ISPO UK MS ANNUAL SCIENTIFIC MEETING

12 & 13 October 2018
Grand Harbour Hotel, Southampton

"Advancing our understanding of the body interface in Prosthetics and Orthotics"

THE COMPENDIUM

With thanks for support from

NORTH SEA PLASTICS LTD
www.northseaplastics.com


amparo
start confident
Ready for the first steps
IN ONLY 1 HOUR
HEAT
MOLD
WALK
CONFIDENCE SOCKET
The fastest interim socket technology
Try it! @ ISPO, Southampton
www.amparo.world

Contents

	Page
Welcome	1
Conference Programme	2
Guest Speakers	6
Abstracts	10
Poster Abstracts	36
Commercial Exhibition	37


FREE Orion3 MPK Certification Courses
ORION3
Features:
Standing Support Mode
3 day battery life
Weatherproof
Smart Programming App
Courses are open for booking now
To book your training day please contact your local Blatchford Education and Training Representative:
Northern England & Scotland Alastair Ward 07736 890151
Midlands Scott Kilby 07801 217219
Southern England & Wales Laura Ritchie 07770 843282
Follow Blatchford:
@BlatchfordGrp
/BlatchfordGrp
blatchford.co.uk
+44 (0) 1256 316600
customer.service@blatchford.co.uk
blatchford

Welcome

We are delighted to welcome you to Southampton for the 2018 ISPO UKMS Annual Scientific Meeting. The guiding theme for this year is **The Interface, advancing our understanding of body interface in Prosthetics and Orthotics**. This crucial area we're sure will be of particular interest since an effective body interface is a prerequisite for successful P&O outcomes. A range of challenges still remain in advancing the science, ranging from prosthetic socket fitting, interface biomechanics, direct skeletal fixation, specialist seating and limb orthotics, diabetic foot as well as tissue mechanics.

ISPO UKNMS is championing these critical challenges and needs. Sensor technology for diagnosis and prognosis at amputee residual limb interfaces and the National Amputee Prosthetics Outcomes Registry (AMPROM) are some of the research focus at Southampton. AMPROM was developed by ISPO UK MS from a platform conceived initially at a Southampton FortisNet event in 2016. The need for outcome data and the importance of **The Interface** has been underscored by a record-breaking number of abstract submissions this year from which to construct the program.

The 2018 ISPO program brings multidisciplinary expertise and learning together, to share the latest developments and research. We have arranged the program into four main theme areas, i.e. Body interface with P&O, Rehabilitation-data and outcome measures, Advanced components and assistive technologies, Surgical and Rehabilitation methods.

We are very fortunate to have many keynote Guest Speakers to cover specific areas of P&O. These include talks from Mr & Mrs Arthey (amputees' perspectives on the socket interface), Prof. Dan Bader from University of Southampton (Tissue health at the skin-device interface), Graham Bowen from Solent NHS Trust (Diabetic foot problems), John Sullivan & Carolyn Young (AMPROM update), Dr. Alex Dickinson from the University of Southampton (P&O Global challenge), Prof. Jane Burridge from Southampton (NeuroRehabilitation), Dr Nadine Stech from Blatchford (MovAid). We are also pleased to have presentations relating to P&O interface challenges for children with limb loss as they face even more difficult challenges due to rapid skeletal growth and supporting physical development and sports activities. Recent research funded by the StarWorks initiatives will be presented, Gemma Wheeler will summarize work to date, and steps taken forward in the area.

The prestigious Blatchford Lecture will be presented by Prof Dr Bernhard Greitemann (Muensterland Rehabilitation Hospital) focusing on a review of surgical techniques and rehabilitation processes in Germany. Prof. Malcolm MacLachlan, from Maynooth University, Ireland, will present the OETT Lecture for Assistive Technologies, and hopefully he will share his student sailing experience in Southampton some years ago.

We also congratulate Prof Jan HB Geertzen, from University Medical Center Groningen, The Netherlands, who will be awarded the prestigious George Murdoch Prize Medal in recognition of his outstanding contribution to prosthetic medical rehabilitation. He will present his lecture closing the first day. In the evening there will be an entertaining and social event.

This meeting could not take place without the support from my colleagues at the University of Southampton as members of the Scientific Committee, ie. Dr. Alex Dickinson, Prof. Jan Burridge and Prof. Dan Bader. We are also grateful for the sponsorship from North Sea Plastics and the support from commercial companies who contribute through exhibiting in Southampton.

This is the first time the ISPO UKMS Annual Meeting and Exhibition has been held in Southampton. The location is close to the waterfront and in view of the ancient city walls and dock where the Titanic set sell. There are many nearby historic sites (e.g. Sea City Museum, City Art Gallery, and Tudor House) all in walking distance to the Grand Harbour Hotel, and of course, the beautiful New Forest national park is only a short distance away. We hope you enjoy the conference and have a memorable experience in Southampton.

Professor Sir Saeed Zahedi
Chair
ISPO UK MS

Prof Liudi Jiang
Chair, Scientific Committee
ISPO UK ASM 2018

Programme

Friday 12th October 2018

0830 hrs **Registration**

0930 hrs **Welcome** – Prof Liudi Jiang, ISPO UK MS Scientific Chair & Prof Sir S Zahedi, ISPO UK MS Chair

Theme: Body Interfaces with Prostheses and Orthoses

Chair: Prof Liudi Jiang, ISPO UK MS Scientific Chair & Prof Sir S Zahedi, ISPO UK MS Chair

0940 hrs ***"Above Knee Amputee stump interface management – an endurance athlete's perspective"***
Guest Speakers: Chris and Denise Arthey, Surrey, UK

1005 hrs ***"Bioengineering Strategies to Monitor Tissue Health at the Skin-Device Interface"***
Guest Speaker: Prof Dan Bader, Faculty of Health Sciences, The University of Southampton, UK

1030 hrs ***"The tsunami of Diabetic foot disease: A global health problem"***
Guest Speaker: Graham Bowen, Clinical Lead for Podiatry, Solent NHS Trust, Southampton, UK

1100 hrs **Refreshments, Commercial Exhibition and Poster Exhibition**

Chair: John Sullivan, ISPO UK MS Vice-Chair

Free Paper Presentations

1130 hrs ***"Quantitative evaluation of a perforated prosthetic liner for sweat management using a residuum-socket simulator"***
Dr M McGrath, Research Scientist, Chas A Blatchford & Sons Ltd., Basingstoke, UK

1145 hrs ***"Reliability of three different methods for assessing amputee residuum volume"***
Dr E Seminati, University of Bath, Bath, UK

1200 hrs ***"The Design and Manufacture of a Bespoke Neoprene Prosthetic Liner - A Case Study"***
M Young, Centre Manager, CAMERA, University of Bath, Bath, UK

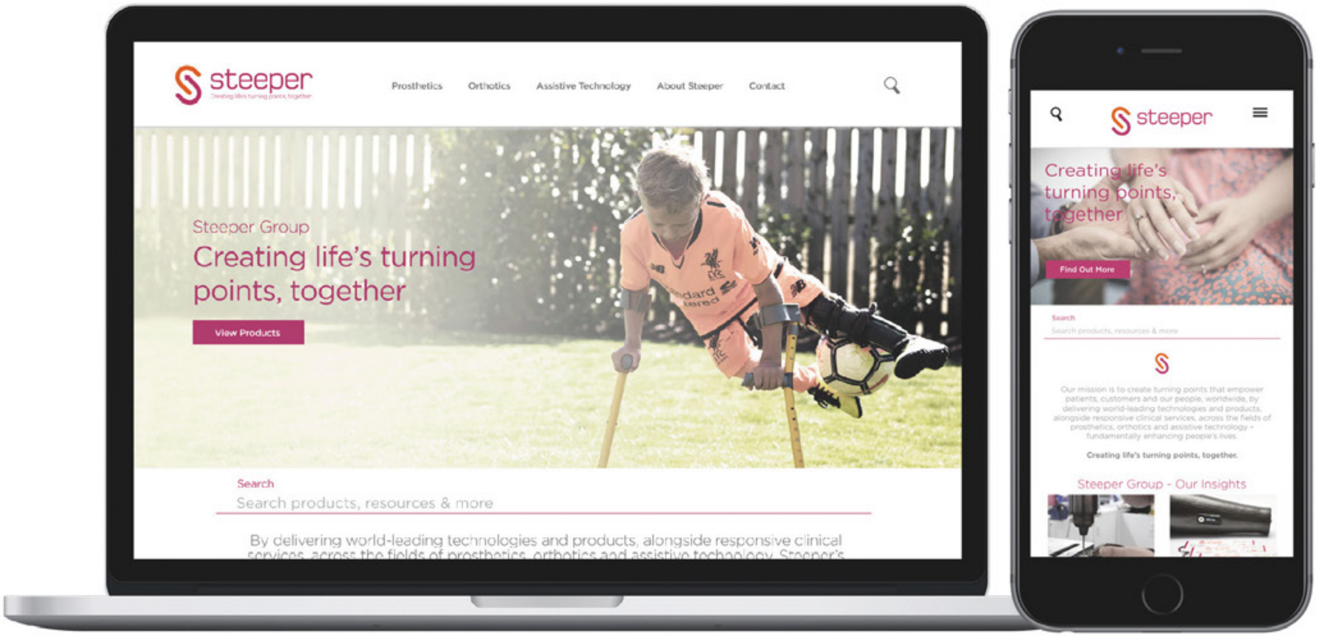
1215 hrs ***"A preliminary study of socket interface loading and socket fit for children with lower limb absence"***
J Tang, Research Fellow, Faculty of Engineering & Physical Sciences, University of Southampton, Southampton, UK

1230 hrs ***"A measurement array to assess prosthesis-limb interface pressures which avoid soft tissue damage"***
J L Bramley, Faculty of Engineering & Physical Sciences, University of Southampton, Southampton, UK

1245 hrs **ISPO UK MS Annual General Meeting**

1245 hrs **Lunch, Commercial Exhibition and Poster Exhibition**

	Theme: Rehabilitation, Data and Outcome Measures
	Chair: Professor Jane Burridge, University of Southampton
1345 hrs	***"National Amputee Prosthetics Outcomes Registry (AMPROM)"*** Guest Speakers: John Sullivan, ISPO UK MS Vice Chair/Stanmore Royal National Orthopaedic Hospital, and Carolyn Young, Lead Commissioner – Rehabilitation & Disability, CRG, NHS England (Midlands & East)
1410 hrs	***"Widening Access to Sustainable Prosthetics Services: a Global Challenge"*** Guest Speaker: Dr Alex Dickinson, Faculty of Engineering & Physical Science, The University of Southampton, UK
	Free Paper Presentations
1435 hrs	***"How quickly are individuals with unilateral trans-tibial amputation able to adapt to a change in stiffness of a running specific prosthesis"*** Dr A De Asha, Research Biomechanist, C-Motion Inc., Germantown, MD, USA
1450 hrs	***"Characteristics of established unilateral transfemoral amputee gait using 3D kinematic, kinetic and metabolic measures"*** Dr B Carse, Clinical Scientist, WESTMARC, Queen Elizabeth University Hospital, Glasgow, UK
1505 hrs	***"Falls risk assessment tool for individuals with a lower limb amputation living in the community - The FRAT-AMP"*** Dr N Vanicek, Reader, University of Hull, Hull, UK
1520 hrs	**Refreshments, Commercial Exhibition, Poster Exhibition**
	Theme: Advanced Components and Assistive Technologies (Part 1)
	Chair: Professor Peter Kyberd, University of Greenwich
1550 hrs	***"Technologies for NeuroRehabilitation"*** Guest Speaker: Prof Jane Burridge, Faculty of Health Sciences, University of Southampton, UK
1615 hrs	**The OETT Lecture:** ***Systems Thinking for Assistive Technology: Redesigning the Future*** Guest Speaker: Prof Malcolm MacLachlan, Maynooth University, Ireland
	Free Paper Presentations:
1645 hrs	***"The effect of socket design on the reliability of EMG signal transduction in trans-radial myoelectric prostheses"*** A Monk, Prosthetist and MSc Student, University of Salford, Salford, UK
1700 hrs	***"How do unintended activations of myoelectric prostheses relate to functionality?"*** Dr A Chadwell, Medical Engineer, University of Salford, Salford, UK
1715 hrs	**George Murdoch Prize Lecture – introduced by Professor Rajiv Hanspal** ***"Amputation in CRPS: which patient qualifies?"*** Guest Speaker: Prof dr Jan HB Geertzen, MD PhD, University Medical Center, Groningen, The Netherlands.
1800 hrs	**Conference close**
1830 hrs	**Exhibition closes**
1930 hrs	**Conference Dinner and Entertainment** Grand Harbour Hotel, Southampton



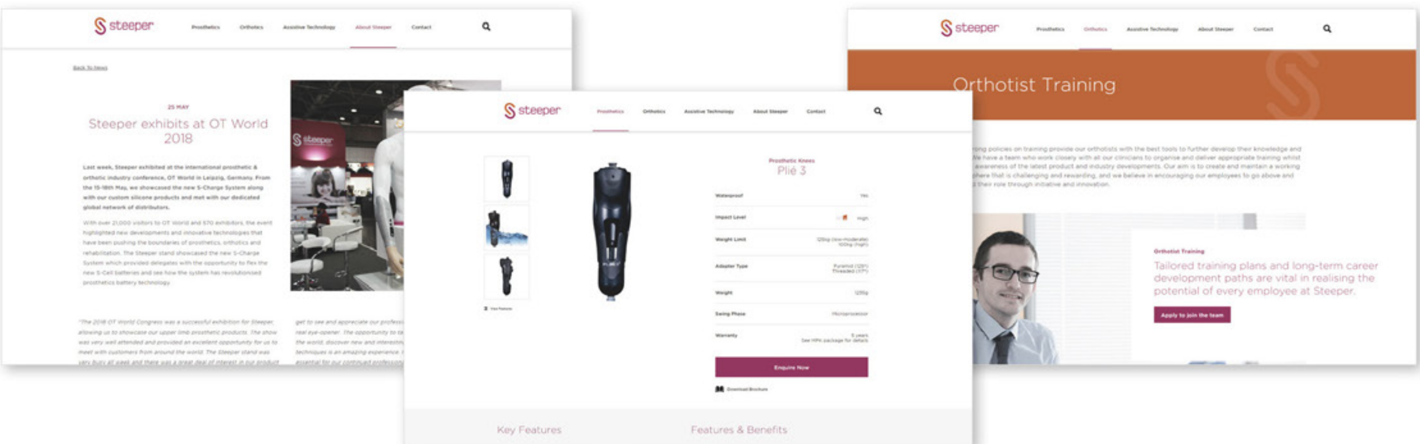
Explore our new website

www.steepergroup.com

Our new website offers quick and easy access to new and detailed product and technical information, complemented by insightful turning point stories from our patients.

Highlights:

- Streamlined product pages
- Full technical details
- Extensive product filters
- Behind-the-scenes videos



What do you think? We'd love to hear your suggestions at marketingteam@steepergroup.com.

www.steepergroup.com

steeper
Creating life's turning points, together

Saturday 13th October 2018

0830 hrs	**Registration**
	<u>Theme: Advanced Components and Assistive Technologies (Part 2)</u>
	<u>Chair: Dr Alex Dickinson, University of Southampton</u>
0900 hrs	***MovAiD – Movement Assistive Devices: Manufacturing of personalised Kineto-Dynamics parts and products for workers, elderly and children*** Guest Speaker: Dr N Stech, Principal Integrated Control Design Engineer, Chas A Blatchford & Sons Ltd, Basingstoke, UK
0930 hrs	***The Starworks Project: Achievements and Next Steps*** Guest Speaker: Gemma Wheeler, The Starworks Network, Sheffield Hallam University, UK
	Free Paper Presentations:
0945 hrs	***"Validating performance of a novel wearable device for long-term activity monitoring during everyday activities"*** P Laszczak, Mechatronic Research Engineer, Chas A Blatchford & Sons Ltd, Basingstoke, UK
1000 hrs	***"STEPFORWARD: A protocol for a randomised feasibility study of a self-aligning prosthesis for older individuals with a vascular-related transtibial amputation"*** Dr C T Barnett, Senior Lecturer in Biomechanics, Nottingham Trent University, Nottingham, UK
1015 hrs	***"Contrasting adverse incident reporting in the UK for prosthetics and orthotics with medical devices overall"*** Dr P Davenport, Medical Device Specialist, Medicine and Healthcare Products Regulatory Agency, London, UK
1030 hrs	**Refreshments, Commercial Exhibition and Poster Exhibition**
	<u>Chair: Dr Imad Sedki, Royal National Orthopaedic Hospital, Stanmore</u>
	<u>Theme: Surgical and Rehabilitation Methods</u>
1100 hrs	**The Blatchford Lecture:** ***"Amputation Surgery and Rehabilitation in lower limb amputees in Germany"*** Guest Speaker: Prof Dr Bernhard Greitemann, Klinik Munsterland, Germany
	Free Paper Presentations:
1130 hrs	***"A Case Series of Non-traumatic Insufficiency Fractures of the Distal Femur or Tibial Plateau observed in four Transtibial Amputees during Inpatient Prosthetic Rehabilitation"*** Dr S Connolly, Musgrave Park Hospital, Belfast, UK
1145 hrs	***"Prosthetic Rehabilitation following Multiple Limb Loss"*** S Steventon, Prosthetist, Queen Mary's Hospital, London, UK
1200 hrs	***"Osseointegration in Bilateral Above Knee Amputees following Blast Injury: 2 year follow up results from the initial cohort of UK Service Personnel"*** L McMenemy, Trauma & Orthopaedic Surgical Trainnee, Defence Medical Services, Imperial College London, London, UK
1215 hrs	***"Do Strength Asymmetries Explain Walking Gait Asymmetries in Unilateral Transtibial Amputees?"*** A R Sibley, Research Student, University of Roehampton, London, UK
1230 hrs	***"Can Cognitive assessment predict lower limb prosthetic success?"*** Dr V Kalansooriya, ST6 Rehabilitation Medicine, Musgrave Park Hospital, Belfast, UK
1245 hrs	**Presentation of Prizes**
1300 hrs	**Lunch & Conference Close**

Guest Speakers

Chris & Denise Arthey

Chris and Denise Arthey are both transfemoral amputees as a result of a road accident ten years ago when they lived in the USA. With the help of modern prosthetics they have been able to rebuild active lives; Chris is a para-athlete competing in marathons and triathlons.

Chris is an engineer and Denise a school teacher. Now they are in their 60s and have finished their ‘first careers’, they are busy with other things. Denise volunteers at the infants’ school where she used to work, loves gardening and singing classics with a local choral society. Chris is completing an MSc in Biomedical Engineering at the University of Surrey, including research on transfemoral amputee skin/liner shear stress. They are frequently invited to speak to various audiences about their experiences and what can be learned from them, and their website is chrisarthey.co.uk . They both help Blatchford Group as new product evaluators and quality assessors and are ambassadors for advanced prostheses.

They have been married for 40 years and have three grown children (and one granddaughter), all settled within a few miles of Godalming, Surrey, where Chris and Denise live.

Professor Dan Bader

After a PhD in Biomechanics at Southampton, Dan Bader moved to the University of Oxford, where his research focused on the bioengineering aspects of pressure ulcer prevention. He later moved to Queen Mary, University of London (QMUL) as a lecturer in biomaterials in the IRC in Biomedical Materials. In 1999, he was appointed first Professor of Medical Engineering in QMUL. In 2011, he moved to Southampton to lead the Skin Health research group. Since 2014 he has led the EPSRC-NIHR Network and NetworkPlus on Medical Devices and Vulnerable Skin www.southampton.ac.uk/mdvsn.

Since 2000, he has been a Part-Time Professor in Soft Tissue Remodelling at Eindhoven University of Technology, the Netherlands. He is Editor-in-Chief of the Journal of Tissue Viability.

Professor Bader’s research interests include:-

- Development of screening techniques to assess soft tissue susceptibility to pressure-induced damage.
- Design of novel support surfaces and medical devices at the patient-body interfaces
- Biomechanics of soft tissues in health and disease at different hierarchical levels;
- Biomechanical conditioning of cell seeded constructs for tissue engineering

Graham Bowen

Graham Bowen is Clinical Lead for Podiatry at Solent NHS Trust. He qualified from Northampton School of Podiatry in 1988 and his clinical career has focussed on diabetic foot disease. He has worked in a wide range of clinical settings both within the UK and Canada developing his interest in the diabetic foot.

In 2004 he became lead Podiatrist for Diabetes for Southampton City Primary Care Trust where Graham led a mulit-professional team that worked across primary and secondary care, delivering the national NICE guidance for the PCT. He was instrumental for the team’s success in reducing the diabetic foot inpatient stay from 50 to 19 days over a three year period, coupled with developing improved routes of admissions to secondary care and the use of new technologies such as the Versajet.

In his present role at Solent NHS Trust, Graham's focus is prevention of diabetes related amputation, advanced wound care by delivering a business case for Versajet and Topical Negative Pressure (TNP), offloading, clinical audit and education of the diabetic foot.

Carolyn Young

Carolyn joined the NHS in 1985 working for East Hertfordshire Health Authority. She has worked in a number of roles across the East of England leading to her appointment as Associate Director for Specialised Commissioning with the East of England Specialised Commissioning Group. Following the establishment of NHS England in 2013 Carolyn was appointed to the role of Programme of Care Lead for Trauma Services for the Midlands & East.

Carolyn is also the NHS England Lead Commissioner for Rehabilitation & Disability which includes complex rehabilitation, prosthetics, augmentative and alternative communication (AAC) and Environmental Controls (EC). Carolyn has been instrumental in leading the work on microprocessor controlled knees which culminated in NHS England approving a routine commissioning policy for microprocessor knee in December 2016.

Dr Alex Dickinson

Alex is a mechanical engineer with 14 years of experience in biomedical engineering. He started work in industry developing orthopaedic implants, covering design, pre-clinical analysis and testing. He has an academic position at the University of Southampton lecturing engineering design and computing, and holds a Royal Academy of Engineering Research Fellowship entitled 'Developing, Testing and Fitting the Next Generation of Prosthetic Limbs' (2015-2020).

He is the Principal Investigator on EPSRC/NIHR Global Challenges Research Fund project 'A Step Change in LMIC Prosthetics Provision through Computer Aided Design, Actimetry and Database Technologies' (2018-2021).

He is most motivated by multidisciplinary work with clinicians, health scientists and industry, aiming to deliver research that is relevant to service users in the real world, and technologies which are fit-for-purpose.

Alex sits on the board of the IMechE's Biomedical Engineering Division (BmED), is a member ISPO UK, the Exceed Research Network, and the British Standards Institution (BSi) Committee CH/150: Implants for Surgery. He is Associate Editor (Reviews) at the IPEM journal Medical Engineering & Physics, and as a STEM Ambassador he frequently visits schools to promote careers in biomedical engineering to the next generation.

Professor Jane Burridge

Jane Burridge is Professor of Restorative Neuroscience at the University of Southampton, where she leads the Neurorehabilitation Research Group. Jane's research is about improving recovery of movement following acquired brain damage. Fundamental to this is understanding the mechanisms associated with normal, loss and recovery of motor function. Jane's work crosses traditional rehabilitation boundaries, collaborating with engineers, neuroscientists and psychologists. She was elected President of The Association of Chartered Physiotherapists in Neurology (ACPIN) in March 2017.

Jane graduated as a physiotherapist, but later changed career and trained as a musician playing and teaching the flute. Her PhD at the University of Southampton enabled response to Functional Electrical Stimulation for drop-foot to be better predicted by accurate measurement of muscle dysfunction.

Jane's current research is with wearable sensors to support home-based rehabilitation and generate objective measures of impairment. She leads a research programme into the use of the Internet to support home-based rehabilitation, and is particularly interested in understanding how rehabilitation technologies can translate into clinical practice.

Professor Malcolm MacLachlan

Malcolm "Mac" MacLachlan is Professor of Psychology and Social Inclusion and Director of the recently established ALL (Assisting Living & Learning) Institute, at Maynooth University, Ireland. Previous appointments include holding a Personal Chair in Global Health at Trinity College Dublin, and Head of the Department of Psychology at the University of Malawi. He has also held visiting professorships at the universities of Stellenbosch, Olomouc and Harvard.
He has worked as an academic, clinician, organisational consultant and policy advisor in Europe, Asia, Africa and South America; with government, civil society, corporates and United Nations agencies.

Mac is currently Research & Innovation Lead for WHO's Global Collaboration on Assistive Technology (GATE) programme; and Knowledge Management Lead for the United Nations' Partnership for the Rights of Persons with Disabilities (UNPRPD). He also serves as a Clinical Advisor to the Irish health service's National Disability Team.

He is a Fellow of the Psychological Society of Ireland and of the British Psychological Society; and Member of the Royal Irish Academy. He is the recipient of a number of awards including the American Psychological Association's International Humanitarian Award (2014) and the Royal Irish Academy's Gold Medal for Social Science (2017).

Professor Dr Jan H B Geertzen

Jan Geertzen is a Physiatrist, Professor in Rehabilitation Medicine and Chairman of the Department of Rehabilitation Medicine at the Center for Rehabilitation, University Medical Center Groningen, the Netherlands. Jan received his PhD degree in March 1998 and became a professor in Rehabilitation Medicine in February 2002.

He has served as Chair/President in a number of national and international associations, most notably the Netherlands Society of Rehabilitation Medicine (VRA) and the International Society for Prosthetics and Orthotics (ISPO).
Jan's research is manly focussed on Complex Regional Pain Syndrome, Phantom Pain and Rehabilitation after (lower limb) amputation. Primarily a clinician, his research is particularly aimed at clinical aspects of these subjects and is directly aimed at improving patient care.

He has published several books including *Rehabilitation for Adults (2014);* and *Rehabilitation after amputation lower extremity (2018).* He is also author of more than 250 international publications.

Dr Nadine Stech

Dr Nadine Stech is Principal Integrated Control Design Engineer at Blatchford. She holds a degree in Engineering Cybernetics from University of Stuttgart and a PhD in Biomedical Engineering from University of Surrey. For her PhD she investigated the impact of control strategies and system integration of lower limb prosthetics on biomechanics of amputees.

Nadine is project champion of the multi-award winning integrated lower limb prosthesis Linx and projectt manager of the Horizon 2020 project MovAiD (www.movaid.eu).

Nadine is author and presenter of numerous scientific papers in the fields of prosthetics, orthotics and gait analysis. Her research interest lies in the field of prosthetics, orthotics, biomechanics, advanced technology, control and system integration.

Gemma Wheeler

Gemma Wheeler is a Researcher based at Lab4Living; a multidisciplinary research group within Sheffield Hallam University, with a focus on bringing Design-led research to fields of health and wellbeing. Lab4Living's work spans a range of health contexts across the entire life course, and is characterised by the use of *creating* and *making* as a means to empower those affected by a research outcome in the research process.

Much of her work is in collaboration with NIHR Devices for Dignity MIC, who aim to act as a catalyst within the NHS for the development of new medical devices, healthcare technologies and technology-dependent interventions. To date, Gemma has brought a design-led approach to supporting projects hosted by TITCH (Technology Innovation Transforming Child Health) and CYP MedTech (Children and Young People MedTech Co-operative), in contexts such as narcolepsy, rare diseases, incontinence, and prosthetics. In her talk she will focus on the latter, and the work conducted to date by The Starworks Child Prosthetics Network.

Gemma's background was originally in Product Design, with subsequent PhD work focussing on exploring and enhancing patient participation in spinal cord injury rehabilitation, engaging patients, families and healthcare staff in the process using both traditional and creative research methods.

Professor Dr Bernhard Greitemann

Bernard Greitemann is a graduate of the University of Meunster, an Orthopaedic Surgeon and Medical Director at the Muensterland Rehabilitation Hospital, Bad Rothenfelde, Germany. He is a member of the Faculty of University of Muenster (Orthopaedics) and University of Witten-Herdecke (Rehabilitation).

Professor Greitemann also serves on the Board Member of the German Association of Orthopaedic and Traume Surgeons (DGOU) and is President of the Vereinigung Technische Orthopädie Section of DGOU dealing with P&O and Foot orthotics, whish is responsible for training in amputation surgery and P&O for residents in Germany.

He is currently Vice-president of ISPO Germany,and a member of ISO-DIN TC 168 and the recipient of several prestigious prizes including the Heine-Preis DGOOC, Carl-Rabl-Price VSOU and Rehabilitation poster price DRV.

Abstracts (in order of presentation)

Title:	**Above Knee Amputee stump interface management – an endurance athlete's perspective"**
Presenters:	**Chris & Denise Arthey**

In this opening keynote lecture, Chris and Denise will describe briefly the road accident in the USA that almost took their lives, but eventually only took some of the use of their left hands and arms, Chris' spleen, and their left legs.

They outline their road to recovery and Chris' return to the world of endurance sports competing against able-bodied athletes. The skills of prosthetists and therapists, and access to technology, have transformed this journey.

Chris uses his 8 years' experience of endurance para-athletics training and racing to provide insights into managing the interface between his stump and the prosthetic legs he uses. Key lessons relate to monitoring the condition of the stump, paying attention to lubrication, dealing with sweat, and maintaining prosthetic fit.

Title:	**Bioengineering Strategies to monitor tissue health at the skin-device interface**
Presenter:	**Professor Dan Bader, Faculty of Health Sciences, University of Southampton**

In the last decade, researchers have adopted an hierarchical approach, involving multi-scale models, to identify the physiological mechanisms each of which play a role in concert in the aetiology of soft tissue damage, in the form of pressure ulcers. A recent focus involves the potential damage caused by medical devices, designed to support functional activities in patients with vulnerable tissues. Devices include respiratory masks, orthotics for paediatrics, the prosthetic socket-stump interface of amputees, as well as support surfaces associated with sitting and lying. Bioengineering strategies have involved monitoring both biomechanical (pressure and shear) and microclimate (temperature and humidity) conditions and examining their effects on the viability of the affected soft tissues. In addition, we have investigated the potential of selected biomarkers to assess tissue response following the prolonged use of medical devices. The resulting parameters can provide threshold values to predict conditions at which soft tissue damage can occur.

Title: **Quantitative evaluation of a perforated prosthetic liner for sweat management using a residuum-socket simulator**

Presenter: **Michael McGrath, Research Scientist, Dr**
Contact Address: Blatchford & Sons Ltd.
Unit D Antura
Kingsland Business Park
Basingstoke
RG24 8PZ
Tel: 01256 316793
Fax: -
Email: mike.mcgrath@blatchford.co.uk

Other Authors: Ana Gallego, Materials Engineer, Blatchford & Sons Ltd.
Joe McCarthy, Senior Prosthetist, Blatchford & Sons Ltd.
John Ross, Senior Prosthetist, Blatchford & Sons Ltd.
Piotr Laszczak, Mechatronics Engineer, Blatchford & Sons Ltd.
David Moser, Head of R&D, Blatchford & Sons Ltd.
Saeed Zahedi, Technical Director, Blatchford & Sons Ltd.

INTRODUCTION - Studies report up to 70% of amputees are affected by excessive sweating[1], affecting quality of life. The causes for this may include a loss of body surface area, inhibiting heat transfer, and increased energy expenditure. Non-porous, silicone liners are commonly worn over the residual limb for cushioning, but this means that sweat cannot transport away from the skin surface, creating a warm, moist microclimate, where bacteria thrive.
To address these problems, a type of silicone liner has been produced that contains perforations along the length and at the distal end. These perforations permit the warm air and moisture to transfer away from the residuum surface.
Due to the complexity and variability of residual limbs, previous work[2] has developed an artificial residuum for use as a residuum-socket interface simulator.

AIM - The aim of this study was to evaluate the efficacy for replicating the interface microclimate, under controlled laboratory settings, using a residuum-socket interface simulator. This was to be achieved through evaluating the effectiveness of perforated liners used for sweat management.

METHODS - A known quantity of water was applied to the artficial residuum surface, as evenly distributed as possible, to act as a sweat analogue. A silicone liner was then donned over the residuum. The test protocol was performed for both perforated (Silcare Breathe, Endolite) and non-perforated liners (Endolite), which were weighed beforehand. The simulator was set up on a mechanical test machine, which applied vertical loading to replicate weight bearing during walking. After completion of the protocol, fluid at different surfaces was then quantified by collecting and weighing absorbent materials. For example, the fluid absorbed by the outer fabric layer of the liner was measured by re-weighing the liner and comparing to the pre-test value.

RESULTS - The regular, non-perforated liner did not allow any water transfer away from the residuum/liner interface, notably pooling at the distal end of the liner. With the perforated liner, ~50% of the fluid was found absorbed by the fabric outer surface of the liner, while ~10% was expelled from the distal end of the socket. This reduced the quantity of fluid that remained on the residuum surface, compared to the non-perforated liner. These findings coincide with common user feedback of each liner type, suggesting similar behaviour to real-life interface conditions.

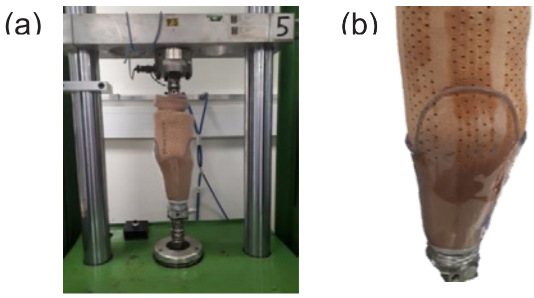


Figure 1: (a) The simulator on the test machine (b) The 'sweat' expelled through the liner perforations

CONCLUSION - Under controlled laboratory conditions, the microclimate of the residuum-socket interface was simulated and the sweat management function of perforated prosthetic liners was demonstrated. The ability to replicate this environment *in vitro* will be useful for further improving sweat management techniques.

REFERENCES

1. Hagberg & Brånemark. *Prosthet Orthot Int*. 2001; 25(3):186–194.
2. McGrath et al. *Proc Inst Mech Eng [H]*. 2017; 231(3):235-42.

DISCLOSURE - The authors are employees of Blatchford; the manufacturer of the liners used in this study.

Title: **Reliability of 3 different methods for assessing amputee residuum volume**

Presenter: **Dr Elena Seminati**
Contact Address: University of Bath*
Claverton Down
BA2 7AY, Bath
Tel: 07478199421
Email: e.seminati@bath.ac.uk

Other Authors: *Young M*. CAMERA Centre Manager, Dept. Computer science*
Canepa Talamas D. Research Ass., Dept. Mech. Eng*
Twiste M. Prosthetist & Senior Lecture, Salford University.
Dhokia V. Lecturer in Design Engineering*, Dept. Mech. Eng*
Bilzon J. Professor; Dept. for Health*

Aims and objectives: Objective methods of assessing amputee residuum volume are required to inform treatment decisions with regard to timing and design of prosthetic sockets. Computer Aided Design (CAD) methods (e.g. optical 3D scanners) can capture surface geometry and colour without the need for reference targets. Data collected on residual limb models suggest these novel methods may have greater validity and reliability than methods currently used in clinical practice[1]. The aim of this study was to assess the reliability of a new 3D laser free scanner compared with two alternative methods previously adopted in clinical practice. We hypothesize that the CAD hand scanner will be more reliable than the other clinical measurement systems, for assessing amputee residuum limb volumes.

Methods: Three different operators measured the residuum volume of ten chronic lower limb amputees (5 transtibial, 5 transfemoral), on three occasions for each operator, using an Artec Eva 3D scanner, an Omega Tracer and a geometrical formula based on anthropometric measures, using a Gulick measuring tape and a crotch stick. Models were manually aligned using anatomical reference points. Intra and inter-rater reliability coefficients were calculated according with Bland-Altman statistic, for measuring indices of residual limb model volume for each method[1]

Results: Participants were chronic (>1 year) lower limb amputees with a mean: body mass 79±13 kg; height 173±11.6 cm and; time post-amputation 25.8±14.6 years). Residual limb volumes ranged from 1077 to 2406 ml. Intra-rater and inter-rater reliability coefficients were respectively 45 ml and 65 ml for the Artec Scanner (2.5 to 3.7% volume)., 70 ml and 72 ml for the Omega Tracer (3.9 % volume) and 112ml and 256 ml (>10% volume) for the anthropometric measurements.

Conclusions: Prerequisites for a clinical method to measure amputee residuum volume are reliability, safety, and portability. Optical 3D scanners, based on laser free technology, are a promising method for assessing residuum limb volume changes in lower limb amputees. The Artec Eva scanner revealed the lowest reliability coefficients (2.5 to 3.7% volume) and could therefore be a useful method for quantifying short-term changes in the residuum volume of lower limb amputees, that might indicate recasting and refitting requirements.

References:

1. Seminati E, Canepa Talamas D, young M, Twiste M, Dhokia V, Bilzon J. Validity and reliability of a novel 3D scanner for assessment of the shape and volume of amputees' residual limb models. *Plos One.* 2017.

Title: **The Design and Manufacture of a Bespoke Neoprene Prosthetic Liner – A Case Study**

Presenter: **M Young, CAMERA Centre Manager, Mr**
Contact Address: University of Bath* Tel: 01225 384548
Bath, BA2 7AY Email: m.r.young@bath.ac.uk
Other Authors: *Odanye T,* Research Assistant, Dept. Mech. Eng*
Seminati E, Research Associate, Dept. for Health*
Dhokia V, Lecturer in Design Engineering, Dept. Mech. Eng*
Canepa Talamas DA. Research Associate, Dept. Mech. Eng*
Bilzon J, Professor, Dept. for Health*

Aims and Objectives: Prosthesis discomfort is a highly prevalent phenomenon that can hinder rehabilitation and negatively impact health and function. The aim of this study was to improve user comfort at the limb-prosthesis interface through the design and manufacture of a bespoke prosthetic liner that precisely mapped the residual limb of a transtibial amputee. It was hypothesized that the new liner would increase the load transmission area, reducing localised pressure on key landmarks and hence improve comfort.

Methods: Residual limb geometry of participant A was reverse engineered using an Artec Eva 3D scanner. Point cloud data was converted into a solid model using Autodesk Inventor Professional (2018) software. This model was then used to design the residuum liner. A non-rigid, custom product was manufactured from neoprene foam using cryogenic CNC machining[1]. This case-study encompassed personalised design considerations, qualitative user feedback and quantitative pressure measurement during activity. Novel Pliance Socket sensors ($2cm^2$ area) were positioned directly on 6 anatomical landmarks on the residuum of the transtibial amputee. The participant performed walking and sit-to-stand activities using both the current prescribed liner (CON) arrangement and the prototype (PRO). Feedback was collected through use of a modified Prosthesis Evaluation Questionnaire (PEQ) and the Socket Comfort Score (SCS).

Results: The bespoke PRO alleviated pressure at key anatomical regions during the peak loading phase of the gait cycle. When wearing PRO, pressure values were 21.2% and 27.8% lower at the distal tibial end and tibial crest, respectively. The range of peak pressure values during the sit-to-stand task were also 61% lower when wearing PRO, indicating a more even load distribution across the residuum. Mean peak pressures were also 17.4kPa lower when wearing the prototype. The bespoke PRO liner scored 8/10 on the SCS and was perceived equivalent in comfort to CON. Qualitative feedback supported use of the PRO liner, with no element rated below 67% of total satisfaction.

Conclusions: Cryogenic CNC machining was demonstrated to be a viable method of manufacturing a personalised, compliant prosthetic liner. There is evidence that creating bespoke prosthetic liners from softer, deformable materials can assist in reducing peak pressure at pressure-sensitive regions of a residuum, during activities of daily living. The neoprene foam material proved functional and was popular with the user. There is potential for bespoke prosthetic liners to benefit transtibial amputees, however further development and clinical trials are required.

References: 1. Dhokia, V, Bilzon, J, Seminati, E, Canepa Talamas, DA, Young, M & Mitchell, W. The design and manufacture of a personalized liner for lower limb amputees. Procedia CIRP 2017; vol 60, pp. 476-481.

Title	**A preliminary study of socket interface loading and socket fit for children with lower limb absence**		
Presenter	**Jinghua Tang, Research Fellow**		
Contact address	Faculty of Engineering & Physical Sciences, University of Southampton, University Road, Southampton, SO17 1BJ, United Kingdom	**Tel** **Fax** **E-mail**	023 8059 2551 N/A Jinghua.Tang@soton.ac.uk
Other authors	Liudi Jiang, Professor, University of Southampton Zhaozong Meng, Research Fellow, University of Southampton Nicholas Hale, PhD student, University of Southampton John Head, Senior lecturer, University of Salford Martin Twiste, Senior lecturer, University of Salford Emma Morley, Research and Information Officer, STEPS Charity David Moser, Head of Research, Chas A Blatchford & Sons Ltd. Saeed Zahedi, Technical Director, Chas A Blatchford & Sons Ltd.		

Introduction - Residual limb growth in children who use lower limb prostheses presents significant challenges in maintaining an effective, comfortable socket fit over time. For children aged between five and ten, the average growth rate of the tibia and femur has been measured to be approximately 1.2 and 1.6cm, respectively. Establishing loading patterns over time could therefore be key in enhancing activity levels in affected children.

Aim - The aim of this study is to assess variation of interface loading profile as a function of socket fit for child amputees.

Methods - A unique residuum/socket interface simulator was developed[1] which comprises an artificial residuum, a socket, a 6-axis load cell and standard prosthetic attachments (Fig. 1). The geometry of the artificial residuum was obtained from a child with lower limb amputation. The socket fit levels were varied to mimic the growth of a child's limb. Tri-axial pressure and shear sensors[2] were placed at the key anatomical landmarks of the interface to measure the multi-directional loads. Typical forces and moments experienced at loading response and terminal stance phases, will be applied to the interface via a loading machine.

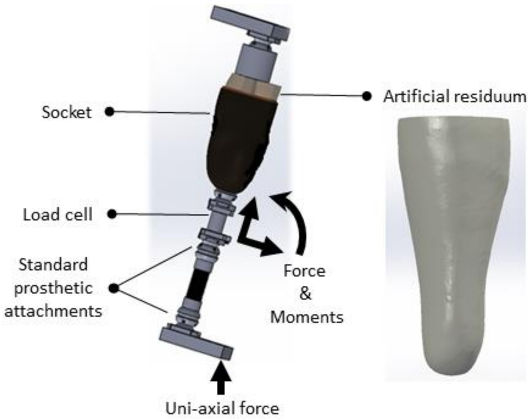


Fig 1: A schematic showing the residuum/socket interface simulator.

Results - The dynamic interface loading profile at typical gait cycles were obtained. Mean peak pressure and shear stresses as a function of socket fit levels i.e. projected growth spurs, were observed. A preliminary methodology to identify the location of the landmark and the corresponding stresses that could potentially underpin the change of socket fit was developed.

Conclusion - These results have demonstrated that, using our TRIPS sensor system, interface loading can be used as a primary indicator to assess socket fit changes with skeletal growth. The study could then underpin the development of a socket fit monitoring system for children with lower limb amputation.
Acknowledgement - This project is funded by NIHR Device for Dignity HTC (D4D) STARworks.

References
1. McGrath MP, Gao J, Tang J, et al. Development of a residuum/socket interface simulator for lower limb prosthetics. *Proc Inst Mech Eng H* 2017; 231: 235-242. DOI: 10.1177/0954411917690764.
2. Laszczak P, McGrath M, Tang J, et al. A pressure and shear sensor system for stress measurement at lower limb residuum/socket interface. *Medical engineering & physics* 2016; 38: 695-700. DOI: 10.1016/j.medengphy.2016.04.007.

Title: **A measurement array to assess prosthesis-limb interface pressures which avoid soft tissue damage**

Presenter: **Bramley, J.L.[1]**

Contact Address University of Southampton
Highfield Campus,
University Rd,
Southampton,
SO17 1BJ

Tel: 02380527665
Fax: N/A
E-mail: j.l.bramley@soton.ac.uk

Other Authors: A Dickinson, A.S.[1], Bostan, L.[2], Everitt, C.[3], Darekar, A.[4], Bader, D.L.[2], Worsley, P.R.[2]
[1] Faculty of Engineering & Physical Sciences, University of Southampton, UK
[2] Faculty of Environmental and Life Sciences, University of Southampton, UK
[3] Department of Radiology, University Hospital Southampton NHS Foundation Trust, UK
[4] Department of Medical Physics, University Hospital Southampton NHS Foundation Trust, UK

Introduction - The soft tissues in an amputated residual limb form a critical interface with a prosthesis, transferring load during activities of daily living. This inevitably creates pressure and shear forces at the skin-device interface, which can result in recurring soft tissue discomfort and damage. There are critical relationships between tissue damage and the magnitude and duration of interface pressure and tissue strain[1], where critical vascular and lymphatic vessels can be occluded by external loads. The aim of this study was to develop a human *in-vivo* protocol for assessing the biomechanical and physiological response of lower limb soft tissues to loads representing prosthesis use.

Methods - Ten participants without amputation were recruited (6M:4F, 23-36yrs). A sphygmanomometer was applied to the right calf mimicking a total surface bearing prosthesis, containing a gel liner and indenters representative of socket rectification. The cuff was inflated from 20-60 mmHg in 10 mmHg increments every 10 minutes. An array of measurements was taken at three sites relevant to prosthetic load bearing, to assess biomechanical response and characterise tissue damage risk[2]:

- Interface pressures (Oxford Pressure Monitor II, Talley, UK);
- Transcutaneous oxygen tension (T_cPO_2) at all sites and carbon dioxide tension (T_cPCO_2) at one site, using skin mounted sensors (TCM4, Radiometer, Denmark);
- T1 Magnetic Resonance Imaging (MRI) at baseline, 20 mmHg and 60 mmHg to characterise direct tissue deformation.

Results - At 60 mmHg cuff pressure, interface pressures ranged from 55-90 mmHg, typically highest at the patellar tendon (61-90 mmHg) and lowest at the posterior calf (55-73 mmHg).

Exemplar transcutaneous data are presented portraying the two trends observed across participants; decreasing T_cPO_2 corresponding with an >25% increase in carbon dioxide above an apparent threshold pressure (Fig.1A) or with <25% increase in T_cPCO_2 (Fig.1B).

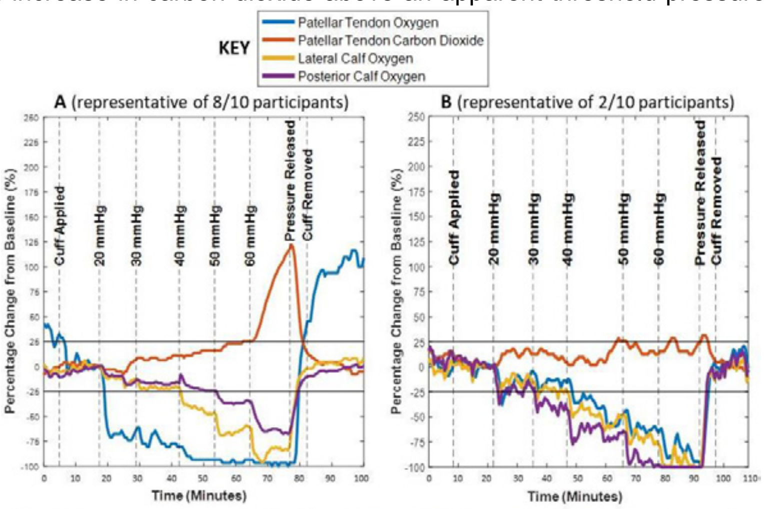


Figure 1 Transcutaneous Oxygen and Carbon Dioxide pressure data for two participants' calves under incremental sphygmanomometer loading from 20-60 mmHg

Decreased T_cPO_2 and increased T_cPCO_2, at the patellar tendon, were indicative of an ischaemic tissue response, observed in:

- 6/10 participants by 40 mmHg, at the patellar tendon;
- 7/10 participants by 50 mmHg, at the lateral calf;
- 5/10 participants by 50 mmHg, at the posterior calf; and
- 8/10 participants by 60 mmHg at all measurement sites.

Exemplar MRI data are presented for one participant (Fig.2).

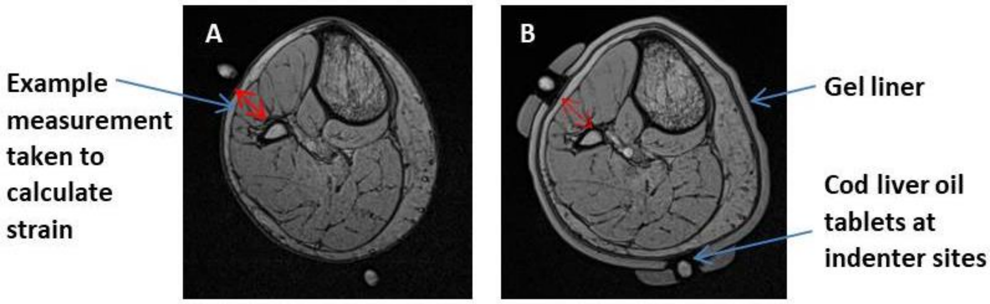


Figure 2 Corresponding transverse section MR images displaying calf of one participant at (A) baseline and (B) loaded with 60 mmHg cuff pressure

Gross strain at indenters ranged from ≈5-38% (mean≈16%) during 60 mmHg loading.

Discussion - The applied loads resulted in an ischaemic response of the skin tissues, represented by a decrease in T_cPO_2 and an increase in T_cPCO_2, precursors to tissue damage. MRI revealed gross tissue strains of ≈5-38% with most of the deformation occurring upon inflation to 20 mmHg. These preliminary tests involved participants with intact limbs, providing information relevant to early prosthetic rehabilitation using a temporary prosthesis. This array of measurement techniques will be translated for prosthesis users, to enhance knowledge of biomechanical adaptation and behaviour of soft tissues following lower limb amputation. In conjunction with interface sensors, this will provide evidence to inform socket design and gait rehabilitation.

Acknowledgements - Study ethics reference ERGO29696. The authors acknowledge funders EPSRC (EP/N509747/1, EP/N02723X/1), IfLS and RAEng (RF/130).

References

[1] Gefen 2008, J.Biomechanics
2] Worsley 2016, Clin.Biomechanics

Title: **Widening Access to Sustainable Prosthetics Services: a Global Challenge**

Presenter: **Dr Alex Dickinson, Faculty of Engineering & Physical Science, University of Southampton**

Approximately 100M people need prosthetic and orthotic devices [1]. Low-cost, robust devices are only half the story; an estimated 80-90% cannot access P&O services "due to a shortage of personnel, service units and health rehabilitation infrastructures" [2]. Access is particularly poor for people in Low Resource Countries (LRCs) such as Cambodia, where prosthetic limb users are typically young and live longer lives of more physical work than those in the UK. Many LRCs have higher levels of trauma amputation from accidents, conflict and landmine injuries [3]. Services are set up primarily for trauma injuries but by 2035 it is estimated diabetes may affect over 500M people, and is growing fastest in LRCs [4].
The above access barriers could be addressed by data. We are developing tools to enhance P&O data, aiming to improve service access, train clinicians and improve efficiency of funding use. Researchers at the University of Southampton and the University of Salford are working with expert clinicians in Cambodia at Exceed Worldwide and with computer scientists at industry partner BluPoint Ltd., to investigate:

1) digital measurement tools to assess a user's residual limb anatomy, gait, typical daily prosthetic limb use patterns, and health status; and
2) the architecture for a portable digital patient casenote system: a robust and secure IT network for travelling prosthetists to visit provincial areas to provide evidence-based treatment for those in remote communities who cannot afford to travel.

Besides the science, the context makes this work challenging. Experience shows that care must be taken in applying healthcare technologies from Western countries directly in LMICs. As well as users' different needs, their relationship with clinicians and prosthetics are different for complex cultural, social and environmental reasons. We have framed our scientific research using an ethnographic study of P&O service providers and users to ensure the developed technologies are practical. We will also conduct business modelling research, producing tools to ensure that technologies are cost effective and can be implemented sustainably.

References:

[1] 2011 World Report on Disability, WHO
[2] Sexton 2016, Rehabilitation of People with Physical Disabilities in Developing Countries, ISPO
[3] Marino 2015, Access to Prosthetic Devices in Developing Countries. IEEE Global Humanitarian Tech Conf [4] Guariguata 2014, Global Estimates of Diabetes. Diabetes Res & Clin Practice.

Acknowledgements:

Funding from The Engineering and Physical Sciences Research Council (EPSRC) refs. EP/R014213/1 & EP/M000303/1, and the Royal Academy of Engineering (RAEng) ref.RF/130, and strategic mentoring and support from the Exceed Research Network (ERN, www.exceed-worldwide.org/research).

Title: **How quickly are individuals with unilateral trans-tibial amputation able to adapt to a change in stiffness of a running specific prosthesis?**

Presenter: **Alan R De Asha, Research Biomechanist, Dr**

Contact Address	C-Motion Inc.	Tel:	+1 301 540 5611
	20030 Century Blvd. Suite 104A	Fax:	n/a
	Germantown, MD, USA 20874	E-mail:	alan.deasha@c-motion.com

Other Authors:
RJ Foster, Lecturer, Liverpool John Moores University, UK
T Skervin, PhD student, Liverpool John Moores University, UK
CT Barnett, Lecturer, Nottingham Trent University, UK

Aims and Objectives:

In recent years it has become common for individuals with lower limb amputation to use running specific prostheses (RSPs) in order to run recreationally. While doing so, individuals with a unilateral trans-tibial amputation (UTA) are known to minimise internal extension moments at the residual knee, in order to reduce in-socket torques. This is likely done in order to reduce residuum discomfort and the sensation of the residuum being 'twisted' out of the socket. When a RSP is altered or replaced, e.g. varying its stiffness, it is unknown whether individuals with UTA can quickly adapt to the subsequent perturbation by modulating moments at the residual knee in order to protect the residuum, or if such adaptations require an extended accommodation period. The purpose of this study was to investigate acute adaptations to a change in RSP stiffness in individuals with UTA.

Methods:

Institutional ethical approval was obtained prior to the study. Optical motion capture (Qualisys, Sweden) and force (AMTI, USA) data were recorded while eight male participants, who had provided written informed consent prior to participation, ran at their self-determined, normal running speed using their prescribed RSP (NORM; all; Blade XT, Blatchford, Basingstoke, UK) and also immediately after it was replaced with both stiffer (STIFF) and more compliant (COMP) RSPs (+/- one spring category, respectively). A 17 segment model (head, torso, pelvis, thighs, shanks & intact foot, with the RSP modelled as nine linked rigid segments) was constructed within Visual3D (C-Motion, USA). All data were low-pass filtered with a cut-off frequency of 15 Hz. Running speed was defined as the average forwards velocity of the whole-model centre of mass through the collection volume. Standard joint kinematics and kinetics were calculated. Joint kinetics were normalised to participants' mass. Running speed, peak residual knee flexion during stance and peak residual knee extension moment during stance were compared between conditions via repeated measures ANOVA with an alpha level of 0.05.

Results:

There was no statistically significant difference in group mean (SD) running speed (NORM 3.49 (0.35) m/s; STIFF 3.53 (0.33) m/s; COMP 3.56 (036) m/s, p = 0.41), in peak residual knee flexion (NORM 33 (2)°; STIFF 33 (9)°; COMP 31 (8)°, p = 0.86) nor in residual knee extension moment (NORM 1.50 (0.84) N.m/kg; STIFF 1.55 (0.87) N.m/kg; COMP 1.62 (0.90) N.m/kg, p = 0.45).

Conclusions:

Individuals with UTA, who run using an RSP, are able to adapt immediately to an alteration in the RSP stiffness in order to minimise sagittal plane moments at the residual knee, and thus potentially minimise torques at the residuum/socket interface. This is achieved without a reduction in running speed or change in residual knee flexion, suggesting that such an adaptation is global, rather than joint specific.

Title: **Characteristics of established unilateral transfemoral amputee gait using 3D kinematic, kinetic and metabolic measures**

Presenter: **Bruce Carse, Clinical Scientist, Dr**

Contact Address: WestMARC
Queen Elizabeth University Hospital
1345 Govan Road
Glasgow
G51 4TF

Tel: 0141 232 4033
Fax: N/A
E-mail: bruce.carse@ggc.scot.nhs.uk

Other Authors: Helen Scott, Team Lead (Prosthetics Physiotherapy), WestMARC, NHS GG&C

Laura Brady, Deputy Lead Prosthetist, WestMARC, NHS GG&C

John Colvin, Head of Service, WestMARC, NHS GG&C

Background
There are several published studies which discuss the biomechanics of how unilateral transfemoral (UTF) amputees walk, however these are often limited by relatively small sample sizes, the study of very specific populations or reporting only selected aspects of full 3D biomechanical datasets. The Scottish Specialist Prosthetics Service (SSPS) was established in 2014 to provide advanced prosthetic components to eligible NHS patients. As part of the service agreement, comprehensive outcome measures were taken, including full three-dimensional gait analysis (3DGA). Prior to measuring the change in gait outcomes it was necessary to understand more about the nature of the gait deficits faced by UTF amputees.

Aims and objectives
The aim was to comprehensively describe how a group of routine NHS Prosthetics service users walk, studying UTF patients with a range of aetiologies, ages and activity levels.

Methods
3DGA data was collected in the WestMARC gait analysis laboratory during routine clinical practice, as part of the SSPS, using mechanical knees prior to the provision of microprocessor controlled knees. A Vicon 3D motion analysis system was used in conjunction with two force plates and a Cosmed K2B4 system, using a full body marker set as described in recent studies [1,2]. Data was collected from 60 patients during level overground walking at self-selected comfortable walking pace and demographic data is provided in Table 1.

Table 1: Participant demographic data

	Participants		Control group	
	n	Mean (SD)	n	Mean (SD)
Gender (M/F)	49/11	N/A	5/5	N/A
Amputation type (UTF/KD)	54/6	N/A	N/A	N/A
Age (years)	60	51 (15.1)	10	51 (9)
BMI (kg m-2)	60	26.7 (5)	10	27.1 (3.8)
Time since amputation (years)	60	19.8 (16)	N/A	N/A
K-level (K1/K2/K3/K4)	0/10/32/18	N/A	N/A	N/A
Aetiology (MT/Infection (B+ST)/PAD-ND/PAD-D/Tumour/Other)	32/7/7/1/8/5	N/A	N/A	N/A

Abbreviations: BMI, body mass index; MT, mechanical trauma; B, bone; ST; soft tissue; PAD-ND, peripheral arterial disease – non diabetes; PAD-D, peripheral arterial disease – diabetes; KD, knee disarticulation

A systematic approach to analysing the 3DGA data was used in order to identify the prevalence of key gait deviations within this group of participants. Published literature, the Prosthetics Observational Gait Score and expert clinical advice was used to develop the list of deviations, and graphical data for each participant was inspected visually for the presence of each deviation to provide ordinal (yes/no) data in the following four categories; lower limb kinematics, upper body kinematics, kinetics (GRF) and kinetics (joint moments and powers).

NHS ethical approval for the retrospective use of data was obtained (18/WA/0097).

Results
The general outcome measures shown in Table 2 highlight the magnitude of difference in walking ability between participants and normal healthy adults across all outcome measures.

Table 2: Gait outcome measures, showing mean (SD)

	GPS (°)	Walking velocity (m/s)	Step length (m)	SLSR	STSR	Vertical GRF symmetry	Oxygen cost†	Step width (mm)	CoM trajectory deviation (%)
Participants	10.7 (2.1)	0.92 (0.25)	0.6 (0.11)	0.87 (0.09)	0.83 (0.09)	16 (13.5)	0.39 (0.13)	330 (58)	1.98 (0.98)
Control group	5.4 (0.7)	1.41 (0.1)	0.74 (0.06)	0.97 (0.03)	0.96 (0.04)	1.32 (1.22)	0.26 (0.05)	238 (32)	0.8 (0.18)
p-value‡	3.5×10^{-11}	1.015×10^{-8}	0.0002	0.001	1.29×10^{-5}	0.001	0.002	7.94×10^{-6}	0.0003

Abbreviations: GPS, gait profile score (describing lower limb kinematic deviation from normal); SLSR, step length symmetry ratio (score of 1 is optimal); STSR, step time symmetry ratio (score of 1 is optimal); Vertical GRF symmetry, symmetry of the vertical ground reaction force taken through each limb (score of zero is optimal); CoM, centre of mass
† Net nondimensional normalised oxygen cost of walking
‡ Between groups comparison using student's t-test

The five most prevalent gait deviations from each category of the 3DGA analysis are listed in Table 3.

Table 3: Prevalence of gait deviations from 3DGA analysis, with percentage prevalence indicated

Lower limb kinematics	**%**	**Kinetics (ground reaction force)**	**%**
Lack of knee flexion in early stance	98	Reduced Fx2 on the prosthetic side	100
Lack of hip extension in late stance	83	Fx2 on intact side greater than Fx2 on prosthetic side	100
Generally increased anterior pelvic tilt	77	Reduced Fz2 on prosthetic side	96
Digging the heel into the ground (early hip extension)	77	Reduced Fx1 on prosthetic side	95
Posterior pelvic flick to initiate swing	65	Fz2 prosthetic side < intact side	81
Upper body kinematics	**%**	**Kinetics (lower limb moments and powers)**	
Increased trunk side flexion ROM in general	92	Reduced knee power absorption in early stance on prosthetic side	100
Thorax global rotation asymmetry	92	Reduced knee power generation in early stance on prosthetic side	100
Increased thorax lateral translation during stance on prosthetic side	87	Reduced prosthetic knee flexion moment in early stance	98
Increased peak thorax obliquity during stance on prosthetic side	85	Reduced peak prosthetic ankle power in late stance	98
Clear asymmetry of shoulder flexion	80	Reduced prosthetic hip adduction moment in early stance	96

Abbreviations: Fx1, posterior 'braking' GRF in early stance; Fx2, anterior 'propulsion' GRF in late stance; Fz2, vertical GRF in late stance

Conclusions
This paper has outlined the magnitude of gait deviations between UTFs and normal healthy adults. It has presented data from a diverse range of patients with different aetiologies, activity levels, ages, BMIs and time since amputation. While there is little published evidence of a causal relationship between gait outcome measures and quality of life, it is the authors' opinion that the discrepancy in all the gait outcome measures reported, particularly with regards to the increased energy cost of walking, is likely to have a negative impact on quality of life and participation. It is clear from this data there is potential for improvement required of the prosthetic components, sockets, suspension systems and rehabilitation programmes, however this paper is unable to determine which of these aspects of prosthetic care are most critical to improving gait outcomes.

References

1. Jarvis HL, Bennett AN, Twiste M, Phillip RD, Etherington J, Baker R. Temporal spatial and metabolic measures of walking in highly functional individuals with lower limb amputations. Arch Phys Med Rehabil 2016; 98: 1389-1399
2. Weinert-Aplin RA, Twiste M, Jarvis HL, Bennett AN, Baker R. Medial-lateral centre of mass displacement and base of support are equally good predictors of metabolic cost in amputee walking. Gait & Posture 2017; 51: 41-46

Title: **Falls risk assessment tool for individuals with a lower limb amputation living in the community: The FRAT-AMP**

Presenter: **Natalie Vanicek, Reader in Clinical Biomechanics, Dr**

Contact Address Sport, Health & Exercise Science Tel: 01482 463607

University of Hull

Cottingham Road, Hull E-mail: n.vanicek@hull.ac.uk

HU6 7RX

Other Authors:

Siobhan Strike, Principal Lecturer in Biomechanics, Roehampton University
Louise Tisdale, Clinical Specialist Physiotherapist Amputee Rehabilitation, Royal Wolverhamptonpton Hospitals NHS Trust
Julia Earle, Clinical Specialist in Amputee Rehabilitation, Kent and Medway NHS and Social Care Partnership Trust
Vicki Russell, Manager at the Artificial Limb Unit, Hull and East Yorkshire NHS Trust
Sarah Smith, Amputee therapy team lead, St George's University Hospitals NHS Foundation Trust
Kate Lancaster, Physiotherapist, St George's University Hospitals NHS Foundation Trust
John Perry, Head of Department of Psychology, Mary Immaculate College

Background: It has been well established that individuals with lower limb loss fall more frequently than age-matched, able-bodied individuals. Miller *et al*. (2001) reported that over 52% of lower-limb amputees fall once a year, with 75% falling recurrently (2 or more times). Moreover, almost 50% of lower-limb amputees report a fear of falling. Risk factors for falling include level of amputation, problems with the prosthesis, pain (musculoskeletal, stump, phantom) and prosthetic experience (4<years post-amputation increased falls risk).[1] There are many validated questionnaires for older adults, however, to our knowledge, there is no amputee-specific questionnaire that assesses falls-risk and can be used as a referral pathway within a clinical context.

Aim: The aim of this paper is to report descriptively on the initial results from the FRAT-AMP questionnaire that is undergoing validation. The aim of the FRAT-AMP is to identify falls history, screen patient-specific risk factors, serve to predict falls, and design a clear pathway for referrals.

Methods: A long version of the FRAT-AMP has been developed following consultation with healthcare professionals and patients. The questionnaire comprises of 69 questions organised into 9 sections: demographics, vision, medication, prosthesis, musculoskeletal function, body and pain, foot and limb management, mood and well-being, and environment. 90 participants will be recruited via four prosthetics centres in England when attending for their routine appointment. Participants complete the same questionnaire independently on two occasions, one week apart, and return via post. Falls incidence is followed up at 6 and 12 months. The study received ethical approval (NHS REC Ref:17/EM/0271) and all participants provide written informed consent.

Results: 55 participants (mean age: 57±12 years, 74% male, 49% transtibial), with different amputation aetiologies and prosthetic experience, have completed the FRAT-AMP to date. Initial findings indicate that 47% of respondents suffer from concomitant health problems and 67% have fallen within the previous 12 months. 46% reported a fear of falling and 36% avoided activities because of their fear. Participants take an average of 4.65 medications, with up to 16 different prescriptions. The average time since having a vision test was 19 months. 80% of respondents wear their prosthesis daily. 82% report that they can walk for at least 2 minutes, but only 67% can walk for 6 minutes; 56% experience difficulty on stairs and slopes. Many participants reported having pain: 62% experience pain in their residual limb; 82% deal with phantom pain; 38% get cramping in their contralateral limb; and 64% experience lower back pain. 67% respondents said they felt upbeat most or all of the time and only 25% lived on their own. 62% reported independently leaving their house every day, however 13% never left their house alone.

Conclusions: These preliminary findings indicate the annual rate of falls among predominantly older individuals with lower limb loss living in the community is higher than previously reported.[1] If identified, some of the risk factors for falls may be modifiable. Once fully validated, the FRAT-AMP will provide a clear and clinical signposting tool for improved treatment through appropriate referrals services.

References:

1. Miller WC, Speechley M, Deathe B. The prevalence and risk factors of falling and fear of falling among lower extremity amputees. *Arch Phys Med Rehabil* 2001; 82: 1031–1037.

Title: **Technologies for NeruoRehabilitation**

Presenter: **Professor Jane Burridge, Faculty of Health Sciences, University of Southampton**

Intensive practice is key to recovery of function following stroke. Physical rehabilitation aims to optimise motor recovery so that patients can achieve independence and a good quality of life. Advances in understanding neuroplasticity, the psychology of motivation and the emergence of new technologies have together provided an opportunity to improve outcomes following stroke. The work is also driven by the need for cost-effective rehabilitation, that is appropriate for current and future care pathways, especially in stroke. This talk will present the case for the use of wearable sensors and other technologies to improve outcomes following stroke. It will combine a very short introduction to the evidence for intensity, the rationale for the technologies and will describe M-MARK a wearable technology that provides feedback on movement quality and intensity for both therapists and patients, that is currently undergoing clinical evaluation.

The OETT Lecture:

Title: **Systems Thinking for Assistive Technology: Redesigning the Future**

Presenter: **Professor Malcolm McLachlan, Maynooth University, Ireland**

Access to assistive technology is problematic globally; with income, geography, life stage, marginalisation and service provision among the factors influencing who does and who doesn't get access. To address these inequities a systemic approach to assistive technology is required. Ten Ps of systems thinking for assistive technology are described: People (or users, as the primary beneficiaries of assistive technology), Policy, Products, Personnel, Provision (as key strategic drivers at systems level); and Procurement, Place, Pace, Promotion and Partnership (as key situational factors for systems). The adoption of this approach requires, among other things: 1) disruption of existing power-relationships, 2) the adoption of a "sufficient practice" ethos, and 3) recognition that the domain of "assistive" is related to, but not synonymous with, health or rehabilitation. Forthcoming developments for the World Health Organisation's Global Cooperation on Assistive Technology (GATE) programme are also briefly previewed.

Title: **The effect of socket design on the reliability of EMG signal transduction in trans-radial myoelectric prostheses**

Presenter: **A Monk, Prosthetist, Masters by Research student**

Contact Address:
University of Salford
Brian Blatchford Building
Frederick Road
Salford
M6 6PU

Tel: 07935264779
Email: A.Monk@edu.salford.ac.uk

Other Authors:
Dr. J Head, Senior Lecturer, University of Salford
Prof. L Kenney, Professor of Rehabilitation Technologies / Research Co-Lead Rehabilitation Technologies and Biomedical Engineering, University of Salford
Dr. A Chadwell, Medical Engineer, University of Salford

Background

The majority of trans-radial myoelectric prosthesis users experience some level of difficulty and disruption in the control of their prosthesis everyday (1). Previous studies by Head (1)and Chadwell et al. (2) have suggested that the fit and/or design of the socket could be a contributing factor in the disruption of prosthesis control by introducing uncertainty and motion artefacts into the control system. However, there is currently no definitive prescription criterion that determines the effect that trans-radial socket design has on myoelectric control.

Aims

To investigate the effect of socket design on:

a) the reliability of voluntary-initiated prosthetic prehensor activation and
b) The avoidance of unwanted prosthetic prehensor activation

Methods

Six participants with a trans-radial limb absence and previous experience of using a myoelectric prosthesis were recruited for the study. The user performance of three different trans-radial socket types, the UK Hybrid, Longitudinal Compression and Muenster socket, were evaluated against a baseline no-socket 'ideal' condition (in which the electrodes are held firmly against the skin).

The participants ability to control myoelectric prosthesis activation was assessed via the use of a reaction time test with the forearm in 2 orientations, each being 45° either side of the horizontal, as described by Chadwell et al (2). The frequency of unplanned movements caused by motion artefacts during these movements was determined by a goniometer situated on the prosthetic forefinger that measured the aperture of the hand, and recorded any unwanted activation. Each participant also completed a questionnaire which evaluated each socket via the following: comfort; ease of control; and overall preference.

Results

The UK Hybrid had the least impact on voluntary activation of the hand for the Open Function (Difference in Spread= 15.83 (Standard Deviation of Reaction Time $_{\text{Socket}}$ – Standard Deviation of Reaction Time $_{\text{No Socket}}$)), and also had a considerably lower standard deviation in reaction times than the no-socket condition in the close function. All three sockets caused unwanted prehensor activations in at least 65% of trials, in comparison to 30.56% of 'ideal' no-socket condition trials, in the functional movement tasks.

Summary

The socket that produced experimental data closest to that of the 'ideal' was the UK Hybrid. The results suggest that the fit of the socket, rather than the specific design, is more important when creating a reliable electrode-socket interface. All participants cited the most comfortable socket as their overall preference, although this finding should be interpreted with caution.

1. Head J. The effect of socket movement and electrode contact on myoelectric prosthesis control during daily living activities. Salford: University of Salford; 2014.
2. Chadwell A, Kenney L, Thies S, Galpin A, Head J. The Reality of Myoelectric Prostheses: Understanding What Makes These Devices Difficult for Some Users to Control. Front Neurorobot. 2016;10:7.

Title: **How do unintended activations of myoelectric prostheses relate to functionality?**

Presenter: **Alix Chadwell, Medical Engineer, Dr**

Contact Address: PO34 Brian Blatchford Building
University of Salford
Salford
M6 6PU

Tel: 0161 295 0456

E-mail: a.e.a.chadwell1@salford.ac.uk

Other Authors: Prof. L Kenney, Mechanical Engineer, University of Salford
Dr. S Thies, Medical Engineer, University of Salford
Dr. J Head, Prosthetist, University of Salford
Dr. A Galpin, Psychologist, University of Salford

Control of a myoelectric prosthesis is reliant on stable contact between the electrodes and the skin; loss of contact, or slippage can lead to unintended activations of the hand. Typically, electrodes are housed in the myoelectric socket, held in place by two rubber ‘legs’. The stability of the electrode-skin contact is dependent, in part, on the tightness of the socket, which will inevitably be a somewhat ill-defined comfort/function compromise. In our study we assessed the impact of 3 factors (the ability of prosthesis users to control the EMG signal from their residuum, the reliability with which the EMG was transduced, and the delay in the response of the prosthesis) on:

a) performance on a goal-oriented task and
b) real-world use of their prosthesis. (1)

In this abstract we focus on the relationship between one measure of the stability of electrode-skin contact (the number of unintended activations of the hand), and measures of performance on a goal-oriented task.

Twenty unilateral trans-radial users of myoelectric prostheses were recruited from six UK centres. Socket design, age and suspension method varied between participants; for example one participant wore a liner with pin-lock and others added a neoprene sleeve over the socket.

To assess the unintended activations of the hand, participants were asked to move their arm from 45° above, to 45° below the horizontal 48 times. The hand began each movement in either a fully open or fully closed position. Whilst ‘transitioning’ the arm, participants were instructed not to attempt to open or close the hand or resist any unintended hand activation. The number of ‘transitions’ where an unintended activation occurred were recorded. This assessment was first undertaken with the electrodes bandaged to the arm in an optimal position, with optimal gain settings (‘ideal’ condition). The assessments were then repeated with the participant wearing their own prosthesis, and again with a 500g mass added to the hand to simulate carrying an object.

Functionality was assessed using a multistage goal-directed task; outcome measures included task success rate, task duration, patterns in the hand aperture during reach-to-grasp, temporal kinematic variability in the linear acceleration of the forearm, and measures of gaze such as the time spent looking at the hand or the object to be grasped.

75% of participants experienced at least one unintended activation of the prosthetic hand (out of 48 ‘transitions’). For the majority of participants the number of unintended activations of the hand increased when wearing the prosthetic socket when compared to the ‘ideal’ interface condition. The number of unintended hand activations was found to correlate with the task success rate (τ_b=-0.402, p=0.037), task duration (τ_b=0.649, p=0.001), and kinematic variability (τ_b=0.583, p=0.001). The results also suggested there may be a link between the number of unintended hand activations and the reliance on visual feedback during task performance.

The findings highlighted the prevalence of unintended hand activations within clinically prescribed prostheses. This study suggests that improvements need to be made to the way in which the electrode-skin contact is maintained within clinically prescribed prostheses.

(1) Chadwell A. The reality of myoelectric prostheses: How do EMG skill, unpredictability of prosthesis response, and delays impact on user functionality and everyday prosthesis use? PhD [thesis]. Salford (UK): University of Salford; 2018.

The George Murdoch Prize Lecture:

Title: **Amputation in CRPS: which patient qualifies?**

Presenter: **Professor Dr Jan HB Geertzen, MD PhD, University Medical Centre, Groningen, The Netherlands**

Complex regional pain syndrome type I (CRPS-I) is a condition characterized by pain, which is disproportionate to the inciting event, combined with sensory, sympathetic, motor and trophic changes. The syndrome often requires long, intensive treatment, including physical therapy, occupational therapy, pharmaceutical therapy, and/or neuromodulation. The pathophysiology is not understood. Within 6 to 13 months of onset, symptoms improve considerably for many patients. However, in some patients the syndrome may become therapy-resistant and patients may express the wish to have their affected limb amputated because of unbearable pain, infections or extremely limited mobility. Nevertheless, amputation as a treatment for long-standing, therapy-resistant CRPS-I remains controversial.

Limited data exists concerning the long-term effect of amputation as a treatment for long-standing, therapy-resistant CRPS-I. Furthermore, little is known about the course of patient's functioning following amputation. In the early nineties of the last century I conducted my PhD on the long-time results of CRPS-I. Persons with CRPS-I could have long-standing problems. Our team became experts in this field in the northern part of the Netherlands. One female patient who demanded an amputation was refused; but two other patients subsequently received amputation of their arm. Both patients did not develop a recidive of CRPS-I that was described earlier in the literature. Based on this experience we started with a CRPS-amputation team (consultant in rehabilitation; traumatologist, physiotherapist and psychiatrist) to see more patients who requested an amputation. Nowadays we are the only expert team in the Netherlands that sees patients with CRPS-I and request an amputation.

This lecture will discuss the results of more than 50 patients (today more than 65), our team approach and our protocol.

Acknowledgement and thanks are extended to the following team members:-

Prof Pieter Dijkstra, PhD, Physical Therapist

Ernst Schrier, MSc, psychologist

Peter Cornet, MD, psychiatrist

Prof Andre Wolff MD, PhD, pain specialist

Prof Clark Zeebregts, MD, PhD, vascular surgeon

Jan van den Dungen, MD, PhD, vascular surgeon

Wilfred den Dunnen MD, PhD, pathologist

Many residents in Rehabilitation Medicine including

- Nathalie Hulsman
- Marlies Bodde,
- Hilde Schreuder,
- Jelmer Schepers

Title: **MovAiD – Movement Assistive Devices: Manufacturing of personalised Kineto-Dynamics parts and products for workers, elderly and children.**

Presenter: **Dr Nadine Stech, Principal Integrated Control Design Engineer,**
Chas A Blatchford & Sons Ltd, Basingstoke

Orthotics service provision faces challenges due to demographic changes, rising costs of social services/health care provision and lack of qualified personnel. #ISPOWER advocates empowerment and social inclusion of people with impaired mobility through improved access to P&O and AHT care.

The Horizon 2020 research project MovAiD investigates how technology and additive manufacturing can address some of the recent challenges. It aims to develop technologies for manufacturing passive and highly-personalized wearable equipment to assist disabled children, the elderly and workers in their everyday lives.

The MovAiD framework consists of the following elements:

- Automated design tools to help creation of personalised devices (compliance to body contour and kineto-dynamic parts)
- Integration platform that manages the full data flow from body scan to delivery of the device
- Embedded sensors to assist with assessment and monitoring of the device
- Investigation and development of additive materials for personalised devices
- Additive manufacturing on local and central level to support device fabrication
- Intelligent supply chain management from device ordering to service support

The technological achievements will be presented into the wider context of growing need for medical care, demographic change, user acceptance, servitisation and Industry 4.0.

Title: **The Starworks Project: Achievements and Next Steps**

Presenter: **Gemma Wheeler, The Starworks Network, Sheffield Hallan University, Sheffield**

Following the announcement in March 2016 of the government's investment of £1.5 million in child prosthetics, National Institute for Health Research (NIHR) Devices for Dignity MedTech Co-operative were given the role of leading the £750,000 fund created to *"incentivise the development of new breakthrough innovative prosthetic products for the NHS."* The agreed approach was to pump-prime the formation of a Child Prosthetics Research Collaboration, which brought together children and their families with key opinion leaders from the NHS, industry, clinical academia and leading national research centres with capabilities in child prosthetics. The aim of this work was to increase research focus across the system to accelerate the translation of new inventions and developments in child prosthetics into everyday use. This initiative is centred on the needs of children, patient and families and the NHS and will ensure there is the ideal balance of 'clinical pull' and 'technical push' to create an energetic environment in which to innovate.

This talk will give an overview of the approach taken to developing a new, much-needed collaborative research network in the field of child prosthetics, including:

- Establishing the network
- A multi-stakeholder needs assessment, considering the perspectives of children and families, clinicians, academics and industry experts.
- A series of 'Sandpit' events, bringing together these key stakeholders to collaboratively explore and innovate in emergent challenge areas
- The funding of ten 'Proof of Concept' projects that respond to these challenge areas, whilst keeping children and families in the centre of the research focus.

As part of this talk, we are also pleased to confirm that Starworks has received further funding from the NIHR to continue to develop the network, reinforcing its current foundations and also extending its reach. We will give an insight into initial plans for 'Starworks 2', and hope that this talk will encourage families, clinicians, academics and industry experts to reach out to us, learn more, and help us to grow the network further.

Title:	**Validating performance of a novel wearable device for long-term activity monitoring during everyday activities**		
Presenter:	**Piotr Laszczak, Mechatronic Research Engineer**		

Contact Address:	Blatchford & Sons Ltd. Unit D Antura Kingsland Business Park Basingstoke RG24 8PZ	Tel: Fax: Email:	01256 316600 - piotr.laszczak@blatchford.co.uk
Other Authors:	Lou-Ann Raymond, Research Engineer, Blatchford & Sons Ltd. Siu-Teing Ko, Research Engineer, Blatchford & Sons Ltd. Michael McGrath, Research Scientist, Blatchford & Sons Ltd. David Moser, Head of Research, Blatchford & Sons Ltd. Saeed Zahedi, Technical Director, Blatchford & Sons Ltd.		

INTRODUCTION

In the prosthetics field, it is useful to monitor patients' daily activities[1]. Level of patient activity may be used to measure the outcome of a prosthetic intervention, and has important implications on residuum health. Furthermore, clinicians need to know a patient's activity level in order to fit adequate prosthetic limbs, and apply for appropriate reimbursement. Typically, they are only able to gather such information in a clinical setting, which may not be representative of all movements/activities performed throughout the day[2]. Therefore, there is a need for wearable devices that may provide accurate information of patient activity in an everyday environment[1].

Many existing devices exhibit short battery life, and thus patients have to remember to re-charge them regularly. Furthermore, motion-based activity monitors (AMs) could lead to spurious step counts. Measuring kinetics may prove a more reliable way of counting steps. In prosthetics, this could be realised by measuring foot shell flexion, which is related to prosthesis loading. This work describes the development of a low power AM using direct load-based measurements and introduces a user interface platform to inform clinicians and patients of their daily activity.

AIM

Development of a novel wearable device for long-term monitoring of daily activities.

METHODS

An AM platform was developed, which included a piezo-polymer foot shell flexion sensor and a power-optimised electronic hardware capable of recording the sensor signals and transmitting them to a user interface platform.

To verify the accuracy of the AM in the everyday environment, a lightweight, portable camera was strapped to an amputee's prosthetic limb and positioned to view the ankle. Simultaneously with the video recording, piezo-polymer sensor signals were measured and recorded on an Android app. The data collection lasted for continuous period of >20% of amputee daytime activity, during which time the participant performed normal everyday activities in an unconstrained environment. The collected data was first used to define a step and subsequently to validate the AM output against the manual step count.

RESULTS

The video recording gave a unique insight into the type of activities amputees perform on daily basis. The video permitted formulation of a step definition, used in subsequent manual counts. The comparison of the manual count and the AM output yielded an error below 5% for all daily activities. The ability to estimate cadence was also demonstrated. Based on the current consumption measurements, it has been estimated that the battery life of the AM will be >1 year without a charge.

CONCLUSION

The results from this study illustrate the performance of a novel activity monitor. When used in everyday circumstances, the AM showed equivalent, or better performance to other commercial solutions currently used in clinical decision-making. However, in comparison to other step counting wearables, the present AM can be used for long-term monitoring of amputee activities maintenance-free. The AM shows strong potential for providing clinicians with reliable outcome measures, assisting them in decision-making and reimbursement applications, as well as in prosthesis fitting and alignment, all of which will be explored in the future.

REFERENCES

1. Aminian, K., & Najafi, B. (2004). Capturing human motion using body-fixed sensors: outdoor measurement and clinical applications. *Computer animation and virtual worlds*, *15*(2), 79-94.
2. Allet, L., Knols, R. H., Shirato, K., & Bruin, E. D. D. (2010). Wearable systems for monitoring mobility-related activities in chronic disease: a systematic review. *Sensors*, *10*(10), 9026-9052.

Title: **STEPFORWARD: A protocol for a randomised feasibility study of a self-aligning prosthesis for older individuals with a vascular-related transtibial amputation**

Presenter: **Dr. Cleveland T. Barnett, Senior Lecturer in Biomechanics**

Contact Address: Erasmus Darwin 244
Clifton Campus
Clifton Lane
Nottingham
NG11 8NS

Tel: 01158483824
Email: cleveland.barnett@ntu.ac.uk

Other Authors: Natalie Vanicek, Reader and Chief Investigator, University of Hull.
Cleveland Barnett, Senior Lecturer, Nottingham Trent University.
Natasha Mitchell, Research Fellow, University of York.
Catriona McDaid, Reader, University of York.
Kerry Bell, Research Fellow, University of York.
Martin Twiste, Senior Lecturer, University of Salford.
Abayomi Salawu, Consultant, Hull and East Yorkshire NHS Trust.
Fergus Jepson, Consultant, Lancs Teaching Hosp NHS Foundation Trust.
Judith Watson, Senior Research Fellow, University of York.

Aims and Objectives: - Self-aligning prosthetic ankle-foot devices, that incorporate a hydraulic articulation between the pylon and prosthetic foot, have been shown to benefit gait in lower activity level (K2) individuals with a unilateral transtibial amputation[1], with this patient group also reporting a preference for such devices[2]. However, older individuals with a transtibial amputation routinely receive a more rigid (standard) prosthesis, which does not accommodate to activities such as stair climbing or slope walking. Self-aligning, hydraulically articulating prostheses are designed to overcome such issues, and are available on the NHS but seldom prescribed to older adults with limited mobility. To date there have been no evaluations of the effectiveness of such devices outside of the controlled laboratory setting. Therefore, the aim of this multicentre study is to assess the feasibility of conducting a randomised controlled trial assessing the effectiveness and cost-effectiveness of a hydraulically articulating, self-aligning prosthesis compared to a standard prosthesis in a group of older patients with health comorbidities.

Methods: - The study will recruit older individuals (>50 years) with a unilateral transtibial amputation due to vascular, diabetic or other diseased aetiology, currently prescribed a standard functioning prosthesis, from three prosthetic centres (Hull, Nottingham and Preston). Following baseline assessment (e.g. clinical assessments, self-report questionnaires and activity monitoring over 7 days), 90 participants will be randomised to either the self-aligning (n=45) or standard (n=45) treatment arm. Participants in the self-aligning group will use their new prosthesis for 12 weeks; participants in the standard group will use their normal prosthesis. Follow-up assessments will be conducted at 8 and 15 weeks following randomisation. The costing approach will be undertaken from an NHS perspective and unit costs will be derived from established national costing sources. Qualitative interviews and focus groups will be undertaken with patients and clincians (consultants, prosthetists) respectively, to discuss their experience of participating in the study and to discuss any barriers to successful delivery of the self-aligning prosthesis.

Results: - The following patient recruitment and completion outcomes will be calculated: number of eligible participants; eligible patients approached for consent; participants approached who do/do not provide consent; participants providing consent who are randomised; participants dropping out between randomisation and follow-up.

Data from the clinical assessments (e.g., two-minute walk test) will be summarised descriptively and categorical data by counts and percentages. Completion rates of all the clinical outcome measures will be reported by study arm.

Conclusions: - The hydraulically articulating, self-aligning prosthesis has been designed for patients categorised as having limited mobility, helping them to adjust to walking on slopes and uneven surfaces, going up and down stairs, and potentially avoiding a fall. This study will help to determine whether the prescription of a more functional prosthesis leads to better patient outcomes and is cost-effective. The potential long-term benefits to patients include improved clinical practice and informed healthcare policy, extending to ensuring a more evidence-based approach to prosthetic prescription.

References:

[1] Barnett CT, Brown O, Bisele M, Brown MJ, De Asha AR and Strutzenberger G. Unilateral trans-tibial amputees with lower activity levels walk more quickly when using a hydraulically articulating versus rigidly attached ankle-foot device. *J Prosthet Orthot* 2018; 30(3): 158-64.
[2] Moore R. Patient Evaluation of a Novel Prosthetic Foot with Hydraulic Ankle Aimed at Persons with Amputation with Lower Activity Levels. *J Prosthet Orthot* 2017; 29(1): 44-7.

This abstract presents independent research funded by the National Institute for Health Research (NIHR) under its Research for Patient Benefit (RfPB) Programme (Grant Reference Number PB-PG-0816-20029). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Title: **Contrasting adverse incident reporting in the UK for prosthetics and orthotics with medical devices overall**

Presenter: **Phillip Davenport, Medical Device Specialist, Dr**

Contact Address: MHRA, 10 South Colonnade, London, E14 4PU
Tel: 020 3080 6461
Fax: 020 8754 3965
Email: phillip.davenport@mhra.gov.uk

Other Authors: C Blake, C Cacou, A Marsden, S Vincent, Medicine and Healthcare products Regulatory Agency

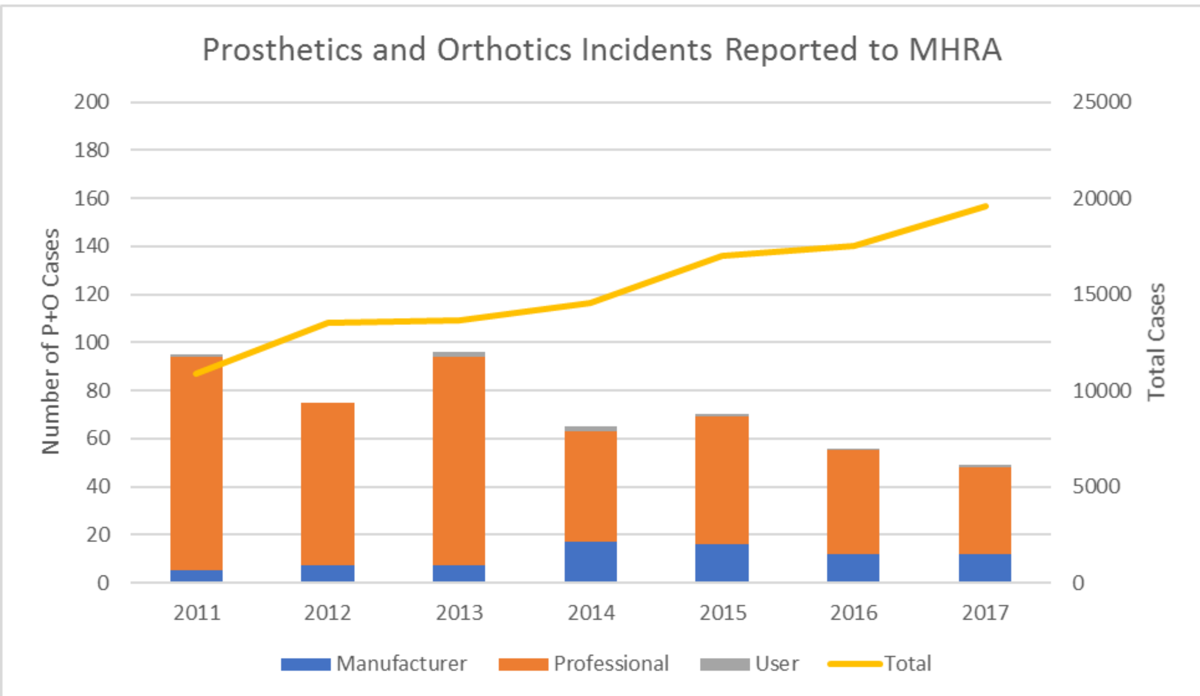
The number of amputees in the United Kingdom is estimated to be around 60,000. Many of these individuals will be prescribed medical devices to aid in their mobility and rehabilitation. The Medicines and Healthcare products Regulatory Agency (MHRA) is the National Competent Authority for medical devices in the UK, with responsibility for monitoring reports of adverse incidents involving medical devices. Incidents may be reported to the MHRA by anyone, including members of the public and clinicians. Manufacturers of medical devices are legally obliged to report adverse incidents they become aware of that meet the vigilance reporting criteria set out in the Medical Device Directive.

Recent times have seen an increase of around 10% per year in the total number of adverse incidents reported involving medical devices of all kinds (from 10,885 in 2010 to 19,579 in 2017) for a variety of reasons including more devices on the market and improved awareness of vigilance requirements: however, this increase was perceived to not have been mirrored in the areas of prosthetics and orthotics. A search of all incidents involving these devices reported to the MHRA over the period January 2011- December 2017 was undertaken to attempt to identify changes in event reporting statistics.

Analysis of reported incidents for prosthetics and orthotics found that the numbers of reported incidents has declined from 95 in 2011 to 50 in 2017. In terms of reporting sources, the proportion of incidents reported by clinicians or users has also reduced from 94% to 72%, with those originally reported to the MHRA by manufacturers changing from 5% to 24%. Absolute numbers of manufacturer reports received has increased slightly over this period.

These results suggest several potential reasons for the change in report volume in prosthetics compared to other medical devices. Potentially prosthetic/orthotic devices suffer fewer faults than in the past. Alternatively, the decline in user reporting may represent a change in perceived importance of reporting incidents to the MHRA or manufacturers or confusion about the roles of local risk management systems, National Reporting Learning System and Yellow card reporting.

The end of the transition to the Medical Device Regulations in May 2020 will bring changes to the adverse incident environment for manufacturers with increased requirements for post-market surveillance. By understanding the issues faced by stakeholders the MHRA can encourage quality reporting of adverse incidents that will aid in identifying trends and signals in these devices, enabling a more responsive regulatory service.



The Blatchford Lecture:

Title: **Amputation Surgery and Rehabilitation in lower limb amputees in Germany**

Presenter: **Prof Dr Bernhard Greitemann, Klinik Munsterland, Germany**

The numbers of major amputations (above the syme-level) are decreasing in Germany by about 4% per year. Despite this hopeful development there are ongoing problems with the surgical techniques and the rehabilitation process due to several reasons, e.g. lack of skilled surgeons, lack of experienced rehabilitation units, problems with changing responsibilities of insurances and especially missing ambulatory treatment knowledge and capacities. Despite the fact that there is an accepted guideline by German Association of Orthopaedic and Trauma surgeons especially rehabilitation has its problems. Therefore the long-time results of rehabilitation in Germany are poor.

This lecture will demonstrate the surgical needs for a good rehabilitation, describes the process of in- and outpatient rehabilitation with mentioning the problems in the different stages of rehabilitation and tries to describe possible solutions.

Title: **A Case Series of Non-traumatic Insufficiency Fractures of the Distal Femur or Tibial Plateau observed in 4 Transtibial Amputees during Inpatient Prosthetic Rehabilitation**

Presenter: **Dr Suzanne Connolly, Specialty Dr in Rehabilitation Medicine**

Contact Address: Ward 1B, Withers
Musgrave Park Hospital
Stockman's Lane, Belfast
BT9 7JB

Tel: 02895041783
E-mail: Suzanne.connolly@belfasttrust.hscni.net

Other authors: Dr Lorraine Graham, Consultant in Rehabilitation Medicine; Dr Josephine Hillan, Consultant in Rehabilitation Medicine

AIMS/OBJECTIVES:
To collate and explore the presentation and investigation of 4 patients who developed acute onset knee pain during early prosthetic walking training. Each patient developed an insufficiency fracture of the distal femur or tibial plateau on the transtibial residuum side.

METHOD:
Retrospective chart review of amputees with non-traumatic/insufficiency fracture of the distal femur/tibial plateau identified during early prosthetic training between January 2013 - December 2017. Patient demographics, medical details, presentation, radiology results, and management were recorded from the hospital notes.

RESULTS:
Patient 1 was a 52 year old female with a right transtibial (TT) amputation admitted for prosthetic rehabilitation. Co-morbidities included peripheral vascular disease (PVD), diabetes mellitus (DM), hypertension, and pulmonary embolism. One fall was noted post-operatively. On day 4 of week 1 prosthetic rehabilitation, she developed medial knee/stump pain on walking. Examination confirmed medial joint line tenderness. X-ray of knee demonstrated osteopenia. Pain persisted. MRI demonstrated undisplaced insufficiency fracture of the posteromedial distal femoral metaphysis. Orthopaedics advised 6 weeks' non-weight-bearing (NWB). Patient did not complete walking due to onset of acute pulmonary oedema.

A 71 year old male with bilateral TT amputations secondary to PVD and DM was admitted for gait training. On day 4 of week 7, he developed medial right knee 'shooting/burning' pain on weight-bearing. X-ray of right knee was normal. MRI confirmed a subchondral medial femoral condyle insufficiency fracture. After a month delay he completed walking training, SIGAM Ca.

A 59 year old female with a right TT amputation secondary to trauma was admitted for prosthetic rehabilitation. Co-existent diagnosis of sarcoidosis. On day 2 of week 2, she developed sudden medial knee/stump pain on weight-bearing. No recent falls were noted. On examination there was tenderness along the medial joint line. X-ray showed mild narrowing of the medial joint space. MRI demonstrated high-grade chondromalacia at the medial femoral condyle with subchondral reactive changes representing early insufficiency fracture. After 6 weeks NWB, the patient achieved prosthetic mobility of SIGAM Ca.

A 59 year old female with a left TT amputation secondary to PVD and DM attended for prosthetic rehabilitation. Co-morbidities included COPD, pancreatic insufficiency, osteoporosis, and bilateral hip fractures. No recent falls. On day 2 of week 2, a left knee joint effusion was observed (with no pain reported). X-ray demonstrated osteopenia and marginal lateral tibiofemoral compartment osteophytes. MRI revealed insufficiency fracture of medial and lateral tibial plateau, with slight depression laterally. After 6 weeks NWB she achieved SIGAM Ca.

CONCLUSIONS/RECOMMENDATIONS:
This case series presents 4 patients with TT amputation who, during walking training, developed pain or knee swelling, and were shown on MRI to have developed insufficiency fractures of the distal femur or tibial plateau. Radiographs did not demonstrate a fracture. Three patients presented with acute knee pain and 1 patient presented with a joint effusion. Only one patient had osteoporosis. We propose that an MRI should be considered in TT amputees who develop persistent knee pain during prosthetic walking training despite having normal knee X-rays.[1]

REFERENCES:
1. Jose J, Pasquotti G, Smith MK *et al*. Subchondral insufficiency fractures of the knee: review of imaging findings. Acta Radiologica 2015;56:714-19.

Title: Prosthetic Rehabilitation Following Multiple Limb Loss

Presenter: **Sioned Steventon, Prosthetist**

Contact Address: Queen Mary's Hospital
Roehampton Lane
London
SW15 5PN

Tel: 0208 487 6060
Fax:
E-mail: sioned.steventon@stgeorges.nhs.uk

Aims & Objectives

Multiple limb amputations are relatively rare. The Douglas Bader Centre at Queen Mary's Hospital, Roehampton, has seen an increasing number of this patient group engage in inpatient rehabilitation over the past ten years. Bilateral lower limb amputations are commonly due to diabetes and peripheral vascular disease however multiple limb amputations can be caused by a number of additional factors, including trauma and purpura fulimans.

The aim of this paper is to record the multiple limb amputees who have undergone inpatient rehabilitation at Roehampton over the past ten years. It will explore the client groups average age of onset, epidemiology and outcomes. A literature review of available research will be included as well as a case study of a quadrilateral patient progressing from primary amputee through to microprocessor knee provision.

Method

A systematic search of available literature was conducted through Medline, EMBASE, CINAHL and AMED using a combination of subject heading and keyword search strategies.

A substantial database has been collated at Roehampton from 2006 to present, detailing each patient who has attended for both inpatient and outpatient rehabilitation at Queen Mary's Hospital. This database was searched for multiple limb amputees. One of these patients was chosen for the case study.

Summary of Results

From the literature search, only five relevant papers were found. Four themes were established; managing multiple limb amputees, upper limb considerations, lower limb considerations and wheelchair use.

In the years between 2006 and 2017 twenty primary multiple limb amputees were identified, all underwent a period of inpatient rehabilitation. Of these 20 patients, 12 remain active, 2 inactive, 3 deceased and 3 have moved centre. The average length of inpatient rehabilitation was 93 days. 45% were female, 55% male. 15% had lost 3 limbs and 85% had lost all 4 limbs. The age range was 17-73 years, with a mean age of 47 years. The causes of amputations were 15% trauma, 5% diabetes mellitus and 80% infections, with 81% of these infections being septicaemia.
The case study comprises of a 46 year old male who became a quadrilateral amputee due to pneumococcal sepsis. He has progressed from short rocker pylons, to SAKL and feet, to free knee walking and now uses microprocessor knees. Six month outcome measures identified a decline in *timed up & go* due to the sit to stand being complex with free knees, but an increase in distance for his *6-minute walk test* and his *PEQ* scores have also improved.

Conclusions

This project has shown that there is minimal literature available on multiple limb amputee rehabilitation. Therefore the rehabilitation process at Roehampton relies upon our past experiences managing this complex patient group. It is clear from both our experience and the literature that patient specific goals are fundamental for each individual. This case study indicates that MPK provision will enhance quality of life for future multiple limb patients.

Title: **Osseointegration in Bilateral Above Knee Amputees following Blast Injury: 2 year follow up results from the initial cohort of UK Service Personnel**

Presenter: **L McMenemy, Trauma and Orthopaedic Surgical Trainee, Defence Medical Services**

Centre for Blast Injury Studies
Imperial College London
South Kensington Campus
Exhibition Road
London

07729461209
l.mcmenemy@imperial.ac.uk

Other Authors: A Ramasamy, Trauma and Orthopaedic Surgeon, Defence Medical Services
B Williamson, General Duties Medical Officer, Defence Medical Services
K Sherman, Physiotherapist, Defence Medical Rehabilitation Centre
R Phillip, Clinical Director, Defence Medical Rehabilitation Centre
J Kendrew, Trauma and Orthopaedic Surgeon, Defence Medical Services

Recent conflicts in Iraq and Afghanistan have resulted in over 250 UK Service Personnel amputees. Above Knee Amputations have been associated with significant morbidity with those rehabilitated with socket prostheses complaining of stump related complications. Osseointegrated implants (OI) utilising direct skeletal fixation have demonstrated improved ambulation and proprioception, and helped reduce stump-prosthesis related complications. OI therefore represent a field of interest for military veterans with promising published unilateral civilian clinical results. We report our 24-month follow up results in the initial cohort of military patients undergoing bilateral transfemoral OI.

We undertook an electronic search for all patients who had undergone implantation with the OGAP-OPL prosthesis with at least 24 months follow up. All were predominantly wheelchair bound pre-op and struggled to mobilise on traditional prostheses. All had undergone a standardised rehabilitation protocol. Pre and post injury activity levels and complications were recorded.

7 patients (14 femora) were identified (mean age 29.8yrs), all injured by dismounted blast. An average of 58 months (range 42-79 months) of traditional rehabilitation had been trialled pre-op. Mean follow up was 35 months (range 25-49 months). All were polytrauma patients with a mean New Injury Severity Score of 54 (range 48-54). All had previous polymicrobial colonisation (average 9 different bacteria identified per patient). Following surgery, all patients mobilised with significant improvement in 6-minute walk time, with a mean improvement of 154m (248m vs 402m, $p=0.008$). The Physical component score for the SF-36 demonstrated a statistically significant improvement from 34.65 to 54.5 ($p<0.001$) representing a change from 'below' or 'well below' to 'same or above' the level expected of an age and gender matched able bodied population. Similarly, the mental component score demonstrated a change (41.55 to 58.19 $p=0.005$) from 'below' or 'well below' to the 'same or above' level. At follow up, no patient required explantation of the implant. Each had been prescribed a minimum of 1 course of antibiotics for superficial erythema with no evidence of deep infection. 3 patients demonstrated distal bone demineralisation of uncertain significance, without further intervention required. One patient suffered a broken dual cone which was fixed in outpatient clinic and three required refashioning of the stoma or stump 12-16 months post op with no subsequent stump complications. One suffered a periprosthetic fracture following trauma requiring surgical stabilisation which has subsequently healed.

OI is an option for Service Personnel who, due to the nature of their injuries, may not be able to tolerate traditional suspension socket prostheses and have exhausted all other treatment options. At a minimum of 2 year follow up, the absence of significant infective complications suggests OI may be utilised in the military blast injured despite chronic polymicrobial colonisation of their residuum which has potential implications for translation to civilian populations. Patient reported and performance outcome measures indicate a normalisation of performance in line with age and gender matched able bodied civilians. Longer term surveillance of these patients is required to assess the long-term suitability of this technique in this cohort of patients.

Title: **Do Strength Asymmetries Explain Walking Gait Asymmetries in Unilateral Transtibial Amputees?**

Presenter: **AR Sibley, Research Student, University of Roehampton**

Contact Address: Department of Life Sciences, University of Roehampton, London
Tel: 020 8392 4174
E-mail: sibleya@roehampton.ac.uk

Other Authors: Dr S Strike, Deputy Head of Life Sciences Dept., University of Roehampton
S Moudy, Research Student, University of Roehampton
Dr NA Tillin, Senior Lecturer, University of Roehampton

INTRODUCTION - Muscular strength can be subdivided into maximum (the maximum force a muscle can produce) and explosive strength (the muscle's capacity to rapidly exert force). The latter is considered functionally more relevant in many human movements, and its decline is hypothesised to lead to decrements in functional capabilities. Individuals with unilateral trans-tibial amputations (TTAs) exhibit decreases in knee extensor maximal muscle strength of up to 57% in the amputated compared to the intact limb[1] and gait changes that include decreased walking speed and increased time in double stance when compared to controls. Additionally, TTAs exhibit asymmetry between the amputated and intact limb in step and stride length[2]. Symmetrical knee extensor maximum strength may improve functional gait performance in TTAs; however, the extent of explosive strength decline between limbs in this population, and its subsequent effect on movement, is unknown. The aim of this study was therefore to quantify the relationship between asymmetries in maximal and explosive knee extensor strength and gait in TTAs.

METHODS - Eight TTAs took part in this study. All participants were male, with similar moderate to high levels of physical activity. Maximum voluntary torque (MVT; measures maximum strength) and rate of torque development (RTD; measures explosive strength) of the knee extensors were measured isometrically in both legs. Additionally, five temporal-spatial features (cadence, single and double support time, step and stride length) were assessed bilaterally during level-walking gait at two self-selected speeds for each participant (habitual and fast). Bilateral asymmetry (BA) was calculated for each strength and gait variable using the equation

$$Bilateral\ Asymmetry = \frac{Intact - Amputated}{Intact} \times 100$$

To analyse the relationship between asymmetries in strength and walking gait at both speeds, semi-partial correlations (co-varied for walking speed) were performed.

RESULTS - All correlation coefficients are reported in Table 1. No significant relationships were found at habitual walking speeds; however, there was a moderate non-significant relationship between BA in MVT and double support (r = -0.643, p = 0.054), suggesting that when maximum strength is asymmetrical, TTAs spend more time in double support. When participants walked at a faster pace, two significant relationships were found. Maximum strength BA was moderately related to single support time BA (r = 0.662, p = 0.001), while explosive strength BA was strongly related to step length BA (r = 0.772, p = 0.025), suggesting that the larger the asymmetry in strength, the greater the asymmetry in step length and support time between limbs in TTAs. No other gait variable asymmetries were related to asymmetry in maximal or explosive strength.

Table 1. Semi-partial correlation coefficients between bilateral asymmetries (BA) in maximum and explosive strength, and temporo-spatial parameters of gait between the amputated and intact limb of unilateral transtibial amputees (n=8) walking at a self-selected habitual and fast speed. Significant relationships are in bold.

	Habitual Speed				Fast Speed			
	MVT		RTD		MVT		RTD	
	r	*p*	r	*p*	r	*p*	r	*p*
Cadence	0.390	0.187	0.231	0.463	0.151	0.736	-0.146	0.745
Single support	0.185	0.665	0.024	0.955	**0.662**	**0.001**	0.281	0.371
Double support	-0.643	0.054	-0. 471	0.203	0.157	0.705	0. 440	0.259
Stride length	-0.229	0.309	-0.189	0.409	0.015	0.972	0.024	0.954
Step length	-0.292	0.360	-0.172	0.602	0.445	0.288	**0.772**	**0.025**

CONCLUSION - These findings provide support for the hypothesis that increasing maximal and explosive strength symmetry of the knee extensors in TTAs will increase gait symmetry in this population. Explosive strength in particular seems to be important for gait symmetry at faster walking speeds. Rehabilitation protocols should therefore focus on reducing strength asymmetries between limbs in TTAs to improve movement patterns. As the relationships between strength and gait asymmetries seem to be stronger when demand on the knee extensors is greater (i.e. at faster walking speeds), further work should focus on relationships between asymmetries in strength and more demanding functional activities such as step ascent and descent.

REFERENCES

1. Lloyd CH, Stanhope SJ, Davis IS, Royer TD. Strength asymmetry and osteoarthritis risk factors in unilateral trans-tibial, amputee gait. *Gait & Posture* 2010; 32(3): 296-300.
2. Powers CM, Boyd LA, Fontaine CA, Perry J. The influence of lower-extremity muscle force on gait characteristics in individuals with below-knee amputations secondary to vascular disease. *Physical Therapy* 1996; 76(4): 369-77.

Title: **Can Cognitive assessment predict Lower limb prosthetic success?**

Presenter: **Vishwa Kalansooriya Dr, ST6 Rehabilitation Medicine**

Contact Address: Amputee Rehabilitation Centre, Musgrave Park Hospital, Stockman's Lane, Belfast BT9 7JB

Other Authors: Lorraine Graham Dr, Consultant in Rehabilitation Medicine

Aims and Objectives:
Cognitive impairment is known to be more prevalent among persons with lower limb amputations than in the general population[1]. Physical and cognitive ability are both vital in successful rehabilitation after lower limb amputation. Studies suggest that poor cognitive function can lead to poor outcome in mobility with prosthesis at 6 months[2].
It is likely that amputees with poor cognitive function will attend amputee rehabilitation centres for assessment for prosthetic use, more frequently, with increasing population longevity and the incidence of Diabetes Mellitus. While, previous study by the authors concluded difference in ability to use prosthesis based on cognitive assessment scores, this was statistically insignificant.
In this study our **aim** was to further explore if a particular score on recognised cognitive assessment could predict failure to mobilise with a prosthesis.

Method:
All patients who attended the Regional Disablement Service, Musgrave Park Hospital over a period of 2 years (April 2015 - April 2017) who were noted on initial assessment by the multidisciplinary team to have cognitive issues and subsequently had a formal cognitive assessment, were included in this retrospective study. These patients had either a prosthesis made or a trial of walking with a PPAM aid or Femurette. Following chart review of these patients' demographics, co-morbidities, Montreal Cognitive Assessment scores, SIGAM, Timed Up and Go (TUAG) and 2 Minute Walking Test (2MWT) outcomes were recorded.

Results:
34 patients who had Montreal Cognitive Assessment (MoCA) administered during limb fitting and gait training were identified. The mean age of the patients was 66.94 yrs (SD=9.26). 76.5% of the sample was male. Level of amputation was recorded as 58.8% trans-tibial, 32.4% trans-femoral and 8.8% Through Knee. 73.5% had PVD as the cause of amputation.

20.6% of the patients were deemed unsafe for continued use of a lower limb prosthesis or PPAM aid (SIGAM A) and walking training had been aborted. This group had a mean MoCA of 17.42 (n=7, moderate cognitive impairment). Those patients who were deemed safe to use a prosthesis (79.4%) (SIGAM B upwards) had a mean MoCA of 25.4 (n=27, mild cognitive impairment). Variance and Standard deviation was calculated and means of both SIGAM A and SIGAM B/C/D groups were compared. The difference was statistically significant at p=0.05.

Conclusion:
Patients with a mean MoCA of 17.42 were more likely not to succeed in walking, resulting in limb abandonment. No clear correlation between MoCA and TUAG/2MWT was observed.

References:

[1] Coffey L1, O'Keeffe F, Gallagher P, Desmond D, Lombard-Vance R. Cognitive functioning in persons with lower limb amputations: a review
[2] O'Neill BF1, Evans JJ. Memory and executive function predict mobility rehabilitation outcome after lower-limb amputation.

Poster Exhibition

"Orthosis opening distance (OOD) or 'Rivet Gap' as measure of orthosis tightness in scoliosis"
Joshua Young BSc(Hons) MBAPO, Orthotist, Queen Mary's Hospital, Roehampton

"Neuro inpatients frequently receive orthotic care: a review of a mixed inpatient neuro rehabilitation cohort in a single centre"
Joshua Young BSc(Hons) MBAPO, Orthotist, Queen Mary's Hospital, Roehampton

"Low cost at home myoelectric training using biofeedback and off-the-shelf hardware"
Dr Matthew Dyson, Reserarch Associate, School of Engineering, Newcastle University

"Bilateral Transfemoral (Above knee) Amputation: A Case Series"
Dr Ali Al-Fadhly, Long Terms Conditions Centre, Harold Wood, Romford

"Osseointegration for Limb amputees – Opportunities and Challenges"
Dr Vijay Kolli, Locum Consultant in Rehabilitation, Queen Mary's Hospital, Roehampton

"An evaluation of the provision of myoelectric prostheses for patients with upper limb loss"
Dr Harriet Grubb, Specialist Registrar, West Midlands Rehabilitation Centre, Birmingham

"Developing thermal simulation of the effect of amputation on muscle heat during physical activity"
Laura E Diment, DPhil Student in Engineering Science, Oxford University

"Fingertip pressure and shear sensing for prosthetic hands"
Nicholas Hale, Faculty of Engineering and Physical Sciences, University of Southampton

"Lower back pain amongst lower limb amputees: a literature review"
Dr Beata Rek, Clinical Research Analyst, Chas A Blatchford & Sons Ltd

"Specialised exercise for individuals with lower limb loss: Reflections from Hull"
Dr Natalie Vanicek, Reader in Clinical Biomechanics, University of Hull

"Living with Pain Group: A Service Improvement Project"
Lindsey Barker, Clinical Specialist Occupational Therapist, Long Term Conditions Centre, Harold Wood, Romford

"Hand and Prosthesis Gesticulation in Congenital and Acquired Amputees"
Nour Odeh, Institute of Cognitive Neuroscience, University College London

"A flexible knee for flexible children"
Dr Stephen Kirker, Consultant in Rehabilitation Medicine, Cambridge University Hospital NHS Trust, Cambridge

"Outcome measurement in an Amputee and Prosthetic Regional Rehabilitation Centre: the experience of Portsmouth Enablement Centre"
Dr Gemma Simons, Rehabilitation Medicine Speciality Registrar, Queen Alexandra Hospital, Portsmouth

"Innovation in delivering limb-fitting services – Can the Hands of X model of co-design for prosthetic limbs become a reality?"
Dr Jo Gooding, Design for Health Interactions AHRC Research Fellow, Kingston University & St Georges NHS Trust

"Clinically useful visualization of socket interface loading data"
Lou-Ann Raymond, Research Engineer, Chas A Blatchford & Sons Ltd, Basinstoke

"Real-time prediction of residuum-socket interface pressure and shear within the socket design process"
J W Steer, Postgraduate Research Student, Bioengineering Research Group, University of Southampton

"Use of prostheses in sport by adolescents with upper limb absence"
Natalie Chinn, Prosthetist/MSc Research Student, University of Salford

"The Me-Amputee Study: Exploring meaningful outcomes of recovery following lower limb amputation and prosthetic rehabilitation: The patient's perspective"
Chantel Ostler, Amputee Specialist Physiotherapist and Research Clinician, Portsmouth Enablement Centre

"An adjustable electrode housing device designed to improve myoelectric signal acquisition and prosthesis control in sockets that accommodate growing residual limbs"
Dr John Head, Senior Lecturer, University of Salford

Commercial Exhibition

Our annual meetings would be incomplete without the support of the commercial organisations and exhibitors. We acknowledge with thanks and appreciate greatly their contribution to the success of our meetings.

amparo GmbH
Lahnstr 17
12055 Berlin
Germany

Contact: Lucas Paes de Melo
E-mail: lucas@amparo.world
www.amparo.world

Chas A Blatchford & Sons Ltd
Unit D Antura
Kingsland Business Park
Basingstoke, RG24 8PZ

Contact: Emma Brown
E-mail: emma.brown@blatchford.co.uk
www.blatchford.co.uk

Drorset Orthopaedic
Unit 16 Headlands Business Park
Ringwood, Hampshire
BH24 3PB

Contact: Kim Walker
E-mail: kimw_dorset-ortho.com
www.dorset-ortho.com

The London Prosthetic Centre
Unit 20 Kingsmill Business Park
Chapel Mill Road
Kingston upon Thames
KT1 3GZ

Contact: Belinda Smart
E-mail: Belinda.smart@thelondonprosthetics.com
www.londonprosthetics.com

North Sea Plastics Ltd
Unit 2, 5 Campsie Road
Kirkintilloch, Glasgow
G66 1SL

Contact: J Blake Jackson
E-mail: blake.jackson@northseaplastics.com
www.northseaplastics.com

Ortho Europe Ltd
Ability House, Nuffield Way
Abingdon, Oxfordshire, OX14 1 RL

Contact: Jessica Mason
E-mail: jessica.mason@abilitymatters.com
www.abilitymatters.com

Őssur UK
Unit No 1 S: Park
Hamilton Road
Stockport, SK1 2AE

Contact: Teri Bacci
E-mail: tbacci@osur.com
www.ossur.com

Ottobock Healthcare Co Ltd
32 Parsonage Road
Egham, Surrey
TW20 0LD

Contact: Stuart Wheatley
Stuart.wheatley@ottobock.com
www.ottobock.com

Steeper Group
Unit 3, Stourton Link
Intermezzo Drive
Leeds
LS10 1DF

Contact: Fliss Newman
E-mail: fliss.newman@steepergroup.com
www.steepergroup.com