconut fiber polymer composite.

METHOD
A mixed method approach was adopted for this project. A quantitative analysis was used to evaluate the flexural properties of the coir/acrylic resin composite while a qualitative analysis was used to investigate the coir/acrylic resin composite based on homogeneity and ease of fabrication. An in-depth study was done to identify the best mixing state that coir and acrylic epoxy resin should have in order to obtain a homogenous mixture and the most effective method identified was used to laminate a prototype transtibial socket using the coir as a reinforcement material.

RESULTS
It was observed that the smaller the coir particle size, the more homogenous the composite mixer. This translated into composites with smaller grain particles having higher flexural strength and modulus. Based on the composites with optimum flexural properties, a prototype transtibial prosthetic socket was successfully fabricated.




DISCUSSION AND CONCLUSION
Based on the findings in this work, incorporating 5% coir fiber with grain size of 0.5 mm into acrylic resin improved the flexural properties of the resin. Furthermore, a prototype transtibial prosthetic socket with 5% coir of grain size, 0.5 mm, was successfully fabricated. Although each of the fiber grades possessed some amount of flexural strength, G1 had the highest flexural strength. It was also revealed that G1 had the best homogenous mixture among all the fiber grades.

ACKNOWLEDGEMENTS I would like to thank Mr. Eric W. Gaba (Lecturer BTPOTC) and Mr. Henry K.N. Larbi (Principal of BTPOTC).

6.34 Influence of the prosthetic foot size in the transtibial amputee gait: two-case report.

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BACKGROUND

Pediatric patients are active users who require a prosthetic foot with dynamic response since these can increase the user's mobility [1]. Five-year-old children and older change foot size in a 6–12-month periods [1,2], an adequate prosthetic foot presents difficulties as it involves the continued growth and cost of prosthetic feet from K4 mobility. An energy return foot that can adjust to 4 different sizes has been developed at the Applied Research and Technology Institute to address this problem.

AIM

Evaluate spatiotemporal parameters and ground reaction forces to determine the influence of the size of a prosthetic foot in the gait.

METHOD

An adjustable foot was designed with carbon fibre and stainless steel. It can adjust 4 different sizes: 24, 25, 26 and 27 cm. Ground reaction forces (GRFs) were measured with AccuPower AMTI force platform and spatiotemporal parameters (STP) were measured with 10 cameras Nexus VICON system. Two K4 volunteers with transtibial amputation and informed consent participated in the study, both have been using a prosthetic device 7 years. For each test, static and dynamic alignment was performed by the same certified prosthetist. Subjects performed the 6MWT at self-selected speed with every foot size. Plug-in-gait Lower Body model was used for gait analysis and data was processed using Matlab.

RESULTS

Both volunteers were using a SWB socket, the first one with active vacuum system (shoe size 25 cm), and the second volunteer with shuttle lock (show size 26 cm). Figure 1 illustrates the knee flexion angle of the prosthetic side. With the first volunteer it is observed that foot size modifies the knee flexion/extension during both stance and swing phase. With the second volunteer no differences were observed despite doing the test. On the other hand, no significant differences were observed in the STP and GRF for both subjects. It is possible that volunteer 1 compensates the different sizes through kinematics, keeping unaltered kinetics. However, with the second volunteer no change was observed with the different feet.

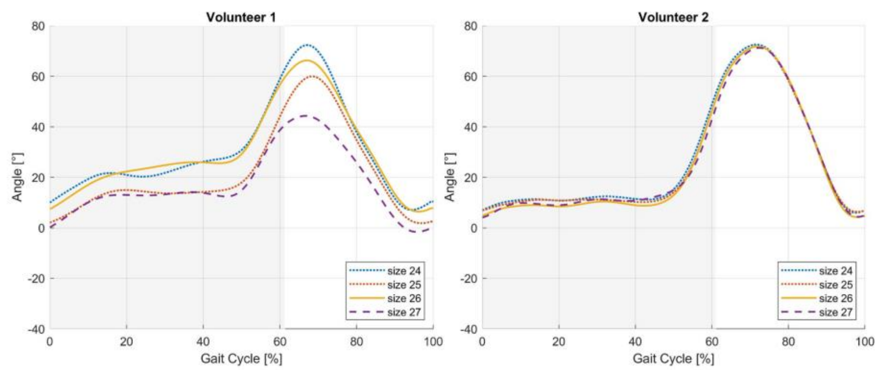

Figure 1. Knee flexion/extension angle for both subjects (prosthetic side). Solid line indicates the correct foot size (equal to sound side)

DISCUSSION AND CONCLUSION

Although only one of the participants showed significant differences in the knee flexion/extension when walking with different foot sizes, and no major changes were observed in most of the STP and GRF, it is important to mention that compensatory movements can generate gait deviations and future injuries. These two volunteers are part of a pilot study. Future work contemplates same tests with more volunteers and a wider range of foot sizes.

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ACKNOWLEDGEMENTS This project is funded by the National Ministry of Science and Technology (FSSS01-C-2018-1, A3-S-47048).

6.35 Evaluation of spatiotemporal parameters and ground reaction forces of prosthetic gait using an adjustable foot: preliminary results

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BACKGROUND

Foot prostheses are fundamental for the rehabilitation of lower limb amputees. The grade of mobility and size for each patient must be met to have the best performance possible. Pediatric users are very active and therefore require a dynamic foot. Unfortunately, most of them can't afford to change their prosthetic components according to their growth ratio. At the InIAT, an adjustable foot was designed to help ensure the correct prosthetic feet along every stage of the pediatrics users' growth.

AIM

To evaluate the spatiotemporal parameters (STP) and ground reaction forces (GRFs) of the prosthetic gait with transtibial amputees using the adjustable foot developed at the InIAT comparing its performance versus commercial prosthetic feet.

METHOD

Two K4 volunteers with transtibial amputation and informed consent, participated in the study. The commercial and the adjustable prosthetic feet were assembled and aligned by the same prosthetist. The 6MWT was performed by each subject with both feet. An adaptation period of one hour was given for the adjustable foot. Vicon Nexus motion analysis system (10 cameras) was used to evaluate the SPT, and two AMTI AccuPower force platforms for the analysis of the GRF's. Only the trails where a single step per platform was accomplished were considered. Data was post processed using Vicon Nexus and MATLAB.

RESULTS

S1: An increment of 4% in stance percentage with the sound side and a lower knee flexion angle during loading response were found for the tested prototype. The vertical force is higher with the commercial foot, showing and increase of the difference at late stance. A higher anterior-posterior force is observed for the commercial foot although the instance when they appear is similar for both feet. S2: A lower symmetry index was achieved with the commercial foot for the step width due to a decrease of 0.03 m with the sound leg when waking with the prototype. Higher vertical and anterior-posterior GRF are found with the prototype.

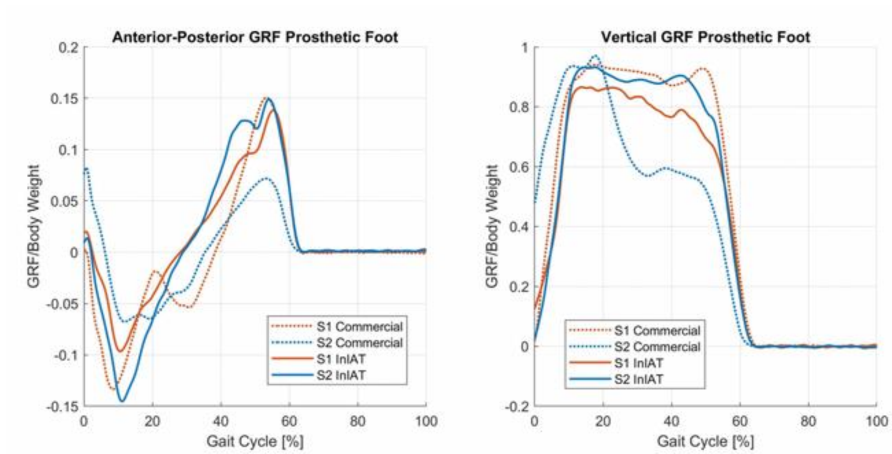

Figure 1. Vertical and anterior-posterior GRF with the prosthetic feet tested.

DISCUSSION AND CONCLUSION

Changes found in stance percentage and knee flexion angle in subject 1 can be explained by the lack of confidence in the new prototype. Longer adaptation periods may help reduce these differences. There is no consistency in the differences observed in the GRFs. The presented data are the preliminary results of an ongoing investigation in which ten study subjects will participate. The results suggest that outcomes obtained with the prototype might be comparable with those found with commercial feet.

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Posters: Prosthetics: Lower limb ankle & foot

6.36 Does lower Limb prosthesis use impair function of the intact foot: a scoping review

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BACKGROUND

Long-term lower limb prosthesis use is associated with joint pain, increased fall risk and risk of reamputation, all of which can contribute to disability. These neuromuscular complications are often attributed to greater reliance on the intact limb but may originate at the level of the foot. Adaptations of the contralateral (intact) foot following unilateral lower limb loss may alter plantar loads and contribute to desensitization of the foot, which can collectively contribute to impairments.

AIM

The purpose of this study was to review the literature to determine if there are differences between the intact foot of lower limb prosthesis users (LLPUs) and able-bodied individuals with regard to: 1) plantar pressure during walking and 2) somatosensation.

METHOD

Searches were conducted in three databases between July and August 2021 and performed following the PRISMA guidelines Searched studies were included if they described subjects using a prosthesis and collected data on sensation, biomechanical function, strength, or plantar pressure of the intact foot or ankle. Studies collecting standing plantar pressure or exclusively involving partial foot amputation were excluded. A standardized form was used to extract data from articles, including: category of intact foot health evaluated (somatosensation, plantar pressure, biomechanical foot function, strength/range of motion), study design and methodology, outcomes assessed and conclusions. Two independent reviewers extracted data from studies and findings were compared to ensure reliability.

RESULTS

Twelve studies (235 participants) were included. Five collected data on plantar pressure alone; two on mechanosensation alone; three on plantar pressure and mechanosensation; one on ankle strength; one on foot deformities. Studies that evaluated vibratory sensation considered individuals with diabetes-related amputation only (N=2), trauma-related only (N=1) or mixed causes (N=1) and reported mixed results. Two studies evaluated light touch sensation in persons with trauma-related amputations and two in those with diabetes-related amputations; all found at least some loss of light touch sensation in at least a portion of subjects studied. Of the seven studies assessing plantar pressure, five reported significant changes to measures on at least one region of the intact foot. The most common reported deformity was plantar callus (14.9%) and 28.9% of participants reported foot pain. Peak ankle torque was not affected by contralateral amputation.

DISCUSSION AND CONCLUSION

General conclusions are difficult to draw due to heterogeneity in measurement techniques and patient populations. Nonetheless there is some evidence that: 1) plantar loading and somatosensation are altered with prosthesis use, depending on the measure of interest and region of foot evaluated; 2) sensory changes in diabetic amputees may reflect underlying disease rather than prosthesis use; 3) people with traumatic amputation show changes in proprioception, light touch sensation and low frequency vibratory sensation; and 4) transfemoral LLPUs increase forefoot loading.

ACKNOWLEDGEMENTS This work was supported by grant 2T35DK074390 from the National Institute of Diabetes and Digestive and Kidney Disease.

6.37 Performance evaluation of dynamic response and adjustable prosthetic foot prototype

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BACKGROUND

Nearly 90% of the amputations carried out in Mexico are from lower limbs, which affects people's mobility. Therefore, a prosthetic foot is an essential prosthetic component, it must fit in size and grade of mobility for each patient. Higher mobility feet are expensive, making difficult to obtain an appropriate prosthesis in size and mobility for the paediatric patients who grow in an accelerated ratio [1]. That been said, an adjustable and dynamic response prosthetic foot could offer the solution.

AIM

To evaluate the adjustable prosthetic foot by applying the AOPA's Foot Project methodology2 for dynamic response foot.

METHOD

A carbon fibre prosthetic foot prototype with a stainless-steel mechanism which provides manual adjustment of four sizes (size 24 to 27) was designed and tested. Keel and heel tests were done following the AOPA's Foot Project methodology [2] for an applied load of 710 N. The foot was tested in all sizes without the cosmetic footshell except for size 27 which was tested with and without footshell. The data was analysed with MATLAB to calculate total displacement and energy return of the foot prototype in all its sizes.

RESULTS

The results of the AOPA's Prosthetic Foot Project Heel and Keel Tests are shown in Figure 1 (Green = Meet AOPA's parameters, Red = Doesn't meet AOPA's parameters). Figure 1A presents the percentage of energy return results and Figure 1B presents the total displacement for each foot. The keel's total displacement exceeds the criteria for dynamic response feet (>25mm) while the heel doesn't (<13mm). For energy return, both keel and heel tests meet the AOPA's requirements (>75% and >82% respectively). However, when the footshell is on, the energy return decreases under 82% for the heel test.

Energy Return [%]				
Foot Size	Footshell OFF		Footshell ON	
	Heel OFF	Keel OFF	Heel ON	Keel ON
INIAT_24	90.725	82.17	X	X
INIAT_25	90.16	77.37	X	X
INIAT_26	90.20	81.65	X	X
INIAT_27	86.857	85.773	81.21	77.46

Figure 1A. Energy return for all sizes. (Heel = Heel test, Keel = Keel test).

Displacement [mm]				
Foot Size	Footshell OFF		Footshell ON	
	Heel OFF	Keel OFF	Heel ON	Keel ON
INIAT_24	7.61	32.93	X	X
INIAT_25	8.12	31.63	X	X
INIAT_26	9.64	35.32	X	X
INIAT_27	11.84	39.92	10.44	41.15

Figure 1B. Displacement for all sizes. (Heel = Heel test, Keel = Keel test).

DISCUSSION AND CONCLUSION

All the tested prosthetic feet without the cosmetic footshell met AOPA's parameters for dynamic response feet. On the other hand, when performing the same tests with the cosmetic footshell, the energy return didn't meet AOPA's heel parameters. This similar behaviour is observed in previously tested commercial prosthetic feet [3]. Finally, the adjustable prosthetic foot meets the AOPA's criteria for dynamic response feet for all sizes when used without the footshell.

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6.38 Viscoelastic model for predicting energy loss in prosthetic foot components

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BACKGROUND

Critical to design improvement of passive keel devices is an ability to predict energy storage and loss during activity. Studies of energy management in non-actuated (passive) prosthetic feet have developed approaches to the analysis and testing of these deformable systems and show mechanical behaviour to be time-dependent and often non-linear [1,2]. Viscoelastic models have been used to predict non-linear and viscous behaviour of the materials used in these devices, but have had limited application to the structures as a whole.

AIM

To develop a modeling method for the dynamic force-time response of a passive prosthetic foot system subject to an arbitrary displacement function under laboratory conditions using quasi-linear viscoelastic (QLV) and standard linear solid (SLS) models.

METHOD

Two phases of experimental testing were performed on a Niagara Foot Keel (DOI, Germany) using a Bionix Model 370.02 MTS Universal Testing Machine. Phase one testing used a displacement-controlled ramp and hold procedure with varying displacement rates and limits to identify convergence of model parameters. Phase two testing used a cyclic procedure to produce consistent hysteresis loops for use in validating the modeled force-time response. Two material models were adapted adapted for structural analysis: the standard linear solid (SLS) model proposed by Geil, et al. [3]; and the quasi-linear viscoelastic (QLV) model proposed by Fung [4].

RESULTS

In all cases, the QLV model showed a better fit to the relaxation response than the SLS model due to the prescence of multiple time constants. The QLV model predicted a reasonably accurate dynamic force response during loading (±7.4 N) and unloading phases (±14 N) when subject to an axial displacement of 15 mm. However, the method was inaccurate in predicting the response of the system during loading (±50 N) and unloading (±31 N) when subject to axial displacements greater than 15 mm. Qualitative comparison of hysteresis loops shown in Figure 1 revealed a singularity, likely due to frictional losses. Modeling was adjusted to include a frictional term of 0.1 at the onset of unloading, which resulted in higher modeling accuracy (Figure 1). Further, the predicted energy return in the system was 81%, which is comparable to cyclic testing.

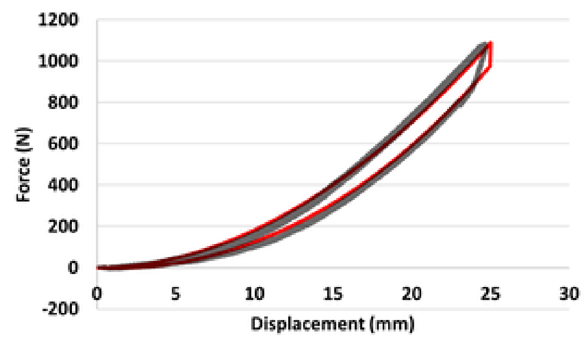

Figure 1: Hysteresis comparison with friction factor. Black: test data, red: model prediction.

DISCUSSION AND CONCLUSION

This study successfully developed accurate empirical models for the nonlinear elastic force-displacement and time-dependent reduced-relaxation behaviour of the Niagara Foot during forefoot loading. QLV methods indicated that non-linear models with multiple relaxation times are required. Consistent hysteresis loops were produced using cyclic testing procedures, but models inaccurately predicted energy loss in the system without a frictional term present. Including a friction factor of 0.1 in modeling resulted in higher agreement between predicted and test results.

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Posters: Prosthetics: upper limb

6.39 Reassessment of the possibilities of restoring of the upper limbs functions by prosthetics

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BACKGROUND

In the rehabilitation of the patients with upper limb defects, nowadays there is a growing disconnect in goals and approaches between psychologists, orthopedists and prosthetics technicians. The situation is aggravated by the desire of primary patients to restore totally lost segments of the hand, which, given the diversity of manual function, for 100% is impossible. Our research is intended to open a discussion about real modern possibilities of prosthetics at different levels of amputations and congenital defects of upper limbs.

AIM

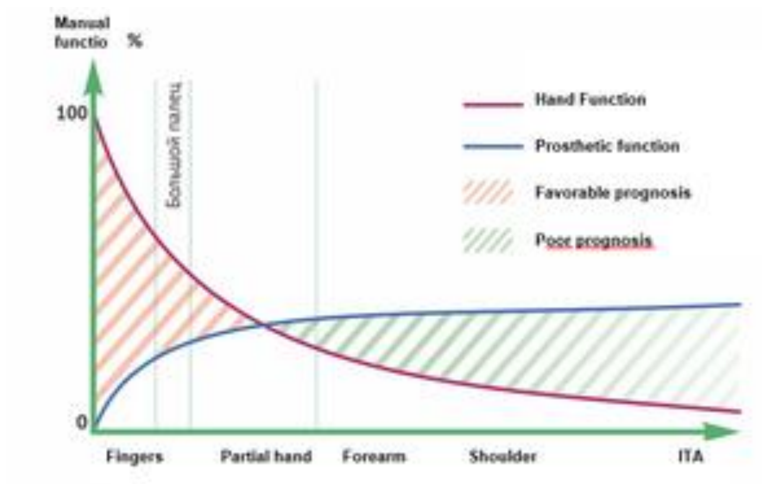
To develop achievable principles of prosthetics of arms based on the idea of transformation of the preserved manual function.

METHOD

The hypothesis of the research is based on the experience of prosthetics of more than 1000 patients with different levels of defects in Scoliologic.ru from 2015 to 2022. In-depth research of the evaluation of the quality of functional and cosmetic prosthetics was conducted on 50 patients with hand and finger defects. These patients were offered to undergo DASH and SF-36 questionnaires before prosthetics, and a bench test also. Similar research was conducted after cosmetic and functional prosthetics. Based on the results of the standard period of use for 2 years, we estimated how many users applied for prosthetics again. The results were processed by modern statistical methods.

RESULTS

The obtained results of prosthetics of the hand showed contradictions in the degree of restoration of manual function according to DASH and bench tests and the level of quality of life according to SF-36. The level of quality of life according to the subjective assessment of patients did not increase, despite the excellent results of an objective assessment. The contradiction only intensified after the analysis of the return of users for next prosthetics, which showed low values. A sample of patients with higher truncations – forearms, shoulders and shoulder separations, showed that the subjective assessment of improving the quality of life was higher, and the objective assessment was lower. The returnability was also higher. Thus, we formed a hypothesis about the potentially favorable and unfavorable outcome of prosthetics. We need to look for new approaches to patients with partial hand defects.



DISCUSSION AND CONCLUSION

This study opens up a discussion about prosthetic predictions depending on the level of amputation: the principles of prosthetics for partial defects of the hand should differ from the principles of classical modular prosthetics of higher amputations; the main goals of rehabilitation should not be the restoration, but the transformation of existing opportunities by various methods, including prosthetics. We must make the results of prosthetics achievable, which will improve the quality of life of the patient, and not disappoint him.

6.40 Determination of socket comfort, activity daily living, range of motion between traditional & compression release stabilized socket in trans-radial prosthesis

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BACKGROUND
Upper limb amputations are typically the result of congenital issues, traumatic accident, infection, vascular disease or burn and result in amputations at the trans-radial and trans-humeral levels. Traditional trans-radial sockets facilitate function but difficulty donning and doffing the prosthesis, sweating with prolonged use are known issues. Compression Release Stabilized Socket (CRS) which have fenestrations for ventilation of the residuum in order to reduce sweating and abrasion with the application of compressive force and prevent loss of motion.

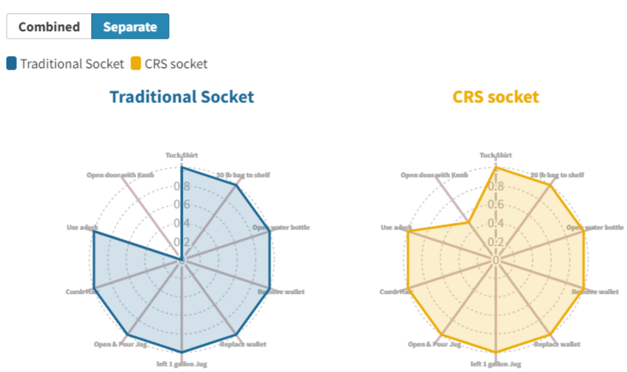
AIM
To evaluate the effect of socket comfort, activities of daily living between the Compression Released Stabilized (CRS) socket and traditional socket prostheses in trans-radial amputee.

METHOD
One participant was assigned to use two different types of functional trans-radial prosthesis, traditional socket and CRS socket design. Both of those socket designs were custom-made by a certified prosthetist, in order to ensure the quality of prostheses and safety during using in daily living. The participant was asked to come to Sirindhorn School of Prosthetics & Orthotics (SSPO) for 3 times to cast, fitting and 3 times for outcome measures such as 9 Hole Peg Test, Brief Activity Measurement for upper limb (BAM-ULA) and Socket Comfort Score (SCS) during 2 months.

RESULTS
The experimental results represented a positive result in aspect of 9-Hole Peg Test for traditional socket was 69s and 69.3s in CRS socket. BAM-ULA gave 9.5 points in CRS socket and 9 points in traditional socket whereas Socket Comfort Score was 9 in CRS and 7 in traditional socket. The results of this small project indicated that both prostheses provided function equally, however, the participant felt more comfortable with CRS socket and could perform greater range of motion than traditional socket.

Table 1: Results

	CRS socket	NWS socket
9-hole peg test	69	69.3
BAM-ULA	9.5	9
SCS	9	7



DISCUSSION AND CONCLUSION
From this study, both prostheses provided function equally, but the participant felt more comfortable with CRS socket and could perform more range of motion than traditional socket. However, this small study offered an opportunity to prosthetist to explore a different type of sockets and apply both functional and patient reported outcome measurement.

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6.41 Development of Novel Adeno-Associated Viruses (AAVs) for targeting of Low-Threshold Mechanoreceptors (LTMRs) to restore touch in prosthetic systems

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BACKGROUND
Greater than 50% of upper-limb prosthetic users abandon their prostheses, and one common factor is the lack of sensory feedback and increased cognitive load associated. When surveyed, over 80% of prosthetic users detailed that grip force and feeling contact with objects was an extremely important feature desired in prostheses. An optogenetic interface, which can communicate directly with the nervous system at single axon levels using genetically targeted optically sensitive proteins, may enable precise sensory feedback necessary for prosthetic systems.

AIM
The goal of this study is to develop novel AAVs for delivery of light-sensitive proteins to touch-receptor neurons (LTMRs); the first step to reintroduce touch-feedback to prosthetics. Only LTMRs will express optical proteins, enabling LTMR-specific optical stimulation to induce touch.

METHOD
AAVs are viral targeting constructs with genes of interest in place of viral genomes. Combinations of cell-specific promoters with appropriate serotype (virus strain) allow for tissue-specific targeting. Here we detail methods to determine efficacy of our developed AAVs specifically targeting LTMRs. First, to determine the optimal packaging serotype for targeting somatosensory neurons, four different serotypes with universal promoters will be injected into both DRGs and sciatic nerves. Expression efficacy in sensory neurons will be evaluated based on fluorescent marker intensity and quantity. Secondly, the optimal serotype will package our novel LTMR-targeting AAV. This AAV will then be injected, and successful LTMR-targeting will be evaluated through expression intensity and off-target expression.

RESULTS
The results of the first AAV injections will reveal the ideal serotype to use in peripheral sensory nerves. We have established surgeries for direct viral injection into both sciatic nerves and DRGs. The serotype constructs have a universal promoter to target all tissue; allowing the serotype expression to be evaluated and establish the ideal serotype to package our novel AAV construct. All selected serotypes have been successfully used to target neurons in previous literature, with expectations that AAV-PHP.S will express best, as it is designed for expression in the periphery. Following ideal serotype identification, our novel AAV constructs with promoters unique to LTMRs will be packaged and injected. These constructs should only express in the LTMR subset of peripheral sensory neurons and DRG cell bodies. This will be confirmed through the analysis of neuron size and myelination, and histochemical markers.

DISCUSSION AND CONCLUSION
Testing four different serotypes with a universal promoter will allow for the determination of the ideal serotype package to target peripheral sensory neurons using AAVs; the best expressing serotype will provide the optimal package for our novel AAV design to target LTMRs successfully. Following successful LTMR targeting, experiments will be conducted to optically determine neural firing patterns in response to various touch stimuli. Successful targeting of LTMRs is the first step towards reintroducing touch, and sensory, feedback, to prosthetic users.

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6.42 Design and evaluation of a soft myoelectric hand for children with upper limb amputation

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BACKGROUND
Globally, many children suffer from upper limb amputations [1]. Children's constant growth requires frequent replacement of prosthetics, which is not affordable for many families [2,3]. Also, there are many challenges in fitting actuation and control systems in a small size prosthetic hand while maintaining the weight at the comfort level for children. Currently, there is only one available commercial myoelectric prosthetic hand and a few body powered prostheses in the market.

AIM
This study aims to evaluate a new 3-D printed myoelectric prosthesis on a 16-year-old child with upper-limb amputations. In addition to simple structure, the new prosthesis is also reasonably priced. The size and weight are also suitable for children.

METHOD
After we developed and manufactured the new prosthesis, its functionality was evaluated in one case study against the standard benchmark tests, demonstrating its capability. We evaluated this prosthetic arm on a 16-year-old child and measured three subset University of New Brunswick (UNB) test.

RESULTS
According to the UNB test, the participant was evaluated on the following items and all UNB tests were correctly completed by this participant. Three UNB test subsets include brushing teeth, pulling zippers, wearing gloves, tying shoelaces with the healthy hand, putting on clothes, moving small cards, removing chocolates from the table, opening band-aids, removing pencils from pencil cases, carrying large and medium clothes boxes. In addition, the child was able to grip spherical and cylindrical objects up to a maximum weight of 10 kg, move them in space, and release them effortlessly. The only limitation was getting a pinch grip since thin objects fell out between the fingers.

DISCUSSION AND CONCLUSION
A 3D printed hand designed for children proved to be very useful in this study. All UNB tests were successfully completed by the subject in this study. This prosthetic hand can be compared with Ottobock myoelectric hand. While the price of Ottobock prosthetic hand is high-priced, this prosthesis costs only $100. Children's conditions and growth can be easily adapted to this device.

Children can benefit from the convenience and reasonable price of this prosthesis.

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6.43 Analysis and comparison of single vs double differential sEMG systems for use in prostheses

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BACKGROUND
Crosstalk is a common problem noted from surface electromyography (sEMG). Crosstalk is when a signal from a nearby muscle is incorrectly detected and interpreted as a signal from the target muscle. Using a Double Differential (DD) topology, this crosstalk can be reduced, providing a device with better selectivity and potentially better clinical applications. Guerrero et. al. (2016) took this idea and designed a DD system using four operational amplifiers, resulting in a less complex system, requiring less power.

AIM
By comparing a single differential system to double differential systems while considering changes in geometry, this study aims to determine the ability of the system to differentiate between the signals of the individual digit muscles consistently and correctly.

METHOD
The DD systems were compared to their original papers to confirm the results of the prior research. To standardize the changes in geometry, an EMG system with three, movable, dry electrode bars was created.

Each system will be tested at each distance by placing the EMG electrodes on the forearm and flexing the wrist 10 times. The data will be collected using a MATLAB-NScope API and then it will be imported to another MATLAB script for processing, filtering, and analysis.

These systems will later be tested again, looking for their ability to detect signals from the target muscles and reject signals from surrounding muscles.

RESULTS
The results of this are still being processed and data is still being collected.

The results will show comparisons of the signal to noise ratios of the systems, while considering the changes in electrode spacing, frequency analyses, and other features (wave-length, mean absolute value, etc.) that would be useful later in pattern recognition studies.

DISCUSSION AND CONCLUSION
This study hopes to determine the better method of collecting EMG data for improved control of prostheses (single differential vs double differential, at what distances).

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ACKNOWLEDGEMENTS Weir Biomechatronics Development Laboratory; University of Colorado Anschutz

6.44 Development and and durability test of pediatric terminal device for horizontal-bar activity

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BACKGROUND
Participation to physical education and sports are essence of healthy development for all juvenile and infants. The marketed terminal device for horizontal bar is durable but limited to one size and heavy for infants.

AIM
The objective of this research is to develop a lighter weight terminal device with improved strength and durability. The quantitative evaluation is conducted under newly developed adequate tensile and repeat tests.

METHOD
A terminal device that consists of 2 Carbon Fiber Reenforced Plastic hook plates, a 3-D printed PLA hook cover, aluminium alloy base block is developed. The device is designed to weigh less than 100g and the inner curve is design to swing and sustain the body weight on the diameter 28-mm horizontal bar. This diameter is a standard dimension of horizontal bar place in Japanese school grounds and parks. The hook shape and dimensions are designed with Finite-Element-Analysis to reduce the tensile stress within the CFRP strength. A durability experiment equipment was developed to oscillatory rock the terminal device while applying tensile load on the hook and hook cover.

RESULTS
The terminal device weighed 101g. The CFRP hook unit bear tensile load up to 743N without fractures in the adhesive layer between the CFRP plates.

A durability experiment equipment was developed with a 4-bar lever crank mechanism to oscillatory rock the terminal device with a wire tensing at 735N. The rocking motion was driven with a DC servo motor. The cycle was counted by a magnetic counter. The repeated moving load test, the cover of the terminal device made of glass fiber-reinforced filament (PPGW) showed delamination after 6941 cycles, which was much less than 97,200 cycle that is equivalent to the three years of terminal device's target service life.

DISCUSSION AND CONCLUSION
A light-weight terminal device (101 g) was fabricated from a composite material consisting of a carbon fiber-reinforced plastic hook, an aluminium alloy base, and a glass fiber-reinforced filament cover. The fabricated terminal device shows sufficient strength in the suspension direction and can be used by children for weight bearing. However, a lack of fastening between the cover and the hook was found by repeated load tests, and the hook was damaged after 6941 cycles.

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6.45 Open-source 3D-printed upper limb prostheses: prototypes or alternative solutions

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BACKGROUND

The cost of commercial prostheses is a limiting factor for underprivileged individuals (e.g. no health insurance, low-income, warzones). Therefore, many opted for open-source (OS) 3D-printed(3DP) upper limb prostheses, representing an affordable solution. Although these OS prosthetic devices were developed and manufactured for a decade by non-governmental organisations or private individuals to succour people needing assistive devices, they were poorly studied. Rare review reports discussed their properties, often lacking methodology in devices selection [1,2].

AIM

This study aimed to provide an objective portray of current open-source 3D-printed upper limb prostheses with quantitative and qualitative data, and to address their position in the prosthetic field.

METHOD

A review of the scientific literature was performed to identify peer-reviewed articles discussing development or applications of OS, or freely accessible, 3DP upper limb prostheses. Additionally, 18 online repositories hosting 3D-printable designs were searched. Selection criteria were elaborated to specifically include devices that are freely obtainable, designed for daily use, completed projects and provided with reliable instructions for printing and assembly. Quantitative information on the mechanical and kinematic specifications and 3D-printing technology employed was extracted for each prosthesis. Proofs of continuing technical support and development of those prosthetic devices were searched. Settings and findings from included studies were also recorded.

RESULTS

Six articles were found. Four studies discussed the use of OS 3DP prostheses to fit patients, children and adult, suffering from limbs malformations or amputations. Two works assessed prostheses functionalities. Body-powered and passive hand (5/6) and myoelectric forearm (1/6) prostheses were studied. All studies incorporated already existing OS 3DP prostheses, no development of new OS prostheses was found. Mechanic and kinematic data were not systematically reported. Material costs varied from \$20 to \$449. Increased satisfaction of recipients and improvement in gross dexterity were described but no objective validation of devices was reported. From online repositories, only 29 OS prosthetic devices were included. Most (22/29) prostheses were hand and forearm body-powered prostheses, initially designed for children. Mechanical and kinematic data were poorly reported. No material cost and functionality assessment were provided. Oldest prostheses, still produced, were uploaded in 2014.

DISCUSSION AND CONCLUSION

Open-source 3D-printed upper limb prostheses stand as potential alternatives to classic commercial prosthetic devices. Individuals worldwide opt for them as they represent functional and affordable solutions. Nevertheless, much research is warranted to improve their robustness and objectively assess their impact on recipients’ life. Guidelines are required for indications, production and fitting to expedite their implementation in clinical routine and their acceptance by healthcare providers (e.g. prosthetists, orthopaedists).

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Posters: Seating and wheelchair

6.46 Data collection on the performance of 4 different rough-terrain wheelchairs on dessertic Sahel surfaces in Niger

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BACKGROUND
Over 80% of Niger's surface lies in the Sahara Desert and most of the roads are sandy where standard wheelchairs sink and are difficult to propel. Despite an estimated need of 210'000 wheelchairs, there are only a few mobility devices locally available, which are frequently not adapted to the needs of the users and the environment.

AIM
Analyse the performance and the user assessed functionality of four models of rough-terrain wheelchairs in the local condition as a part of a bigger project aiming to reinforce team's training and inform future action.

METHOD
Wheelchairs are tested by a small group of ten participants, including adults, minors, women, men and different types of physical disability. Every participant uses two of the four types of wheelchairs for a month each, with performance assessments before (baseline) and after. The wheelchairs' performance on sandy terrain as well as the impact on participation, accessibility of life space and capacity to execute everyday tasks is measured through the following four standardized tests: Functional Mobility Assessment (FMA), Wheelchair Outcome Measures (WhoM), Life Space Assessment Scale (LSA) and Physical Performance Test (speed and endurance).

RESULTS
We will only present here the highlights of the results with the FMA as it was the test that provided us the most useful data and we have limited wordcount:

Children:

- Comparison between wheelchairs: Remarkable differences on independence (40/80), self-care (33/60), and tasks at higher level (40/70)
- Comparison W2 with baseline: almost 3 time more comfort (35/85), almost double in posture (50/90) and independence (45/80) and had also improvements on participation (75/90), tasks at higher levels (55/70) and personal care (40/60). They reported negative scores on the use of transport (40/27) and transfers (50/40)

Adults:

- Scored improvements of an average of 9% in relation to the baseline in 6 domains and reported negative scores on 4 domains for the two models. The cumulative average score shows a very discreet improvements for both wheelchairs (W3:65-BL/71 W4: 65 BL/69).

DISCUSSION AND CONCLUSION
The data collection originated a change of perception from the professional's and wheelchair users on what it is possible. One Pediatric wheelchair produced good results. Therefore, it has been selected as the model to introduce in the new service to start. For the adults, one of the models performed slightly better than the other and both showed poor improvement in functionality. Much more efforts/time/money needs to be invested to develop/adapt a mobility solution for sandy areas.

ACKNOWLEDGEMENTS Thanks to the innovation department in Headquarters and management of ICRC delegation in Niamey for listening and learning with us.

6.47 Sustainable supply of appropriate wheelchairs through national manufacture in Kenya

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BACKGROUND

Recent research [1] shows that that only 5% of disabled Kenyans have the wheelchair they are entitled to. The few wheelchairs that are available—just 827 supplied by Kenyan hospitals and rehabilitation services in 2019—rely on charitable donations and increasingly expensive imports. This means that around 95,000 people in Kenya either do not have a wheelchair or have one that exacerbates health issues, is not usable in their environment or can't be repaired locally.

AIM

Improve wheelchair user's health/wellbeing, improve inclusion, contribute to the Kenyan economy and reduce waste by creating an economically viable and sustainable supply model for manufacturing appropriate, international-standard wheelchairs in Kenya, and sharing the model with other regions/countries.

METHOD

Founded on existing, tested and successful wheelchair designs, a Kenya–UK team of designers, engineers, clinicians and researchers are developing and field testing a prototype for an attractive, affordable, international standard compliant, three-wheeled chair.

In parallel, discussions are underway with Kenya-based suppliers and manufacturers about materials, tooling and high-volume production and research studies are being established to understand: 1) User outcomes; 2) Financial model; and 3) Learning and replicability of the model. There is ongoing engagement with the Kenyan Government and with potential regional and international customers for the wheelchair.

RESULTS

Figure 1. Prototype three-wheeled chair. Manufacture and field testing of the initial prototype is planned for December 2022, and the start of full production planned for early 2024.

DISCUSSION AND CONCLUSION

Access to a wheelchair is a human right but the current models for wheelchair provision in low-and middle-income countries are insufficient and unsustainable. It is not possible at this stage to say definitively that the national manufacturing model described above will work. However, we believe it is critical to intelligently invest time and money in testing it as a potential solution to the chronic gaps in wheelchair provision.

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ACKNOWLEDGEMENTS Project is funded by a European philanthropic foundation. We are seeking their permission to include their name in the poster.

Poster: Paediatrics

6.48 Minuscule serial static hand orthosis (SSHO) in treating neonatal amyoplasia contractures [deformity confined to hand]

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BACKGROUND

Amyoplasia contractures [congenital anomaly] in neonates (< 14 days babies) diagnosed and recommended for SSHO* [conservative treatment programme] to reduces contractures and to prevent deformity progression: ‘a phase where surgical intervention less prescribed’. Skill expertise involved in design, fabrication, fitting of orthosis for neonate markedly differs in comparison with regular orthosis models. Musculoskeletal structures of neonate are much tiny and the frictional force involved in handling must be proportionally adjusted to avoid excessive pressure and simultaneously achieve corrective position without causing discomfort.

AIM

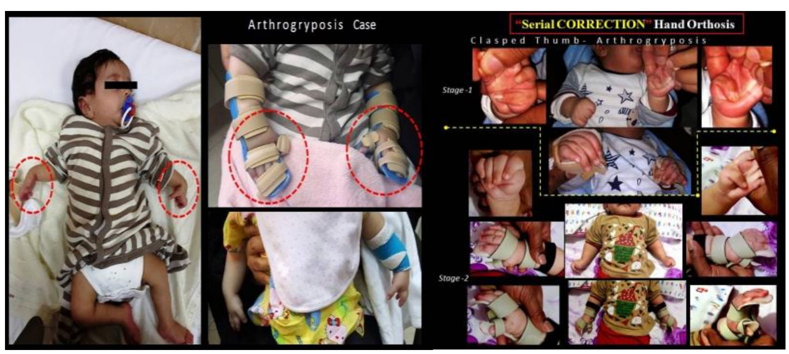
To study the effectiveness of minuscule SSHO in reducing neonatal amyoplasia contractures, and to document precision grip skills' significance involved in fabrication and fitting procedures.

METHOD

Minuscule SSHO treatment programme: design, fabrication and fitting of 3 stage orthosis at successive interval of 14 to 21 days. Step 1: 3 Neonates selected - 1. Arthrogryposis Multiplex Congenita (AMC); 2. Congenital clasped thumb; 3. Amyoplasia congenita. Step 2: Evaluation: Wrist Hand condition - abnormal clenching of fist with restricted finger extension [stiffness at MCP & IP]; absence of Moro reflex; atrophied palmar grasp. Step 3: Documentation and recording by video/pictures: Effect of orthosis in reduction of amyoplasia contractures at each 3 stages. Step 4: Effect comparison: Step 2 evaluation with Step 3, to check the effect of SSHO in terms of contracture reduction and improved ROM @ CP, MCP & IPs.

RESULTS

1. Wrist and fingers angulation and position when compared with Step 2 with Step 3, Step 4 evidently showed marked improvement in contracture reduction and better ROM @ CP, MCP & IPs. 2. Good dexterity (precision skill) was noticed to be significant as it provided the crucial frictional force required in: a) handling neonates in terms of positioning their tiny wrist and hands during clinical evaluation, measurements, procedures; b) fabrication process, fitting and adjustment of minuscule orthosis [as the surface area for grasp was markedly minimal]. Leading to further study on precision skills significance and their development programmes as there wasn't much knowledge material on fine dexterity skills involved in designing minuscule orthosis.



DISCUSSION AND CONCLUSION

The SSHO treatment programme proved effective in reduction of amyoplasia contractures in neonates. Simultaneously details were recorded on frictional force involved in angulation, positioning and strapping of baby’s tiny fingers with delicate pressure that was observed to be paring with precision grip. Leading to further study on precision grip skill [good dexterity] as it displayed significance while handling, designing, fabricating and fitting of minuscule SSHO for neonates.

Poster: Psychosocial issues / quality of life

6.49 Impact of the caregiver-patient relationship on the quality of care orthopedic

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BACKGROUND
This study is to evaluate the impact of the relation between the caregiver/patient on the quality of the services and orthopedics care.

AIM
Evaluate the quality of the caregiver-patient relationship in the orthopedic setting orthopedic.

METHOD
This was a cross-sectional, quantitative and qualitative study on the patients and those accompanying patients who cannot express themselves (children or bedridden patients) having been received during January 2020 to February 2020 at National Center for Orthopedic Equipment of Lomé (CNAO-L).

RESULTS
With a sample of 34 patients, 41.2% of patients, i.e. 14 patients found the waiting time often short, 61.8% said they were satisfied with their relationship with the orthoprosthetist (P&O), 55.9% of the patients questioned declared that their P&O who is always courteous towards them, most of the patients i.e. 47.1% declared to be very often informed of the care process by P&O, 55.9% said that the P&O asked very often their consent, 50% stated that they were satisfied with the welcome given to them by the P&O.

DISCUSSION AND CONCLUSION
The caregiver-patient relationship is of paramount importance. Indeed, she contributes to facilitating the work of the carer and involving the patient, in order to make a good diagnosis and allow better patient care. He emerges from our study, the primordial role of communication in the quality of the caregiver-patient relationship, in order to contribute to effective patient care.

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ACKNOWLEDGEMENTS National Center for Orthopedic Equipment of Lomé (CNAO-L). International committee of the red cross - Mali.

Posters: Outcome measurements

6.50 Monitoring and Improving the quality of prosthetics and orthotics services - a case study in Rwanda

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BACKGROUND

Monitoring the quality of the prosthetic and orthotic services is often challenging. Usually, the service user's (SU) feedback is collected to know their satisfaction level; this provides the perceived quality from the users' perspective, but this does not necessarily define the quality of the devices from a clinical standpoint. The International Committee of the Red Cross (ICRC) has developed a tool to assess within the same questionnaire the SU feedback and a technical assessment (TA).

AIM

To share ICRC experience on monitoring and improving quality of prosthetics and orthotics (P&O) services at the University Teaching Hospital of Kigali (CHUK) in collaboration with the Rwanda Society of Prosthetics and Orthotics (RSPO), using the assessment tool.

METHOD

After a short training on use of the assessment tool, the ICRC and the RSPO staff collaborated to assess the quality of the P&O services at the CHUK for three consecutive years. The team analysed the data using Epi Info software to identify the gaps in quality and to address them systematically to improve the quality of services. In addition, the team provided immediate feedback to the prosthetist, orthotist and physiotherapist involved in the service provision as well as a set of recommendations discussed on a yearly basis. The recommendations were also used to develop an annual training plan to ensure relevant post graduated development.

RESULTS

The monitoring data measures taken at CHUK show an overall improvement in quality of the services provided. There was a progressive improvement in all the indicators. Significant change was noted in workmanship (480%), Fitting (380%), appointment for follow up (122%), comfort while wearing the devices (81%), information provided to service users about the rehabilitation process (66%), multidisciplinary team approach prior to receiving devices (54%), staff friendliness (33%). Minor changes noticed in hygiene and prescription. There were some inconstancies in the domain of training, function, appointment for service follow up and multidisciplinary team approach post device fitting. COVID-19 strongly affected the gait training of the users.

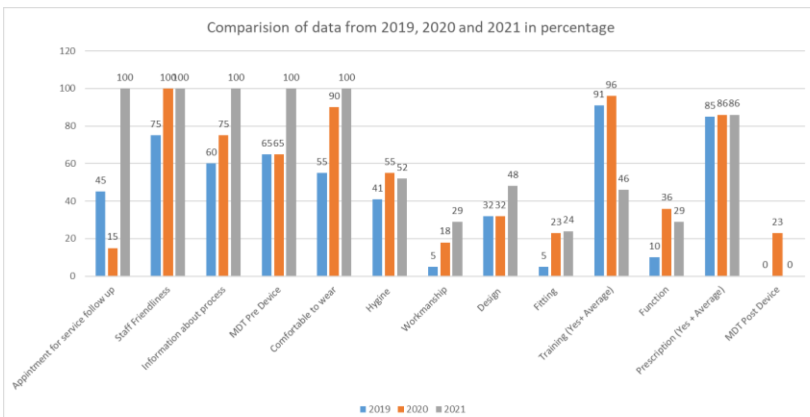

Figure 1. The graphs show quality improvements in some area over the years.

DISCUSSION AND CONCLUSION

The degree of quality improvement varies according to factors such as infrastructure development, availability of materials, staff training in areas where a gap in quality was identified. Involvement of the centre management helped implementing the improvement plan. The strong collaboration with RSPO ensured sustainability to the project and confirms the relevance of this tool (blend of SU feedback and TA). Further studies are needed to assess its psychometric values of the tool which required limited training and is user friendly.

ACKNOWLEDGEMENTS Thanks to the management of ICRC, RSPO and CHUK for conducting the quality assessment and implementing the improvement plan.

6.51 Comparative study on access enhancement: a digitally managed physical rehabilitation project overview in a conflict-affected region In North-Eastern Nigeria

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BACKGROUND

Most Persons with Disabilities (PwD) struggle to get access of acceptable and affordable quality Physical Rehabilitation Services (PRS) in Nigeria, distinctly in its north-eastern conflict-ridden areas. Number of people living with a disability has been estimated more than 19 million by National Population Commission in 2020. As conflicts become more protracted, Physical Rehabilitation Center (PRC) at University of Maiduguri Teaching Hospital (UMTH) supported by the ICRC provided PwD with continuing clinical and technical support, imported materials.

AIM

Analyze access to PRS since implementation through technical efficiency and controlled monitoring using DCMS.

METHOD

Digital Center Management System (DCMS) document medical record and enterprise resource planning in single window comprehensive dashboard, which assesses beneficiary management and impact measurement. The project has evolved to enhance existing services quality to retain minimum standard technology. Service users served between January 2021 to August 2022 were the studied population. Using Medical Activity Database (MAD) PROD DHIS2 tools: gender, age, numbers of prosthesis, orthosis, mobility aids, and therapeutic sessions for consecutive two years data were extracted. Data were analysed with a correlation study between characteristics and access to PRS. The interferential statistics obtained in the year 2021, were compared with projected values for 2022 to identify quantitative percentile values.

RESULTS

A total of 826 health service users have received PRS. Projected service delivery for 2022 indicates an upturn of 78.3% of access to children when compared with the preceding year. Whilst adhering to the country's post-pandemic guidelines, an increase of 150% in physiotherapy services was noted, as well as a 3.7% reduction of conflict-stricken beneficiaries. An increase of wait-listed service users was served in 2021. Increases of respectively 22.5%, 166.6%, and 134.3% service users for prosthetic, orthotic services, and mobility solutions were noted.

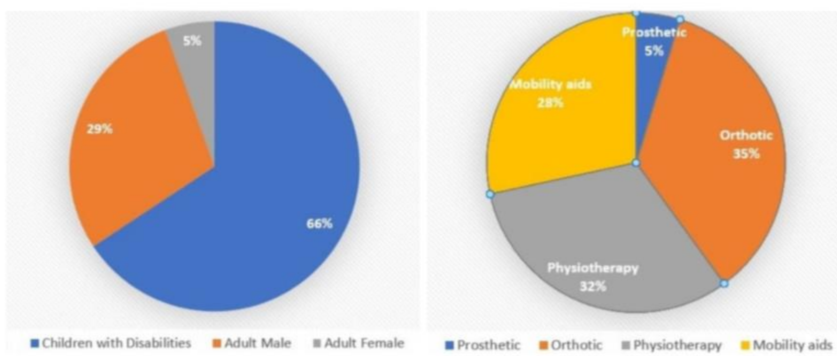

Figure1. comparative inclination of service provision between Jan-Dec 2021 & Jan-Aug 2022

DISCUSSION AND CONCLUSION

The population of North Eastern Nigeria lived through numerous unfavorable conflicts between 2009 and 2016 and the aftermaths remain: socio-political unrest, inadequately trained professionals, deprived attention to PRS. Deployment of the DCMS at the UMTH PRC through ICRC support are subsidizing the administrative, technical, and managerial gaps. However, capacity building and sustainability of project shall remain a priority to ensure a foreseeable self-reliant future.

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ACKNOWLEDGEMENTS DCMS is solely owned and funded by ICRC. Service users, ICRC & UMTH PRS team are appreciated for their support.

6.52 A combined protocol of functional tests for structured assessment of mobility and balance in people with a lower limb amputation

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BACKGROUND
People with lower limb amputations (PLLA) have an increased risk of falling [1]. Therefore, assessing their balance abilities is of great importance to identify those with poor balance which consequentially may have a high fall risk. Balance-specific functional tests and/or questionnaires are reliable tools to facilitate this, while requiring little instrumental effort. In this study, a combination of different tests was investigated.

AIM
To assess if a combination of different balance specific functional outcomes is feasible in a clinical setting.

METHOD
12 unilateral PLLA (6 transtibial/6 transfemoral; 9 male/3 female; 48±16.1years; 179±6.75cm; 87.51±17.98 kg) was recruited. The protocol consists of 8 performance-based tests (AMP=Amputee Mobility Predictor; BBS=Berg Balance Scale [2]; POGS=Prosthetic Observational Gait Score; NBWT=Narrowing Beam Walk Test [3]; FSST=Four Square Step Test; FRT=Functional Reach Test; L-Test; 2MWT=2min Walk Test) and a questionnaire (ABC= Activities-specific Balance confidence). Performance was documented using five synchronous video cameras and a tablet based digital protocol. Correlations between balance-specific tests were tested according to Spearman. Mann-Whitney U-Test was used to examine whether tests can differentiate between amputation levels PLLA K-Levels.

RESULTS
Results are presented in Table 1. FSST and NBWT could not be completed by every subject. In our cohort, no statistically significant correlations between NBWT and other balance-specific tests or ABC were found. Further, no significant differences were found when comparing results between amputation levels TF (trans-femoral) and TT (trans-tibial). When stratifying and comparing results according to K-Level significant differences were found (FSST and NBWT not considered due to too small a sample).

			performance-based scores			performance-based measures					balance confidence & stumbles / falls		
participant ID	level of amputation	K-Level [poorest 0, best 4]	AMP [max. 47]	BBS [max. 56]	POGS [poorest 30]	NBWT [normalized distance]	FSST [s]	FRT [cm]	L-Test [s]	2MWT [m]	ABC [max. 100]	stumbles	falls
56027	TF	1	23	31	8	no data	no data	17	74	45	38	2	none
56016	TT		31	20	4	no data	no data	14.5	47	66	61	none	none
56003	TF	2	30	31	6	no data	no data	17	100	52	86	2	none
53607	TT		39	53	6	71%	11	12	23	119	61	none	none
54442	TT	3	45	54	2	55%	10	31	22	136	81	4	none
50621	TT		40	49	3	no data	10	18.5	21	141	97	none	none
54021	TT		45	50	4	69%	8	31	15	182	99	none	none
53242	TF	4	43	56	4	54%	13	26	21	138	98	none	none
53406	TF		43	51	4	50%	11	32	19	150	96	none	none
55664	TF		45	56	3	64%	12	55	21	167	97	none	none
56023	TF		45	56	1	52%	10	34	16	169	99	none	none
56020	TT		47	56	0	97%	10	38	16	153	97	none	none
		MEAN	39.7	46.9	3.8	63.8%	10.6	27.2	32.9	126.4	84		
		SD	(± 7.3)	(± 11.8)	(± 2.1)	(± 14.6%)	(± 1.3)	(± 11.8)	(± 26.0)	(± 44.7)	(± 19.3)		
		MEDIAN	43.0	52.0	4.0	59.3%	10.0	28.5	21.0	139.3	96		

Table 1: Results of the combined test protocol (Typically higher results or scores are indicators for higher function; for POGS, FSST, L-Test lower results represent better results; Clarification for test abbreviations can be found in the text; K-Level = functional level; TF=trans-femoral; TT=trans-tibial)

DISCUSSION AND CONCLUSION
The combination of BBS, NBWT and FRT in a protocol is well suited to cover a wide range of functional levels, regarding balance abilities of PLLA, as BBS is sensitive to ceiling effects in this population [4]. We could not distinguish subject's amputation level based on their results. However, functional deficits were clearly identified. Therefore, results of this combined protocol are helpful in a rehabilitation setting.

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Posters: Low- and middle-income countries

6.53 The status and use of prosthetic devices by persons with lower limb amputation in Rwanda

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BACKGROUND
Amputation is one of the leading causes of disabilities due to reduced mobility. Without assistive devices specifically prostheses, the quality of life of persons with lower limb Amputation (PLLA) further deteriorates. Therefore, prostheses are fundamental to improving their quality of life.

AIM
To establish the number of persons with lower limb amputation with or without prosthesis and to determine their socio-economic profile in Rwanda.

METHOD
A descriptive, cross-sectional study was conducted in all sectors of Rwanda. Due to Covid-19 movement restrictions, data collection was carried out through telephone calls with participants to complete the questionnaires. Descriptive, inferential statistics and chi-square test were performed to analyze data using SPSS 21.0.

RESULTS
Of the 3026 participants identified countrywide, 68.8% were males, 60.3% of them did not have any prosthesis ($p=0.003$). The majority (62.4%) of those who had prosthetic devices needed repair of their prostheses while 14.8% of participants reported that their prosthetic devices were completely broken/damaged ($p=0.604$). Among the participants, 63.7% had no source of income and 66.7% had dependents ($p=<0.001$).

DISCUSSION AND CONCLUSION
The majority of the persons with LLA in Rwanda did not have prosthetic devices and even those with the prostheses did not fully function, thus required repair. Therefore, adversely affecting their livelihood.

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ACKNOWLEDGEMENTS I acknowledge of all people who supported and contributed to this study, especially the participants and the research assistants.

6.54 Creating increased access of physical rehabilitation services to people with disabilities living in Chittagong Hill Tracts, isolated regions of Bangladesh

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BACKGROUND
Chittagong Hill Tracts (CHT) area of Bangladesh has an estimated population of 620,214. Approximately 10% of whom are Persons with Disabilities (PwDs), who need some kinds of Prosthetic and Orthotic devices (P&O). Rehabilitation services are extremely limited. ICRC is working in close collaboration with Bangladesh Red Crescent Society (BDRCS) and Centre for the Rehabilitation of the Paralysed (CRP), to provide rehabilitation services in this most remote area.

AIM
To make prosthetic and orthotic services accessible to people with disabilities living in the Chittagong Hill Tract (CHT) area, including victims of situations of violence among others.

METHOD
10 BDRCS volunteers from each CHT districts are trained at Chottogram Physical Rehabilitation Centre (PRC) on identification of PwDs through ICRC validated Patient Identification Training (PIT) programmes. They go back to their respective communities and start the identification work. One week later, a mobile camp is organised at the community, where all the identified PwDs are assessed by the visiting rehabilitation professionals. The selected persons are then sent to Chottogram PRC for necessary fitment of P&O devices, who then return to their communities. Later, follow ups of these beneficiaries is carried out by the BDRCS volunteers and the cycle is repeated.

RESULTS
In 2022, the project achieved the following results: 16 volunteers trained during 2 PIT programmes; 2 Mobile Camps and 1 follow up camp were organised. In total: 56 PwDs were identified, out of whom 19 received P&O devices & 4 received wheelchairs.

Plan for 2023: 3 patient identification training programmes for 24 volunteers; 3 Mobile Camps and 4 Follow up camps; 3 disability awareness sessions to be conducted at CHT.

DISCUSSION AND CONCLUSION
ICRC and BDRCS collaboration is aiming strongly at making very positive changes in the lives of many PwDs in Bangladesh, mainly in the areas which are highly inaccessible for physical rehabilitation services. Similarly, CRP, being a partner organisation of ICRC, is also providing much needed P&O devices to the PwDs. ICRC looks forward to enhancing the collaboration and service provision with the improvement in the quality of care for PwDs.

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ACKNOWLEDGEMENTS I would like to acknowledge the work of BDRCS volunteers, CRP, and ICRC physical rehabilitation team for this paper.

6.55 Do Males and Females Have the Same Levels of Satisfaction Regarding Their Prosthetic Devices in Northern Sri Lanka?

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BACKGROUND
Cimino et al.'s [1] systematic review showed that there was a difference between males and females in prosthetic related outcomes. However out of the 66 articles, only 7 studies involved amputees from low- and middle-income countries (LMICs), with most of those articles having an unbalanced gender sample. This gives low confidence that the conclusions of this study are applicable to the tens of million amputees living in LMICs.

AIM
To use a multimethod approach to determine if males and females have the same levels of satisfaction regarding their prosthetic devices in northern Sri Lanka.

METHOD
In July 2022 8 ethnographic observations (4F, 4M) and 14 interviews (6F, 8M) were conducted with amputees in northern Sri Lanka. From July-September 2022, 19 surveys (9F, 10M) were collected, where prosthetic satisfaction was recorded. Ethnographic and interview recordings and transcripts were reviewed to identify level of satisfaction. Fishers' exact tests (alpha = 0.05) with Bonferroni posthoc corrections for multiple comparisons were used to identify sex-based differences in satisfaction, where data from the ethnographies/interviews and surveys were handled separately. Differences between ethnographic/interview and survey data were considered.

RESULTS
No significant differences in satisfaction between sexes were detected in the survey or ethnographic/interview data, likely due to small sample size. Qualitatively, ethnography and interviews provided interesting differences in how men and women viewed the cosmesis of their prosthetic device. The issues raised by females included the size of the convex ankle compared to the size of their SACH foot and their shank, the inability to wear to rings to symbolise their marriage within their culture, and dresses and sari's being caught and ripped in single axis knees. Issues such as the inability to wear TF belts when pregnant was also raised by a female P&O worker. Men did not tend to discuss cosmetic issues.

DISCUSSION AND CONCLUSION
Whilst the surveys provided us with the conformation of equal satisfaction between sex's, the interviews and observations provided invaluable insight into the differences in desires. A limitation of our data is small sample, and only being able to conduct research in the local area due to the fuel crisis in Sri Lanka and lack of transport at the time. It appears, from our results, that surveys should not be relied upon to determine sex differences in satisfaction for prosthetics.

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6.56 Low-cost 3D-printed prostheses for low- and middle-income countries using Artificial Intelligence based socket prediction

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BACKGROUND
Access to prosthetic services is very limited in low- and middle-income countries. Facilities to produce prostheses are not within reach or too expensive.[1,2] Current manual workflows are highly dependent on the prosthetist's experience and skills, implying difficulty in quality assurance, standardization, and scalability. 3D technologies can offer a solution. Last year, our research team investigated the creation of a standardized digital workflow for transtibial prosthetic sockets, to be implemented in our pilot 3D lab at Masanga Hospital in Sierra Leone.

AIM
The overall aim is to enable the local employees to produce prostheses independently. Simple digital automated workflows, using Artificial Intelligence based socket prediction, could offer a solution to improve prosthetic fitting in underserved regions worldwide.

METHOD
Using machine learning, an Artificial Intelligence algorithm has been developed to standardize the shaping step of the positive mold of transtibial prosthetic sockets. By comparing 130 transtibial scans of residual limbs with the corresponding manually corrected models, an algorithm has been created, which has been incorporated into a design program. From October – December 2022 a within-subject cohort study will be performed with ten Dutch patients to test the AI-based sockets and compare comfort socket scores with conventional designs. If successful, local staff in Sierra Leone will be trained in the use of the software in February - March 2023, and a new cohort will be provided with a transtibial prosthesis.

RESULTS
The average displacement (mm) of the corrected transtibial socket design is shown in Figure 1. The first results of the AI-based socket predictions, tested by Dutch patients are promising. Using the digital automated design software program, a prosthetic socket could be designed within 3 minutes, after which it was 3D-printed in 12-14 hours. At the ISPO conference, we will present the results of the Dutch study and we will evaluate the impact on the independence of the local staff in Sierra Leone.

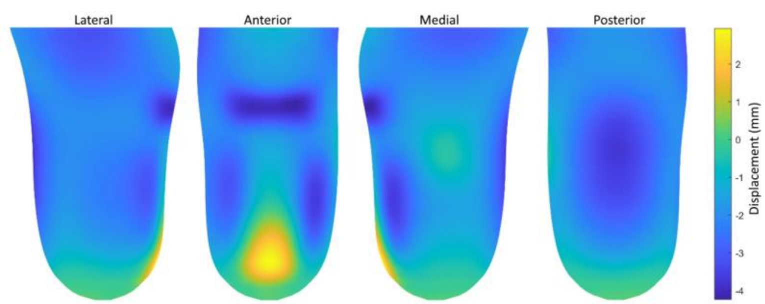

Figure 1. The average displacement (mm) of a corrected transtibial socket design.

DISCUSSION AND CONCLUSION
The newly developed software package, including the AI model, is a step towards independence for local employees in low- and middle-income countries to produce transtibial prosthetic sockets. In the meantime, similar digital workflows are being created for below and above the arm and above the knee prostheses. We aim to provide a complete package consisting of software, hardware, and training as a solution for the need for prostheses around the world.

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6.57 Determinants of the social reintegration of people with disabilities physical disability having benefited from an orthopedic package of reintegration

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BACKGROUND
Most people with disabilities are not employed, there has never been a policy to ensure effective care for them by the government. In South Kivu, people with disabilities live in a deplorable humanitarian situation and are often victims of all kinds of discrimination within the community. The majority of them turn to a life of begging in the streets, reflecting poor social reintegration. The determinants of a good social reintegration of these people are not yet clearly established.

AIM
The objective of this work was to determine the rate of social reintegration of people with physical disabilities after having benefited from the PRP package and to identify the determinants of this social reintegration.

METHOD
This is a retrospective study of 192 beneficiaries of the orthopaedic reintegration package residing in the city of Bukavu offered by the PRI at the Heri-Kwetu Centre for the Disabled in 2020. A simple and multiple logistic regression was performed on the different variables collected to determine their association with the social reintegration of the disabled with p<0.05 and a significance level of 95%.

RESULTS
In our study, it was observed that subjects with no education were in the majority (35.60%), followed by those with secondary education (30.37%) and primary education (26.7%) respectively. Finally, those with a university degree represented less than 10%.

However, no significant difference was observed in terms of educational level between the different educational groups. As regards the WHODAS score, it was found that almost half of our subjects recovered their independence. Furthermore, it was observed that subjects with Physical Independence were statistically significantly better integrated than those with Physical Dependence. With regard to the factors associated with social reintegration, our results show that the female gender, having polio sequelae as a cause of disability and having recovered a normal life without dependence were associated with good social reintegration.

DISCUSSION AND CONCLUSION
A better understanding of the factors underlying the social reintegration of people living with disabilities remains the key to better oriented interventions in their favour.

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ACKNOWLEDGEMENTS ICRC's programme has made it possible to improve social reintegration of patients with disabilities in South Kivu

Posters: Education

6.58 Knowledge, Attitude and Practice (KAP) among Health Care workers regarding physical disability in Peshawar

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BACKGROUND
Disability causes enough global disease burden. Physical disability is the loss of motor function or movement restriction. Appropriate knowledge of physical disability, attitudes and practice of disability leads to early diagnosis and disability treatment which ultimately impacts outcomes of patients. To amend the attitude and knowledge they should be assessed. The findings of KAP study enables informed design and implementation of policies, awareness, programmes and strategies.

AIM
The main purpose of this study was to evaluate and measure rate of knowledge, attitude and practices of doctors and nurses related to physical disability.

METHOD
This study was descriptive cross-sectional. This study was conducted in a major tertiary care public and private hospitals in Peshawar. The inclusion criteria included medical doctors and Nurses only. For data collection convenient sampling technique were used. The total number of participants in this study were 100 out which 56 were male and 44 were female. 69% respondents were medical Doctors and 31% were nurses. The duration of study was 06 months. SPSS version 21 was used to analyze data.

RESULTS

Do you have an idea about physical disability and its related issues?	Frequency	Percentage
Yes	93	93%
No	7	7%

Knowledge of Health Care professionals about the disability

The results of this research showed that mean percentage of male respondents were 56% and female respondent were 44%. Ages from 22 to 30 is 61% and 31 to 45 is 32%. 31% of the respondents were nurses and 69% were doctors. Knowledge: 61% of the respondents have good knowledge and 33% have poor knowledge of physical disability. Attitude: 70% had positive attitude and 30% had negative attitude. Practice: 65 % had good practice and 35% had poor practice.

DISCUSSION AND CONCLUSION
Knowledge regarding prosthetic and orthotic services was not very good. Findings of this study showed that health care professionals in Peshawar were aware of physical disability as compared to other developing countries but still the room for improvement is open.

6.59 Development of an Adjustable Simulation Model for Adolescent Idiopathic Scoliosis Orthosis Training

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BACKGROUND

Adolescent idiopathic scoliosis (AIS) is a three-dimensional deformity commonly found in teenagers [1]. It is also the majority group of patients in the Sirindhorn School of Prosthetics and Orthotics (SSPO) clinic and Thailand. In the SSPO undergraduate P&O program, practicing with model patients is essential for developing students' skills [2]. However, most high-school patients are not available during working hours and issues related to numerous exposures can be stressful and affect patients' psychological well-being [3].

AIM

To design an adjustable simulation model of AIS and to gather preliminary feedback on the model for future model development.

METHOD

A 14-year-old AIS female subject with a double curve was recruited for anatomical measurements, plaster casting, 3D scanning, and photo shooting. The inner skeletal structure was built as 3 separate parts including the head, thorax, and pelvis. A metal rod, ball bearings, and springs were used to connect the three parts and create the coronal plane adjustable mechanism. Silicone was used for the outer covering to mimic the patient's skin color. Twelve SSPO teaching staff were asked to perform the measurement and casting for model evaluation using a 5-point Likert scale questionnaire, which is divided into three domains: fabrication, appropriateness, and utility.

RESULTS

The mean score for the fabrication domain, which permitted the evaluator to reference original participant models and measurements, was 4.1 (±0.8), utility 3.9 (±0.9), and appropriateness 3.8 (±0.7). The highest score of 4.8 (±0.4) is given to the safe use of the model whereas, the curve flexibility domain obtained the least score of 1.9 (±0.8). The highest score in the fabrication domain interprets that the model properly demonstrates the bony landmarks and natural shape of AIS however, the silicone material was too dense which makes it difficult during corrective force application in casting practice. In terms of utility, the lowest score was obtained due to the partial-flexible property and heavyweight.

Figure 1. Adjustable AIS simulation model

DISCUSSION AND CONCLUSION

The model should be developed particularly in the flexibility feature for improving transverse plane correction. It is also suggested that the model could be difficult for beginner-level students to practice casting. Even though scores were less than optimal for all three evaluations, evaluators agreed that it is beneficial for the practice of measurement and bony marking and there is a potential to utilize the model in an academic setting in the future.

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6.60 Improving Clinical Gait Analysis Teaching in Low Resourced Settings using a 2D Video Analysis System: Case Study Of Togo

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BACKGROUND

In low resourced settings, gait analysis is one of the challenges of Prosthetics and Orthotics students mainly due to lack of equipment. Three-dimensional (3D) motion capture systems are considered the gold-standard in gait analysis in terms of accuracy and reliability but they are expensive and complicated to apply in regular clinical practice. A recent study found 2D video analysis (simple to use, affordable) to be reliable. Thus, for low resourced settings, 2D could be a solution to overcome these challenges.

AIM

The aim of this study is to assess the outcome of using Kinovea® (2D video analysis) to teach students clinical gait analysis and to evaluate their satisfaction and confidence toward clinical gait analysis using Kinovea®.

METHOD

This was an experimental study conducted in 2022 at ENAM Lomé, Togo, involving four students. They were given three patients and asked to do gait analysis with the traditional method, using the Observational Gait Analysis form (OGA). They were later trained to use Kinovea and after, they were asked to do gait analysis on the same three patients using Kinovea, and the OGA. The data on the two forms per patient, per student were compared to check if there were evolution or not. The last stage was to assess the satisfaction and confidence of students toward the use of Kinovea, with the Students' satisfaction and self confidence in Learning Scale.

RESULTS

Three participants could perform better the gait analysis when using Kinovea than with the traditional method. The fourth participant had similar observations with Kinovea and without it. But all the four participants reported high levels of satisfaction and confidence in learning with Kinovea.

Table 1: Students satisfaction and self confidence in Learning Scale

Satisfaction with Current Learning	SA	A	UN	D	SD
1. The teaching methods used in this simulation were helpful and effective.	2	2	0	0	0
2. The simulation provided me with a variety of learning materials and activities to promote my learning the P&O curriculum.	3	1	0	0	0
3. I enjoyed how my instructor taught the simulation.	4	1	0	0	0
4. The teaching materials used in this simulation were motivating and helped me to learn.	4	0	0	0	0
5. The way my instructor(s) taught the simulation was suitable to the way I learn.	1	3	0	0	0

SA= Strongly Agree // **A** = Agree // **UN** = Undecided // **D** = Disagree // **SD** =Strongly Disagree

Table 1: Students satisfaction and self confidence in Learning Scale

Self-confidence in Learning	SA	A	UN	D	SD
6. I am confident that I am mastering the content of the simulation activity that my instructors presented to me.	2	2	0	0	0
7. I am confident that this simulation covered critical content necessary for the mastery of P&O curriculum.	1	3	0	0	0
8. I am confident that I am developing the skills and obtaining the required knowledge from this simulation to perform necessary tasks in a clinical setting	4	0	0	0	0
9. My instructors used helpful resources to teach the simulation.	3	1	0	0	0
10. It is my responsibility as the student to learn what I need to know from this simulation activity.	3	0	0	0	0
11. I know how to get help when I do not understand the concepts covered in the simulation.	3	1	0	0	0
12. I know how to use simulation activities to learn critical aspects of these skills.	0	4	0	0	0
13. It is the instructor's responsibility to tell me what I need to learn of the simulation activity content during class time..	3	1	0	0	0

SA= Strongly Agree // **A** = Agree // **UN** = Undecided // **D** = Disagree // **SD** =Strongly Disagree

DISCUSSION AND CONCLUSION

Clinical gait analysis could be improved by the use of a simple, affordable, easy-to-use software like Kinovea and this would definitely help the students master gait analysis and lead them in their professional life to better prescription of devices, better treatment and improved assessment of management in low and middle income rehabilitation centres. The time has come to find ways to offer the best possible treatment to people with disabilities and improve their quality of life in low resourced settings.

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6.61 Impact of local prosthetic and orthotic education program on prosthetics and orthotic services in Bangladesh.

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BACKGROUND

Bangladesh has a large disabled population, and the demand for prosthetic and orthotic services is very high. But there is a lack of P&O professionals and service providers within the country. The diploma in prosthetics and orthotics program has been running at BHPI since February 2014. A total of 30 graduates from BHPI are working in different rehabilitation setups in Bangladesh. After more than 3 years, it became important to evaluate the impact of the program in the country.

AIM

To understand the impact of the diploma in the Prosthetics and Orthotics Program run by BHPI School of Prosthetics and Orthotics in the Prosthetics and Orthotics services in Bangladesh.

METHOD

It is a mixed-method study. The total number of graduate participants will be 30, and the total patient sample is 60 (30 prosthetic users and 30 orthotic users). Potential participants will be identified from the graduate lists of the School of Prosthetics and Orthotics, BHPI. Each graduate will select two patient participants (1 orthotics and 1 prosthetic user). The study will be conducted in the workplaces of the graduates; different prosthetic-orthotic clinics across Bangladesh. Data is also collected from the clinic managers of the graduates. Data is be collected using structured questionnaires from students, service users and the managers,

RESULTS

The study is still in progress. Data analysis is not yet complete. Complete results will be shared after completion of data analyses.

DISCUSSION AND CONCLUSION

The study is still in progress. Data analysis is not yet complete. Complete discussion and conclusion will be shared after the completion of data analysis.

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Posters: Rehabilitation medicine and surgery

6.62 Rehab of patients after transfemoral amputations suffering uncontrollable infection of total knee arthroplasty.

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BACKGROUND
In the last years, we observed an increasing number of transfemoral amputations following uncontrollable periprosthetic joint infection (PJI) after total knee arthroplasty (TKA).

AIM
We analysed patients in the rehab who had undertaken a transfemoral amputation after an uncontrollable PJI of TKA, because infection is one of the most feared complications. In Germany, the PJI rate 3 years after primary standard TKA is 1.0%.

METHOD
PCT study: From January 2007 to December 2015, 787 amputees were rehabilitated, 435 of them with transfemoral amputees. 10 patients (2.3%) underwent a transfemoral amputation due to an uncontrollable PJI of TKA after multiple salvage procedures (7 to 57 operations) to save the limb. The BARTHEL Index and the standardized mobility classification for amputees (K-Level) were collected on admission and discharge.

RESULTS
Average age at amputation 71.62 y, 5 women and 5 men. Marital status: 7 pat married (70.0%), 1 divorced, 1 widowed, 1 single. 7 pat graduated elementary school. All patients retired. 3 pats survived a sepsis by MRSA. 2 pats presented an infection by MSSA, 1 pat infection by MSSA and MRSE after resuscitation. Other 3 pats showed mixed infections; Pseudomonas aeroguinosa, MSSE, E. coli and Enterococcus faecalis.

The BARTHEL index was 61 points on admission and 73 points leaving the rehab - the increase of 15 points showed a satisfactory result. Most were able to manage their lives independently.

MOBILITY CLASSES: mobility class 0 on admission. After rehab only 2 patients were in mobility class 0 (not able to walk); while 4 pat were in class 1 and 4 pat in class 2 - a satisfactory result.

DISCUSSION AND CONCLUSION
This PCT study shows for the first time that a transfemoral amputation due to an uncontrollable PJI after TKA is not uncommon - we found 2.3% in our patient rehab population.

Since 2014 / 2015 we hold regular discussions with the German Arthroplasty Register EPRD and found that it is not yet possible to make any statements about whether a transfemoral amputation has taken place or about the frequency of transfemoral amputations.

6.63 Days to prosthetic fitting after major lower limb amputations – national data from Sweden

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BACKGROUND

A multidisciplinary team is important in the care of patients undergoing lower limb amputations. A common goal is to commence prosthetic rehabilitation as soon as possible. Time to prosthetic fitting might be influenced by e.g., amputation level, surgical technique, postoperative regime, and way of prosthetic service. The Swedish registry for lower extremity amputations and prostheses (SwedeAmp)[1,2] collects data for time until prosthetic fitting as a measure of the efficacy and quality of the care.

AIM

To report time from amputation to first prosthesis in patients with transtibial or transfemoral amputations based on Swedish registry data.

METHOD

SwedeAmp collects individual patient level data for amputation, prostheses and outcome in a web-based platform. Data registration is done voluntary by clinicians. From this dataset, number of days from the date of a primary amputation or re-amputation until date of first prosthetic fitting of a transtibial (TT) or transfemoral (TF) prosthesis were analysed. First prosthetic fitting was defined as the date the patient tried the first individual made prosthesis. The median number of days for three periods of years (2013-2015, 2015-2018 and 2019-2021) are reported. Extreme values between <5 and >500 days were excluded in the analysis. Within all TT prosthesis data was compared based on surgical flap technique.

RESULTS

Until 2021 the registry contained 9510 patients (61% men, 39% women; mean age 74 years), and 13654 surgical procedures (83% caused by vascular disease and/or diabetes). Date of amputation and first prosthetic fitting were available for 1536 TT- and 307 TF-prostheses, respectively. For both levels, days to first fitting had decreased by time and was currently 58 days for TT- and 84 days for TF-prostheses (Table 1). A transtibial sagittal or scew flap resulted in 19 fewer days until first fitting as compared to a transtibial long posterior or anterior/posterior flap (n=757, Md 50 days versus n=205, Md 69 days) (p<0.003).

Table 1. Number of days from amputation to first prosthetic fitting.

	2013-2015	2016-2018	2019-2021
TT-prosthesis	73 (13-492) n=320	64 (11-449) n=524	58 (14-494) n=674
TF-prosthesis	104 (29-484) n=62	94 (19-381) n=104	84 (21-406) n=141

Md (min-max)

DISCUSSION AND CONCLUSION

SwedeAmp aims for equal care of patients undergoing amputations and provide yearly reports[2]. A national registry provides a large dataset over years and reflects the clinical practice. However, the data is difficult to control and misinput can occur. In this report we show that time to prosthetic fitting in Sweden currently is about two months after a transtibial amputation and three months after a transfemoral amputation. For early start of a TT-prosthesis a sagittal or scew flap is preferred.

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ACKNOWLEDGEMENTS The SwedeAmp registry is funded by the Swedish local authorities and county councils.

6.64 Transcutaneous osseointegration for patients with a history of burn trauma

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BACKGROUND

Patients who have had lower limb amputation due to severe burn trauma often struggle with traditional socket prosthesis (TSP) wear even more than typical amputees because the socket irritates the compromised skin. This leads to poor mobility and quality of life (QOL). Transcutaneous osseointegration has been proven to be a safe and effective alternative to TSP rehabilitation which usually provides superior mobility and QOL. However, the compatibility of osseointegration with burned skin is unknown.

AIM

This study aims to evaluate what are the changes in mobility, QOL, and complications experienced for burned-related amputees following osseointegration.

METHOD

A retrospective review of our osseointegration registry identified five patients whose amputation was performed due to burn trauma: one unilateral transfemoral amputation (TFA), one unilateral transtibial amputation (TTA), one bilateral TFA, and two bilateral TTA. 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 burn amputees were also noted. Means were compared using Student's t-test and frequencies using Fisher's Exact test with significance set as $p<0.05$.

RESULTS

Patients who wore their prosthesis >12 hours daily improved from 0/2=0% vs 3/4=75% (p=0.400), and patients with a K-level of at least 2 improved from 0/3=0% vs 3/3=100% (p=0.100). Patients with a TUG of >50 improved from 0/4=0% vs 2/3=66% (p=0.143). QTFA global scores improved from 45.83±29.47 vs 54.17±30.81 (p=0.768) though QTFA mobility score worsened from 55.28±44.87 (p=0.711). QTFA problem score improved from 26.66±10 vs 19.79±13.35 (p=0.563). SF36 PCS improved from 27.09±10.39 vs 32.53±16.92 (p=0.647) and SF36 MCS improved from 47.81±13.27 vs 44.74±16.13 (p=0.800). Four patients had complications prompting operative intervention this includes debridement for infection and removal of implant. A specific benefit of osseointegration was noted for two patients who had flexion contractures of their hips and knees, respectively, while using a TSP, but which markedly improved following osseointegration.

DISCUSSION AND CONCLUSION

All of the patients specifically reported substantial improvement of their burned skin following the elimination of a socket prosthesis. Transcutaneous osseointegration is a safe and effective rehabilitation option for amputees with a history of burn trauma. No patients have had skin breakdown or other skin issues associated with being an osseointegrated amputee. Mobility and quality of life have improved, though not significantly. Although infection can occur, revision osseointegration can restore the mobility and QOL benefits following the eradication of infection.

6.65 Osseointegrated implants in patients with peripheral vascular disease

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BACKGROUND

Osseointegration is an alternative treatment for amputees who have inability or difficulty in wearing socket prostheses. Although the majority of limb amputations are due to vascular disease, they represent perceived contraindications for osseointegration surgery. For the first time, this case series reports the outcomes of osseointegrated reconstruction in patients with limb amputation due to peripheral vascular disease in Australia, Canada and United States.

AIM

The objective of this study is to look at success of osseointegration for patients with peripheral vascular disease in comparison to a traditional socket prosthesis and the rate of occurrence of all subsequent complications after a patient receives osseointegration surgery.

METHOD

This is case series with minimum 24-months post-operative follow-up in patients with trans-tibial and trans-femoral amputation and a history of peripheral vascular disease, who have received osseointegration implants during 2014–2020. Clinical and functional outcomes assessed included pain, prosthesis wearing time, mobility, walking ability, and quality of life. Adverse events were monitored and recorded, including infection, fractures, implant failure, revision surgery and death.

RESULTS

17 trans-tibial and 16 trans-femoral amputees (aged 30–87 years) were included in this case series with two patients being bilateral amputees. All patients were pain-free and using the osseointegrated prosthesis at follow up minimum 24-months post-operation. The mobility of all patients improved at follow-up. Notably, 9 of the 32 patients had mobility of K0 level, but all were able to walk again and perform daily activities post-operatively. Two patients underwent removal of osseointegration implant within an average of 1.9 years post-op due to recurrent infections. Three patient experienced ongoing pain which was successfully treated with a neurectomy procedure. Four patients were deceased, however it was not OI related.

DISCUSSION AND CONCLUSION

Patients with limb amputations and a history of peripheral vascular disease have been traditionally excluded from prosthetic reconstruction. An osseointegrated implant may be considered as a feasible alternative to the conventional socket prosthesis for these patients. The osseointegrated prosthesis may provide such patients with immense benefits, including improved function, mobility, quality of life, and even survival. Further evidence is required to confirm the possibility of implementing osseointegration surgery as the standard of care for these patients.

6.66 Prosthetics and Rehabilitation in Bilateral Below Knee Amputation and Cervical Spinal Cord Injury Patient with Electrical Burns: A case report.

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BACKGROUND

Electrical injuries cause vascular and thermal damage with potentially devastating complications and sequela. Spinal Cord Injury (SCI) occurs in 2-20% of electrical accidents[1]. Amputation incidence following burn injury is about 2%[2]. Finding SCI and bilateral lower limb amputation coexisting in a patient is unusual, both are devastating conditions causing severe disability. Here in we report a case of a bilateral below knee amputation and cervical SCI patient.

AIM

To report multidisciplinary approach and outcomes of a patient with bilateral amputation and incomplete cervical spinal cord injury due to electrical injury.

METHOD

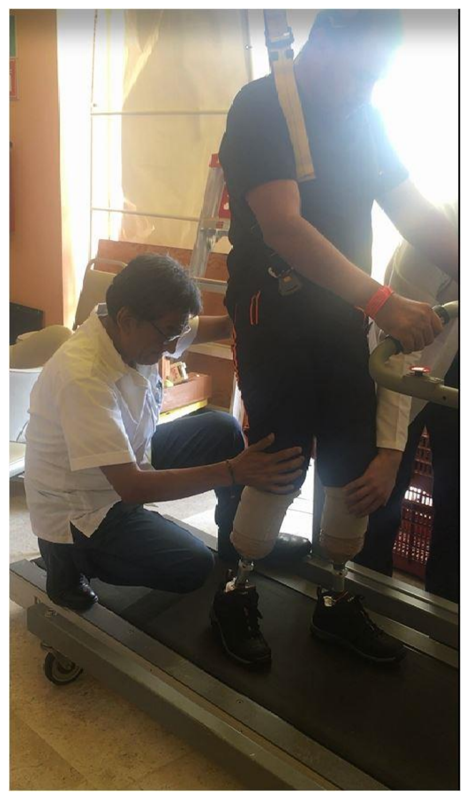
A 34 year-old male, construction worker with no comorbidities, suffers electrical burn with head entrance and bilateral foot exit, presents scalp and distal legs necrosis requiring thigh musculocutaneous flap for scalp reconstruction and bilateral below knee amputation. He had tetraplegia and sensory impairment, with normal magnetic resonance image (MRI), C4 SCI ASIA C was diagnosed. He was dependent for all activities of daily living (ADL), using wheelchair. Eye surgery for bilateral electric cataract was performed.

RESULTS

Inpatient rehabilitation program was conducted to improve mobility and strength, ADL, neurogenic bowel and bladder management, psychological and nutrition support. Spasticity was treated with oral baclofen, botulinum toxin in hamstrings and adductor muscles, and physical therapy.

Once stump management and SCI rehabilitation program were completed, prostheses were fitted with Kondylen Bettung Münster sockets, pelite inner sockets and SACH feet. He underwent partial weight-supported treadmill gait training to improve balance and walking ability, with further parallel bars and walker use.

Nowadays he has a Walking Index for Spinal Cord Injury II (WISCI II) of 6, being a community ambulator using bilateral prostheses and a walker, is independent for all ADL, scoring 79 in the Spinal Cord Independence Measure III (SCIM III), with normal bladder and bowel management.



DISCUSSION AND CONCLUSION

Prosthetic fitting is a challenge in SCI patients due to impaired sensation and motor control. Well fitted and comfortable prosthesis allowing independent donning and doffing should be assured for successful ambulation[3].

Electrical injury can potentially cause multiple complications with significant functional limitations. Interdisciplinary approach and early rehabilitation are essential to obtain a favorable outcome in patients with multiple disabilities.

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Poster: Training and therapy

6.67 Neuromotus for Phantom Limb Pain - does it work?

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BACKGROUND
It is estimated that phantom limb pain (PLP) affects between 60-80% of amputees. Scientific understanding of the phenomena is still a work in progress and the most common method of treatment centres around pharmaceuticals with limited success. Recent research has investigated the use of augmented reality as an advanced version of mirror therapy to control PLP and is further expanding to utilise the remaining musculature in the amputated stump to facilitate neuroplasticity through myoelectric pattern recognition and computer-based gaming.

AIM
Neuromotus is a unique and innovative technology based on phantom motor execution. The treatment aims to reduce phantom pain by utilising actual phantom movement and augmented reality to enhance neuroplasticity in the brain and decrease painful stimuli.

METHOD
5 male clients, between 34 and 73, completed treatment at an amputee specialist outpatient clinic. 3 clients had transtibial amputations and 2 were transfemoral. Surface electrodes were placed on the remaining stump and clients were instructed to move the phantom limb seen on the screen by contracting the muscles within their stump. To progress, clients were then instructed to use their phantom limb to play computer games and different joint movements were practised as phantom control improved. Sessions stopped when a client lost the ability to control their phantom limb due to fatigue. Outcome measures were recorded at the start, every second session and finish of the treatment programme.

RESULTS
Results were taken from the inbuilt questionnaire in the neuromotus software completed at least 4 times during training.

On a numerical rating score out of 10, average pain scores improved by 1.6 marks. 3/5 clients had an improvement with 2 of them seeing an overall improvement of 4 marks.

Clients chose a pain descriptor word. Two clients had an improvement with the most significant change being from ‘terrible’ to ‘moderate’.

The interference of phantom limb pain in daily living improved by 1.4 marks on a scale out of 10 with 0 being no interference and 10 being complete interference. 2 clients saw an improvement of at least 3 marks.

The biggest change was seen in sleep with 3 clients improving. On average scores improved by 2.8 marks with 2 clients changing from 8 (significant interference) to 2 (minimal interference).

DISCUSSION AND CONCLUSION
The results indicate that although neuromotus does not fully resolve phantom limb pain, it does help reduce the severity and intensity of symptoms felt and can significantly improve sleep quality. Our study group was very small and therefore the results cannot be generalised for the amputee population as a whole however, we feel this is a positive start and one that should be investigated further to provide amputees with a non-pharmacological treatment option for phantom limb pain.

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Posters: Gait and balance

6.68 Pelvis kinematics and the muscle activation pattern of the lumbar-erector-spinae and the rectus-abdominal during functional tests in people with lower-limb-amputation.

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BACKGROUND
Low back pain (LBP) is a common secondary disorder after amputations. Unilateral lower-limb-amputees (LLA) modify their movements and should adapt to new gait conditions, preferring the use of the contralateral limb with an asymmetrical movement of the pelvis. Back muscles compensate for these asymmetries and may lead to LBP. Previous works had studied the muscle activation pattern during walking, sit-to-stand and on unstable sit tests [1-5].

AIM
To compare the pelvis kinematics and the muscles activation pattern of the lumbar erector spinae and the rectus abdominal during functional test in people with and without a lower limb amputation.

METHOD
10 LLA and 10 non-amputees (NA) were studied. The participants were asked to answer the Oswestry questionnaire and later were instructed to walk through 7 m, to perform the Timed-Up-and-Go Test (TUG). After that the TUG they were asked to stand in an orthostatic position for 30 seconds. General tempo-spatial parameters of gait and kinetics of the pelvis were measured with an IMU (G-Sensor). The muscles activation was recorded with electromyography EMG (FreeEMG) bilaterally from the lumbar erector spinae (LES) and the rectus abdominal (RAB). The stabilometric data were collected by using the baropodometric platform P-Wlak. All participants signed the informed consent letter.

RESULTS
The participants were 40±16 years of age. There was no correlation between Oswestry disability index and results of functional tests. The higher TUG test score (14.9±3.7 s) the higher the elliptical area of the center of pressure (COP) trajectory (sway area) (150.4±220 mm2) was observed ($r=0.655$, $p<0.05$). The global symmetry index of the gait (5.39±5.93) was also higher while the TUG increased ($r=0.702$, $p<0.01$). The LES activity was higher than RAB for all tasks and it was greater during stand-up task of TUG test (Filtered RMS envelope, 61.11±54.3 mV and 65.7±38.6 mV, right and left side respectively). The amplitude of muscle activation increased with the increment of TUG test ($p<0.05$). The pelvis tilt was higher in LLA compared with NA, ($p<0.01$).

DISCUSSION AND CONCLUSION
No patient had fall risk according to the score of TUG test. Transtibial amputees (TTA) showed similar sway area respect to NA. However, LLA showed higher LES muscles activation than NA. Results confirm the higher asymmetry of the global index of gait, anterior pelvis tilt and the higher of muscles activation in the prosthetic side. Further participants should be analysed in future to increase the quality of the results.

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6.69 SenseBal - a protocol to investigate the relationship between residual limb sensitivity and balance in people with a trans tibial amputation

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BACKGROUND

A trans tibial amputation (TTA) leads to changes in sensory information, as those were previously obtained via the natural foot. Moreover, it has been shown that about 50% of those with a lower limb amputation fall once and more than 1/3 fall at least twice within one year [1]. The residual limb acts as direct contact to the prosthesis and takes over essential sensory functions [2,3].

AIM

In this pilot study, the relationship between residual limb sensitivity and balance is planned to be examined.

METHOD

A “Rydell-Seifer" tuning fork is used to determine depth sensitivities (Fig.1A&B). Surface sensitivity is recorded via monofilaments (Fig.1C)., whereby filaments of different thicknesses are applied to the residual limb (Fig.1A). Sensitivity measures of the unaffected side and data of unimpaired people are used as a reference. Dynamic balance is evaluated by the following tests: Functional Reach, Four Square Step, Narrowing Beam Walking as well as BALEVA (acronym for Balance Evaluation). During BALEVA the person control their centre of pressure to target points [4]. Static balance is determined by the medio-lateral and anterior-posterior deflection of the CoP while standing (eyes open/closed, soft/normal surface) on force-plates.

RESULTS

In this planned cross-sectional study, persons with TTA at least 6 months after amputation, with well-fitting prosthetic socket and unimpaired reference subjects will be examined. We opt to recruit N= 10-15 per group. Monotonic correlations between the ratio-scaled variables of balance and the ordinal-scaled variables of sensitivity are to be tested by Spearman rank correlation. Non-parametric statistics will be used to determine whether discrete values differ between groups.

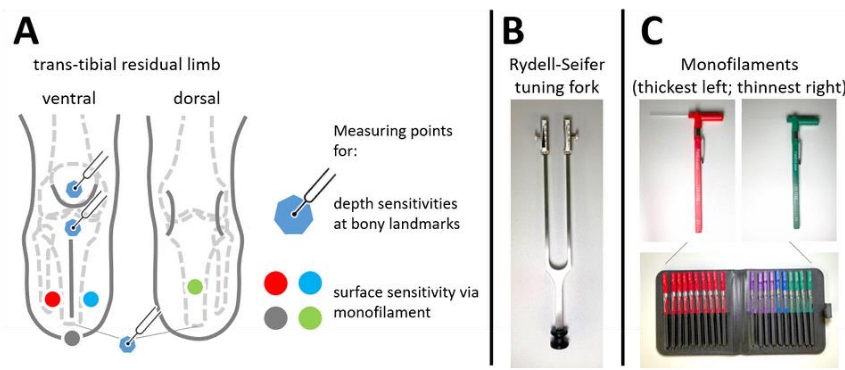

Figure 1: (A) Measuring points on the residual limb of people with a trans tibial amputation (TTA), with the “Rydell-Seifer" tuning fork (B) and monofilaments (C)

DISCUSSION AND CONCLUSION

Studies already showed that altered residual limb sensitivity influences balance [2,3]. Yet, these studies included people with TTA after vascular insufficiency and some with diabetes mellitus. This limits the significance of these studies, as polyneuropathy could contribute to changes in sensitivity as a confounding factor. Here, only persons with a traumatic or tumour-related amputation will be included to exclude possible sensitivity disorders due to concomitant diseases. It is expected that reduced residual limb sensitivity is associated with worsened balance.

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Posters: Sports and physical activity

6.70 Experiences and impact of mobility training for people with limb loss.

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BACKGROUND
Mobility following amputation is reduced and people with limb loss are often discharged from rehabilitation programs with some degree of mobility limitation [1]. Mobility clinics are designed to extend gait and mobility training beyond rehabilitation programs. Research into participants’ experiences of these multidisciplinary, experience-based, clinics is limited to a single study based in a single country. Research is needed to ensure clinics meet intended goals, including understanding the motivation and experience of attendees and the impacts of training.

AIM
To explore the experiences of people with limb loss attending mobility clinics, and the perceived impacts of mobility training on daily living.

METHOD
Approach: Grounded within a constructivist epistemology, this exploratory and inductive qualitative study utilises semi-structured interviews and thematic content analysis to investigate the experiences of people with limb loss at mobility clinics.

Data is collected via individual, in-depth interviews of ten adults who have attended mobility clinics across Australia, the United States of America and South Africa. Topics for exploration the experience of the clinic, the barriers and facilitators to attendance and participation and the longer-term impacts of the clinic from the peer understanding, education and physical training perspectives.

Data is presently being collected and analysed concurrently, with two investigators undertaking coding and analysis using Braun and Clarke’s methods.

RESULTS
Results from this multinational study will be presented following the completion of thematic analysis of the data.

DISCUSSION AND CONCLUSION
Gait training for people following LLA is often limited, occurs within a short time frame from amputation and is focused on basic mobility skills, such as walking in a straight line, standing from a seated position and stepping up stairs. Higher-level training that improves a person's confidence and skill are likely to have impacts beyond improved physical ability and impact on other aspects of daily life, community participation and potentially a person's perception of themself.

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6.71 Use of mobile application to guide and record the performance of physical exercises of the patients with adolescent idiopathic scoliosis

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BACKGROUND

Though physical exercise intervention for adolescent idiopathic scoliosis (AIS) has been introduced for more than 80 years [1], its effectiveness is still controversial. The main issue to be addressed is how to monitor and record compliance reliably. A previous study [2] found that group exercise may enhance the adherence of doing physical exercises, but no comprehensive studies have been conducted to compare the compliance between the individual and group physical exercises in the patients with AIS.

AIM

This study aimed a) to apply an AI-based exercise mobile application to guide and record the physical exercises done by the patients with AIS; and b) to compare the compliance between the individual and group physical exercises.

METHOD

The target population for this prospective study was those with AIS and accepted orthosis treatment who met the inclusion criteria from the SOSORT [3] and SRS [4]. All the participants have been prescribed the exercise programme under the physiotherapist's guidance. They were randomly divided into two groups (individual exercises and group exercises). An AI mobile application that uses image recognition in the selfie camera to guide the users doing the exercises, was applied to monitor the compliance of doing physical exercises. Compliance assessments included the quality and the quantity of doing physical exercises.

RESULTS

In the first month as an adaptation period, the patients were prescribed to perform 10-minute exercises three days per week. In this study, the patients who exercised in group had higher compliance rate than those who exercised alone, with the mean compliance rate of 0.46 and 0.39, respectively. However, a few patients were still reluctant to do exercises under the group arrangement. For the individual exercise group, the compliance of the males was lower than that of females, while there was no significant difference in the compliance between the males and females under the group exercise. This preliminary study will be continued with larger sample size, and the treatment effects, including scoliosis progression, spine mobility, muscle function and quality of life, will be evaluated in the following treatment period. More data will be shared by the time of the conference.

DISCUSSION AND CONCLUSION

This study observed that the patients who accepted exercises in a group showed higher compliance than those doing exercises on their own. Group exercises may enhance adherence to physical exercise, psychological aspects, and social interactions. With the assistance of the AI application, the quality and quantity of the home exercises can be recorded and tracked, which provides a new and useful means for monitoring the physical exercises in the patients with AIS.

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6.72 Improving Access to Sports and Leisure for People with Balance Issues

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BACKGROUND
Frame-runners are an adaptive mobility device that is propelled using the feet (not pedalled) and steered using the hands and/or arms. They open up participation in sport and leisure activities for millions of people with balance or certain mobility issues. However, current frame-runners typically cost more than US$2,000 and are reported as uncomfortable, difficult to transport, and hard to tailor for multiple users in sports clubs.

AIM
Improve health and wellbeing through participation in track sport, walking, hiking and other activities by developing a globally available, comfortable, customisable and affordable frame-runner.

METHOD
Working closely with sports clubs and other potential users of the frame-runner, work is underway to design key components: chassis, saddle and pads.

The working prototype will be used to solicit user feedback and refine the design, leading to full-scale manufacturing. In parallel, work is underway with sports federations and clubs to increase participation and help support frame-running's journey to become a Paralympic sport, and to reach out to a wider audience of people who could use the device in a broad range of leisure activities.

RESULTS

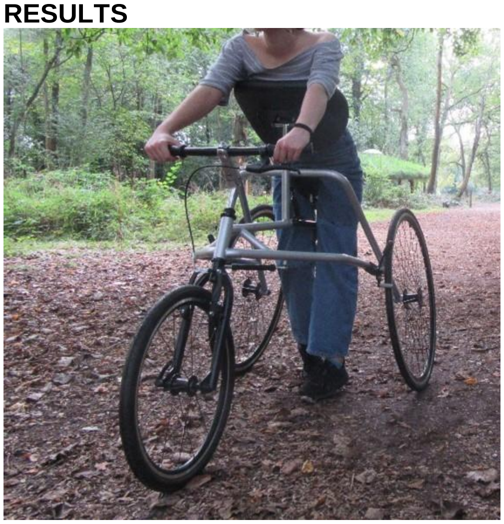

Figure 1. The initial frame runner design, which will be modified significantly as the project progresses

DISCUSSION AND CONCLUSION
Globally, tens of millions of people live with conditions such as cerebral palsy, stroke and spina bifida that can limit their mobility. An affordable frame runner that can be easily personalised and transported would increase people's opportunities to enjoy and benefit from a wide range of exercise and leisure activities.

ACKNOWLEDGEMENTS We gratefully acknowledge support of RERC RecTech, National Institute on Disability, Independent Living and Rehabilitation Research (Grant number 90REGE0019).

6.73 Improving Physical Function and Quality of Life of Transtibial Amputee using a Fitness Application

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BACKGROUND
Amputation of the limbs has been reported to be a significantly stressful event for an individual. Prosthetics comes in to supply for the loss of limbs and enable an amputee individual to regain autonomy and become independent. But, in order to fully enjoy one's prosthesis, physical strength and well-being play an important role. Many "home" solutions are available nowadays, low-cost, but are not well known in low-middle-income countries. Some of these solutions are fitness applications specifically designed for amputees.

AIM
The aim of this study is to show how transtibial amputees' physical function and quality of life could be improved by a physical exercise program using a fitness application.

METHOD
Our study is an experimental study conducted in Lomé in 2022. Two transtibial amputees were involved. Initial clinical and quality of life assessments and special tests were conducted on participants, after which they underwent a daily fitness program based on Ottobock Fitness application for three weeks. After the intervention, a second clinical and quality of life assessments and special tests was performed on participants for comparison with the initial tests. The outcome measures that were used are Oxford manual muscle test scale, Timed Up and go, 2MWT, Single leg stance test, and EQ-5D-5L to assess endurance and strength, balance and coordination as well as the quality of life.

RESULTS
The patients' physical function and well-being improved after the fitness exercises. The improvement is clearly seen in the tables and graphs below:

- Figure 1: General characteristics
- Figure 2: Manual Muscle Test
- Figure 3: Other tests
- Figure 4: EQ-5D-5L patient 1
- Figure 5: EQ-5D-5L patient 2

DISCUSSION AND CONCLUSION
The findings give evidence that the participants physical function and quality of life improved even though it was not systematic over all the different outcomes. Rehabilitation centres and professionals should promote and encourage amputees to do fitness exercises whether they are already fitted with a prosthesis or not yet. And amputees themselves should be concerned about their health and quality of life, engage in physical activity and avoid sedentarism.

Posters: Device fabrication and design

6.74 Design and Clinical Evaluation of a Hip Prosthesis Simulator: A Pilot Study

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BACKGROUND

People with a limb loss at the level of the hip or pelvis have the most difficulty returning to walking compared to those with a lower amputation. Prosthesis simulators provide a real-life prosthetic experience to researchers who design such components and provide a testing platform for new research and development innovations.

AIM

The objective of this study was to build and evaluate a device that allows able-bodied individuals to walk with a hip disarticulation prosthesis.

METHOD

software to connect the prosthetic components to this orthosis. This adapter was mechanically tested using an INSTRON machine (68TM-50). To use the simulator, the leg on the prosthetic side is off the ground, since a 4 cm shoe sole is worn on the contralateral limb (i.e., increasing leg length). After ethics approval, three able-bodied individuals from the research team with an average weight of 85.3 (SD = 9.1) kg, height of 174.6 (SD = 4.9) cm, and age of 30.7 (SD = 11.6) years volunteered to perform the 2-Minute Walk Test and L Test with and without the hip simulator.

RESULTS

The hip prosthesis simulator allowed frontal, lateral, or distal mounting of different prosthetic hip joints. The simulator does not require a customized socket and can be used by any able-bodied individual after size and alignment adjustments have been made. Mechanical testing confirmed that the designed adapter can withstand forces and moments experienced during ambulation. Participants took between 4 and 8 1-hour sessions to walk safely with the simulator, with all participants using a cane. The average 2MWT results were 39.3 (SD = 4.6) meters when using the hip simulator compared to 171.6 (SD = 20.5) meters without the simulator. Moreover, participants completed the L-test in 70.7 (SD = 5.4) seconds compared to 16.0 (SD = 3.6) seconds when walking without the simulator.

Figure 1: Hip prosthesis simulator using an off-the-shelf hip abduction orthosis and an adjustable adapter.

DISCUSSION AND CONCLUSION

This simulator is believed to be capable of assisting researchers and rehabilitation practitioners in experiencing the use of hip-level prostheses. In future research, this device will be evaluated on a larger sample of able-bodied individuals.

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ACKNOWLEDGEMENTS The authors would like to thank Ossur and AMPOS clinic for providing the prosthetic components and materials.

6.75 Additive Manufacture in Orthotics and Prosthetics

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BACKGROUND

Since the 1980s, Additive Manufacturing (AM) technology has emerged in different fields. It has been adopted in P&O to address the challenges faced with traditional manufacturing and respond to the tremendous increased demand for P&O services by improving the manufacturing technology, components, and materials used during fabrication of these devices to meet with society needs. The term AM covers a broad range of rapidly emerging technologies; selecting the most appropriate for a particular application is not a straightforward task.

AIM

This study involves identifying, categorizing, and reviewing technologies that are currently in use or have the potential to be used in orthotic or prosthetic manufacture, to recommend policies that healthcare providers could adopt.

METHOD

This study has followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) format [1]. It did not include all components typically included in a systematic review but has followed the general structure where possible and applicable. Only limited to studies written in the English language, a thorough electronic search was carried out across three databases: Pubmed, Scopus, and Google Scholar. Studies published from 1980 up to April 2021 were searched using relevant keywords and various combinations. The quality of studies was assessed using the Critical Appraisal Skills Programme.

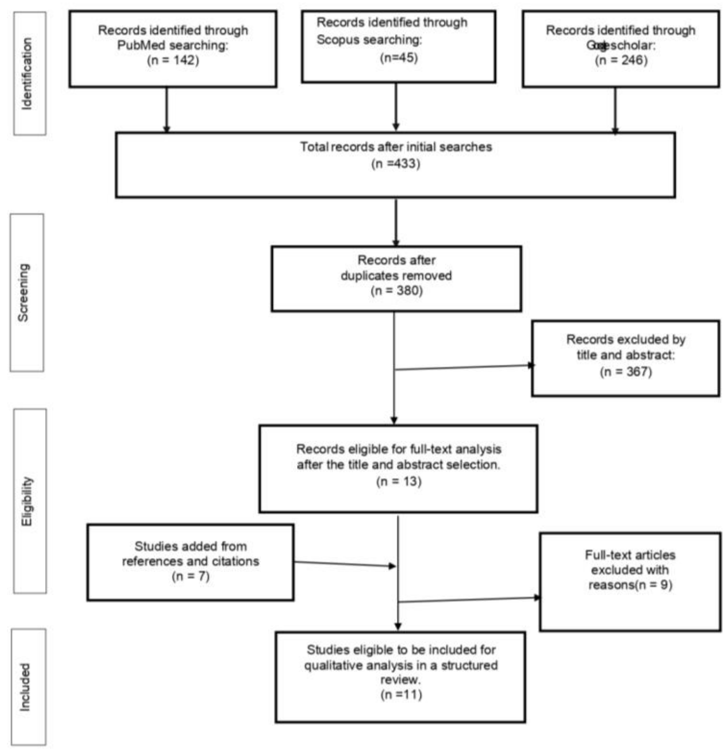

Figure: Results of the search strategy presented in a PRISMA flow chart.

RESULTS

433 studies were identified from the selected databases plus seven other studies from citations. After a thorough screening, only thirteen potentially eligible studies were found for full-text analysis, and there were seven other papers from references and review citations. Of these 20 papers, nine were found not to meet the inclusion criteria described in the methodology.

DISCUSSION AND CONCLUSION

AM can be the potential manufacturing technique in the P&O sector as it offers a wide range of flexibility for patients and clinicians. In the P&O, the most used AM are SLS, SLA, and FDM; SLS and SLA give better results. Although AM has great potential, there are challenges regarding regulatory and safety. Local professional bodies must ensure the quality of produced P&O devices and have to set who is eligible to produce these devices.

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6.76 Residuum Health of Individuals Suffering from Limb Absence: Opportunities and Challenges to Design the Next-generation Diagnosis Devices

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BACKGROUND

Individuals suffering from limb absence frequently experience neurological phantom and residuum pain, as well as neuromusculoskeletal disfunctions susceptible to compromise their residuum health [1]. Care providers have limited ways to diagnose these disfunctions, particularly when using the prosthesis during daily living [2]. There is a need for wearable and non-invasive diagnostic devices that can assist care providers to better assess and maintain residuum health by establishing the pathophysiological cause-and-effect relationship between prosthetic care interventions and residuum neuromusculoskeletal dysfunctions [3].

AIM

This study outlines opportunities and challenges to the development of the next generation of diagnostic devices [2-4]. The specific objectives were to inform the identification, invention, and implementation phases of the Biodesign innovation process specific to diagnostic devices.

METHOD

This narrative review summarized first-hand observations, grey literature, and peer-reviewed publications. We included over 30 publications focusing on the assessments of residuum neuromusculoskeletal dysfunctions associated with mechanical constraints applied on the skin and topography of the tissues within the residuum as well as computational modelling of the residuum published between 2000 and 2021. We subjectively evaluated the invasiveness, comprehensiveness, and practicality of each technology deemed appropriate to be integrated into the next-generation diagnostic devices.

RESULTS

Our assessments of these technologies suggested that it will be feasible and worthwhile to develop user-friendly diagnostic devices that could be used safely, efficiently, and routinely by qualified clinicians at critical points of care. However, future novel diagnostic devices will have to overcome the current significant barriers associated with design (e.g., loading measurements, topography of residuum tissues during real-life activities, and computational modelling, gaps between technology readiness levels of essential parts), clinical roll-out (e.g., identification of primary user), and commercialisation (e.g., limited interest from investors inherent to niche market). Future diagnostic devices supporting the management of limb loss must sustain personalized evidence-based prosthetic care, patient empowerment and development of bionic solutions, whilst positively disrupting the organisation of healthcare by enabling cost-utility analyses required by fee-for-device business models and addressing healthcare gaps due to labour shortages.

DISCUSSION AND CONCLUSION

The selection of studies was biased toward systematic reviews and secondary selection of specific articles. We overlooked the strength of the methodology, level of evidence and recommendations of the selected studies. The appraisal of the potential contributions of a particular device was subjective. Nonetheless, we anticipate that the next-generation diagnostic devices will play a key role in bionic innovations that will safely increase mobility and quality of life of the growing population of individuals suffering from limb loss.

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6.77 Dogs Orthosis Guide for Novice: A Technical Note

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BACKGROUND

The history and evolution of human prosthetics and orthotics began for a long time to help people overcome obstacles in mobility to have a better quality of life. While the history and evolution of veterinary-orthotic and prosthetic has been vague and there is little academic information talking about it.

AIM

The present paper aimed to present a dogs orthosis guide for novice orthotists and veterinarians, describing casting, fabrication, fitting and evaluation including indication guide and take-home message.

METHOD

In order to provide a comprehensive dogs orthosis guide to novice orthotists and veterinarians interested in making orthosis devices for animals, the entire workflow from 21 cases with 26 devices is reported, consisting of general information, prescription and design, gait deviation photo, necessary tools for assessment and casting, fabrication and material selection, fitting procedure and essential rehabilitation with veterinarian after receiving the orthosis.

RESULTS

The paper showed an initial assessment and casting part which included necessary tools, position and alignment with three differences in design. (Figure 1) Fabrication process and material using rust-proof for the dog that needs the hydrotherapy. Moreover, the fitting and delivery section have issues that need to be concerned.

Figure 1. (Left) Assessment with a puddle dog. (Center) Casting with a chihuahua dog. (Right) Fitting with a Thai Bangkaew dog.

DISCUSSION AND CONCLUSION

The whole steps for making a veterinary-orthosis are described for orthotists and veterinarians who are interested in the way to improve the quality of life in terms of preventing further deformities, immobilizing and enhancing gait deviation by using orthotics knowledge. This guideline is a fundamental of veterinary-orthotic which has to be developed and there is a standard theory using outcome measurements and gait analysis etc. to know how effective and improve the quality of the dog's life.

6.78 Comparison of the mechanical strength of ankle joints Tamarack, Oklahoma with the custom made-overlapping ankle joint in AFO

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BACKGROUND
There are many ankle joints in used in AFO. Many of them are expensive and many people using in high-income countries while low-income countries cannot afford them. To overcome this situation orthotics and prosthetics clinic in Siriraj hospital using custom made articulating (overlapping joint) from local material which is cheap and affordable for patients. For this custom made AFO, there is no study done on mechanical strength, so we would like to test the mechanical strength of it.

AIM
To compare the mechanical strength of the different ankle joints. Tamarack dorsiflexion, Oklahoma with the custom made AFO overlapping ankle joints.

METHOD
Same positive model was used to fabricate all six AFOs to maintain the test standard and then same thickness (5mm polypropylene) plastic was used to fabricate all AFO.

We used the machine which is using for testing the Sach foot durability test.

After fitting AFO in the machine and keep all the parameter in the machine same for all AFOs than we find out durability for each AFO joint by comparing the cycles that these joints can resist until it broke or deformation occur in it, the force which we adjust was the minimum force (0.500KN=50.98KG) in the machine which was required to operate ankle joint in that machine.

RESULTS
As the average of the test result showed that the Tamarack joint resist the force till 11 cycles similarly Oklahoma joint resist till 5 cycles whereas the overlapping joint worked till 52 cycles without any breakage or damage at the joint. The force and other parameters in the machine were the same for all testing AFOs.

So, with this test result we can conclude that the overlapping joint has about 5 times more strength to resist the force provided than the Tamarack and about 10 times than Oklahoma joint.

The mechanical strength of AFO using overlapping joint is more than the tamarack dorsiflexion and Oklahoma ankle joints.

DISCUSSION AND CONCLUSION
The result of our testing with 2 set of AFOs for each joint, this result might have some error. we saw the result of Tamarack in 1st set it took 17 cycles whereas in 2nd set in 5 cycle it broke. We used minimum forces that we can give to AFO to operate ankle motion from that machine,

In our opinion, further research is needed to test the strength of AFO with more than 20 sets of AFO.

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ACKNOWLEDGEMENTS We also would also like to thank Mr. William C. Neumann for his early involvement in our research.

6.79 A mechatronic device for proprioception replacement in prosthesis users

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BACKGROUND
The loss of a limb implies a whole rehabilitation process in addition to the design and adaptation of the prosthesis, in such a way that a prosthesis user must adapt to new mechanical elements, however the issue of replacing the lost sensitivity has been little addressed.

AIM
Design a mechatronic device adaptable to any prosthesis so that the patient can perceive certain nervous stimuli that helps to recover proprioception feedback useful during the rehabilitation process.

METHOD
The user-centred design method has been used to find a solution to the problem of proprioceptive sensitivity substitution, which involves not only the patient but also the rehabilitation therapist and orthotists and prosthetists. Interviews are essential to determine the needs and requirements of the device, also the translation to specifications must be made in order to obtain conceptual design solutions for the device. Also tests of performance must be made in volunteer patients.

RESULTS
The basic needs for the device have been obtained, of which the following stand out: lightness of the elements, flexibility of the cables, battery life, customization of the intensity of the stimuli, and that it does not affect the alignment or adaptation of the prosthesis. A design of a mechatronic system has been proposed that consists of a microcontroller that has the algorithm controlling the intensity of a vibratory stimulus proportional to the amount of pressure exerted on a sensor located in an external area of the prosthesis. A prototype has been tested on a transfemoral prosthetic user.

DISCUSSION AND CONCLUSION
This work shows the collaboration of a multidisciplinary team to design a system capable of providing new proprioceptive information useful in the rehabilitation of patients with amputation.

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6.80 Fabrication of Prostheses and Orthoses Components using Indigenous Technology in Developing Countries

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BACKGROUND
By means of experimentation and innovative thinking relying on available intellectual literature and online audio-visual teaching-aids, the fabrication of some of these Prostheses and Orthoses components is achieved in Nigeria using indigenous technology, hands-on skills and technical know-how. Attempts are also made to improve on them by subjecting samples of made components to Quality testing and life span testing procedures of repetitive cyclic mechanical loading. Knowledge of materials technology in conjunction with acquiring well-grounded technical hands-on skills is also essential.

AIM
i) Indigenous fabrication of Prostheses and Orthoses components in developing countries is essential for affordable and accessible rehabilitation health care; ii) Prosthetics and Orthotics education in developing countries emphasis on indigenous components fabrication is essential.

METHOD
The experimentation and innovative thinking conducted is based on information provided by available intellectual literature and online instructional audio-visuals. The mass, physical configuration and dimensional mensuration of standard components from OttoBock, Proted and other Prostheses and Orthoses components manufacturers were documented and a range of materials, procedures, stages and technical skills were involved in fabricating two passive terminal devices of different materials among other components. One of the fabricated terminal devices is made of silicone, moulded in a die formed from donor hand and imbedded with a metal frame and light stuffing. While second terminal device is made of layers of measured macro-cellular rubber sculpted based on donor hand.

RESULTS
Passive hand fabrication guide values and glove moulding guide values were utilised in comparison to the outcome of the fabricated hand and glove. Comparative measurement values were deduced between donor hand and fabricated hand and glove. Comparison of measured values of standardized passive terminal devices and locally fabricated devices is also done for analysis purpose. Observations from the results obtained includes: i) the comparative difference of dimensional values of donor hand and the fabricated hand and glove is zero (0); ii) the comparative difference of dimensional values of the standardized passive terminal device and the fabricated hand is zero (0); iii) the moulded silicone passive terminal device boldly depicted the palmar crease and real-like skin markings with a humanoid pigmentation and has no moving parts; iv) the sculpted macro-cellular rubber passive terminal device has no palmar crease impression.

DISCUSSION AND CONCLUSION
Dimensional comparative difference value of zero (0) is an indication that custom sculpted terminal much more satisfactory of individual amputee cosmesis of a complete real-like hand [1]. Weight differences observed is an indicate that silicone moulded hand is negligibly heavier than OttoBock system hand while Becker plylite hand is negligibly heavier than sculpted macro-cellular rubber hand respectively, agreeing with Belter et al. [2] that minimizing weight in general is vital.

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Posters: Healthcare policy and services

6.81 Revision of the Basic Manufacturing Method for postural support devices in the Japanese public funding system: A preliminary study

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BACKGROUND

Since 1950, Japan has been providing prosthetic limbs and wheelchairs to people who are physically handicapped as public welfare services. In 1990, postural support devices (PSDs) were added to that service. At that time, in Japan, PSDs were regarded as custom-made wooden chairs used for postural support. Therefore, a cost calculation method based on a series of anticipated fabrication processes, known as the Basic Manufacturing Method (Table 1), was introduced and is still in use in 2022.

AIM

Recently, several new technologies, such as modules and CAD/CAM, have been used, raising doubts about the validity the Basic Manufacturing Methods. This study clarifies how PSDs are currently provided in Japan to analyze the Basic Manufacturing Method.

METHOD

Interviews were conducted with domestic manufacturers' organizations and stakeholders to gather information on recent actual manufacturing processes. Additionally, based on government statistics [1], we investigated the public funding of PSDs over 16 years from FY2005 to FY2020.

RESULTS

Based on an analysis of the actual process, it was confirmed that the positive models anticipated in the basic method were not always produced. Because of the modularization of related products, body dimensions were measured and modules were widely used according to the PSD method of construction. In FY2020, 9,415 new cases of PSDs were provided by public funding systems, at a total cost of approximately 3.6 billion yen (USD 25M) or about 382,000 yen (USD 2,653) per case. The annual trends showed a slight decrease in the number of payments and a slight increase in the total cost.

Table 1. Basic Manufacturing Method in Japan's public funding system for postural support devices

Process	Work content	Facility
Observation and evaluation of physical conditions	Observation of body deformation, spasticity, tension, involuntary movement, etc., and understanding these characteristics, determination of posture, and confirmation of purpose.	
Taking measurements	Measurement of dimensions and angles required for production and recording on information cards.	
Casting	Taking a positive model with a molder or a negative model with a plaster cast.	Molder
Blueprint creation	Creation of blueprints necessary for production.	
Production and modification of positive models	Casting casts on negative models and fabrication, modification, and surface finishing of negative models required for fabrication of supports.	
Processing/assembly	Processing and assembly based on positive models and blueprints.	
Temporary fitting (intermediate conformity inspection)	Inspection and modification of fit to the body and each function of the device.	
Finish	Installation and finishing of each part	Sewing machine
Conformity inspection	Final body fit and inspection of each function of the device.	

DISCUSSION AND CONCLUSION

Because the non-fabrication of positive models is becoming increasingly widespread, it is necessary to clarify the actual fabrication status and revise the cost calculation method to accommodate this situation. As this study is a preliminary investigation based on interviews with relevant parties, further investigation, including confirmation with individual operators, is needed.

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ACKNOWLEDGEMENTS This study was supported by JSPS KAKENHI 22K01971.

6.82 Lack of Educational Opportunities and Trained Prosthetic Professionals: the impact on Rehabilitation of Amputees in Mexico!

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BACKGROUND

The National Institute of Statistics and Geography (INEGI)(1) reported 779,967 amputees in the 2010 census. The Academy of Surgery estimates this number increases by 50 people per day(2). Rapidly increasing diabetes and obesity rates contribute to rising amputation numbers. To meet this significant rehabilitation needs of amputees in Mexico, there are currently 300 technicians and 150 professionals. Additionally, the country has only one program for the educating and training future prosthetists, a Bachelor's program offered at UNAM.

AIM

Awareness within the International Prosthetic and Orthotic community must be increased in order to address the profound shortage of trained Mexican prosthetic professionals and degreed programs.

METHOD

Statistical data was collected on current estimated numbers of amputees (National Institute of statistics and Geography) as well as the rate of daily amputation (Academy of Surgery) as a comparison to the number of available prosthetic professionals to meet the growing rehabilitation needs of amputees.

RESULTS

An evaluation of information available in Mexico, highlights the following problems:

- The growing number of people lacking one or several limbs was estimated to be 779,967 in 2010 and has grown at an average rate of 50 amputations a day. It can be assumed that currently the number of amputees reaches 900,000 in Mexico
- The number of technicians and professionals available to provide the required rehabilitation services is inadequate
- A single university offering a degree in Orthotics and Prosthetics in not sufficient to meet the need of the community.

DISCUSSION AND CONCLUSION

CRIMAL is a non-profit institution serving amputees with limited economic resources for 30 years. It has been determined that the best outcomes are obtained when the patient receives comprehensive treatment:

- Specific medical treatment
- Psychological assessment and treatment
- Nutritional recommendations
- Pre, trans and post prosthetic physiotherapy
- Design, manufacture and adjustment of the appropriate prosthesis for each patient.

It is essential to create more institutions that, filling out the necessary curriculum, train the required number of professionals to satisfy the urgent need.

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Posters: Other topics

6.83 A Case Study of Child Right Lower Limb Congenital Proximal Femur Deficiency Rt Pffd 7 Years Old Child

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BACKGROUND

Proximal femoral focal deficiency is a complex birth defect in which the upper part of the femur bone is either malformed or missing, causing one leg to be shorter than the other. PFFD is common condition that affect a bone. *Genetic consultation at an age of 3 months observed a prominent forehead, midfacial hypoplasia with flat nasal bridge, hypertelorism, telecanthus and micrognathia. *Challenge we usually face is how we can provide children with a device that will help them practice normal healthy upbringing.

AIM

The aim of study is to develop a standard, light weight and cost-effective and performance of proper functional prosthesis for right lower limb to improve the gait pattern and reduce the load on left limb.

METHOD

Child was 7 years old. He was born with congenital both lower limb. Right lower limb is PFFD (Given that there is no femur) after surgery to fix tibia in pelvis. It was the same result can't use R lower limb in weight bearing. Therefore, the socket designs as a hip disarticulation. Conventional casting of stumps was done putting into consideration pressure points, techniques necessary for performing a socket. (Included the congenital limb). A total embracing socket is made by making a plaster cast of individual's pelvis allowing socket to enclose the iliac crest(s) [1]. The socket will also contain abdominal and pelvic contents.

RESULTS

There are 2 main ways of casting for the socket, using forming blocks or total contact casting. Weight bearing within the socket is transferred to ischial tuberosity. used for suspension with upper edges of the socket grasping/locking over iliac crests. then plaster negative is removed, closing lateral and lower wall to get the plaster positive. After modification using lamination to get a hard socket (will need open a window in lateral side from right limb to allow the congenital limb pass it) after tasting the socket will installations upper part from artificial hip joint (made a local join to reduce the cost) using lamination. Complete prostheses by tube and feet. After training to get stability, we can use knee joint on same tube.

DISCUSSION AND CONCLUSION

The 7-year-old boy was at first able to stand unsupported using a walker, by the second week he was able to walk supported with two crutches. After training he will be able to walk without crutches. Difficulties are present just when attempting to rise from sitting position on the floor to standing position. There are no rules for different patients, each patient should be taken individually and device are tailored accordingly according to our biomechanical principles.

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6.84 Attitude of Prosthetic and Orthotic Students towards Person with Disabilities

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BACKGROUND

The prevalence of disability is considerably higher in low-income countries in contrast to higher income countries. According to a world report, about 80% of the disabled people live in low-income countries. In Pakistan, according to national censes 1998, about 2.38% of the population have disability problems [1]. Persons with disability (PWD) are facing various physical, social, political and economic challenges [2] and pathetic attitude is one of the most potential barriers faced by these people since long [3].

AIM

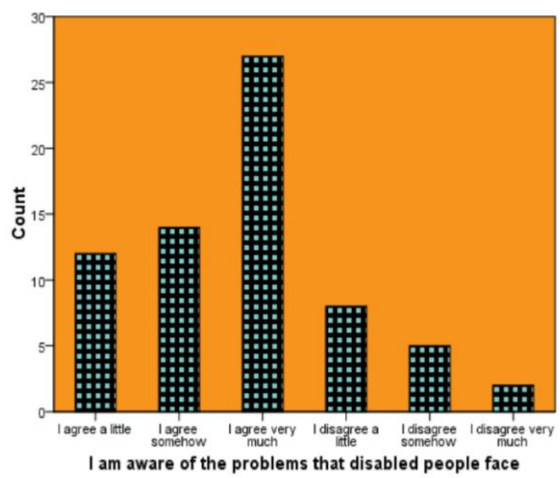
To determine the attitude of students of PIPOS (Pakistan Institute of Prosthetic and Orthotics Sciences) towards people with disabilities.

METHOD

The research strategy for this study was cross sectional survey. This study was conducted in a renowned Prosthetic and Orthotic School in Pakistan known as, Pakistan Institute of Prosthetic and Orthotic Sciences (PIPOS). For data collection census method were used to collect the data from the students of all semester which were 68. Out of 68 students 14 (21%) students were female and 54 (79%) students were male. The duration of the study was three months from September 2021 to November 2021.The data was analyzed by using SPSS (Statistical Package for Social Sciences version 21).

RESULTS

In this research total 68 students participated in which population of the students 60(88%) had positive attitude while rest of them 8(12%) had negative attitude towards people with disabilities. Mostly all the senior students show positive attitude i.e. semester 4th shows most positive attitude 89%, semester 8th shows second most positive response 88%, semester 6th shows positive response 86% and then semester 2nd shows positive response 80%. Overall attitude of the students was positive towards people with disabilities.



		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I agree a little	12	17.6	17.6	17.6
	I agree somehow	14	20.6	20.6	38.2
	I agree very much	27	39.7	39.7	77.9
	I disagree a little	8	11.8	11.8	89.7
	I disagree somehow	5	7.4	7.4	97.1
	I disagree very much	2	2.9	2.9	100.0
	Total	68	100.0	100.0	

DISCUSSION AND CONCLUSION

This study assesses the students attitude towards people with disability. In this research total 68 students participated in which population of the students 60 (88%) had positive attitude while rest of them 8 (12%) had negative attitude towards people with disabilities. Overall attitude towards the disability was positive whereas the most positive attitude was shown by senior students. Some juniors' students' shows a little negative attitude because they don't have much interaction with patients.

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6.85 Fitting and Rehabilitation in Right Hemipelvectomy and Left Peroneal Nerve Injury: Case Report.

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BACKGROUND

Hemipelvectomy is an injury with high morbidity and mortality rate, usually as a consequence of high energy trauma. It represents a great rehabilitation challenge with a low success rate due to biomechanical alterations and can add complexity if it is concomitant with a peripheral injury of the remaining limb such as peroneal nerve damage leading to foot drop.

AIM

We report the rehabilitation of a young patient with traumatic hemipelvectomy who also has contralateral peroneal nerve injury and drop foot. A modification of his current prosthesis was chosen, as well the formulation of an AFO for his foot drop.

METHOD

We report the rehabilitation of a young patient with traumatic hemipelvectomy who also has contralateral peroneal nerve injury and secondary drop foot. Given his recovery potential, it was decided to formulate a modular prosthesis for right hemipelvectomy type amputation with pelvic basket socket in resin with polypropylene endosocket with foam-rubber coating, monocentric hip joint with extension assistance, monocentric knee joint with load blocking and right sach type foot with foam and cosmetic stocking. A rigid ankle-foot orthosis (AFO) with a 90° neutral foot collar was also formulated for the left foot.

RESULTS

A right-sided fitting process was performed with left orthotic management instead of confining him to a self-propelled wheelchair.

A scope of rehabilitation and recovery of independence is evidenced by an independent gait with assistance by Canadian canes.

DISCUSSION AND CONCLUSION

Fitting in hemipelvectomy is difficult and most patients choose to use a wheelchair, mainly because of concomitant complications. Ankle-foot orthoses are an alternative for the management of foot drop due to peroneal nerve injury. The materials and extent of prosthetic and orthotic fitting depend on the patient's functional ability and determination to achieve independent walking.

Correct prosthetic fitting and control of associated complications secondary to other injuries will allow better rehabilitation and a higher level of independence and function.

6.86 Change of mechanical hip joint prosthetic system for hydraulic system in patient with chronic use of conventional system: case report.

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BACKGROUND

Hip disarticulations represent 0.5% of lower limb amputations [1], and the adjustment process becomes a challenge for rehabilitation medicine [2]. Prosthetic acceptance depends on discomfort in the socket, weight of the prosthesis, loss of mobility, instability and high energy consumption [3,5]. Proper selection of prosthetic components based on functional level and proper biomechanical alignment contribute to a functional gait pattern and energy savings.

AIM

To describe the mechanical advantage and energy savings in a hip disarticulated patient when exchanging a monocentric prosthetic hip joint with a hydraulic monoaxial knee component, for a hydraulic monoaxial hip joint and hydraulic polyaxial knee.

METHOD

A 50-year-old male patient, disarticulated left hip, with right sciatic nerve injury, who has been using a conventional Canadian-type hip prosthesis for 25 years, with a resin pelvic basket, monocentric mechanical hip joint, hydraulic monoaxial knee, dynamic carbon foot fiber (Fig.1). He was evaluated in joint prosthesis, finding a left stump with a healthy scar, palpable ischium, dropped right foot. On gait, prosthetic hip circumduction with poor hip flexion in swing phase is observed, compensating with pelvic retroversion. Due to the functional level of the K3 patient, it was decided to change the prosthetic system that provides better mechanical use and energy savings.

RESULTS

The patient attends the second prosthetic meeting in April 2022 to deliver the new prescribed prosthetic device, which consists of a hip disarticulation prosthesis with a carbon fiber pelvic basket, hydraulic monoaxial hip joint, hydraulic polyaxial knee, adapter 360° rotational knee pad, mid-profile Carbon fiber dynamic response foot (Fig. 2). Assessment of pelvic basket positioning and biomechanical alignment of joints, hip joint location inferiorly and anteriorly of the normal axis of the hip and articular axis of the knee with recurvatum, so that while the prosthesis supports weight, the load transmitted between the foot and the hip joint passes in front of the knee joint, ensuring stability (Fig.3).

Figure 1

Figure 2

Figure 3

DISCUSSION AND CONCLUSION

Monocentric hip joints have been the most widely used for prosthetic prescription, however, stability control is limited during stance and swing [2]. In contrast, a hydraulic prosthetic joint provides controlled resistance to movement during the stance and swing phase, allowing precise adaptation of step length, with mechanical advantages in gait speed [3]. Proper selection of prosthetic components can result in significant improvements in mobility and independence in high-level amputations.

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6.87 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, it remains a relatively new technique, and many hospitals and rehabilitation centres remain uneducated. 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. Patients who underwent the OGAAP-2 rehab protocol were seen to have fewer rates of complication and achieve greater mobility.

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 OGGAP-2 system is still in its early phases and as the number of patients receiving this implant increases, 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 it into a standard procedure.

6.88 Digital workflow and 3D printing in the orthotic & prosthetic world- art of the possible

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BACKGROUND
The Orthotic & Prosthetic (O&P) world is profoundly connected to craftsmanship, art, experience, and healthcare practice. Aids have been reliant and conditioned by the physical constraints of traditional manufacturing. Additive manufacturing (AM) is emerging in all industries and O&P is not exempt of it, a digital workflow and 3D-print enables optimization and/or creation of new aids and better outcome. This work consists of clinical examples unlocked by a digital workflow and 3D-printing.

AIM
The purpose of this work is to describe and share the art of the possible using a digital workflow and 3D-printing in the O&P world.

METHOD
This work comprises of aids produced in Blatchford Norway with a digital workflow, including 3D scanning for the patient shape, 3D modelling to clinically rectify and design the aid, and 3D printing to achieve the physical product. All aids were custom-made, clinically design based on a diagnose and had a holistic approach. The aids admitted represent solutions that would be utterly hard and/or time consuming to be traditionally manufactured. The orthotics and prosthetics presented are subdivided to neck, spinal, upper limb, and lower limb. The materials used include a rigid plastic (pa12) and a soft plastic (TPU) from HP MJF printing technology.

RESULTS
This paper comprises in 11 cases, depicted in the pictures following. All aids had satisfaction and positive feedback were given by the patients.

Figure 1- Summary of the end results

DISCUSSION AND CONCLUSION
A digital workflow and 3D-printing enables a more precise, faster, and traceable work. It reduces manufacturing errors, patient rejection, and production waste, leading to an improved outcome with an appealing design. With no manufacturing limits a full design freedom and focus on the aid is enabled. A digital, visual and easier multidisciplinary collaboration is possible, allowing decisions before any production. Results outperformed previous aids and improved quality of life, although further appointments are required to assess and compare them.

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