



Trent International Prosthetics Symposium



International Society for Prosthetics and Orthotics  
United Kingdom Member Society Annual Meeting



British Association of Chartered Physiotherapists  
in Amputee Rehabilitation Members Meeting

**20<sup>th</sup> – 23<sup>rd</sup> March 2019**

**The Lowry, Salford, UK**



“Moving beyond the lab”

# The Compendium





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## WELCOME

Welcome to the 2019 symposium and to Salford, Manchester's twin city. The cities have grown over the last 250 years from a series of villages and hamlets to arguably the world's first industrial conurbation, starting out in textiles but moving to the design and production of many of the things that make the modern world from the first inter-city passenger railway station to the first electronic stored-program computer, and the discovery of Graphene. It was the cradle of social reform through direct action, is the home to world-famous musicians and artists, and hosts two major football teams. It is also the home of the Salford P&O school, and a reason for siting the conference here. We wish to introduce the next generation of the profession to the latest developments in P&O, and if you meet one of the students in a break or over dinner, we hope you will be able to pass on a little of your knowledge to them.

Much as Greater Manchester is the result of the coming together of the cities, this symposium is the blending of the Trent International Prosthetics Symposium with not only, the ISPO National members Annual meeting, (as in 2016) but this year we welcome BACPAR to join us in Salford. We are in challenging times, not only for those of us from the UK, but across the world there are barriers being placed in the way of people like the prosthetics community, but it is gatherings such as this which aim to create knowledge and understanding which has the potential to improve the lives of many. The theme of this symposium is: **"Moving beyond the Lab"** with which we aim to discover how to integrate the findings in the lab and at the clinic into actions and improvements in daily life for our patients here and across the world. We have invited some exciting keynote speakers to start the process, but the value for all of these symposiums is the interactions throughout the conferences, at the breaks, in the dinners and with the questions at the end of a presentation. We look forward to meeting all of you over the four days.



Alix Chadwell  
*University of Salford*



Fiona Davie Smith  
*BACPAR and WestMARC Glasgow*



Laurence Kenney  
*University of Salford*



Peter Kyberd  
*Portsmouth University*



Louise Tisdale  
*BACPAR and Royal Wolverhampton NHS Trust*



Kia Nazarpour  
*Newcastle University*

# PROGRAMME

Wednesday 20<sup>th</sup> March 2019

08:30 Registration Opens

08:45 Welcome address

Chair: Tamar Makin and Kengo Ohnishi

09:00 **Targeted muscle reinnervation for individuals with a transradial amputation**

*T. A. Kuiken, Center for Bionic Medicine, Shirley Ryan AbilityLab, Chicago, IL, USA*

09:15 **In-Home Use of Phantom Motor Execution for the treatment Phantom Limb Pain**

*E. Lendaro, Electrical Engineering Department, Chalmers University of Technology*

09:30 **A Retrospective Review of all Persons Undergoing Upper Limb Amputation in Scotland, 2012-2018**

*S. J. Day, University of Strathclyde, Glasgow, UK*

09:45 **60 Years of active prosthesis use: Self-report case study with recommendations**

*D. Latour, Single-Handed Solutions, LLC*

10:00 **Refreshments/Exhibitor Showcase**

Chair: Kia Nazarpour and Morten Kristoffersen

10:30 **The quest for a bionic hand: recent achievements and future perspectives**

*Silvestro Micera, Ecole Polytechnique Federale de Lausanne*

11:30 **Are prosthetic limbs represented as hands or tools? An fMRI study**

*R.O. Maimon Mor, Nuffield Department of Clinical Neuroscience, University of Oxford, UK*

11:45 **Rehabilitation of phantom limb pain using a multimodal VR haptic system: clinical outcomes**

*P. Snow, University College London, Royal National Orthopaedic Hospital, Stanmore*

12:00 **Lunch/Exhibitor Showcase**

Chair: Rui Loureiro

13:00 **Sensorimotor Learning for Control of Prosthetic Hands**

*K. Nazarpour, Newcastle University, UK*

13:15 **Implications of movement coordination for developing myocontrolled prostheses**

*R. M. Bongers, University Medical Center Groningen, University of Groningen, Netherlands*

13:30 **Multi-Day Real-time Myoelectric Control using Intramuscular EMG**

*E. N. Kamavuako, Centre for Robotics Research, King's College London, UK*

13:45 **Mimicking EMG features of amputated limbs by restricting unaffected limbs**

*M. B. Kristoffersen, University Medical Center Groningen, University of Groningen, Netherlands*

14:00 **Comparison of EMG pattern distinctness in the affected and non-affected arm in amputees**

*A. W. Franzke, University Medical Center Groningen, University of Groningen, Netherlands*

- 14:15 **Marker-based vs. Inertial-based Motion Capture: Musculoskeletal Modelling of Upper Extremity Kinetics**  
*V. H. Nagaraja, Institute of Biomedical Engineering, University of Oxford, UK*
- 14:30 **Pre/post operative nerve injury interventions using VR and low-cost 3D printed bionic limbs**  
*R. C. V. Loureiro, University College London, Royal National Orthopaedic Hospital, Stanmore*
- 14:45 **Refreshments/Poster exhibition 1/Exhibitor Showcase**
- 15:30 **Manufacturers' workshops**  
*Coapt/Fillauer, Össur, College Park, Ottobock*
- 17:00 **DAY END**
- 19:00 **Welcome drinks reception**

## Thursday 21<sup>st</sup> March 2019

Chair: Corry van der Sluis

- 08:30 **Using Materials Libraries to Explore Material and Sensory Preference with Amputees**  
*S. Wilkes, Institute of Making, University College London and Duncan of Jordanstone College of Art and Design, University of Dundee*
- 08:45 **A Comparison Between Three-Dimensional Printed and Traditional Upper Limb Prostheses**  
*T. Alexander, National Centre for Prosthetics and Orthotics, University of Strathclyde, UK*
- 09:00 **Bespoke Socket Liners with embedded growth tracking & active fluidic cooling channels for child prosthesis**  
*B. Oldfrey, University College London, UK*
- 09:15 **Assessment of Adjustable Electrode Housing Device for Transradial Myoelectric Prostheses**  
*A. Jabran, University of Salford, Salford, UK*
- 09:30 **Open fitting socket for the patient with allergy to laminated socket-case study**  
*M. Burgar, University Rehabilitation Institute republic of Slovenia*
- 09:45 **The contribution of new manufacturing processes to the next generation of prosthetics**  
*R. A. Harris, Future Manufacturing Processes Research Group, University of Leeds, UK*
- 10:00 **Refreshments/Exhibitor Showcase**

Chair: Laurence Kenney and Robert Ssekitoleko

- 10:30 **Understanding Human Grasping and Manipulation and the Design of Low-Dimensional Mechanical Hands**  
*Aaron Dollar, Yale University*
- 11:30 **Harnessing Public and Patient Involvement for upper limb prosthetics design**  
*M. Donovan-Hall, School of Health Sciences, University of Southampton, UK*
- 11:45 **Treatment for upper limb malformation in different areas of the world**  
*L. Hermansson, Faculty of Medicine and Health, Örebro University, Sweden*

- 12:00 **Lunch/Exhibitor Showcase**
- 13:00 **Case studies**  
*Chris Gough, Nigel Ackland, TBC*
- Chair: Aaron Dollar*
- 14:00 **Gaze training enhances prosthetic hand learning, visual control and neural efficiency**  
*J. V. V. Parr, School of Health Sciences, Liverpool Hope University, UK*
- 14:15 **Gesticulation with Hand and Prosthesis in Congenitals One-Handers and Acquired Amputees**  
*R. O. Maimon Mor, WIN Centre, Nuffield Department of Clinical Neuroscience, University of Oxford, UK*
- 14:30 **The effect of three training types on switching in multiarticulating hand prostheses**  
*A. Heerschop, Rijksuniversiteit Groningen and Universitair Medisch Centrum Groningen, Netherlands*
- 14:45 **Refreshments/Poster exhibition 2/Exhibitor Showcase**
- Chair: TBC*
- 15:30 **Myo Plus prosthetic control**  
*S. Amsüss, Ottobock Healthcare Products GmbH*
- 15:45 **The future of prosthetics is here - low cost, custom-made, stylish prosthetics**  
*J. Gibbard, Open Bionics*
- 16:00 **Osseo-neuromuscular limb prostheses**  
*M. Ortiz-Catalan, Chalmers University of Technology, Integrum AB, 3 Gothenburg University*
- 16:15 **Developing a new innovation in powered wrist rotation**  
*A. Goodwin, Ossur*
- 16:30 **Real-World use of Myoelectric Pattern Recognition: Successes and Challenges**  
*B. A. Lock, Coapt, LLC*
- 16:45 **Clinical Impact of Myoelectric Interface and Control Technologies**  
*M. Wernke, The Ohio Willow Wood Company*
- 17:00 **DAY END**
- 19:00 **TIPS Dinner**

## Friday 22<sup>nd</sup> March 2019

- Chair: Maggie Donovan-Hall*
- 08:30 **Designing a new training method for advanced hand prostheses**  
*C. Widehammar, University Health Care Research Centre, Faculty of medicine and health, Örebro University, Örebro, Sweden*
- 08:45 **Falls and balance control of persons with upper limb loss**  
*M. J. Major, Northwestern University & Jesse Brown VA Medical Center, Chicago, IL USA*
- 09:00 **Development of Prosthetic Wrist Function Assessment Device**  
*K. Ohnishi, Tokyo Denki University, Japan*



09:15 **Exploring the impact of control method on embodiment of a myoelectric prosthesis using Immersive Virtual Reality**

*A. D. Hodrien, University of Salford, Salford, UK*

09:30 **Comparing path performed by body-powered and myoelectric simulator**

*H. Burger, University Rehabilitation Institute; University of Ljubljana*

09:45 **Reliability for Assisting Hand Assessment -Prosthetics, Amputations, Deficiencies**

*A. Stockselius, Aktivortopedteknik, Solna, Sweden*

10:00 **Refreshments/Exhibitor Showcase**

*Chair: Peter Kyberd and Roni Maimon Mor*

10:30 **Scaling-up research in upper limb prosthetics**

*Corry van der Sluis, Department of Rehabilitation Medicine, University Medical Center Groningen*

11:30 **The Future of Prosthetics: A User Perspective**

*H. Jones, Newcastle University, United Kingdom*

11:45 **40 TMR cases and counting. Current UK experience of TMR for upper and lower limb amputees.**

*N. Kang, Department of Plastic Surgery, Royal Free Hospital, London*

12:00 **Lunch/Exhibitor Showcase**

*Chair: Sarah Day and Peter Snow*

13:00 **The Starworks Network**

*G. Wheeler, Sheffield Hallam University, UK*

13:15 **Effect of prostheses on motor skills in children with upper limb deficiencies.**

*S. Fujiwara, The University of Tokyo Hospital, Department of Rehabilitation Medicine, Japan*

13:30 **Parent's role in decision and treatment of children with limb malformation**

*L. Sjöberg, School of Health Sciences, Örebro University, Sweden*

13:45 **Use of prostheses in sport by adolescents with upper limb absence.**

*N. Chinn, University of Salford, Salford, UK*

14:00 **Home-based Myoelectric Training using Biofeedback Gaming**

*M. Dyson, Newcastle University, United Kingdom*

14:15 **Bespoke Cycling Device for Child with Congenital Trans-Radial Absence**

*A. Khan, Steeper, Specialist Rehabilitation Centre, Leeds*

14:30 **Treatment Concepts for Children and adolescences with congenital malformation of the upper extremity**

*M. Schaefer, POHLIG GmbH, GERMANY*

14:45 **Prizegiving and Refreshments**

*Chair: Louise Tisdale and Matthew Dyson*

15:30 **UK Centre for Doctoral Training in Prosthetics and Orthotics**

*M Granat, University of Salford*

- 15:45 **How a legal claim for an amputee is calculated**  
*G Martin, Exchange Chambers*
- 16:00 **Introduction to legal claims; how amputees can make the most of compensation and rehab**  
*D. Easton, Leigh Day*
- 16:30 **An initial exploration of the impact of Ugandan prosthetic provision and repair services on users**  
*B. M. Deere, Bristol Centre for Enablement*
- 16:45 **Use of Prosthesis Simulator to Create Body-Powered Prosthesis for Functional Needs**  
*D. Latour, TRS; Handspring Clinical Services*
- 17:00 **DAY END**
- 19:00 **ISPO/BACPAR Dinner**

## Saturday 23<sup>rd</sup> March 2019

Chair: Fiona Davie Smith

- 08:30 **The Blatchford Lecture - Advances in Prosthetic rehabilitation evidence-based practice with clinical outcomes**  
*Friedbert Kohler,*
- 09:15 **An analysis of self-assessed physical activity in people with transtibial amputation**  
*M. Asher, University of Roehampton*
- 09:30 **The development of a running class for lower limb amputees**  
*G. Ferguson, Physiotherapist, Westmarc, Queen Elizabeth University Hospital, Glasgow*
- 10:00 **Refreshments/Exhibitor Showcase**

Chair: Alix Chadwell

- 10:30 **The OETT Lecture - Advanced Technology for Assessment and Orthotic Management of the Patients with Adolescent Idiopathic Scoliosis (AIS)**  
*Man-sang Wong, The Hong Kong Polytechnic University*
- 11:15 **Initial Experiences with Intelligent Variable Resistance Knee Ankle Foot Orthoses**  
*E Lemaire,*
- 11:45 **Heat and Perspiration When Using the SmartTemp Liner: A Double-Blinded RCT**  
*M. Wernke, The Ohio Willow Wood Company*
- 12:00 **Lunch/Exhibitor Showcase**

Chair: Edward Lemaire and Mick Prince

- 12:45 **NHS England Rehabilitation & Disability CRG Policy Update from Prosthetic Review**  
*A. Mistlin and C. Young*
- 13:15 **Living With Pain Group: A Service Improvement Project**

*L. Barker, North East London Foundation Trust (NLFT)*

13:30 **Prosthetics Education Standards**

*C. Harte*

13:45 **The Timed “Up and Go” Test: An audit of TUG scores for lower limb prosthetic users within a clinical environment**

*C. Wilson, Musgrave Park Hospital, Belfast Health and Social Care Trust, Northern Ireland*

14:15 **Does Elevated Vacuum Suspension Improve Limb Health?**

*M. Wernke, The Ohio Willow Wood Company*

14:30 **Monitoring socket fit for children with lower limb absence**

*J. Tang, Faculty of Engineering and Physical Sciences, University of Southampton*

14:45 **Prizegiving**

# LIST OF POSTERS

- 1     **User experiences of digital prostheses in daily functioning in people with an amputation of thumb or finger**  
*V.G. van Heijningen, Rijndam at Erasmus Medical Center, Rotterdam, the Netherlands*
- 2     **Neural correlates of hand augmentation**  
*D. Clode, Institute of Cognitive Neuroscience, University College London, UK*
- 3     **Innovative methods and materials used to produce trans-radial SSOS prosthetic sockets that can be easily used by under-resourced communities.**  
*C.Liu, University of Strathclyde, Glasgow, UK.*
- 4     **The Play Attachment Project**  
*M.Tulloch, Steeper Group, Harold Wood Long Term Conditions Centre*
- 5     **Occupational therapy for children after amputation of hand**  
*D. Brezovar, University Rehabilitation Institute*
- 6     **De Hoogstraat Xperience Prosthesis; an unique innovative test-prosthesis**  
*I. E. M. Roeling, De Hoogstraat Rehabilitation and OT Centre, The Netherlands*
- 7     **Assessing embodiment in elite prosthesis users and expert tool users: preliminary results**  
*H. R. Schone, Institute of Cognitive Neuroscience, University College London – London, UK*
- 8     **Abstract Myoelectric Control in Amputees**  
*M. Dyson , Newcastle University, UK*
- 9     **Reimagining prosthetics services, combining limb fitting and co-creation**  
*G. Pullin, DICAD University of Dundee; Kingston School of Art*
- 10    **Patient Specific Canoe Limb**  
*S.Baker, Steeper, Harold Wood LTCC*
- 11    **Motion Capture Analysis & Plotting Assistant: An Opensource Framework to Analyse Inertial Sensor-based Measurements**  
*R.Cheng, Wadham College, University of Oxford, UK*
- 12    **The Impact of Provision of Multi Articulating Hands in Scotland**  
*C. McGill, SSPS*
- 13    **Effective experiment design for myocontrol**  
*C. Castellini, DLR – German Aerospace Center, Oberpfaffenhofen*
- 14    **User satisfaction with upper limb prosthesis and service in Slovenia**  
*M. Mlakar, University Rehabilitation Institute Republic of Slovenia*
- 15    **Extension of the Target Achievement Control Test to an Immersive 3D Virtual Environment**  
*J. Leestma, Shirley Ryan AbilityLab*
- 16    **Developing Self-Advocacy: the McGann Client Feedback Form**  
*D. Latour, Handspring Clinical Services*
- 17    **VVITA – Validation of the Virtual Therapy Arm**  
*M. Nowak, German Aerospace Center, Institute of Robotics and Mechatronics*
- 18    **A Content Analysis of factors associated with embodiment of upper limb prostheses**  
*A. D. Hodrien, University of Salford, Salford, UK*
- 19    **Learning to control prosthetic fingers with an intuitive myoelectric interface**  
*A. Krasoulis, Newcastle University, UK*
- 20    **Game-based training for EMG decoding algorithms**  
*V. Jayaram, Max Planck Institute for Intelligent Systems*

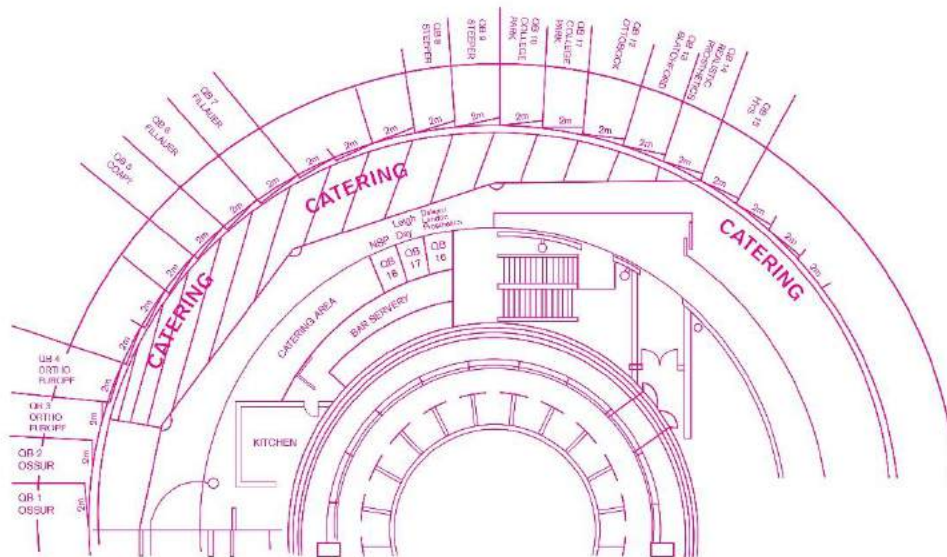


- 21 **Prosthetics and Orthotics facilities in Uganda**  
*A. Cockroft, University of Salford and Knowledge 4 Change, Salford, UK*
- 22 **Long term use of embroidered EMG electrodes**  
*S. S. G. Dupan, Newcastle University, UK*
- 23 **Experiences with a novel Pattern Recognition System used in a below-elbow prosthesis with a multiarticulating Hand**  
*M. Schaefer, POHLIG GmbH, GERMANY*
- 24 **Relationships between upper limb prosthesis use, embodiment, and balance confidence**  
*K. Turner, University of Indianapolis, Northwestern University*
- 25 **Limb Length Estimation in Body-Powered and Myoelectric Prostheses Users**  
*S. M. Engdahl, Dept. of Biomedical Engineering, University of Michigan, USA*
- 26 **The influence of practice on SHAP task performance when using a body-powered prosthesis**  
*A. Chadwell, University of Salford, Salford, UK*
- 27 **Unlimbited Wellness: A Unifying Telehealth Program**  
*D. Latour, Single-Handed Solutions, LLC*
- 28 **EMG control in a virtual reality environment and the effect on phantom limb pain**  
*D. M. Pressney, Shirley Ryan AbilityLab*
- 29 **An audit to examine the prevalence of psychological distress amongst patients with digit and finger tip amputations.**  
*M. Jacobs, Queen Mary's Hospital, Roehampton, UK*
- 30 **Characterising compensatory movements of Upper Limb Prostheses**  
*C. H. Chua, University of Nottingham, Centre for Additive Manufacturing, UK*
- 31 **Groupwork For Children With Limb Loss**  
*L. Barker, North East London Foundation Trust (NLFT), UK*
- 32 **A Bi-Manual Evaluation Setup for Upper Limb Prostheses in Real-Life Settings**  
*A. Gigli, Deutsches Zentrum fur Luft- und Raumfahrt*
- 33 **Investigating the use of 3D printing as a method to produce upper limb sports prosthesis.**  
*B. Jones, University of Salford, UK*

# LIST OF EXHIBITORS

## QUAYS THEATRE BAR

TIPS / ISPO  
March 2019



### LOVER LEVEL

LM 1 - Legs 4 Africa  
LM 2 -  
LM 3 - Open Bionics  
LM 4 - (Thursday only)  
LM 5 -

## Quays bar area



Leigh Day

Fri-Sat only



## Quays theatre foyer lower level



Thursday only

# GUEST SPEAKERS

## **Prof Silvestro Micera (TIPS Keynote)**



Silvestro Micera is currently Associate Professor of Biomedical Engineering at the Ecole Polytechnique Federale de Lausanne (Lausanne, Switzerland) where he is holding the Bertarelli Foundation Chair in Translational NeuroEngineering and Professor of Biomedical Engineering at the Scuola Superiore Sant'Anna (SSSA, Pisa, Italy). He received the University degree (Laurea) in Electrical Engineering from the University of Pisa, in 1996, and the Ph.D. degree in Biomedical Engineering from the Scuola Superiore Sant'Anna, in 2000. From 2000 to 2009, he has been an Assistant Professor of BioRobotics at the Scuola Superiore Sant'Anna where he is now Professor and the Head of the Translational Neural Engineering Area. In 2007 he was a Visiting Scientist at the Massachusetts Institute of Technology, Cambridge, USA with a Fulbright Scholarship. From 2008 to 2011 he was the Head of the Neuroprosthesis group at the Institute for Automation, Swiss Federal Institute of Technology, Zurich, CH. In 2009 he was the recipient of the "Early Career Achievement Award" of the IEEE Engineering in Medicine and Biology Society.

Dr. Micera's research interests include the development of neuroprostheses based on the use of implantable neural interfaces with the central and peripheral nervous systems to restore sensory and motor function in people with disability. In particular, he is currently involved in translational experiments for hand prosthesis control in amputees, and the restoration of vestibular function, grasping and locomotion in different neurological disorders.

He is author of more than 100 ISI scientific peer-reviewed papers and several international patents. He is currently Associate Editor of IEEE Transactions on Neural Systems and Rehabilitation Engineering. He is also member of the Editorial Boards of the Journal of Neuroengineering and Rehabilitation, Journal of Neural Engineering, and of the IEEE Journal of Translational Engineering in Health and Medicine.

## **Prof Aaron Dollar (TIPS Keynote)**



Aaron Dollar is an Associate Professor of Mechanical Engineering and Materials Science at Yale University, where he directs the Yale GRAB Lab. He earned a B.S. in Mechanical Engineering at the University of Massachusetts at Amherst, S.M. and Ph.D. degrees in Engineering Science at Harvard University, and was a postdoctoral associate at MIT in Health Sciences and Technology and the Media Lab. Prof. Dollar is the recipient of a number of awards, including young investigator awards from AFOSR, DARPA, NASA, and NSF, is the founder of the IEEE Robotics and Automation Society Technical Committee on Mechanisms and Design. He is a major proponent of open-access research results, spearheading efforts including the Yale OpenHand Project, the Yale Human Grasping Dataset, the YCB Object and Model Set, OpenRobotHardware.org, and RoboticsCourseware.org.



### **Prof Corry van der Sluis (TIPS Keynote)**

Corry K. van der Sluis (1964) is a professor and consultant in Rehabilitation Medicine at the University Medical Center Groningen, the Netherlands. Her field of interest is the rehabilitation of persons with upper limb disorders. Her professional activities comprise patient care, teaching and research. Her research focuses on upper limb amputations and prostheses. A main research topic is the development of training programs for people who use upper limb prostheses. Innovative technology such as serious games are integrated in this research. A second main research topic is the decrease and prevention of musculoskeletal complaints in persons with upper limb disorders. She is author of over 90 internationally peer reviewed publications and she contributed as an author to 5 book chapters. She gave over 50 international presentations.



### **Prof Friedbert Kohler (The Blatchford Lecture)**

Friedbert Kohler has specialised in Rehabilitation Medicine since 1992 and is currently an Associate Professor and Conjoint Associate Professor at the University of New South Wales, Australia. Further responsibilities include his role as Clinical Stream Director – Aged Care and Rehabilitation – for the South Western Sydney Local Health District and Director of Rehabilitation Medicine at Braeside, Liverpool and Fairfield Hospitals; Director of Medical Services at Braeside Hospital and Director of the Braeside Rehabilitation Research Group. He is also a Senior Staff Specialist in Rehabilitation Medicine.

A past President of the Australian National Member Society of ISPO, Friedbert is currently the President of ISPO; a member of the editorial board of Prosthetics and Orthotics International and the German Rehabilitation Journal Physikalische Medizin. He is also a reviewer for multiple rehabilitation and quality journals. He is Chair of implementation of the ICF subcommittee of the ISPRM and is a member of numerous other committees of ISPO, AFRM and health services.

Other professional associations include membership of the Australasian Stroke Society and the Australian and New Zealand Society for Geriatric Medicine.

His primary research interests include areas of clinical application of the International Classification of Functioning, Disability and Health (ICF), outcome measures, rehabilitation outcomes, developing improving and measuring quality of rehabilitation service delivery and models of care and funding for amputee, stroke and general rehabilitation services.





### **Dr Man-sang Wong (The OETT Lecture)**

Dr. M. S. WONG serves as the Chair of Departmental Learning and Teaching Committee and Programme Leader of the B.Sc. (Hons.) programme in Biomedical Engineering and Jockey Club Rehabilitation Engineering Clinic Coordinator at The Hong Kong Polytechnic University (PolyU).

He is a clinician as well as an engineer and has been practising in the public and private sectors of the prosthetic and orthotic services over 25 years. His main research interests include scoliosis, spinal orthotics, prevention of fragility fractures, gait and posture analysis, CAD/CAM in prosthetics and orthotics, and prosthetics and orthotics outcome evaluation.

He is currently Vice-President of ISPO-Hong Kong NMS, Vice-President & Treasurer of the Hong Kong Society of Certified Prosthetist-Orthotists, and sits on the organizing Committee of the Hong Kong Prosthetics and Orthotics Scientific Meeting. On an International level, he is the Scientific Committee Chair and Executive Board Member of ISPO International, Coordinator of ISPO Asian Region, and an Executive Board Member of the International Research Society of Spinal Deformities. He has given over 80 invited lectures, authored over 200 peer reviewed publications and has supervised over 15 research students.

### **Prof Malcolm Granat**



Malcolm Granat is Professor of Health and Rehabilitation Sciences at the University of Salford. He is engaged in research looking at the quantification of free-living physical behavior using body-worn monitors. Malcolm has published over 100 peer-reviewed papers and is President of International Scientific Society for the Measurement of Physical Behaviours (ISMPB) and Director of the EPSRC Centre for Doctoral Training in prosthetics and orthotics.

### **Gerard Martin QC**



Gerard is a renowned silk who has a wealth of experience dealing with claims for amputees. "His knowledge of prosthetics and amputee injuries is phenomenal. He has taken it upon himself to know everything there is to know about prosthetics. He commands the respect of the court and his preparation is first-rate." Chambers and Partners

### **Prof Edward Lemaire**



Professor Edward Lemaire, PhD is actively involved with research on technologies that improve mobility for people with physical disabilities. He is an Investigator at The Ottawa Hospital Research Institute's Centre for Rehabilitation Research and Development; Professor at the University of Ottawa Faculty of Medicine; and Adjunct Professor in Mechanical Engineering, Human Kinetics, Health Sciences, and Systems Design Engineering. He is also active with the International Society of Prosthetics and Orthotics, as a board member and incoming President. Dr. Lemaire's research has resulted in over 500 published papers and presentations that include intelligent prosthetics and orthotics, biomechanical walking analysis in 3D virtual environments, smartphone approaches to improve decision-making, and eHealth technology to enhance access to education and rehabilitation services.



### **Col Alan Mistlin**

Col Mistlin Qualified from Guy's Hospital in July 1989 with MBBS. After Pre-registration jobs in London embarked on General Duties in Germany, Northern Ireland, Aldershot and Africa and the Caribbean. A return to hospital medicine in 1994 saw a junior doctor rotation through Rinteln, QEMH Woolwich, Frimley Park, The Royal Brompton, Musgrave Park and Bosnia. Selected for specialist training in Rheumatology and Rehabilitation Medicine in 1997 after gaining MRCP. A six-year programme through Defence Medical Rehabilitation Centre, Guy's and St Thomas Hospitals, The Royal London, The Hospital for Neuro-Disabilities, Putney and the Royal National Orthopaedic Hospital, Stanmore. Certificate of Completion of Specialist Training gained in 2003.

Appointed a Consultant at the Defence Medical Rehabilitation Centre, Headley Court 2003. Has worked as the consultant lead to Spines and Neuro-Rehabilitation Group. Currently consultant lead to the Complex Trauma and mild Traumatic Brain Injury Groups. Col Mistlin holds a full time clinical consultant appointment within the MOD and NHS in Rheumatology and Rehabilitation Medicine at The Defence Medical Rehabilitation Centre and Frimley Park Hospital. Until January 2015 he was Medical Director of the only self-managed Military Unit with responsibility for all clinical outputs, providing clinical direction and policy, Healthcare Governance and Clinical Delivery. He has directed liaison with NHS care providers. Nationally he has represented the AF on the BSRM Specialist Interest Group in Amputation Medicine. He is Chair of the Clinical Reference Group for NHSE for Complex Rehabilitation and Disability. He sits on the Veterans Prosthetic Panel with NHS England delivering seamless transfer of Military patients to NHS care and chaired the RSM SEM Section.

As Complex Trauma Rehabilitation and mild traumatic brain injury lead he has driven forward the developing rehabilitation service for injured servicemen. The service has evolved using DMRC staff and evaluation of advanced technology. Previously he has lead the Spinal and Neurological services at DMRC. He believes that rehabilitation medicine in the UK can develop into a world leading service. Rehabilitation needs to look forward and use the experience and knowledge of Neurological, Prosthetic, SCI, AAC, EC and the Military experience to prepare not only for the patients that NHSE already treats but also needs to be prepared for emergency situations such as those experienced in Paris, London and Madrid.

Col Mistlin was awarded FRCP(London) and FFSEM.

### **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.

# ABSTRACTS

Wednesday 20<sup>th</sup> March

Session 1 (08:45-10:00)

Title: **Targeted muscle reinnervation for individuals with a transradial amputation**

Authors: A.M. Simon, K. Turner, L.A. Miller, L.J. Hargrove and T.A. Kuiken

Presenter: A.M. Simon

Affiliation: Center for Bionic Medicine, Shirley Ryan AbilityLab, Chicago, IL, USA

E-mail: [asimon@sralab.org](mailto:asimon@sralab.org)

## Abstract

Targeted Muscle Reinnervation (TMR), a surgical technique where residual nerves are transferred to remaining muscle, combined with pattern recognition, an advanced algorithm that that can provide more intuitive myoelectric control, has been successful in improving prosthesis control for higher-level amputees (1). At the transradial level, it is currently unknown whether additional neural control information, specifically of intrinsic hand muscles, provided by TMR surgery, could improve control of multi-articulating hand prostheses. The goal of this study was to develop transradial TMR surgical techniques and evaluate the potential benefits of this surgery.

Four individuals with a unilateral transradial amputation were fitted with a Touch Bionics i-limb revolution hand, a passive wrist, and a Coapt Complete Control System with pattern recognition (Figure 1). They participated in two 8-week home



Figure 1. Two individuals using a multi-articulating hand post-TMR surgery.

trials pre- and 6 months post-TMR surgery. For the TMR surgery, the ulnar nerve to the flexor carpi ulnaris muscle and the median nerve was transferred to either the flexor digitorum superficialis or brachioradialis muscle. Following each home trial, individuals performed a

suite of outcome measures. The Jebsen-Taylor Hand Function test showed a significant improvement post-TMR surgery compared with pre-surgery measures (paired-t-test  $p < 0.05$ ) (Figure 2). Outcomes measures including the Box and Blocks test and Southampton Hand Assessment Procedure (SHAP) did not reach a significant change (Figure 2). Individuals reported several clinical benefits of the surgery including reduction of pain and increased ability to move their phantom hand. We continue to evaluate additional subjects for the TMR

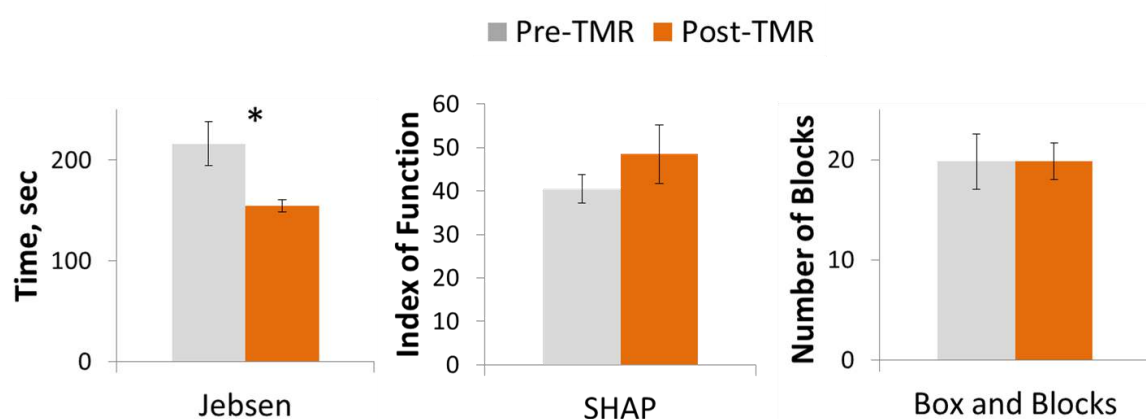


Figure 2. Average pre- and post-TMR outcome measure results including Jebsen-Taylor Hand Function Test, Box and Blocks, and SHAP. For the Jebsen-Taylor Hand Function Test a reduction in time indicates better prosthesis control, and for the SHAP and Box and Blocks higher numbers indicate better control. \* indicates significance at the  $p < 0.05$  value.

surgical benefits following transradial amputation.

### Acknowledgements

This work is being supported by the National Institutes of Health NIH R01HD081525.



Title: **In-Home Use of Phantom Motor Execution for the treatment Phantom Limb Pain**

Authors: E.Lendaro, A.Middleton, S.Brown and M.Ortiz-Catalan

Presenter: Eva Lendaro

Affiliation: Electrical Engineering Department, Chalmers University of Technology

E-mail: [lendaro@chalmers.se](mailto:lendaro@chalmers.se)

## **Abstract**

Phantom Limb Pain (PLP) has been hypothesized as arising from the stochastic entanglement of the pain neurosignature with impaired sensorimotor circuitry (1). Coherently with the implications of this hypothesis, a myoelectric pattern recognition device has been developed to promote Phantom Motor Execution. The device guides patients through a series of exercises that engage the musculature of the residual limb and utilize Augmented and Virtual Reality (AR/VR) as well as serious gaming to provide real-time feedback (2). Preliminary evidence has been sought through a clinical trials (3)(4). However, these experiments have been only conducted in a clinical setting supervised by a therapist. Here we investigate the use of Phantom Motor Execution as a self-treatment strategy for PLP, aiming to explore the benefits and the translational challenges encountered in the transition from clinic to home use. Five limb loss patients (2 upper and 3 lower limb) initially experiencing phantom limb pain participated in this study. All patients were provided with and trained to use a myoelectric pattern recognition and AR/VR device. Patients then took these devices home and used them independently over the course of 3-12 months. We show that home therapy yields efficacious results in pain reduction comparable to findings observed in the clinic, with the advantages of independent use outside of the hospital, as patients adapt the therapy according to their individual preferences and lifestyles.

## **Acknowledgement**

This work was funded by the Stiftelsen Promobilia, VINNOVA, and European Pain Federation—Grünenthal—Research Grant (E-G-G).

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Title: **A Retrospective Review of all Persons Undergoing Upper Limb Amputation in Scotland, 2012-2018**

Authors: S. J. Day, A. Buis

Presenter: Sarah Day

Affiliation: National Centre for Prosthetics and Orthotics, Department of Biomedical Engineering, University of Strathclyde, Glasgow, UK

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## **Abstract**

There is a lack of evidence about the population of people living with an upper limb amputation or congenital upper limb deficiency, and the treatment that they receive. This means that it is difficult to ascertain the needs of the patient population and plan services effectively. In order to understand what is required and how we should be directing our research we should first understand the demographics of those undergoing an upper limb amputation or being born with an upper limb anomaly. This should include all persons within the population group, not only those who have benefitted from prosthetic care. The purpose of this study was to go back to basics to find this information, and then track the patients from amputation or birth, through their treatment processes to discover if any trends exist in areas such as access to care, prescription and outcome. Using data linkage of routinely collected information we reviewed the profiles and treatment of all persons who had undergone an amputation or been born with a congenital limb deformity in Scotland from 2012 to May 2018. Around 10,000 cases were reviewed, which included persons undergoing upper limb amputation, lower limb amputation and those being born with a limb deficiency. Initial findings, including the demographic profile of the upper limb amputee population in Scotland, will be presented.

## **Acknowledgement**

This work, funded by The Centre of Excellence in Rehabilitation Research (CERR), uses data provided by patients and collected by the NHS as part of their care and support.

Title: **60 Years of active prosthesis use: Self-report case study with recommendations**

Authors: D.Latour

Presenter: Debra Latour

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## **Abstract**

Individuals who experience unilateral upper limb loss or congenital difference would likely be obvious candidates to experience secondary conditions related to overuse of the sound upper limb. While much evidence has been published about individuals with acquired upper limb loss, little has been documented about the aging individual with congenital limb difference until recently (1). Jones and Davidson (2) investigated the presence of conditions affecting function of the sound arm among individuals with unilateral upper limb loss; Gambrell (3) conducted a review of literature noting consequences and importance of prevention of overuse syndrome. Recently, Sheehan and Gondo (4) reported on the impact of limb loss in the United States, stating that the number of individuals experiencing limb loss is expected to double by 2050, and secondary conditions include disparities affecting physical health and mental health. Murray's research (5) suggested that personal identities and self-management of patient's ability status should be a priority for the health professionals involved in prosthesis-users medical care and personal development. This presentation offers insight to the experiences of an individual over six decades of active and diverse prosthesis use and incorporates the compelling perspective of the individual as a consumer of prosthetic technology, clinician and contributor to the population and the industry. Social issues, overuse symptoms, adaptive strategies and assistive devices are chronicled through developmental

milestones and stages of childhood and adulthood, and substantiated through medical documentation, personal journals, and photographs.

## **Acknowledgement**

The author would like to acknowledge her parents, Edmund and Sayre Hulseberg for their vision, creativity, unending love, encouragement, support and ability to pass along resilience.

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Wednesday 20<sup>th</sup> March

Keynote (10:30-11:30)

*“THE QUEST FOR A BIONIC HAND: RECENT ACHIEVEMENTS AND  
FUTURE PERSPECTIVES”*

**Silvestro Micera**

Replacing a missing upper limb with a functional one is an ancient need and desire. Historically, humans have replaced a missing limb with a prosthesis for many reasons, be it cosmetic, vocational, or for personal autonomy. The hand is a powerful tool and its loss causes severe physical and often mental debilitation. The need for a versatile prosthetic limb with intuitive motor control and realistic sensory feedback is huge and its development is absolutely necessary for the near future.

Among the possible solutions to achieve this goal, interfaces with the peripheral nervous system, and in particular intraneural electrodes, are a very promising choice. In this presentation, the results achieved so far by using thin-film transversal intraneural electrodes (TIMEs) for sensory feedback are summarized.

First, we are going to describe the results achieved during experiments with trans-radial amputees who received TIME implants to restore sensory feedback. In particular, we are going to show how tactile and proprioceptive information can be restored providing also embodiment and pain reduction. The possibility of obtaining more natural and effective sensory feedback using biomimetic encoding algorithms will be also shown. Finally, the next steps to achieve a fully implantable device will be briefly summarized.

Our findings demonstrate that these interfaces are a valuable solution for delivering sensory feedback to subjects with transradial amputation. Further experiments are necessary to better understand the potentials of this approach during chronic experiments.

Wednesday 20<sup>th</sup> March

Session 2 (11:30-12:00)

Title: **Are prosthetic limbs represented as hands or tools? An fMRI study**  
Authors: R.O.Maimon Mor, T.R.Makin  
Presenter: Roni O Maimon Mor  
Affiliation: Nuffield Department of Clinical Neuroscience, University of Oxford, UK  
E-mail: [roni.maimonmor@ndcn.ox.ac.uk](mailto:roni.maimonmor@ndcn.ox.ac.uk)

### **Abstract**

When using a prosthetic limb, the brain may utilize one of two existing frameworks to represent and control the novel object: the visuomotor body network or the tool-use network. Images of prosthetic arms have recently been shown to activate hand-selective areas in the occipitotemporal cortex (OTC) in prosthesis users. This area is also known to be activated by hand-held tools. Here, we wished to determine whether prosthesis representation resembles that of upper-limbs, in terms of pattern structure, or whether instead it resembles tool representation. Individuals with acquired or congenital upper limb loss (hereafter one-handers) were tested to investigate how limb loss and hand-substitution (wearing a prosthesis) shape categorical reorganisation in OTC. We used Representational Similarity Analysis of functional MRI data from 32 one-handers and 24 two-handed controls. Participants viewed images of upper-limbs, tools, others' prostheses, and one-handers' own prosthesis in an event-related design. A region of interest in OTC was independently localised by contrasting images of headless-bodies and objects. Experience-dependent reorganisation was found in one-handers' prosthesis representation, for both congenital and acquired one-handers, those who use a prosthesis more in daily life, show greater representation of others' prostheses as an independent category, distinct from hands and tools. However, when observing their own prosthesis, congenital and acquired one-handers prosthesis

representation differed, with congenital, but no acquired amputees, displaying a prosthesis representation more similar to upper limbs than tools. Together, our results provide evidence of an adaptable use-dependent categorical visual representation, while challenging current views of prosthesis “embodiment”.

### **Acknowledgement**

R.O.M.M. is supported by the Clarendon scholarship and University College, Oxford. T.R.M holds a Sir Henry Dale Fellowship funded by the Wellcome Trust and the Royal Society, and an ERC Starting Grant.

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Title:           **Rehabilitation of phantom limb pain using a multi-modal VR haptic system: clinical outcomes**

Authors:       P. W. Snow, P. Ramamurthy, I. Sedki, M. Sinisi and R. C. V. Loureiro

Presenter:     Peter Snow

Affiliation:    University College London, Royal National Orthopaedic Hospital, Stanmore

E-mail:        p.snow / [R.Loureiro@ucl.ac.uk](mailto:R.Loureiro@ucl.ac.uk)

## **Abstract**

Phantom Limb Pain (PLP) is a well-known effect post amputation that affects a substantial number of amputees. A number of non-invasive technological based approaches have been proposed that make use of virtual reality, however the effectiveness of these has been called into question with respect to their effectiveness in reducing pain. In lieu of the current gaps within current technology-based treatments a multimodal immersive sensorimotor system was created that facilitates retraining of simple manipulation tasks. Participants were able to perform motor tasks using our immersive haptic sensorimotor training system that provides, direct physical contact to the haptic device, mapping of the information from the device to the virtual representation of the physical limb, and an application that maintains challenge and interest to the individual. Based on these elements, the haptic system acquires EMG commands, residual limb kinematics and displays the combined residual limb movements in a virtual reality environment that includes force-based interactions with virtual objects. Visualisation is provided via a Head Mounted Display so as to facilitate first-person view of the virtual environment and embodiment of the residual limb with the virtual representation. The system was designed to allow the participants to experience three core elements represented in Fig 1; to feel, control and see. In this paper, we present the results obtained with 11 participants that have completed our ongoing first-in-man clinical study, who have shown an

overall pain reduction of 64%, with three participants being pain free following nine hours of therapy over three weeks, sustained over 12 weeks following the intervention.



Fig. 1 The three elements used by the AMPSIM system for Phantom Limb Pain treatment

## Acknowledgements

This work was supported in part by the Defence Science and Technology Laboratory, UK, under contract No. DSTLX-1000064225

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Wednesday 20<sup>th</sup> March

Session 3 (13:00-14:45)

Title: **Sensorimotor Learning for Control of Prosthetic Hands**  
Authors: M. Dyson, E. Brunton, A. Krasoulis, C. Silveira, S. Dupan, H. Jones and K. Nazarpour  
Presenter: Kianoush Nazarpour  
Affiliation: Newcastle University, UK  
E-mail: [Kianoush.nazarpour@newcastle.ac.uk](mailto:Kianoush.nazarpour@newcastle.ac.uk)

### **Abstract**

Acquiring a new skill, for example learning to use chopsticks, requires accurate motor commands to be sent from the brain to the hand, and reliable sensory and visual feedback to the brain. Over time and with training, the brain learns to handle this two-way communication flexibly and efficiently. Inspired by this sensorimotor interplay, our research at Intelligent Sensing laboratory in Newcastle University is guided by a conviction that progress in prosthetic limb control is best achieved through a strong synergy of motor learning and feedback. We therefore study the interaction of neural and behavioural processes that control the hand movements to ultimately innovate prosthetic control solutions that users would find fit for purpose. At TIPS2019, we will provide corroborating evidence from several parallel studies that show with training participants can improve their performance in biofeedback myoelectric control tasks, within a short period, regardless of the level of the intuitiveness of the myoelectric control space. We therefore will emphasise the important role that sensorimotor learning and user adaptation can play in enhancing the myoelectric control of prosthetic hands (1). In addition, we will share our early results on the development of flexible inter-neuronal electrodes to directly interface with the nervous system for provision of sensory feedback.



## Acknowledgement

Authors would like to acknowledge Engineering and Physical Sciences Research Council (EPSRC), UK, for funding via a Healthcare Technology Challenge Award ([EP/R004242/1](#)).

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Title: **Implications of movement coordination for developing myocontrolled prostheses**

Authors: R. M. Bongers, A. Franzke, M. B. Kristoffersen, T. A. Valk, M. Nowak, C. K. van der Sluis and C. Castellini

Presenter: Raoul Bongers

Affiliation: University Medical Center Groningen, University of Groningen, Netherlands

E-mail: [r.m.bongers@umcg.nl](mailto:r.m.bongers@umcg.nl)

## **Abstract**

The current presentation critically discusses the viability of myocontrolled upper extremity prostheses using insights from the coordination of movements. This is inspired from the finding that despite decades of research, users often report the control to be not straightforward and often reject the prosthesis. Part might be due to limitations using surface EMG. Here, novel issues related to myocontrol will be discussed. Independent of whether conventional, direct control or pattern recognition methods are used, for proper control of the prosthesis the myosignals need to be accurate, related to movement intent, and consistent over repetitions of the same intent. We will discuss whether these requirements are viable considering the properties of myosignals in goal-directed movements in an unaffected arm. First, myosignals do not accurately represent movement intent because muscle activations compensate for external force. Therefore, while myocontrol assumes myosignals to be the drivers of movement, myosignals may have a different role. Second, with respect to consistency over repetitions, in the natural situation muscle activation patterns are variable over repetitions of performing the same task, because an abundance of muscles is exploited. Thus, myosignals might have properties that differ from what is required for good myocontrol. The implications of these properties of myosignals will be translated into recommendations for future directions to develop myocontrolled prostheses. Moreover, it will be discussed how these recommendations relate to what these properties of myosignals mean for alternative ways to detect movement intent, such as measuring force in the socket or directly measuring the neural signals.

Title: **Multi-Day Real-time Myoelectric Control using Intramuscular EMG**  
Authors: A. Waris, Z. M. Ur-Rehman, I.K. Niazi, M. Jochumsen and E.N Kamavuako  
Presenter: E.N. Kamavuako  
Affiliation: Centre for Robotics Research, King's College London  
E-mail: [ernest.kamavuako@kcl.ac.uk](mailto:ernest.kamavuako@kcl.ac.uk)

## **Abstract**

Pattern recognition (PR) algorithms have been widely studied in the literature and have shown promising results in acute experiments. However, the clinical usability of PR based myoelectric control is limited by unsatisfactory robustness to non-stationarities. Despite the body of evidence that time has an effect on classification performance, the influence of time on real-time performance on intramuscular EMG recordings has received less attention in the literature. The aim of this study was to investigate the real-time performance of intramuscular recordings over multiple days and to propose an experimental protocol to test three different training strategies using a Fitts' law approach. Three pairs of wire electrode were inserted in the extensor and flexor muscles (Figure 1) and kept inside these muscles for five continuous days in two able-bodied subjects. Four Fitts' law metrics (Table 1) were assessed using three train-test strategies: (i) An artificial neural network (ANN) classifier was trained on data collected from the previous day and tested on present day (BDT) (ii) Trained and tested on the same day (WDT) and (iii) trained on all previous days including present day and tested on present day (CDT) for five days. For both subjects, results are presented in Table 1. Results of this study have confirmed the previous offline findings stipulating that daily calibration is important for stable performance. Nevertheless, the results from two subjects cannot make the basis for a meaningful conclusion. We recommend that PR control scheme be tested and compared over several days to really capture the behavior of the system.

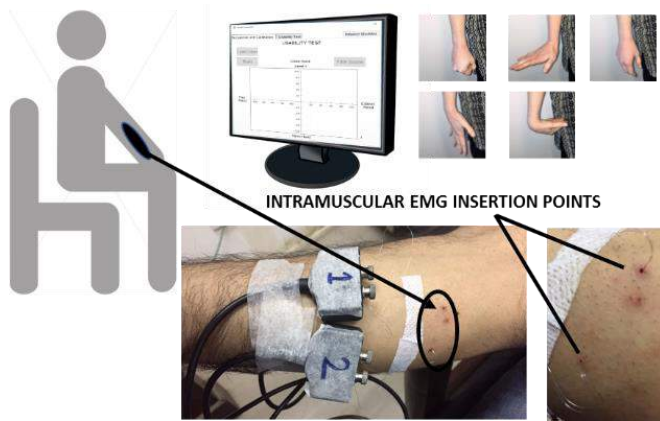


Figure 1: Experimental setup with the subject comfortably sitting in front of a computer that visualizes the motions to be elicited. The photographs are actual placement of the electrodes and insertion points.

Table 1: Results of the performance measures used in this study

		WDT	BDT	CDT
<b>Throughput</b>	Sub 01	$38.13 \pm 0.21$	$35.14 \pm 0.15$	$37.15 \pm 0.91$
	Sub 02	$38.02 \pm 0.51$	$36.89 \pm 2.21$	$38.95 \pm 0.35$
<b>Completion Rate</b>	Sub 01	$94.44 \pm 4.19$	$81.25 \pm 4.54$	$94.79 \pm 2.08$
	Sub 02	$95.28 \pm 1.73$	$78.47 \pm 13.8$	$93.40 \pm 5.13$
<b>Path Efficiency</b>	Sub 01	$84.91 \pm 1.00$	$84.56 \pm 0.91$	$86.64 \pm 0.82$
	Sub 02	$81.85 \pm 0.9$	$82.77 \pm 0.89$	$83.10 \pm 0.46$
<b>Overshoot</b>	Sub 01	$13.37 \pm 1.81$	$15.24 \pm 4.39$	$12.89 \pm 1.30$
	Sub 02	$14.16 \pm 0.18$	$13.18 \pm 1.40$	$15.32 \pm 0.96$

Title: **Mimicking EMG features of amputated limbs by restricting unaffected limbs**  
Authors: M. B. Kristoffersen, A. W. Franzke, A. Murgia, C. K. van der Sluis and R. M. Bongers  
Presenter: Morten B. Kristoffersen  
Affiliation: University of Groningen, University Medical Center Groningen, Netherlands  
E-mail: [m.b.kristoffersen@umcg.nl](mailto:m.b.kristoffersen@umcg.nl)

## **Abstract**

Machine learning techniques have been proposed for the control of upper-limb prosthetics. Electromyography (EMG) signals from able-bodied participants are often used to test new algorithms and techniques. Restricting the unaffected hand has been suggested to best mimic the EMG features of the affected limb. It remains unclear whether this results in more comparable EMG features between the two limbs. In this study we measured EMG from both the affected and unaffected limbs of 11 participants who had an amputation at the trans-radial level, while they performed seven different symmetric bi-manual movements. This was done in two conditions, namely with and without restricting the unaffected limb. We hypothesised that the EMG features of the unrestricted unaffected limb differ more from the affected limb than the EMG features of the restricted unaffected limb. Hudgins' features (1) of the EMG signals as well as offline accuracy of the movements were calculated. Preliminary results show a small-to-medium, but close to significant, interaction effect ( $p=.071$ ,  $\eta^2_G = .06$ ) of hand\*restriction on wavelength suggesting that wavelength has a tendency to be higher for the unaffected limb in the unrestricted condition, while this would not be the case in the restricted condition. No effects were found for the remaining features and offline accuracy. Further analysis will need to be performed to confirm the robustness of this finding. Based on the current analysis it is suggested that in experiments with able-bodied participants, the hand

should be restricted to best mimic the EMG features of people with an amputation.

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*IEEE Trans Biomed Eng.* 1993;40(1):82–94.



Title: **Comparison of EMG pattern distinctness in the affected and non-affected arm in amputees**

Authors: A.W. Franzke, M.B. Kristoffersen, A. Murgia, R.M. Bongers, C.K. van der Sluis

Presenter: Andreas W. Franzke

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## **Abstract**

In myocontrol of upper limb prostheses using machine learning techniques, a basic requirement is the user's ability to generate sufficiently distinct surface electromyography (sEMG) signals for different movement intents, over a wide range of arm orientations.<sup>1</sup> Experiments with regard to training this ability are often conducted on able bodied, but it is unclear to what extent findings in non-affected limbs are representative for the affected limb. In this study we investigated whether sEMG patterns are more distinct in the unaffected compared to the affected side, and whether distinctness is affected by arm posture. 11 individuals with transradial amputation performed seven bimanual movements in three different arm orientations (hanging down; on arm rest; reaching out in front). sEMG patterns were recorded simultaneously on both arms with 8 electrodes. Distinctness was assessed by estimating the distance between sEMG patterns in the sEMG feature space using a modified mahalanobis distance measure. The data analysis showed that distinctness was significantly higher in the unaffected arm ( $p = 0.027$ ) and no effect for orientation of arm and no interaction effect between arm and orientation of arm ( $p = 0.21$ ) was found. These findings suggest that sEMG pattern distinctness is negatively affected by the absence of a limb. Generating sEMG patterns of sufficient distinctness for proper myoelectric control might therefore be more challenging for an individual with amputation compared to an able-bodied individual, which

could have implications for machine learning myocontrol studies conducted on able bodied populations.

### **Acknowledgement**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 687795, project Acronym INPUT.

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Title: **Marker-based vs. Inertial-based Motion Capture: Musculoskeletal Modelling of Upper Extremity Kinetics**

Authors: V.H.Nagaraja, R.Cheng, E. (M.T) Kwong, J.H.Bergmann, M.S. Andersen, and M.S.Thompson

Presenter: Mr Vikranth H. Nagaraja, D.Phil. Student

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## **Abstract**

Growing implementation of 3D-printed prostheses has offered enhanced personalisation and improved device accessibility in low-resource countries, although, the evidence on their clinical-efficacy and effectiveness is lacking [1]. Recently, numerous affordable prostheses have been proposed, and there is a need to evaluate device performance in the final end-user's setting. For improved objectivity in analysing prosthetic arm movements, *in vivo* (e.g., joint and muscle) loading have either been estimated or measured; however, multi-body musculoskeletal (MS) model-based approach in this field is limited. Robustness and computational-efficiency of Inverse Dynamics make it the most-suitable MS-modelling technique for kinetic analysis, however, *a priori* knowledge of involved motions is a pre-requisite. For input, Inertial-Based motion capture (mocap) Systems (IBS) are portable and cost-effective, providing full-body measurement capabilities in a field-condition, compared to the 'gold-standard' Marker-Based mocap Systems (MBS). Recently, only lower-extremity kinetics have been compared using MS-modelling through MBS and IBS inputs [2]. Hence, this study's objective is to compare upper-extremity kinetics estimated by MS-modelling for MBS and IBS inputs. This study was approved by the local Research Ethics Committee and three adult able-bodied participants consented to participate. Synchronised data capture, corresponding to three trials of *Reach-to-Grasp* task, involved 16-camera Vicon and Full-body

Xsens MVN-Awinda systems. *Simple Full-Body* and *Inertial MoCap models* in the AnyBody Managed Model Repository v.2.1.1 were adapted to calculate respective kinetics. Preliminary results indicate that the kinetic outputs estimated for both mocap inputs are comparable. Detailed MS-analysis is planned for our upcoming study involving field-based IBS mocap for affordable prosthetic arm assessment.

### **Acknowledgements**

Vikranth's studentship was supported by the RCUK Digital Economy Programme grant number EP/G036861/1 (Oxford CDT in Healthcare Innovation). Additional support through a Wellcome Trust Affordable Healthcare in India award 103383/B/13/Z.

### **References**

1. Diment LE, Thompson MS, Bergmann JH. Three-dimensional printed upper-limb prostheses lack randomised controlled trials: A systematic review. *Prosthetics and orthotics international*. 2018 Feb;42(1):7-13.
2. Karatsidis A, Jung M, Schepers HM, Bellusci G, de Zee M, Veltink PH, Andersen MS. Predicting kinetics using musculoskeletal modeling and inertial motion capture. *arXiv preprint arXiv:1801.01668*. 2018 Jan 5.

Title: **Pre/post-operative nerve injury interventions using VR and low-cost 3D printed bionic limbs**

Authors: R. C.V. Loureiro, P. W. Snow, E. Magee, I. Caplan, M. Croysdale,  
R. Magbagbeola, I. Sedki, M. Sinisi

Presenter: Rui Loureiro

Affiliation: University College London, Royal National Orthopaedic Hospital, Stanmore

E-mail: [R.Loureiro@ucl.ac.uk](mailto:R.Loureiro@ucl.ac.uk)

### **Abstract**

There is evidence to suggest that Phantom Limb Pain (PLP) is connected with the idea of an internal feed-forward model, and the maladaptive reorganisation, which takes place in the sensorimotor cortices and descending motor pathways, disrupts the integrity of sensory feedback in amputees leading to a mismatch with the comparator movement that causes PLP [1].

Complex Regional Pain Syndrome (CRPS) on the other hand, is often referred to the acute and chronic post traumatic neuropathic pain suffered by individuals who have experienced a painful event such as an injury or surgery, with the pain affecting one or more limbs [2]. Despite not including an amputation, neuropathic pain and PLP share neuroscientific similarities, clinical findings and referred sensations [3].

We have developed novel treatments based on Virtual Reality (VR) and Robotics targeting neuropathic pain in amputation, nerve injury and spasticity in spinal cord injury. The research has resulted in two first-in-man clinical trials at the Royal National Orthopaedic Hospital and a world's first – the delivery of a 3D printed bionic hand for pain management on the NHS.

In our paradigm we use VR [4] as a preconditioner to the surgical intervention and the 3D printed bionic hand to enhance pain management post-surgery. We report on a single case study, who has been pain free since the intervention. We have delivered the project in 4 weeks

and spent less than £4k with estimated cost savings to the NHS with ongoing follow up treatments of over £500k.

### **Acknowledgements**

This work was supported in part by the Royal National Orthopaedic Hospital Charity, by the University College London, and by the Defence Science and Technology Laboratory, under contract No. DSTLX-1000064225.

### **References**

- [1] Kawato, M. "Internal models for motor control and trajectory planning", *Current Opinion in Neurobiology* 9 (6): 718–727, 1999. doi:10.1016/S0959-4388(99)00028-8
- [2] Rho R. H., R. P. Brewer, T. J. Lamer, and P. R. Wilson, "Complex Regional Pain Syndrome," *Mayo Clinic Proceedings*, vol. 77, no. 2, pp. 174–180, Feb. 2002.
- [3] Acerra N. E., T. Souvlis, and G. L. Moseley, "Stroke, complex regional pain syndrome and phantom limb pain: Can commonalities direct future management?," *J Rehabil Med*, vol. 39, no. 2, pp. 109–114, 2007.
- [4] Snow, W. P., Comley, R, and Loureiro, R.C.V. "Sensorimotor Rehabilitation of Phantom Limb Pain". *Trent International Prosthetic Symposium*, 2016.

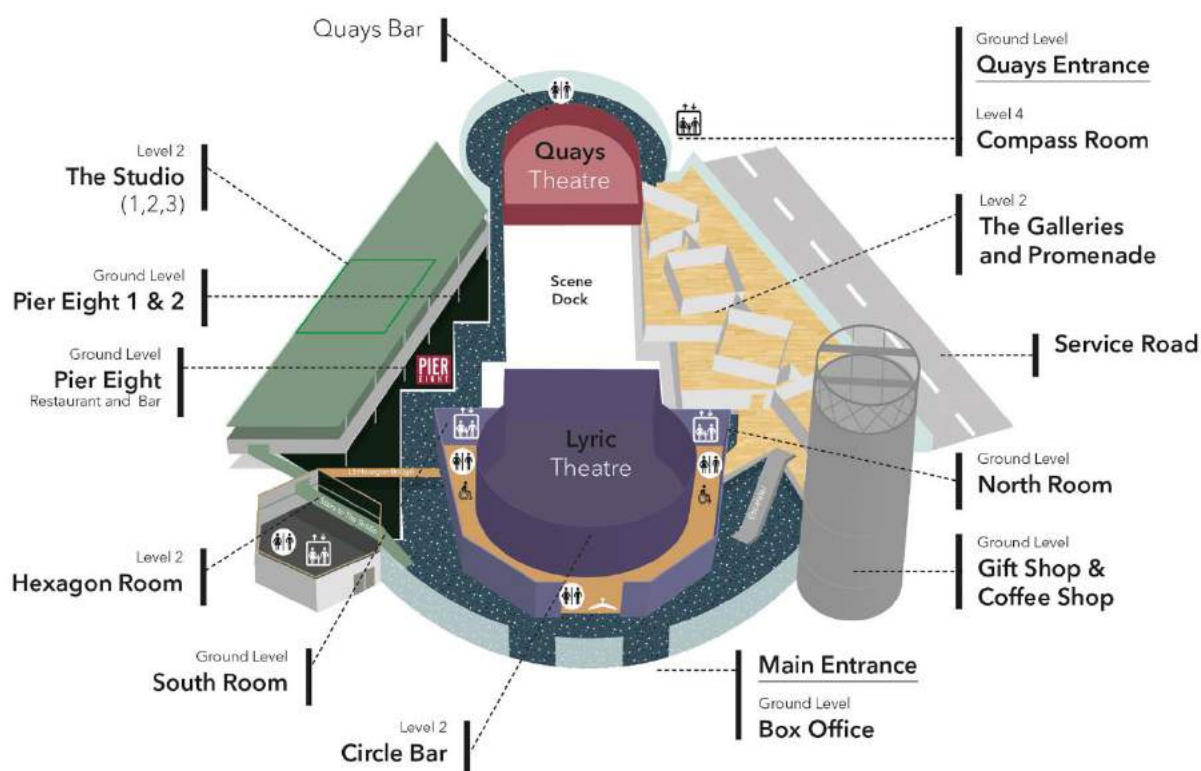
# Wednesday 20<sup>th</sup> March

## Manufacturers' Workshops

Manufacturers' workshops will be run in four different locations throughout the building:

- Quays theatre (Main conference space)
- Pier 8 rooms (Poster rooms)
- The Hexagon Room (Upstairs above the Pier 8 bar)
- The South Room (Next to the Lyric theatre)

Each session will repeat three times, however, as spaces are limited in each session, please collect a ticket from the registration desk.





## Quays theatre



Coapt pattern recognition in Europe:  
Coming to you via Fillauer!



The Coapt COMPLETE CONTROL pattern recognition system for upper limb prosthesis control has seen widespread US success for more than 5 years.

This life-changing enhancement has been fit to upper limb prosthesis wearers of all levels and is compatible with all major manufacturer devices. The highly anticipated Generation 2 Coapt system is coming to Europe and will be available through Fillauer and its affiliated distributors. Join this workshop to learn something new about the technology and find out how it will be available near you.

## Pier 8 rooms



Effective use of Physiotherapy and Occupational  
Therapy to optimise i-limb and i-digit use

Össur strongly advocates the importance of dedicated therapy services to help achieve successful outcomes for patients fit with its bionic solutions including the i-limb ([www.touchbionics.com/products/active-prostheses/i-limb-quantum](http://www.touchbionics.com/products/active-prostheses/i-limb-quantum)) and i-digits portfolio.

Achieving successful patient outcomes with myoelectric upper limb prostheses can be challenging and, without the correct training, an advanced prosthesis may ultimately be rejected by the patient.

This workshop brings together the expertise of our therapist colleagues illustrating use of assessment tools such as virtu-limb and then clinician and user apps such as biosim and my i-limb that help user optimise their prostheses, including talking advantage of the new Grip Chips.

## Hexagon room



### The Espire Elbow from College Park: Innovation for the Transhumeral amputee

This presentation will cover new innovations from College Park Industries, including the Espire Elbow family of elbow systems. In addition to determining which member of the Espire family would be most appropriate for your patients, control strategy selection criteria for the Pro and Hybrid will be discussed.

## South room



### Up close to the Ottobock MyoPlus Pattern Recognition System

In this workshop you'll get the opportunity to get "up close and personal" with the new Ottobock Myo Plus Pattern Recognition System.

Split into smaller working groups, our Ottobock Experts will guide you through the system's functionality and demonstrate the programming app.

Better still, one of our experts uses Myo Plus system himself, so all of your questions and queries can easily be answered by a real life user.

We look forward to seeing you.

Thursday 21<sup>st</sup> March

Session 1 (08:30-10:00)

**Title: Using Materials Libraries to Explore Material and Sensory Preference with Amputees**

**Authors:** S. Wilkes, C. McMullan, A. Cook, G. Pullin and M. Miodownik

**Presenters:** Sarah Wilkes and Caitlin McMullan

**Affiliation:** Institute of Making, University College London and Duncan of Jordanstone College of Art and Design, University of Dundee.

**E-mail:** [s.wilkes@ucl.ac.uk](mailto:s.wilkes@ucl.ac.uk)

### **Abstract**

With its roots in the [Hands of X](#) project, this study was jointly developed by Caitlin McMullan, a Glasgow-based designer, researcher and below knee amputee, and Sarah Wilkes, a materials researcher at UCL, and takes a participatory approach to research into materials selection for prosthetic limbs. The selection of materials for prosthetic limbs has implications for the wearer beyond function and comfort: Cairns et al. (1) and Sansoni et al. (2) have demonstrated that the appearance of a prosthesis affects its acceptance and that improving aesthetic qualities can help to improve the body image and psychological wellbeing of the wearer. However, despite an increasing number of private initiatives that provide wearers with more materials choice (e.g. The Alternative Limb Project, Open Bionics), relatively little research has been done to systematically explore wearers' materials, aesthetic and sensory preferences. In this paper, we will discuss the methods used to explore material and sensory preferences, examining the pivotal role of the materials library collection in enabling this research. We will discuss the development of specially made object sets to represent a range of sensory and aesthetic properties (e.g. hard-soft, rough-smooth, sticky-slippery) for use in object-handling tasks coupled with questionnaires and semi-structured interviews. We will also share the findings of this study, which have the potential to direct the materials choices offered by

prosthetics manufacturers and limb fitting centres, as well as discussing the potential use of this method to explore the link between specific material properties or textures and phantom limb sensations.

### **Acknowledgement**

This study is funded by a Wellcome Trust Humanities & Social Sciences Fellowship (200354/Z/15/Z).

### **References**

1. Cairns N, Murray K, Corney J, McFadyen A. Satisfaction with cosmesis and priorities for cosmesis design reported by lower limb amputees in the United Kingdom: Instrument development and results. *Prosthetics and Orthotics International* 2014; 38(6):467-73.
2. Sansoni S, Wodehouse A, Buis A. A new design system of below-limb prostheses - the role of a visual prosthetic designer. In: *DS 80-1 Proceedings of the 20th International Conference on Engineering Design (ICED 15) Vol 1: Design for Life*, Milan, Italy, 27 July 2015, paper no. 15, pp. 351-360.

Title: **A Comparison Between Three-Dimensional Printed and Traditional Upper Limb Prostheses**

Authors: T.Alexander, S.Day

Presenter: Tory Alexander

Affiliation: National Centre for Prosthetics and Orthotics, University of Strathclyde

E-mail: [toryalexander3@gmail.com](mailto:toryalexander3@gmail.com)

## **Abstract**

Upper limb loss or absence can have a major impact on a person's life. Some users have rejected current traditional prostheses for reasons including cost, weight, appearance, function and comfort (1). Manufacture of upper limb prosthetic devices using 3D printing aims to provide a solution by addressing some of these issues. The aim of this investigation was to make a comparison between current 3D printed and traditional upper limb prosthetic devices. Two of the most commonly used prostheses from each category, 3D printed and traditional, were manufactured and tested. Different specifications of each device were measured, these included; cost, manufacture time, weight, size, appearance and functionality. This investigation has found that, when compared to traditional prostheses, 3D printed devices cost considerably less and can provide some functional benefit to patients. However, traditional devices are more functional, more robust, have improved comfort and are less bulky. Due to the limitations of 3D printing found in this investigation, the permanent use of 3D printed devices for patients who have access to traditional prostheses is not recommended. Applications of 3D printed upper limb prosthetics could be as a temporary, secondary or transitional device. There is potential for permanent use of 3D printed upper limb prostheses in developing countries for users who have no other access to prosthetic treatment. The author hopes that this work can help further develop the design, manufacture

and prescription of low cost prosthetic devices, and in turn, improve the quality of life for people with upper limb amputations globally.

## References

1. Biddiss EA, Chau TT. Upper limb prosthesis use and abandonment: a survey of the last 25 years. *Prosthetics and orthotics international*. 2007;31(3):236-57.

Title: **Bespoke Socket Liners with embedded growth tracking & active fluidic cooling channels for child prosthesis**

Authors: B. Oldfrey, M. Croysdale, I. Sedki, C. Holloway, R. Loureiro, M. Miodownik

Presenter: Ben Oldfrey

Affiliation: University College London

E-mail: [ucbpbmo@ucl.ac.uk](mailto:ucbpbmo@ucl.ac.uk)

## Abstract

The interface between a residual limb and a prosthetic requires a liner material that ensures transmission of forces while ensuring comfort and preventing skin damage. For a child, this is a particular challenge because their body not only changes size and shape throughout the day,

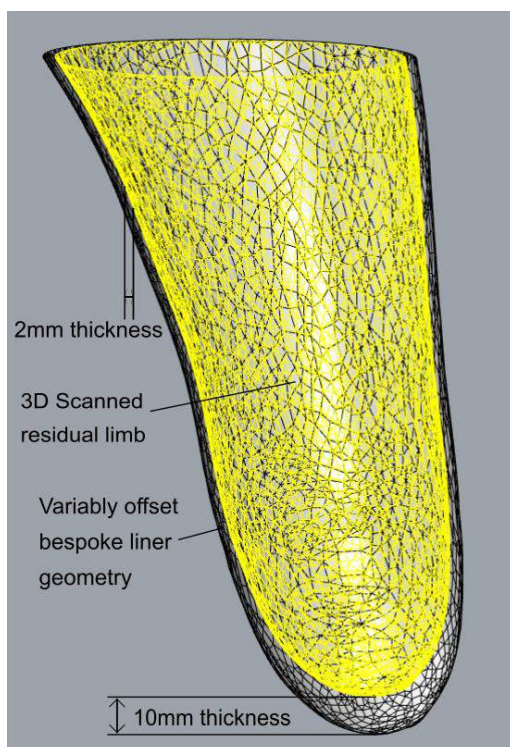
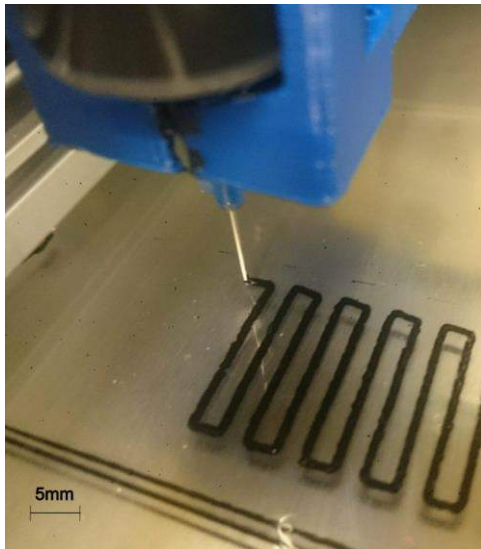


Figure 1 Bespoke Liner Geometry from 3D scan data

but also sees permanent growth over the longer term. Skin damage occurs due to a number of factors including high temperatures at the skin interface [1]. Interviews with patients and our work with prosthetists on understanding the thermal comfort of users indicates that diagnosing problems before they become critical requires real-time and continuous monitoring of stress states [1]. This approach of continuous monitoring has been shown to be feasible with off-the-shelf sensors [2].

However, to date sensors have been used to monitor only [2]. We evolve the sensing technology, allowing feedback to adapt the skin-liner interface. We present here a low-cost fabrication method based on additive manufacturing techniques for a bespoke liner specifically aimed at addressing the user needs. Using 3D scan data, we have produced a liner that when positioned correctly, will not have any initial

stretched/thinned areas (a problem associated with generically sized liners). Embedded within



*Figure 2 Novel Printing of CNT-based stretch sensors for growth tracking*

the liner is a bespoke network of nanocomposite stretch sensors (Figure 2) enabling growth tracking, and fluidic cooling channels that can circulate coolant to exterior heat dispersion panels, enabling thermal management. The behaviour of elastomeric stretch sensors is generally highly complex and non-linear. To address this, we also present a novel deep learning-based approach to the calibration of these sensors

using Long Short Term Neural Networks (LSTM) trained on visually mapped strain data, requiring minimal electronics. Finally, we present the results of in-situ testing and comfort feedback from our test user.

## **Acknowledgement**

We would like to thank the Medical Devices and Vulnerable Skin Network (MDVSN) and Starworks for funding this project.

## **References**

1. Williams RJ, Holloway C, & Miodownik M. The Ultimate Wearable: Connecting Prosthetic Limbs to the IoPH. *ACM 2016* DOI:10.1145/2968219.2972711
2. Williams, R J, Takashima A, Ogata T, Holloway C. A pilot study towards long-term thermal comfort research for lower-limb prosthesis wearers. *Prosthet Orthot Int* 2018 DOI:10.1177/0309364618791604.



Title: **Assessment of Adjustable Electrode Housing Device for Transradial Myoelectric Prostheses**

Authors: A. Jabran, F. Tomanec, L.P.J. Kenney, D. Howard, D. Davys, L. Jiang, N. Hale and J. Head

Presenter: Ali Jabran

Affiliation: University of Salford, Salford, UK

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## **Abstract**

Myoelectric prostheses require reliable transduction of muscle electrical signals from socket-located electrodes for their operation. To achieve this, the electrode(s) should be correctly aligned and the security of the electrode-skin interface should not be influenced by external loads, e.g. those that may occur when the user picks up an object with their hand<sup>1</sup>. However, clinicians often fit children's sockets with growing room, with a view to reducing the number of appointments needed. As current electrode housings do not allow for user adjustment of the electrode relative to the socket, a loose socket may lead to poor electrode-skin contact, unreliable operation of the prosthesis, and hence a frustrated child. We propose an adjustable electrode housing, based on the one reported in Head et al. (2013)<sup>1</sup>, that will enable parents to adjust electrode contact pressure, position and orientation, but will be:

- more compact;
- provide the capacity to enable appropriate adjustment over a typical period between clinical visits and;
- be easily adjustable by parents, with a "parental lock"

We have developed two schematic device designs and will be starting the evaluation study later this Autumn. The study will compare the new designs against the conventional housing, building on a protocol developed by Chadwell<sup>2</sup> and will require the participants to undertake

simple arm movements, with a standard EMG clinical assessment tool, the Otto Bock 'Myoboy', capturing relevant EMG signal information during these activities. The evaluation will also employ a new sensor (TRIPS), developed at the University of Southampton, which measures pressure and shear.

## **Acknowledgements**

This research is part of the StarWorks Project and is funded by NIHR Devices for Dignity MedTech Co-operative.

## **References**

1. Head JS, Howard D, Hutchins SW, et al. The use of an adjustable electrode housing unit to compare electrode alignment and contact variation with myoelectric prosthesis functionality: A pilot study. *Prosthet Orthot Int* 2016; 40: 123-8.
2. Chadwell A, Kenney LPJ, Thies S, et al. The Reality of Myoelectric Prostheses: Understanding What Makes These Devices Difficult for Some Users to Control. *Front Neurorobot* 2016; 10: 7.

Title: **Open fitting socket for the patient with allergy to laminated socket-case study**  
Authors: M. Burgar, H. Burger, M. Mlakar  
Presenter: M. Burgar  
Affiliation: University Rehabilitation Institute republic of Slovenia  
E-mail: [matej.burgar@ir-rs.si](mailto:matej.burgar@ir-rs.si)

### **Abstract**

The 69 years old men as a child lost his right hand in an injury with explosive. He has transradial amputation. The stump is short, cylindrical shape and the skin is healed. After fifty years of wearing the prosthesis he developed an allergy to the hardener in laminated socket. We produced for him a laminated socket where we coated the interior with thermoplastic foam material. The problem with allergy was solved, but he had more and more problems with severe sweating. His body weight also often varies. The result is that his socket is often too big or too tight. At times he used the prosthesis all day for many activities of daily living, but today he use it only at home, because he's afraid that prosthesis slip him uncontrollably from the stump. Our team decided to try to fit him with Open fitting socket. The Delft University of Technology has developed an Open Fitting (1) for arm prostheses, which leaves 75% of the skin uncovered. As a result the skin can freely breathe. This prevents excessive perspiration and skin irritation. The socket is made from a stainless steel tube that runs around the humerus condyles and is attached to the lower part of the socket which made by laminated or thermoplastic. The stainless tube is covered with thermoplastic foam material. He will evaluate laminated socket and Open fitting socket with QUEST (Quebec User Evaluation of Satisfaction with assistive Technology)(2). Results will be presented.

## References

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2. Demers L, Weiss-Lambrou R, Ska B. Development of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST). *Assist Technol.* 1996; 8(1): 3-13.

Title: **The contribution of new manufacturing processes to the next generation of prosthetics**

Authors: R. A. Harris

Presenter: R. A. Harris

Affiliation: Future Manufacturing Processes Research Group, University of Leeds

E-mail: [R.Harris@leeds.ac.uk](mailto:R.Harris@leeds.ac.uk)

### **Abstract**

New manufacturing processes can make a significant contribution towards realising new capabilities in a range of prosthetic applications. This ranges from; increasing their accessibility and applicability through lower costs and/or providing patient specific devices, through to enabling new forms of functionality by the creation of advanced subcomponents. This presentation will describe work of the Future Manufacturing Processes Research Group in new digitally-driven manufacturing processes and their relevance across a number of prosthetics applications. This will cover several elements of our current manufacturing process research, including: fundamental engineering work to assist biological understanding, the creation of variable and multi-material coatings for wearable devices, the efficient fabrication of anti-microbial surfaces, and transportable manufacturing capability for near-patient and case-specific assistive devices.

Thursday 21<sup>st</sup> March

Keynote (10:30-11:30)

*“UNDERSTANDING HUMAN GRASPING AND MANIPULATION AND  
THE DESIGN OF LOW-DIMENSIONAL MECHANICAL HANDS”*

**Aaron Dollar**

The human hand is the pinnacle of dexterity – it has the ability to powerfully grasp a wide range of object sizes and shapes as well as delicately manipulate objects held within the fingertips. Current robotic and prosthetic systems, however, have only a fraction of that manual dexterity. In this talk, I will discuss two ways that my group attempts to address this gap: studying daily grasping and manipulation function of non-amputees and amputees, and using this understanding to design novel robotic and prosthetic hands that prioritize mechanical and control simplicity. In terms of hand design, we strongly prioritize passive mechanics, including incorporating adaptive underactuated transmissions and carefully tuned compliance, and seek to maximize open-loop performance while minimizing complexity. To motivate and benchmark our efforts, as well as for general basic research purposes, we are extensively examining human hand and prosthesis usage during daily activities as well as quantifying other aspects of hand function.

Thursday 21<sup>st</sup> March

Session 2 (11:30-12:00)

Title: **Harnessing Public and Patient Involvement for upper limb prosthetics design**  
Authors: M. Donovan-Hall, A. Chadwell, D. Zuleima Morgado Ramirez, R. Ssekitoaleko, M. Sobuh, C. Holloway and L. Kenney  
Presenter: Maggie Donovan-Hall  
Affiliation: School of Health Sciences, University of Southampton, UK  
E-mail: [mh699@soton.ac.uk](mailto:mh699@soton.ac.uk)

### **Abstract**

Increasing numbers of people in Lower Middle Income Countries (LMICs) are living with upper limb absence, however, access to P&O services are limited. This can have a devastating impact on engagement in activities of daily living, as when living at a subsistence level and without appropriate prostheses, daily tasks can be challenging to perform. The overall aim of this study is to develop a 'fit-for-purpose' upper limb prosthesis. However, to optimise the use and acceptability of a new prosthetic device, it is essential to understand the social, cultural and historical context of the environment.

Scoping and exploratory work was carried out to underpin the research and design parameters of a 'fit-for-purpose' body-powered upper limb prosthesis suitable for two LMICs, Uganda and Jordan. This involved three key aspects:

1. Informal scoping interviews within a 'Public, Patient Involvement' (PPI) framework with clinicians, technical staff, and people with upper limb absence
2. The development of thorough 'scoping reports' through the observations and note taking across a range of public, NGO and charity services
3. Telephone and Skype PPI interviews with International Committee of the Red Cross (ICRC) Rehabilitation Managers

The collated findings provide clear insight into the specific needs of the users and wider stakeholder. This is essential for the next stage of the research in the following ways: a) an insight into key social and cultural issues, b) influencing the remit of the study in terms of adjustable socket designs, c) establishing system and manufacturing considerations to ensure sustainability, and d) developing relationships and partnerships.

### **Acknowledgements**

This work is funded by the Engineering and Physical Sciences Research Council and National Institute for Health Research under the grant number EP/R013985/1.

### **References**

- Sexton Rehabilitation of people with physical disabilities in developing countries.  
*Brussels, ISPO 2016*
- World report on disability, *WHO* (2011) ISBN9789241564182



Title: **Treatment for upper limb malformation in different areas of the world**  
Authors: L. Hermansson and W. Hill  
Presenter: Liselotte Hermansson  
Affiliation: Faculty of Medicine and Health, Örebro University, Örebro, Sweden  
E-mail: [liselotte.hermansson@regionorebrolan.se](mailto:liselotte.hermansson@regionorebrolan.se)

## **Abstract**

Children with upper limb malformation may present with deficiencies in many ways and the treatment that they are offered may vary greatly around the world. Handsmart is a volunteer organization with the mission to support and empower people world-wide who are engaged in this field of rehabilitation through [www.handsmart.org](http://www.handsmart.org) . A web-based survey was used to gather data about treatment for children with upper limb malformation in different areas of the world. Sixty-eight respondents from 18 countries representing Oceania, Asia, Europe, and North America with 35 occupational therapists, 6 physiotherapists, 23 prosthetists, and four other health care professionals participated. Only five countries do not have governmental funding for the provision of care for people with upper limb loss. Intervention is guided by the presentation of the limb. Most surgical procedures are made for functional benefits. Not all respondents report that they fit body-powered prostheses for children. The majority of respondents stated that training is offered for use of the prosthesis in their country. In some clinics (12 of 68 respondents), no treatment other than functional prostheses is provided for these children. Overuse or repetitive strain injuries are common with this population, especially as children age into adolescence and adulthood. Many people stated they would like to see clear guidelines used by multi-disciplinary teams to fit children. Recommendations should include treatment guidelines and follow-up practices.

## **Acknowledgements**

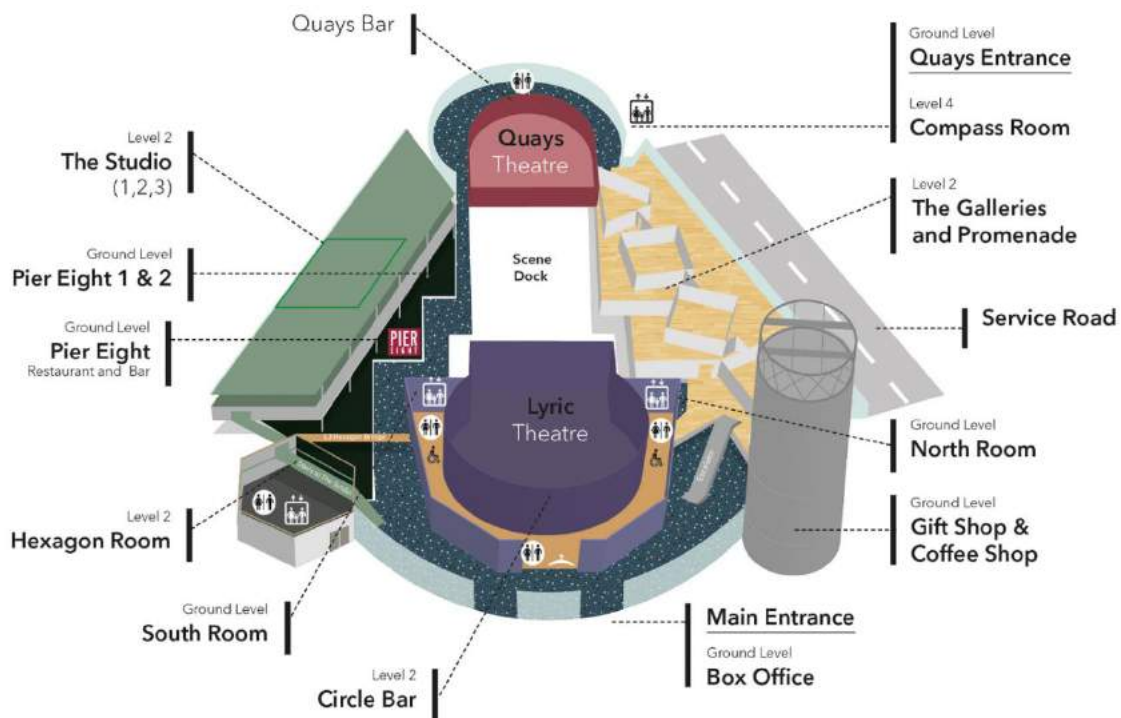
Authors acknowledge Claudia Winkler, physiotherapist at Pohlig, Germany, for contributing to the design of the survey. We also acknowledge the Handsmart group for sharing the survey around the world.

# Case Studies

Case studies will be run in three different locations throughout the building:

- Quays theatre (Main conference space)
- Pier 8 rooms (Poster rooms)
- The South Room (Next to the Lyric theatre)

Each session will repeat three times, however, as spaces are limited in each session, please collect a ticket from the registration desk.



## Quays theatre

**Chris Gough**  
Growing up with the NHS

Chris was born during the second world war, with a left transverse congenital absence below the elbow. For the first six years of his life, he wasn't provided with a prothesis, and was quite happy without one, but the establishment of the NHS shortly after the war led to Chris being sent to Roehampton to receive his first prosthetic arm. Although he has tried myoelectric control, Chris prefers to use cosmetic prostheses, which he employs for various tasks including gardening and playing the keyboard, despite these limbs having no active grasp. As a retired Headteacher, Chris is well versed at encouraging and supporting learning, something that he continues to do as a volunteer professional patient at the University of Salford.

## **Pier 8 rooms**

### **Nigel Ackland**

**Ordinary Man, Extra-Ordinary Life.**

In 2007, following an accident at work; Nigel chose to have a trans-radial amputation. Five years later, and having used a number of basic prosthetics, he became the World's first long term tester of the Bebionic V3.

In 2013, Nigel was invited to speak at the launch of the 2045 Initiative in New York. Since then Nigel has been internationally recognised as one of the most passionate advocates for access to prosthetics for amputees. He has been raising awareness of high tech prosthetics by speaking at Universities in the UK and at events throughout Europe and across the World. These include The Singularity University's Conferences, WIRED Health, TEDx Athens & New Scientist Live. He has become a regular speaker at events in Russia. He often helps other amputees raise funds to purchase their own prosthetics, and has taken part in commercials for Microsoft, IBM, Engie, BMW and the British Paralympics.

## **South room**

### **Roy Haycock**

**A life saved for others**

Roy lost his right arm above the elbow when he was just 6 years old, under the wheels of a lorry. He was inches from death, and since this time, he has been thankful for the life he has had, and has spent much of that life helping countless other people come to terms with upper limb loss. Now 85, and still a key member of the limbless association, Roy continues to support others, helping them to carry on doing the day to day tasks that the able bodied often take for granted.

Thursday 21<sup>st</sup> March

Session 3 (14:00-14:45)

Title: **Gaze training enhances prosthetics hand learning, visual control and neural efficiency**

Authors: J.V.V Parr, S.J.Vine, M.R.Wilson, N.R. Harrison, G.Wood

Presenter: J.V.V Parr

Affiliation: School of Health Sciences, Liverpool Hope University, Liverpool, UK

E-mail: [parrij@hope.ac.uk](mailto:parrij@hope.ac.uk)

### **Abstract**

A prosthetic hand imposes a high cognitive burden on the user that often results in fatigue, frustration and prosthesis rejection. In two experiments, we provided the first evaluation of this cognitive burden using measurements of EEG and gaze behaviour (Experiment 1), and then explored how a novel psychomotor intervention (gaze training; GT) might alleviate this cognitive burden (Experiment 2). In experiment 1, able-bodied participants (n = 20) lifted and moved a jar, first using their anatomical hand and then using a myoelectric prosthetic hand simulator. Results revealed that when using the prosthetic hand, participants performed worse, exhibited more hand-focused visual attention, and exhibited a global decrease in EEG alpha power (8-12Hz) suggesting increased cognitive effort. In experiment 2, a GT group (n=12) and a movement training (MT) group (n = 12) trained with the prosthetic hand simulator over three separate one hour sessions. The GT group received instruction regarding how to use their eyes effectively during a picking up coins task, while the MT group received movement-related instruction typical of rehabilitation settings. Results showed that GT expedited learning, reduced demands on visual attention, and reduced conscious movement control – as indexed by reduced T7-Fz coherence. Whilst the MT group improved performance, they did not reduce hand-focused visual attention and showed increased

conscious movement control. The benefits of GT also transferred to a more complex tea-making task. These findings have implications both for our general understanding of the cognitive control of psychomotor skills, and specifically, for the design of prosthetic hands and their associated training.

Title: **Gesticulation with Hand and Prosthesis in Congenitals One-Handers and Acquired Amputees**

Authors: R.O Maimon Mor, E.Obasi, N.Odeh, A.Tarall-Jozwiak, M.Macsweeney, S.Goldin-Meadow and T.R.Makin

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## **Abstract**

Upper limb prostheses have been in mass production for over a century. As a hand substitute, the functional usage and dexterity of prostheses have been studied extensively, neglecting an important role our hands play in non-verbal communication such as hand gestures. Being an ‘unconscious’ behaviour, even performed by congenitally blind individuals, we consider the incorporation of prostheses in communication as an indirect measurement of prosthesis embodiment. Here, we aimed to characterise the use of upper-limb prostheses in gesticulation and its relationship to everyday usage and embodiment. One-handed participants (both congenital one-handers and acquired amputees) and age-matched two-handed controls participated in two gesture-facilitating tasks: naturalistic storytelling of a video and similar objects description. Gestures were measured using offline video coding and acceleration-monitors worn on the wrists of the hand and prosthesis. Everyday prosthesis usage was assessed using questionnaires and accelerometry. Embodiment was also assessed using questionnaires. The three groups did not differ in the amount of gestures they produce per minute. However, they did differ in their gesture profile. Both amputees and congenital one-handers gesticulate with their prosthesis, but differ from controls in the amount of reliance on their intact hand in gestures. Amputees and congenitals differed from one another in the magnitude of gesture movements. Reliance on intact hand in gestures positively correlated with measures of everyday usage obtained over 2-days, making it an ecological measurement of usage that can be used in the clinic. A fascinating positive correlation was also found between everyday usage and prosthesis embodiment.

## Acknowledgements

R.O.M.M. is supported by the Clarendon scholarship and University College, Oxford. T.R.M holds a Sir Henry Dale Fellowship funded by the Wellcome Trust and the Royal Society, and an ERC Starting Grant.

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Iverson, J.M., Goldin-Meadow, S. *Why people gesture when they speak*. (1998) *Nature*. 396, pp 228.



Title: **The effect of three training types on switching in multiarticulating hand prostheses**

Authors: A. Heerschop, C.K. van der Sluis, E. Otten, R.M. Bongers

Presenter: A. Heerschop

Affiliation: Rijksuniversiteit Groningen and Universitair Medisch Centrum Groningen

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## **Abstract**

Most multi-articulating myoelectric prosthetic hands use proportional and switching control. Proportional control, used to open/close the hand, has been studied frequently. Switching control, used for switching between grip-types, has received less attention, especially the extent to which switching can be learned. This study assesses 1) the effects of different types of training on switching control performance (changes in accuracy of co-contraction over a 5-day training period) and 2) the transfer of switching control to actual prosthesis use (using a clothespin task in a pre-test, post-test design). 28 able-bodied participants were randomly assigned to one of four experimental groups, all training 15 minutes a day. Participants were assigned to three training groups: 1) prosthesis (PGroup), 2) serious game (GGroup), 3) visualized EMG (EGroup) and a control group receiving a sham training (CGroup). The clothespin task was performed using a prosthesis simulator. Effect of training; the three training groups all significantly improved accuracy of co-contraction. The groups did not differ in improvement. Transfer to prosthesis use (pre- and post-test); all groups, including the CGroup, improved on the clothespin task. A trend suggested that the three training groups all improved more than the CGroup. Our results show that training improves switching ability, although this seems to be indifferent for type of training. Training effects did not significantly transfer to prosthesis use, which suggests that duration, frequency or content of training should be improved.

## **Acknowledgement**

This research was done within a project that is funded by the University Campus Fryslan (UCF13 032.2013.1011) and the Revalidatiefonds Nederland (R2014073).

Thursday 21<sup>st</sup> March

Session 4 (15:30-17:00)

Title: **Myo Plus prosthetic control**  
Authors: S. Amsüss, B. Bischof  
Presenter: Sebastian Amsüss  
Affiliation: Ottobock Healthcare Products GmbH  
E-mail: [sebastian.amsuess@ottobock.com](mailto:sebastian.amsuess@ottobock.com)

### **Abstract**

Myo Plus is a new prosthetic controller employing pattern recognition (PR) with a biofeedback training app. We postulate that optimized patient training will be key to the success of PR based hand prosthesis control (1). Biofeedback training was implemented by displaying the 8 EMG input signals of the control system to the user and was used together with imitation and contralateral movement training. Six transradial amputees (experience in prosthetic conventional control (CC) 1-21 years, average 7 years) were trained this way. The two main goals for the users were to generate (i) visually well differentiable patterns in the plot which were (ii) repeatable and constant. Training time was around 1-3 hours (depending on subject). Performance in the modified box and blocks test, clothespin relocation test and a proportional control task (open/close clothespins without dropping) was assessed after the training. Improvements were observed in the clothespin relocation test in all 6 amputees (26% improvement straight after training on average), and in proportional control (5-10% less dropped clothespins, depending on required force). Time needed to complete the modified box and blocks test was shorter with CC, by 21%. Considering the relatively short training time of just a few hours, the proposed training method proved to be very successful. However, due to the limitations of the study layout and the low number of participants, no statistically sound conclusions can be drawn from these positive data trends. Further investigations and refinements of the training protocol are thus warranted.

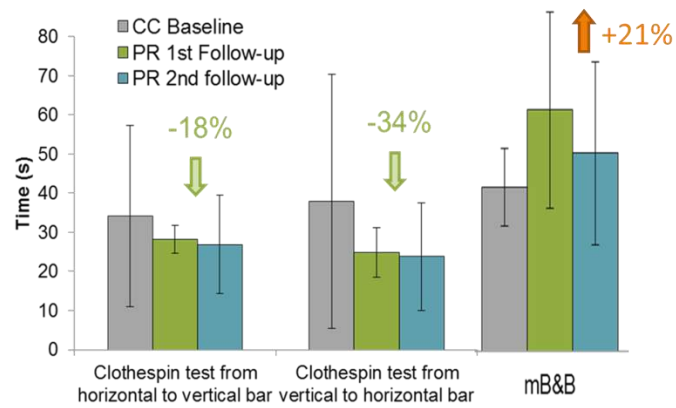


Figure 1: Results of the clothespin test and the modified box and blocks test.

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Title: **The future of prosthetics is here - low cost, custom-made, stylish prosthetics**  
Authors: J.Gibbard  
Presenter: Joel Gibbard, CEO of Open Bionics.  
Affiliation: Open Bionics  
E-mail: [joelgibbard@openbionics.com](mailto:joelgibbard@openbionics.com)

## **Abstract**

Following four years of R&D and collaboration with the limb-different community, Open Bionics has 'moved beyond the lab' and launched the Hero Arm in April 2018. The Hero Arm is the world's most affordable multi-grip myoelectric prosthesis. Each Hero Arm is custom-made using innovative 3D-printing manufacturing methods and feature a revolutionary flexible and breathable socket that increases the user's comfort and enhance the prosthesis cosmetic appearance. Its light weight makes Hero Arm suitable for children as young as eight years old.

The Hero Arm has already received a significant success thanks to its innovative technical and functional features, as well as its unique appearance, but also thanks to Open Bionics breakthrough approach in terms of clinical services and pricing: we offer a complete prosthetic solution, rather than just a hand; we appreciate the financial pressure for individuals or health systems to fund bionic hands and our approach aims to democratise the access to advanced prosthetic fittings to a wider population, including the paediatric population or individuals living in emerging markets.

Our presentation will go through this breakthrough approach by focusing on three areas: firstly the 3D-manufacturing method and fitting process of the Hero Arm, secondly the features that makes the Hero Arm unique in particular for children and adolescents, and

thirdly our strategy to get a recognition of the Hero Arm by various international funding or reimbursement systems.

Title: **Osseo-neuromuscular limb prostheses**  
Authors: M. Ortiz-Catalan, J. Millenaar, A. Thesleff, B. Håkansson, and R. Brånemark  
Presenter: Max Ortiz-Catalan  
Affiliation: Chalmers University of Technology, Integrum AB, 3 Gothenburg University  
E-mail: [maxo@chalmers.se](mailto:maxo@chalmers.se)

## **Abstract**

Current prosthetic devices deliver limited functionality and do not purposely provide sensory feedback, mainly due to the use of superficial skin electrodes. Implanted neuromuscular electrodes have been long thought as a solution to provide a more natural control of limb prostheses. However, their clinical utilization has been hindered by the lack of a long-term stable percutaneous interface. We have developed long-term stable, bidirectional osseo-neuromuscular interfaces for upper and lower limb prostheses as a solution for this long-standing problem. The discovery of osseointegration allowed for the first successful skeletal attachment of a limb prosthesis. We enhanced the pioneering device for skeletal attachment of limb prostheses, the OPRA implant system (1), to also allow for bidirectional communication between neuromuscular electrodes and the prosthetic device. This enhanced OPRA (e-OPRA) allowed for the first time, that a transhumeral amputee utilized implanted electrodes for the daily control of his prosthetic arm, outside of controlled environments (2). Furthermore, the e-OPRA also allows amputees to receive intuitive sensory feedback via direct peripheral nerve stimulation in daily life. The transhumeral e-OPRA system is continuously functional and in daily use up to date (over five years after implantation). We have now developed transradial and transfemoral versions of the e-OPRA system. These implant systems have been verified in bench experiments and the first recipients are planned to be implanted in the near future.

## Acknowledgements

This work was funded by Stiftelsen Promobilia, VINNOVA, Swedish Foundation for Strategic Research, and the European Commission (H2020 - DeTOP project).

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Title: **Developing a new innovation in powered wrist rotation.**  
Authors: A. Goodwin  
Presenter: Alison Goodwin  
Affiliation: Ossur  
E-mail: [alison.goodwin@touchbionics.com](mailto:alison.goodwin@touchbionics.com)

## **Abstract**

Many recent developments in upper limb prosthetics have focussed on the myoelectric hand. As multi-articulating hands become the new norm there is a requirement for the other elements of the upper limb prosthesis to also progress. Considering powered wrist rotators and how they function alongside the multi-articulating hand, can a new standard be created that offers more than we currently expect? Taking on this challenge, the development of a powered wrist rotator was undertaken with the aim of offering increased functionality to the user. The resulting powered wrist rotator communicates with the hand to enable simultaneous movement of the hand and wrist. This co-ordinated movement results in the wrist automatically rotating when a grip is selected, this avoids the requirement to position the hand and the wrist separately in two separate actions. A pre-launch investigation was conducted to assess if the new wrist rotator offered the expected user benefits. Taking the development journey out of the lab into users' environment and daily activities. The investigation involved 4 users with 5 prostheses (1 bilateral user), utilising the wrist rotator with their existing multi-articulating hand, with one exception who was new to both hand and wrist. The users were asked to complete questionnaires pre-fitting, immediately post fitting and after a 1month home trial. The investigation found that users reported the benefits of simultaneous rotation upon grip selection. The powered wrist rotator will be launched in

2019, bringing the benefit of simultaneous and co-ordinated motion between hand and wrist to users daily lives.

Title: **Real-World use of Myoelectric Pattern Recognition: Successes and Challenges**

Authors: B. A. Lock, M. K. Cava, and E. W. Karlson

Presenter: B. A. Lock

Affiliation: Coapt, LLC

E-mail: [blair.lock@coaptengineering.com](mailto:blair.lock@coaptengineering.com)

## **Abstract**

In the Orthotics and Prosthetics marketplace, introduction of novel and/or new approaches is often met with an appropriate burden of proving clinical relevance. When a new approach is presented—especially with the perception of significant technology—the expectations are greater; the solution is expected to provide exceptional improvement over the incumbent, be applicable to the majority, while still maintaining cost-effectiveness. Pattern recognition of myoelectric signals for control of upper limb prostheses has been poised to meet this high bar for new-technology. While pattern recognition has been the focus of significant engineering and clinical research for decades, currently the only commercially-available platform is produced by Coapt, LLC. Coapt pattern recognition systems have included in definitive prostheses and delivered to hundreds of upper limb prostheses users since late 2013. While the majority of wearers find great benefit and value, not every user of a pattern recognition finds immediate or resounding success. Early reports of real-world pattern recognition use combine to report an 85.7% acceptance rate of the technology.<sup>1,2,3</sup> Coapt has collected a series of examples that highlight some of the real-world challenges that have been experienced and will present a spectrum of these cases. Representation from users of various limb difference presentations, who have diverse prior prosthetic experience, and from a spectrum of clinics is covered. The findings provide significant, real-world insight into areas where the technology can be improved and ultimately benefit the prosthesis user.

## Acknowledgements

This work was not supported by any of Coapt LLC's funded research programs.

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Title: **Clinical Impact of Myoelectric Interface and Control Technologies**  
Authors: M.Wernke, M.Haynes, A.Jackson, C.Kelley, A.Albury, J.Colvin  
Presenter: Matthew Wernke PhD  
Affiliation: The Ohio Willow Wood Company  
E-mail: [mattw@owwco.com](mailto:mattw@owwco.com)

## **Abstract**

Critical for achieving proper control of a myoelectric prosthetic limb is obtaining noise-free surface EMG signals. Sockets are generally made tight to prevent loss of contact between the electrode and the skin; however changes in volume, interactions with objects, and motion provide changes to maintaining contact. Also, the tight sockets negatively impact the donning. To address these challenges, several attempts have been made to include a gel liner into myoelectric socket interfaces<sup>1-3</sup>. The Shirley Ryan Ability Lab developed a gel liner with integrated electrodes<sup>3</sup> which has been licensed by WillowWood. The purpose here is to present a subset of results from an ongoing study comparing various interface designs and control methodologies, an area currently lacking evidence. Unilateral transradial amputees participated in the study. The Activities Measure for Upper Limb Amputees (AMULA) is used to assess functional performance. Orthotics and Prosthetics User Survey (OPUS) was used to capture subjective data. Study conditions included traditional control and Coapt pattern recognition with socket-embedded electrodes, and the myoliner with Coapt pattern recognition. Data was collected before and after a 6 weeks use period with each condition. Results indicated that the AMULA scores were highest with the myoliner and lowest with direct control. Responses on the OPUS sections indicate this improvement may be through better fit, comfort, easier donning, and contact of the electrodes. The myoliner and/or pattern recognition may provide a significant improvement to the current standard of

myoelectric interface and control methodology that increases the acceptance and usability of these advanced prosthetic devices.

### **Acknowledgements**

The work is funded by the United States Department of Defense.

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Friday 22<sup>nd</sup> March

Session 1 (08:30-10:00)

Title: **Designing a new training method for advanced hand prostheses**  
Authors: C. Widehammar, K. Eriksson, L. Hermansson  
Presenter: Cathrine Widehammar  
Affiliation: University Health Care Research Centre, Faculty of medicine and health,  
Örebro University, Örebro, Sweden  
E-mail: [cathrine.widehammar@regionorebrolan.se](mailto:cathrine.widehammar@regionorebrolan.se)

### **Abstract**

New prosthetic hands with advanced technology making it possible to perform many different grasps and positions are now available on the market. This new advanced technology is also difficult for users to control, and studies have shown that the new hand functions are not used to the extent expected (1). When introducing a new prosthetic hand with questionable merits, the reasons for these results need to be considered. Maybe the training programs for the new hand models are not extensive enough? The aim was to design a training method for advanced prosthetic hands. This was achieved by a review of existing training programs for advanced myoelectric prosthetic hands combined with clinical experiences and the treatment philosophy with early fitting and regular follow up used in Örebro. The new training method follows a structured program based on the 14 steps described in Skills Index Ranking Scale Adult (SIRS Adult). The SIRS Adult comprise integration, control training and activity performance. The ADL's are chosen individually through a Canadian Occupational Performance Measure interview. Further, regular support and feedback from an occupational therapist is an important part of the training. The capacity to use different grasps and integrating the new prosthesis when performing ADL's is evaluated through the Assessment of Capacity for Myoelectric Control (2). The method has now been used on patients with good

results and can be applied upon prescription of all advanced multifunctional prosthetic hands to enhance the functional use of the hands.

### **Acknowledgements**

We acknowledge the support from University Health Care Research Centre, Region Örebro County.

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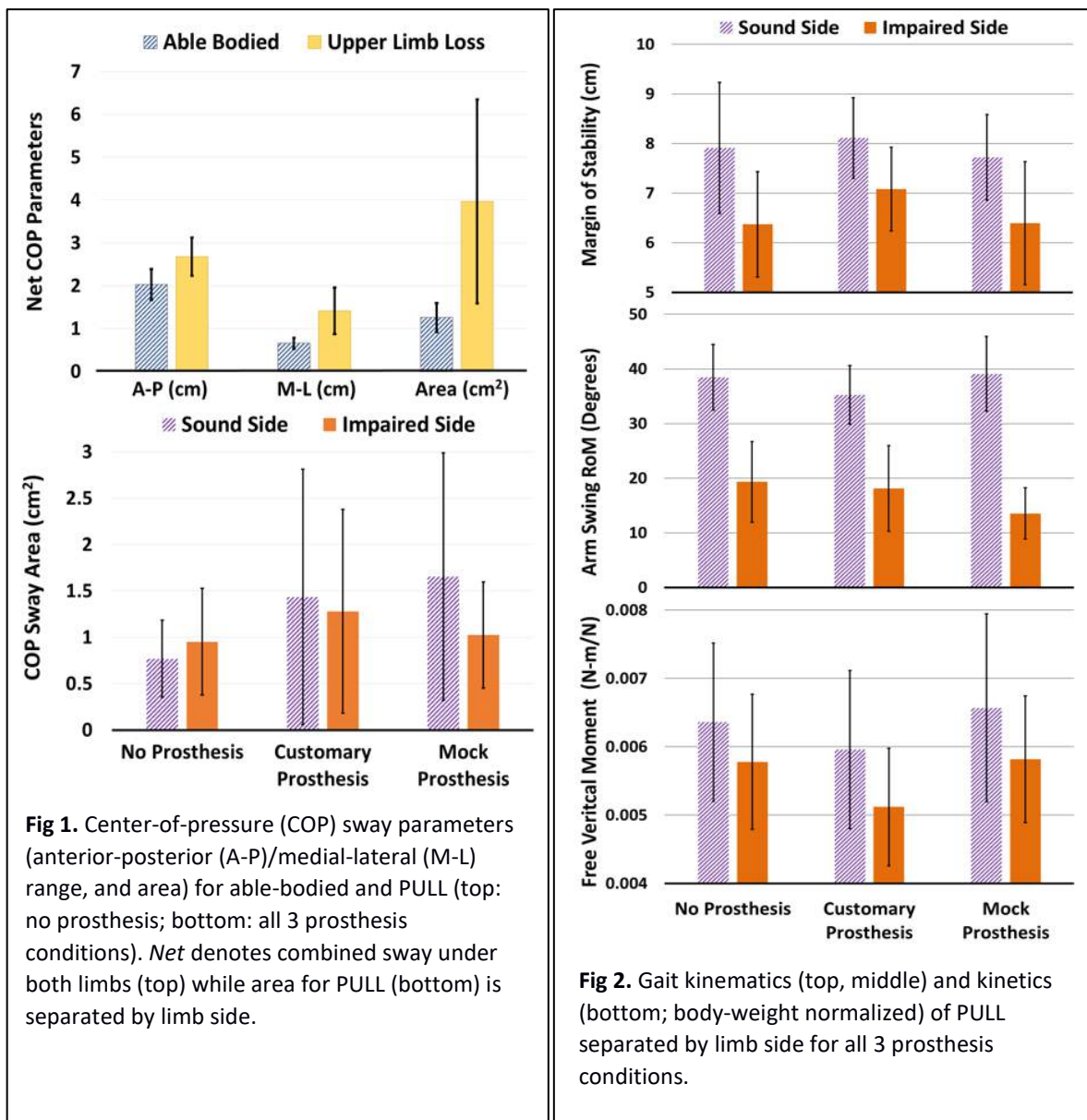
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Title: **Falls and balance control of persons with upper limb loss**  
Authors: M.J. Major, R.L. Stine and S.A. Gard  
Presenter: Matthew J. Major  
Affiliation: Northwestern University & Jesse Brown VA Medical Center, Chicago, IL USA  
E-mail: [matthew-major@northwestern.edu](mailto:matthew-major@northwestern.edu)

## **Abstract**

Arms are important for postural control by regulating whole-body angular momentum and constraining the body's center-of-mass within a stable base-of-support (2), which has implications for persons with upper limb loss (PULL). This paper describes findings from a series of studies to characterize falls and postural control in PULL. *Study 1* surveyed 109 PULL on fall history and prosthesis use. Fall likelihood contributors were evaluated using logistic regression analysis. *Study 2* investigated standing balance of 10 able-bodied controls and 11 PULL (unilateral) when not wearing a prosthesis, wearing their customary prosthesis, and wearing a mock prosthesis that matched the sound limb mass and inertia. Center-of-pressure sway was captured during quiet standing on two force plates. *Study 3* investigated gait stability of 10 PULL under the same conditions of *Study 2*. Kinetics and kinematics were captured with force plates and an optical motion capture system, respectively. *Study 1* results suggest that 45.7% of PULL fall at least once per year (28.6% fall twice or more) and prosthesis use increases fall likelihood by six times (2). *Study 2* results suggest that PULL display greater sway than controls which increases with prosthesis use (Fig 1). *Study 3* results suggest that PULL display larger margin-of-stability, arm swing, and free vertical moment on the sound limb side irrespective of prosthesis use (Fig 2), but step width decreased when wearing the mock prosthesis. Combined, these studies suggest that PULL experience a high fall prevalence and altered postural control that may be compromised with prosthesis use.



## Acknowledgement

Work supported by the U.S. Department of Veterans Affairs (Awards #1K2RX001322 and #1I21RX001388).

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Title: **Development of Prosthetic Wrist Function Assessment Device**  
Authors: K. Ohnishi, M. Shibuya, T. Morita and K. Hayashi  
Presenter: Kengo Ohnishi  
Affiliation: Tokyo Denki University  
E-mail: [ohnishi@mail.dendai.ac.jp](mailto:ohnishi@mail.dendai.ac.jp)

### **Abstract**

The prosthetic assessment protocol, i.e. SHAP, may be efficient for evaluating hand function, yet the limitation of tasks, objects, and conditions makes it non-sensitive for evaluating the efficiency of the prosthesis's wrist control function and performance. In this research, we propose a robotic device to evaluate the properties of hand orientation responsiveness.

A 3-DoF evaluation device was developed assembling 3 servo motor to rotate the clothes pin pinched on to a plate fixed to the motor shaft (Fig. 1, left). The clothes pin is sequentially oriented to the commanded target posture angle while measuring the orientation of the device end and the forearm with 6-axis IMU sensors. Three non-amputee right handed students participated as subjects. Total of 84 data were recorded for 14-orientations 2-conditions experiment. The orientation of the clothes pin was presented of pitch angle 0 deg. and roll angle from 0 to 90 deg. in 15 deg. interval, and Roll angle 90 deg. and pitch angle 0 to 90 deg. in 15 deg. interval, in random order. The subjects performed to regulate the posture of the arm to pick up with their sound hand and donning a prosthetic hand with automated wrist angle adjustments. The results showed that the deviation of the sound hand performance time is minimal while the prosthetic hand performance took 2sec longer minimal and delayed longer when pitch angle were set between 60-90 deg (Fig. 2). This showed that this evaluation device is capable for evaluating the wrist function of the upper limb prosthesis.

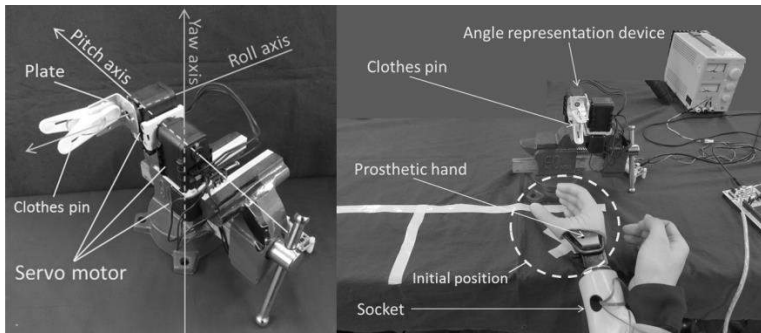


Fig. 1. Experimental environment and devices

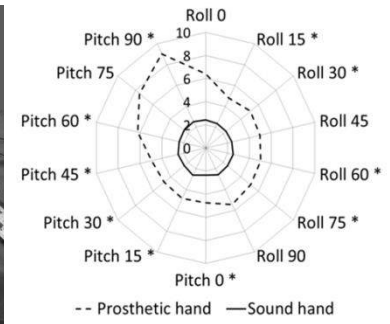


Fig. 2. Performance time

## References

- 1) M. Shibuya, et al., Networked multimodal sensor control of powered 2-DOF wrist and hand. *Journal of Robotics*, 2017 ; 2017 : 7862178.
- 2) C. M. Light, et al., Establishing a standardized clinical assessment tool of pathologic and prosthetic hand function: Normative data, reliability, and validity. *Clinical Biomechanics*, 2010; 25: 523-529.

Title: **Exploring the impact of control method on embodiment of a myoelectric prosthesis using Immersive Virtual Reality**

Authors: A. D. Hodrien, A. J. Galpin, D. J. Roberts, and L. P. J. Kenney

Presenter: Andrew Hodrien

Affiliation: University of Salford, Salford, UK

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## **Abstract**

Prosthesis embodiment, the feeling of a prosthesis being 'part of' the user, is reported by some users, whereas others feel their prosthesis as just a tool. Users have noted the difficulty in controlling myoelectric prostheses as a reason for prosthesis rejection. The effect of myoelectric control factors on embodiment, such as the use of wrist muscles to open and close the hand, the delay between EMG onset and hand movement, and the uncertainty over hand behaviour<sup>[1]</sup>, are under-explored. As embodiment is proposed as a goal of rehabilitation, designers need to understand the impact of such factors. The study employed a version of the virtual hand illusion (VHI), shown to encourage feeling ownership over a virtual hand through movement synchronised with a real hand.<sup>[2]</sup> We asked how control method affected embodiment by comparing between 31 anatomically-intact participants controlling a virtual prosthesis via a myoelectric prosthesis simulator and an anatomical hand. Embodiment measures included a questionnaire, recording ownership and agency scores, and skin conductance responses following a virtual knife threatening the virtual prosthesis. For both conditions, ownership was positively correlated with agency, suggesting these aspects of embodiment possibly encourage each other. Skin conductance showed an effect of the virtual threat but no difference between conditions. Ownership was significantly higher in the hand compared to prosthesis condition, suggesting in the VHI-paradigm, control via EMG produces weaker embodiment, than control via tracking of anatomical hand movement., and informing

future prosthetics VR studies to consider the current protocol's suitability in exploring prosthesis embodiment.

### **Acknowledgement**

Research supported by a Pathways to Excellence PhD scholarship from University of Salford.

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Title: **Comparing path performed by body-powered and myoelectric simulator**  
Authors: H Burger, M Burgar, M Mlakar , D Brezovar ,U Miklič , S Šlajpah , M Mihelj  
Presenter: Helena Burger  
Affiliation: University Rehabilitation Institute; University of Ljubljana  
E-mail: [helena.burger@ir-rs.si](mailto:helena.burger@ir-rs.si)

### **Abstract**

Upper limb prosthesis users perform several compensatory movements in remain joints and with trunk (1). The aim of our study was to compare the path of movements in shoulder (flexion/extension, abduction/adduction, rotations), elbow flexion/extension and wrist rotation during the Southampton Hand Assessment Procedure (SHAP test; 2) performed by clinicians working with people after upper limb amputation using body-powered (BP) and myoelectric simulator (Myo). Seven clinicians (one MD, 3 CPO, 3OT; 5 women; 43 - 67 years old), all with over 10 years of experience, were included into the study. They performed the SHAP test first with the right, and later with BP and Myo simulator in a random order. Kinematic parameters were assessed by 5 inertial measurement units placed on prosthetic hand, forearm, upper arm, chest and back. In wrist for 21/26 activities path with BP simulator was shorter, similar trend was observed for rotation and ab/adduction in shoulder, for other movements at more activities was no difference between simulators, only twice Myo simulator has shorter path than BP. The main limitation of our study is small number of able-body subjects who had no training. In this circumstances the path performed is in favour to BP simulator.

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Title: **Reliability for Assisting Hand Assessment -Prosthetics, Amputations, Deficiencies**

Author: A.Stockselius

Presenter: Anita Stockselius

Affiliation: Aktivortopedteknik, Solna, Sweden

Email: [anita.stockselius@aktivortopedteknik.se](mailto:anita.stockselius@aktivortopedteknik.se)

Assisting Hand Assessment - Prosthetics Amputation Deficiencies (AHA-PAD) is a new version of Assisting Hand Assessment (AHA)(1). It is intended to assess how effectively children and adults with unilateral lack of part or whole hand as well as with different types of arm prosthetics use their hands in bimanual activity. The AHA-PAD manual contains 21 sub-scales and is evaluated on a three-level Likert scale. The purpose of the study was to investigate whether AHA-PAD is consistent in relation to inter- and intra-assessment reliability in assessing how effectively a person uses his affected hand in bimanual activities. For inter-rater reliability, two raters assessed 20 filmed activities. Analysis was performed with "Two-way random effect model" ICC 2.1 absolute agreement. Intra-rater reliability was performed by one rater who assessed 20 filmed activities at 2-3 weeks intervals. This was analyzed by "One-way random effects model" ICC 1.1 absolute agreement. For both inter- and intra-rater reliability, Standard Error Measurement (SEM) was analyzed. The result showed that ICC for inter-rater reliability had very good match between the two assessors, 0.98. Even for intra-rater reliability, the consistency was found to be very good between the first and second estimates, 0.99. The high level of compliance both in terms of inter and intra-rater reliability indicates that assessment of how efficiently a person with one well-functioning hand and one hand with missing parts or whole hand or arm prosthetics can be made under the guidance of the AHA-PAD manual.

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A Rasch-built measure intended for children with unilateral upper limb impairment.  
*Scan J Occup Ther* 2003;10;16-26

Friday 22<sup>nd</sup> March

Keynote (10:30-11:30)

*“SCALING-UP RESEARCH IN UPPER LIMB PROSTHETICS”*

**Corry K. van der Sluis**

“Scaling-up” reflects a bottom-up model that involves researchers devising innovative interventions or treatments, testing and refining these innovations and then implementing the innovations across multiple sites. The result of scaling-up should be a wide-spread usage of these effective innovations. If we look at scaling-up research activities in upper limb prosthetics, two main issues should be discussed: (1) the quality of the current research activities, including the available evidence on the effectiveness of innovations; (2) the implementation and translation into clinical practice of research innovations.

Quality of research will be addressed by revealing the state of affairs of Evidence Based Medicine (EBM) and Evidence Based Practice (EBP) in current research on upper limb prosthetics. EBM is the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients. EBP includes the integration of best available research, clinical expertise, and patient values and circumstances. We will see that the level of evidence of current research is low, mostly due to small study populations. Furthermore, the interventions of interest are mostly complex and there are many variables hampering the execution of a high level study, such as a randomized controlled trial.

Friday 22<sup>nd</sup> March

Session 2 (11:30-12:00)

Title: **The Future of Prosthetics: A User Perspective**

Authors: H.Jones, S.S.G. Dupan, K.Nazarpour

Presenter: Hannah Jones

Affiliation: Newcastle University, United Kingdom

E-mail: [hannah.jones@newcastle.ac.uk](mailto:hannah.jones@newcastle.ac.uk)

**Abstract:**

At the centre of prosthetic device development and clinical care are users with limb difference. To enable user needs to be addressed through the work of academia, the NHS and industry, a collaborative user-centred approach is needed, which can lead to better outcomes (1). In December 2018, the Intelligent Sensing laboratory at Newcastle University will host a workshop with key collaborative stakeholders: academics, NHS clinicians, industry specialists, charity executives and users. The aim of the workshop is to identify user needs and establish how stakeholders can work together to address those needs over the next ten years. To date, a working group [Figure 1] has highlighted current user needs, which have been captured into six themes [Figure 2]. A user pre-workshop survey has been created to identify the most important themes that academia, the NHS and industry should focus upon. Preliminary data shows that all five users have selected Function as the most important. Since each user is completing the survey based on personal perspectives, themes such as Media vary in terms of importance. At TIPS2019, we will provide insights associated with each of the six themes, sourced from the pre-workshop survey and the content that will be captured during the workshop. The key focus areas for stakeholders will be shared, to ensure user needs are justly reflected through research and clinical care development, with an overarching potential to inform policy renewal within academia and healthcare.

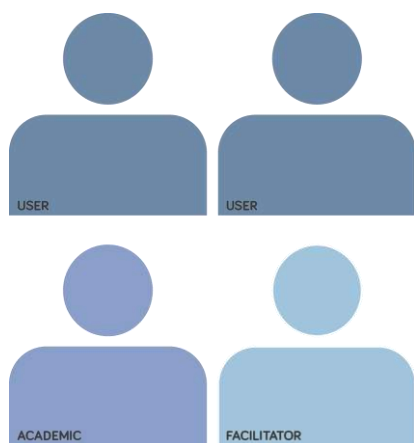


Figure 1: Working Group Members

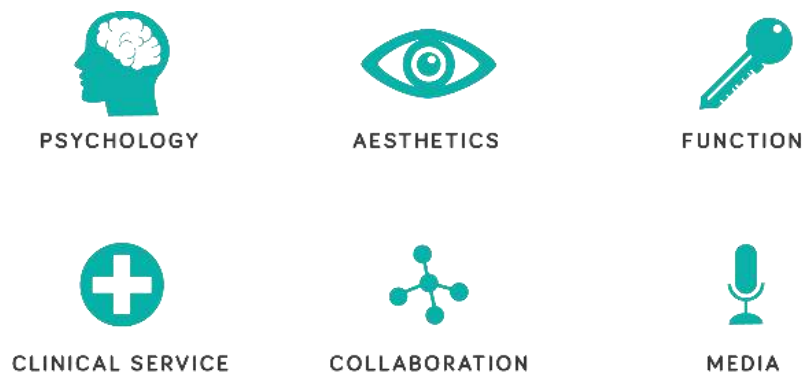


Figure 2: Workshop Themes

## Acknowledgements

This work is funded by the Mobility Matters initiative of the charity PORT-ER and by the UK EPSRC research grants EP/N023080/1 and EP/R004242/1.

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Title: **40 TMR cases and counting. Current UK experience of TMR for upper and lower limb amputees.**

Authors: N.Kang, A.Woollard and D.Michno

Presenter: Alexander Woollard

Affiliation: Department of Plastic Surgery, Royal Free Hospital, London

E-mail: [alex.woollard@gmail.com](mailto:alex.woollard@gmail.com)

## **Abstract**

Targeted muscle reinnervation has irreversibly changed the way in which we now approach a patient with limb loss. Currently, we are able to improve the lives of many amputees with otherwise untreatable neuroma and/or phantom limb pain (PLP)<sup>(1,2)</sup>. We report on the experiences of the first 40 cases undergoing TMR surgery, treated over a 5 year period (from 2013 to the present). Pain levels before and 3, 6 and 12 months after surgery were assessed using a simple self-reported scale (1 - 10). The amount of medication (pregabalin, gabalin, or opiates) used was recorded before and 12 months post-operatively along with any complications of surgery and episodes of "unmasking" or worsening of pain. The vast majority of patients noted an improvement in their neuroma and phantom limb pain. In many cases, patients were able to stop using any form of pain medication. Complications after surgery were minimal with a few cases of post-operative wound infection and a few cases who experienced unmasking of pain in other sites in the stump. The most notable side-effect was temporary (3-6 months) worsening of PLP. TMR surgery was originally devised to improve the ability of an upper limb amputee to control a prosthetic limb<sup>(3)</sup>. The effect on both neuroma and PLP was serendipitous but now is the main indication for carrying out this procedure for the UK amputee population, both upper and lower limb<sup>(2,4)</sup>. We will discuss the best indications for treatment with strategies for dealing with the side effects of TMR surgery.

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Friday 22<sup>nd</sup> March

Session 3 (13:00-14:45)

Title: **The Starworks Network**  
Authors: G. Wheeler and N.Mills  
Presenter: Gemma Wheeler  
Affiliation: Sheffield Hallam University, UK  
E-mail: [G.Wheeler@shu.ac.uk](mailto:G.Wheeler@shu.ac.uk)

### **Abstract**

The Starworks Network is a young people's prosthetics research collaboration who bring children and their families together with key opinion leaders from the NHS, Industry, Clinical Academia and leading National Research Centres with capabilities in child prosthetics. Department of Health funding has allowed us to build a collaboration which aims to increase research across the system in order to accelerate the translation of new inventions and developments in child prosthetics into everyday use. This initiative is centred on the needs of children and their families as well as 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 and to partner with industry. We would like to propose presenting an update of what was achieved in the first phase of the Starworks Network, with a specific focus on upper limb prosthetic products, including:

- Establishing the network
- Eliciting the perspectives and ideas of all stakeholder groups through an initial needs assessment, followed by creative, collaborative 'Sandpit' events.
- The funding of ten 'Proof of Concept' projects that respond to these challenge areas.

We would also like to present the plans for the Network going forward, reinforcing its current foundations and also extending its reach. By also highlighting the opportunities to get involved



in 'Starworks 2,' we 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: **Effect of prostheses on motor skills in children with upper limb deficiencies.**  
Authors: S.Fujiwara, H.Mano, N.Haga  
Presenter: Sayaka Fujiwara  
Affiliation: The University of Tokyo Hospital, Department of Rehabilitation Medicine  
E-mail: [fujiwaras-ort@h.u-tokyo.ac.jp](mailto:fujiwaras-ort@h.u-tokyo.ac.jp)

## **Abstract**

Background: Children with upper limb deficiencies have individual weaknesses in motor skills, and these weaknesses increase with age<sup>1)</sup>. Objective: Elucidate the effectiveness of upper limb prosthesis therapy on motor skills improvement in children with upper limb deficiencies. Methods: The subjects were nine children ranging from 0 to 6 years of age with unilateral upper limb deficiencies at the level distal to the elbow. We measured their adaptive behaviour and motor skills at the implementation of prosthetic therapy and after 1.5-year, using the Vineland Adaptive Behaviour Scales, Second Edition. Results: Motor skills were significantly lower than the median scores of the domains at the implementation. This motor skills weakness was significantly improved after 1.5-year prosthetic therapy. Conclusions: Although children with upper limb deficiencies have individual weaknesses in motor skills behaviours, this weakness can be improved by upper limb prostheses therapy. Limitations: The sample size of nine children in the present study was somewhat small and this might have influenced our results. The duration of intervention in this study was about one-and-a-half year, and the long-term course is unknown. Therefore, further longitudinal research that examines a larger sample size will be needed to resolve such problems.

## **Acknowledgement**

This work was supported by research grants on JSPS KAKENHI Grant Number 18K17890. The funder had no role in study design, data collection and analysis, decision to publish, or manuscript preparation.

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Title: **Parent's role in decision and treatment of children with limb malformation**  
Authors: L.Sjöberg, L.Hermansson, and C.Fredriksson  
Presenter: Lis Sjöberg  
Affiliation: PhD student, School of Health Sciences, Örebro University, Sweden  
E-mail: [lis.sjoberg@oru.se](mailto:lis.sjoberg@oru.se)

## **Abstract**

Parents of children with limb malformation are facing many decisions related to their child during the child's first years, e.g. when, or if to start, and to choose from different interventions. Usually the interventions concern surgical and/or prosthetic treatment options. A family-centred approach indicates the importance of providers to understand family belief systems with respect to the involvement of family members and is, thus, important to implement in childcare. The aim of this study was to describe parent's experiences of their role in decision-making and treatment for children with limb malformation. A descriptive, qualitative design was used. Semi-structured interviews were conducted with 17 parents of children with upper and/or lower limb reduction deficiency, including mothers (n=12) and fathers. Mean age of their child was 5.9 years. Data was analysed using qualitative content analysis with inductive approach. The results show that parental role in making decisions included: awareness of being a decision-maker in this context, and experiences of the role to make the best decisions for another person's future as self-evident but maybe not wanted. The parental roles in treatment processes included: being a collaborator within the family and between health care providers and family; being a constant supporter for challenges in everyday life; and handling a variety of needs based on psychosocial issues. We conclude that the results contribute to new knowledge and understanding of parents' as decision makers

and may improve family centred health service and enhance the care for children with limb malformation.

### **Acknowledgement**

The research is funded in part by Norrbacka Eugenia-foundation, University Health Care Research Center, Region Örebro County, and Faculty of Medicine and Health, Örebro University.

Title: **Use of prostheses in sport by adolescents with upper limb absence.**

Authors: N. Chinn, L. Kenney, A. Chadwell, A. Williams and J. Head

Presenter: Natalie Chinn

Affiliation: University of Salford, Salford, UK

Email: [n.m.chinn@edu.salford.ac.uk](mailto:n.m.chinn@edu.salford.ac.uk)

### **Abstract**

Sports participation has numerous physical and psychosocial benefits, but disabled people are half as likely to participate as their able-bodied peers. Encouraging sports participation from youth is important; evidence shows that active youths typically become active adults (1). Data regarding sports participation levels in young upper limb prosthesis users is scarce and the impact of Government funding for children's sports prostheses on sports participation is unknown. This feasibility study aims to gather data on sports participation in adolescents with upper limb absence (ULA), capture objective data on prosthesis wear and usage patterns in adolescents with upper limb absence, and capture the views of adolescents on their prostheses and reasons for use/non-use in sport. Four UK based adolescents, aged 10-19 years with unilateral ULA who participate in sport will be recruited, along with four able-bodied individuals. Both groups maintain activity diaries and wear two wrist-mounted activity monitors for two weeks. Prosthesis wear time and symmetry of upper limb activity will be measured (2). The ULA group will also participate in semi-structured interviews, analysed using a thematic approach. One limb absent and three able-bodied participants have completed the study; Participant 001 (ULA) uses an everyday split hook for non-water-based sports and he has a terminal device designed for kayaking but does not use it, reporting this particular 'sport-specific' device to be 'too heavy' to use. Figures 1 & 2 show that activity distribution is skewed towards the anatomical side, with heavy reliance on the anatomical limb whether participating in sport or not.

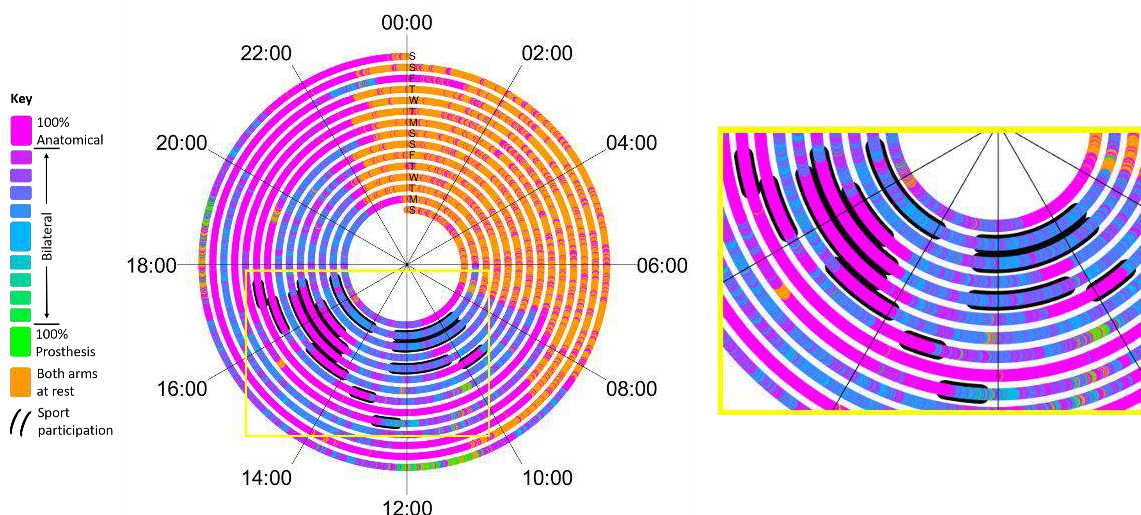


Figure 1: Spiral plot(8) showing the upper limb activity of a 14-year-old unilateral ULA male (001) over a 2 week period. The colours represent the symmetry of upper limb activity for each minute. The magnified portion shows the self-reported sports participation periods (highlighted in black).

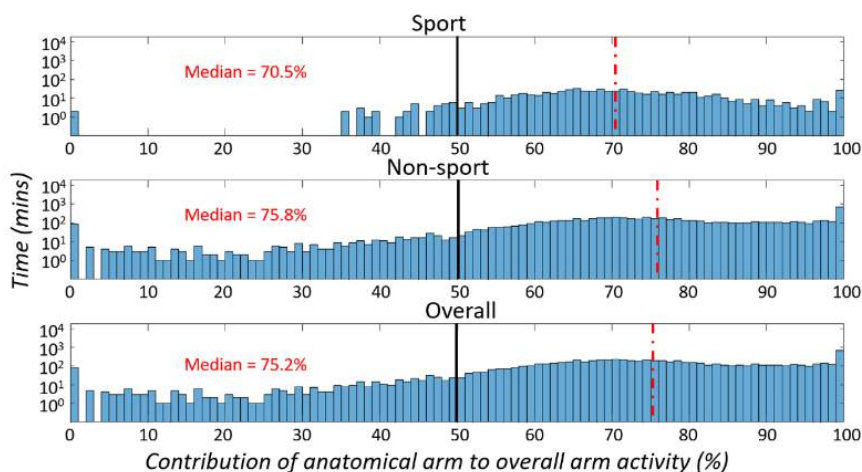


Figure 2. Histograms showing a comparison of reliance on the anatomical limb to the prosthetic limb for each minute over a two-week period for the same 14-year-old male.

## Acknowledgements

This project is self-funded as part of an MSc by Research degree with some assistance from supervisors' discretionary funds.

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Title: **Home-based Myoelectric Training using Biofeedback Gaming**  
Authors: M. Dyson and K. Nazarpour  
Presenter: M. Dyson  
Affiliation: Newcastle University, United Kingdom  
E-mail: [matthew.dyson@newcastle.ac.uk](mailto:matthew.dyson@newcastle.ac.uk)

## **Abstract**

We have developed two independent systems for myoelectric muscle training based on biofeedback. Both training platforms implement a recently proposed abstract myoelectric decoding method based on motor learning (1). The first system is intended for adult users and only provides routines necessary for calibration and muscle conditioning. This system uses royalty-free methods for rendering graphics on embedded systems which dramatically reduces hardware requirements and overall costs. Our second system is orientated toward children and has been developed as part of the National Institute for Health Research (NIHR) / Devices for Dignity (D4D) Starworks Child Prosthetics project. Our child friendly system is based on a cross-platform game engine and embeds the abstract myoelectric decoding method within an interactive goal-orientated environment. Because the signal processing used in both biofeedback systems is limited to the use of linear filters we are able to side-step the sampling problem associated with low-cost commercially available surface electromyography systems (2). At TIPS2019 we will present data obtained using both systems and discuss the challenges faced designing myoelectric games for the home environment.

## **Acknowledgements**

This work has been supported by the National Institute for Health Research (NIHR) / Devices for Dignity (D4D) Starworks Proof of Concept Funding and the Engineering and Physical Sciences Research Council (EPSRC) via grants [EP/R004242/1](#) and [EP/M025594/1](#).



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Title: **Bespoke Cycling Device for Child with Congenital Trans-Radial Absence**  
Authors: A. Khan  
Presenter: Asad Khan  
Affiliation: Prosthetist, Steeper, Specialist Rehabilitation Centre, Leeds  
E-mail: [asadullah.khan@steepergroup.com](mailto:asadullah.khan@steepergroup.com)

## **Abstract**

A poster presentation of a case study of a child with a unilateral trans-radial congenital absence provided with a bespoke activity specific prosthetic device for cycling. The patient was provided her first cosmetic prosthesis when she was 9 months old. At the age of 2 years, she started learning to ride a bike. In 2016 a cycling prosthesis was provided which was a gutter socket attached to bike handle bar. The patient was able to ride the bike but found it hard and preferred to lean with her forearm on the bike handle. Her second prosthetic cycling device which consisted of a laminated socket with the Criterium Cycling device and an elbow sleeve for suspension. This allowed her to ride different types of bikes and she started participating in races. The patient found that she was unable to fit and remove it from bike handle bar without help of her right hand, in addition, she found sharp turns difficult due to the lack of rotation, flexion or extension at the wrist. This poster documents the development of a bespoke device for the patient. This device allows easy attachment to and removal from the bike handle without using the sound hand. In addition, she is able to control the resistance of the attached device to the bike handle and she can rotate, flex and extend the wrist. The poster includes

- Technical details and photographs of the parts used and final device – see figures 1&2
- Socket design and manufacturing techniques,

- Fitting details, including measuring and setting up the check socket, first fitting and final product on the bike.
- Improvements made and goals achieved
- Photographs of the patient using the prosthesis on her bike in varied terrain.



*Figure 3: Bike Handle Bar Attachment*



*Figure 4: Socket and device*

The conclusion summarises the benefits of activity specific devices, particularly for children participating in sport and the technical challenges associated with their development. With good technical support, some knowledge or experience of working with para-athletes and good communication with patients and their carers, bespoke devices can achieve goals at a low cost.

### **Acknowledgement**

All equipment used and time spend on manufacturing was through a normal NHS budget.

Title: **Treatment Concepts for Children and adolescences with congenital malformation of the upper extremity**

Authors: M.Schaefer, F.Muders, S.Kunz

Presenter: Michael Schaefer

Affiliation: POHLIG GmbH, Grabenstaetter Str. 1, 83278 Traunstein, GERMANY

E-mail: [m.schaefer@pohlig.net](mailto:m.schaefer@pohlig.net)

### **Abstract**

The orthopedic care of children with congenital malformations of the upper extremities presents a particular challenge. Although the clinical picture of a transversal limb deficiency resembles that of an amputation, the strategies of care are more multifaceted. The acceptance of prostheses depends on various factors (clinical conditions, stump length, family situation, inclinations, environment, wishes, actual functional gains) and is not always given. Technical orthopedics therefore requires a differentiated treatment approach. Functional assistive devices (Fig.1), prostheses (Fig.2) or no aids are used. The goal of care can always be seen as an improvement of the child's participation in everyday life, whereby the development of bimanual abilities, the avoidance of compensatory consequential damages and the functional gain in the everyday life. The best possible age-appropriate development to children of the same age is at the center of the efforts. In older children, the need for restoring the physical shape and hence the appearance is increasingly becoming the focus. The use of silicones, for example, not only increases the mechanical and functional characteristics of the aid but also helps to improve wearing comfort due to the specific material properties. Likewise, ultra-lightweight carbon fiber prepreg composites and novel 3D printed designs can support stabilizing and dynamic properties as well as the acceptance of an auxiliary. The

lecture should bring the manifold supply possibilities for our fellow humans with congenital malformations on the basis of most different examples closer.



**Fig.1**



**Fig.2**

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Friday 22<sup>nd</sup> March

Session 4 (15:00-17:00)

*Guest lecture “UK CENTRE FOR DOCTORAL TRAINING IN  
PROSTHETICS AND ORTHOTICS”*

**Malcolm Granat**

We have just secured funding from the EPSRC to set up the UK’s first doctoral training centre in prosthetics and orthotics. This “EPSRC Centre for Doctoral Training in prosthetics and orthotics” combines expertise from the University of Salford, Imperial College London, the University of Strathclyde and the University of Southampton with more than 27 global industry partners and national facilities. The Centre will set to train at least 60 individuals to doctoral level over the next eight years. This Centre will create a new generation of highly skilled researchers who can deliver the technology and service innovations needed to meet the aspirations of prosthetic and orthotic users. Our training will enable students to work across the continuum of skills required in the sector, understanding how high-quality and interdisciplinary science and engineering research can improve the everyday lives of people across the globe.

*Guest lecture “HOW A LEGAL CLAIM FOR AN AMPUTEE IS  
CALCULATED”*

**Gerard Martin**

A fifteen minute whistle stop tour of how we put together a claim for a trans radial amputee that settled for £2.3 million.

Title:           **Introduction to legal claims; how amputees can make the most of compensation and rehab**

Authors:       D. Easton

Presenter:     Daniel Easton

Affiliation:    Leigh Day

E-mail:        [deaston@leighday.co.uk](mailto:deaston@leighday.co.uk)

### **Abstract**

There is significant uncertainty about legal claims for compensation; who can claim, what for and how much can they get? This presentation will seek to give an overview of legal claims and break down some of the mystery surrounding the law. I will explain how there can be helpful interaction with legal claims and discuss how a claim might be able to complement and benefit existing treatment and rehab. I will give an outline about the types of cases which are brought successfully, both arising from everyday accidents and negligence within a medical setting; I will explain examples and then consider some of the more complex issues surrounding compensation recovery, such as 'contributory negligence' and 'causation' in CRPS cases. We will consider how private rehab, OT, equipment and early 'interim payments' can be obtained through claims and we will look at claims for lost income and why getting back to work should be encouraged and assisted by lawyers. We will also consider the interplay between treating doctors and 'medico-legal experts' and try to enhance understanding of why reports are obtained and how they can be used outside a legal case. We can also look at different methods of dealing with compensation payments, such as protecting money in a trust fund, and managing 'periodical' payments over the remainder of an amputees' lifetime. Lastly, I can offer advice on what patients should look out for when choosing a lawyer to ensure they get a specialist who can best represent their interests.



## **Acknowledgements**

All funding for me is provided by my firm, Leigh Day.

Title: **An initial exploration of the impact of Ugandan prosthetic provision and repair services on users**

Authors: B. M. Deere, S. W. McCormack, R. T. Ssekitoleko, H.L. Ackers, L. P. J. Kenney

Presenter: B. M. Deere

Affiliation: Bristol Centre for Enablement, North Bristol NHS Trust, Bristol, UK

E-mail: [Bernadette.Deere@nbt.nhs.uk](mailto:Bernadette.Deere@nbt.nhs.uk)

## **Abstract**

Provision of assistive technology in Uganda is severely limited due to high costs and lack of government support for disability services. In particular, few upper limb prosthetics are prescribed to users. To address the issue, the Fit-for-Purpose project aims to develop an affordable body-powered upper limb prosthesis suitable for provision in low and middle income countries. To inform the design process, an exploratory trip was conducted to Uganda to investigate the experiences of orthopaedic technologists and prosthetic users, focusing on the impact of prosthetic failure and the process for prosthetic repairs. 3 orthopaedic workshops were visited and semi-structured interviews were conducted to understand the service model for repairs. 13 prosthetic users were interviewed, 11 with lower limb amputations and 3 with upper limb amputations. Interviews were audio-recorded and notes were transcribed and later analysed. The biggest issue facing all 3 workshops was access to components and materials. Adjustments and basic repairs could be completed free of charge, but if new materials or components were required users would have to cover the costs. This is often unaffordable therefore the repair isn't done or an improvised repair is completed. 11 out of 13 interviewees had experienced at least one failure of their prosthetic, with 4 experiencing 3 or more failures. In all but 2 cases the clients had returned to the original workshop to get their prosthetic fixed. Half of those receiving a repair were charged. 2 of the interviewees had also completed their own repairs on their prosthetics. The visit highlighted

the challenges involved in developing an upper limb prosthetic for provision in Uganda as there is a fundamental lack of high quality services available to support the provision and repair of prosthetics

Title:           **Use of Prosthesis Simulator to Create Body-Powered Prosthesis for Functional Needs**

Authors:       Debra Latour, OTD, M.Ed., OTR/L, Cassandra Delgado, MSPO, CO

Presenter:     Debra Latour, OTD, M.Ed., OTR/L

Affiliation:    TRS; Handspring Clinical Services

E-mail:        [latour@trsprosthetics](mailto:latour@trsprosthetics) or [debra.latour@myhandspring.com](mailto:debra.latour@myhandspring.com)

## **Abstract**

### **INTRODUCTION**

Prosthesis-simulators have been utilized for decades to impart empathy and to facilitate understanding operation of the body-powered technology. Bittermann (1968) advocated use of simulators with individuals who have not experienced upper limb loss. Weeks et al (2003) suggested use of simulator with uninvolved upper limb to successfully transfer skill of prosthesis use to the involved upper limb. Correlations have been made between populations of individuals with unilateral upper limb loss and those with unilateral upper limb functional loss. With hemiplegia, individuals may appreciate some return of nerve function, however this may take months and there are no guarantees of return. Oftentimes, there is a focus toward acquisition of skills leading to maximal functional independence. Application of prosthetic components appears to be beneficial to populations with upper limb **functional loss**. In the cases illustrated, prosthetic concepts were utilized, including use of a body-powered prosthesis simulator, to derive maximal functional benefit and enjoyment of quality of life.

### **METHOD**

**Subjects:** Four males who present with unilateral upper limb functional loss; initially referred for externally-powered elbow orthoses but found to be poor candidates for the technology. In considering other options, the body-powered prosthesis simulator to replicate potential functional opportunity.

Subject 1) 19 year-old male with a diagnosis of left hemiparesis s/p right hemispherectomy due to severe seizure disorder. Subject was first-year college student; self-reported limitations include total dependence to cut food with fork and knife; dress lower body; groom nails; fasten zippers, buttons, shoelaces; sweep, rake, shovel; make bed, home repairs and garden. He requires moderate to maximum assistance to serve food into a held plate, tuck in shirt, peel/cut vegetables, open/close doors and hold paper and cut with scissors.

Subject 2) 22 year-old male who presents with unilateral upper extremity nerve damage due to compartment syndrome. He was a student at the time of TBI due to skateboarding injury revealing brain tumor. Brain surgeries caused severe seizures with intermittent medication success. A seizure caused him to pass out, leading to compartment syndrome, fasciotomies resulting in nerve damage. Functional limitations include difficulty to carry items, manage bimanual tasks, fine motor tasks to operate sound boards and to mix music and to complete self-care activities.

Subject 3) 27 year-old male s/p hemispherectomy at age 5 years resulting in left hemiplegia, controlled subtle seizure disorder, visual perceptual challenges and moderately delayed cognition. Lives semi-independently with support; completes own self-care, light home management. Experiences difficulty with bimanual tasks, heavy home management. Holds certificate in film production, seeking supported employment.

**Measures:** Subjects were evaluated by OT and CPO including Quick DASH, McGann Client Feedback Forms, and functional tests. Retesting occurred at intervals post-delivery. The subjects received initial training in the device with application to functional skills, in particular tasks that relate to self-care, home management and vocational-related activities.

## RESULTS

Subsequent testing reveals continued functional improvement, orthosis satisfaction and decreased perceptions of disability. These factors appear to align with the client-centered goals to live as independently as possible, pursue vocational interests and enjoy beneficial quality of life. Subject 1 is beginning Year 2 of college, now living independently on campus. Subject 2 lives in supported setting, requiring less assistance, and has experienced some return of hand function. He uses an elbow-assist device. Subject 3 lives semi-independently with limited support.

## DISCUSSION

Additional subjects will be discussed. The body-powered elbow-wrist-hand orthosis can provide significant functional benefit to the individual with unilateral involvement using collaborative inter-professional practice.

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Saturday 23<sup>rd</sup> March The Blatchford Lecture (08:30-09:15)

*“ADVANCES IN PROSTHETIC REHABILITATION EVIDENCE-BASED  
PRACTICE WITH CLINICAL OUTCOMES”*

**Friedbert Kohler**

Many issues determine advances in rehabilitation. Rehabilitation is a very complex process with interventions affecting body structure, body function, emotional and psychological responses to amputation, body-prosthetic interface, prosthetic components and their interactions with each other and with the individual, activity and participation levels and the interactions between the environment and the individual. All of these are determinants of clinical outcomes which we are beginning to understand more about how they interact.

Over the last decades there have been significant advances in understanding the consumer perspective and their preferred outcomes, the funder and their understanding and desire to have evidence of outcomes to substantiate costs and the various health professionals and their perceptions of important outcomes.

The clinical outcomes of prosthetic are also diverse and equally diverse are the measures which we use to quantify clinical outcomes. However, measurement of clinical outcomes is increasingly important. At a global level, a simple measure is how many individuals who need a prosthesis have access to one initially, and then also have access to ongoing prosthetic and other interventions as needed.

Fortunately, there are advances in all these aspects as well the supporting evidence base.

Saturday 23<sup>rd</sup> March

Session 1 (09:15-10:00)

Title: **An analysis of self-assessed physical activity in people with transtibial amputation.**

Authors: M. Asher, C. Diss, and S. Strike

Presenter: Miranda Asher

Affiliation: University of Roehampton

E-mail: [asherm@roehampton.ac.uk](mailto:asherm@roehampton.ac.uk)

### **Abstract**

The European branch of the World Health Organisation have published recommendations with a weekly minimum of 150 minutes of moderate physical activity (PA) including for people with physical disabilities. The UK government endorses these recommendations and clarifies that walking does not qualify as moderate activity unless it is brisk. Despite the recommendations 40% of UK adults without physical disability do not perform sufficient PA<sup>1</sup>. There is a dearth of literature available on how altered movement patterns associated with amputation affect participation in PA. This study aimed to assess levels of participation in PA by people with transtibial amputation (PTTA) and compare methods of analysis of the international physical activity questionnaire short form (IPAQ-SF). The IPAQ-SF is a self-assessment method of determining weekly participation in PA; Results can be analysed as time spent in different intensities of activity and thresholds defined by government recommendations (figure 1) or as a continuous variable METs (figure 2). MET minutes are multiples of estimated energy expended in rest (i.e. 1 MET is energy expenditure at rest) and IPAQ defines values for activity thresholds in METs (as shown in figure 2). Our study found that the scoring methods influenced results; Participants J, K and L did not meet UK government time recommendations but are categorised within the high MET threshold. Overall participants met government recommendations more often than UK adults and



further research is required to establish the validity of the IPAQ and METs scoring system for this population.

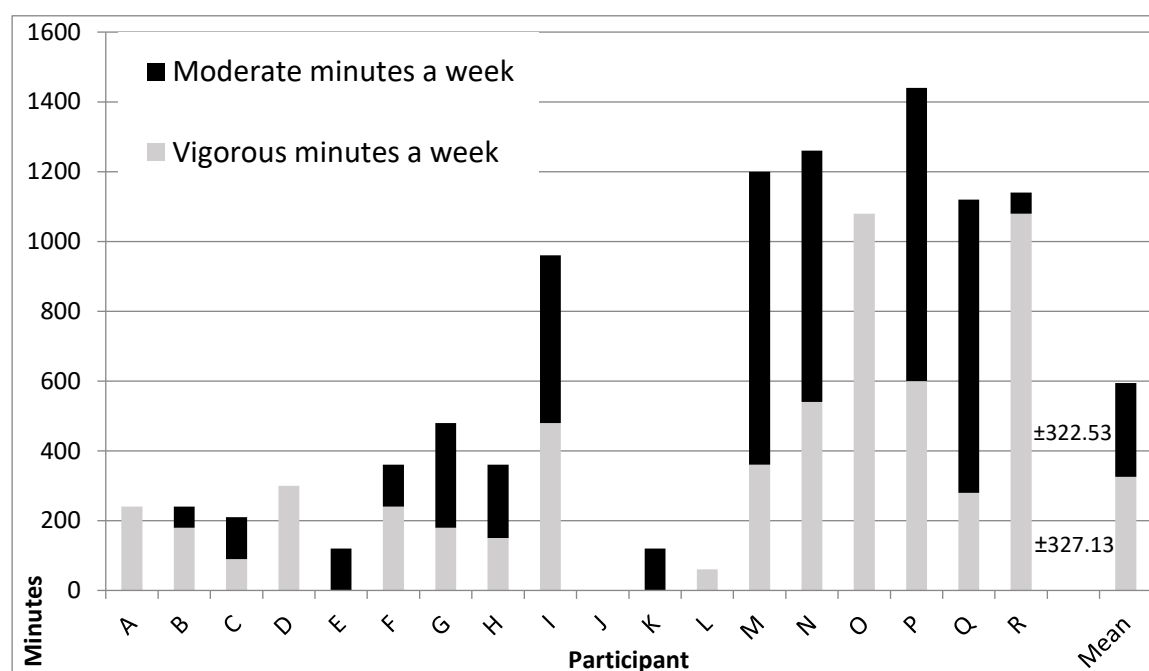


Figure 1: IPAQ vigorous and moderate minutes for PTTA participants, Mean and standard deviation are shown for each activity type.

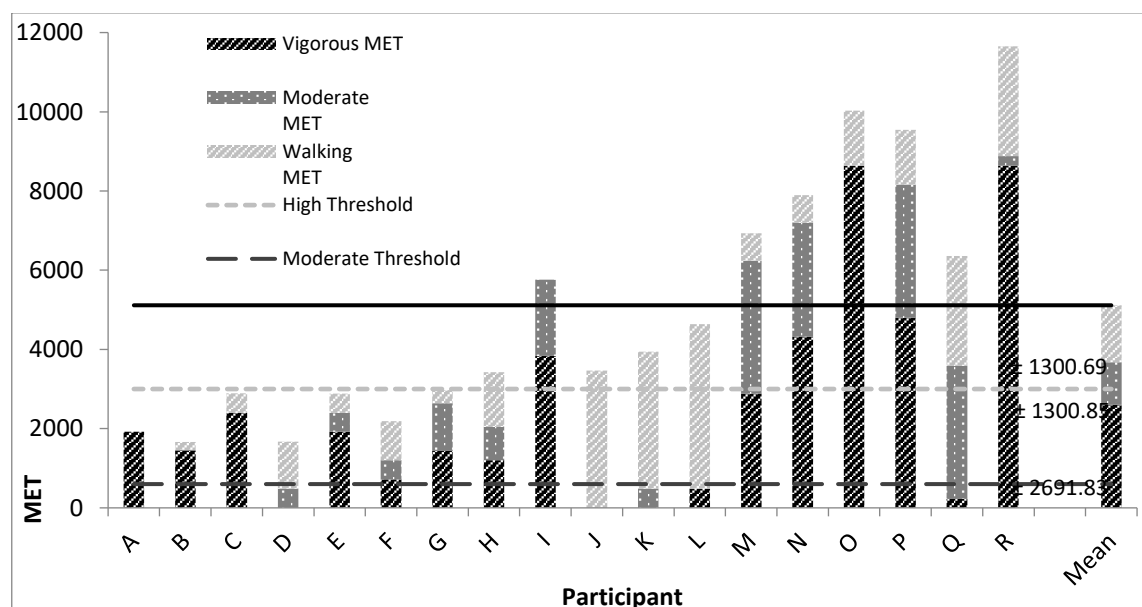


Figure 2: IPAQ MET by activity intensity for PTTA participants, Mean and standard deviation are shown for each activity type.

## References

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Title: **The development of a running class for lower limb amputees**  
Authors: H.M. Scott, G. Ferguson, J. Hebenton  
Presenter: G. Ferguson  
Affiliation: Physiotherapist, Westmarc, Queen Elizabeth University Hospital, Glasgow  
E-mail: [Grace.Ferguson@ggc.scot.nhs.uk](mailto:Grace.Ferguson@ggc.scot.nhs.uk)

### **Abstract**

A weekly running group was set up in WestMARC in June 2018 to teach people with lower limb amputations to run. This new development was prompted by an increased interest in running partly due to improved visibility of paralympic sport but also by the provision of sporting prostheses by the Scottish Specialist Prosthetic Service and the success of 2 locally organised running events. The class consists of a 45 minute Pilates exercise class followed by 30 minutes of running drills and running practise. It is led by 2 physiotherapists and is attended by a maximum of 8 participants. The aim of the class is to help each participant achieve their own particular running goals and may include referring on to a running coach if they require further expert coaching. Since June, there have been 21 referrals to the class, 2 people have been unable to attend, 14 have participated and 7 are on a waiting list. 9 participants completed a questionnaire before beginning the class. 6 of the 9 could not run at all before the class with corresponding extremely low self-reported running confidence. Reasons for learning to run varied between 'wanting to run a half marathon' and 'wanting to run after my 7 year old boy'. The 3 people who have completed the class are now able to run and report being confident to do so. The class is established as a routine part of the service offered to patients at Westmarc and outcomes will continue to be collected.

Saturday 23<sup>rd</sup> March

The OETT Lecture (10:30-11:15)

*“ADVANCED TECHNOLOGY FOR ASSESSMENT AND ORTHOTIC  
MANAGEMENT OF THE PATIENTS WITH ADOLESCENT IDIOPATHIC  
SCOLIOSIS (AIS)”*

**Man-sang Wong**

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

Saturday 23<sup>rd</sup> March

Session 2 (11:15-12:00)

*Guest lecture “INITIAL EXPERIENCES WITH AN INTELLIGENT VARIABLE RESISTANCE KNEE ANKLE FOOT ORTHOSIS”*

**Edward Lemaire, Ted Radstake, Kyle Daines, Chris Duke, Jawaad Bhatti**

A new intelligent knee ankle foot orthosis (KAFO) has been developed to provide microprocessor-controlled variable resistance to enable better mobility for people with knee extensor weakness. This variable resistance stance control KAFO (VSCKAFO) is a modular unit with all sensors and controls localized to the knee joint, enabling the orthotist to integrate the VSCKAFO into the orthosis without requiring central fabrication and also to select appropriate, or no, ankle joints. The device controls are customizable by the clinician to enable optimal knee control across various activities. This presentation will discuss case studies with people who have knee and hip weakness that used the VSCKAFO for level walking, stair navigation, and sitting.

Title: **Heat and Perspiration When Using the SmartTemp Liner: A Double-Blinded RCT**

Authors: M Wernke, R Schroeder, C Kelley, A Albury, J Colvin

Presenter: Matthew Wernke PhD

Affiliation: The Ohio Willow Wood Company

E-mail: [mattw@owwco.com](mailto:mattw@owwco.com)

## **Abstract**

Materials used for prosthetic sockets and liners have poor thermal properties, and therefore insulate the residual limb<sup>1</sup>, resulting in elevated socket temperatures and increased perspiration. Amputees report a decreased quality of life due to these factors<sup>2</sup>. In an effort to improve the thermal properties of the prosthetic liner, a passive solution was developed that augmented the thermal capabilities of silicone by modifying the chemistry with a proprietary phase change material (PCM) to increase the heat capacity of the liner. The purpose of this work is to report results from a double-blinded randomized crossover study evaluating the SmartTemp liner (PCM filled) to a standard silicone liner. Sixteen transtibial amputees participated in the study. Temperature data was collected during a 30-minute exercise and for 10 minutes following exercise at 4 locations on the residual limb. Perspiration data was collected following the 30-minute exercise and again after the 10-minute period following exercise. All activities were performed in a heated room. The results found the average skin temperature and amount of perspiration was significantly lower ( $p < 0.05$ ) when subjects wore the SmartTemp liner compared to the standard silicone liner. The results support anecdotal claims made by amputees that a SmartTemp liner creates a more comfortable temperature environment and less perspiration inside the liner. Regulating the temperature in the socket and reducing the amount of perspiration can lead to improved comfort, health and quality of life for amputees.

## References

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Saturday 23<sup>rd</sup> March

Session 3 (12:45-14:45)

*Guest lecture "NHS ENGLAND REHABILITATION & DISABILITY CRG  
POLICY UPDATE FROM PROSTHETIC REVIEW"*

**Col Alan Mistlin, Carolyn Young**

**Title:** Living With Pain Group: A Service Improvement Project  
**Authors:** L. Barker, K. Lyons and K. Hartie  
**Presenter:** Lindsey Barker (Mrs) Clinical Specialist Occupational Therapist  
**Affiliation:** North East London Foundation Trust (NLFT)  
**E-mail:** [lindsey.barker@nelft.nhs.uk](mailto:lindsey.barker@nelft.nhs.uk)

### **Abstract**

This project was motivated by the lack of treatment for amputees who experience chronic pain, defined as persistent or recurrent pain lasting longer than three months. Research supports Acceptance and Commitment Therapy (ACT) as effective for treating individuals with persistent pain [1] however has not focused specifically on the experiences of amputees. The aim of the project was to set up a pilot group of 6 patients with an upper and/or lower limb amputation who experience persistent pain, and run an 8 session group course using an ACT pain management approach to treatment [2]. The intended outcome of the group was not reduce pain but to facilitate acceptance and increase participation in meaningful activities. The pilot group were asked to complete the pain catastrophe scale (PCS-EN), as well as a number of other health and quality of life measures, at the start and completion of the course. The results show an average improvement across all outcome measures by the end of the group, with depression, anxiety and pain scores reduced, whilst mindfulness and activity levels had increased. Due to the small sample size, the results were analysed at a general, exploratory level rather than examining disparity in scores between participants and individual differences such as age, gender or level of amputation. Although the results are tentative at this stage and cannot be generalised to the wider population, the outcomes are promising. In consequence, future groups using an ACT pain management approach are planned with this client group.



## References

1. Vowles K E and Sorrell J T. Targeting acceptance, mindfulness and values-based action in chronic pain *Cognitive and Behavioural Practice* 2008; 16: 49-58
2. McCracken L M and Vowles, K E. Acceptance and commitment therapy and mindfulness for chronic pain: model, process, and progress *American Psychologist* 2014; 69(2): 178-187

## *Guest lecture “PROSTHETICS EDUCATION STANDARDS”*

### **Carson Harte**

Over the last five years, ISPO has been upgrading and re-aligning its documentation for the education of Prosthetist Orthotists. In September 2018, new standards in education were launched. Alongside the new WHO Standards In Prosthetics and Orthotics Services, this document will set the tone for the profession going forward. ISPO is also upgrading their consultation and recognition process, now promoting accreditation as the baseline.

This presentation will look at the process, the outcome, and how ISPO is working with various international bodies to promote the profession.

Title: **The Timed “Up and Go” Test: An audit of TUG scores for lower limb prosthetic users within a clinical environment**

Authors: C. Wilson, G. Campbell, H. McAneney.

Presenter: Carolyn Wilson

Affiliation: Musgrave Park Hospital, Belfast Health and Social Care Trust, NI

E-mail: [Carolyn.Wilson@belfasttrust.hscni.net](mailto:Carolyn.Wilson@belfasttrust.hscni.net)

## **Abstract**

Objective: Analysis of Timed “Up and Go” scores for lower limb prosthetic users. Design: A retrospective audit of Outcome Measure test scores routinely administered and recorded as part of normal clinical practice. Subjects: Lower limb prosthetic users who attend the Amputee Rehabilitation Service, Northern Ireland over a 3-year period, Jan 2015- Jan 2018. Methods: Timed “Up and Go” test was administered on patients being discharged from gait rehabilitation and at subsequent appointments, by clinicians in the Amputee Rehabilitation Service (ARS). Only unilateral, transtibial and transfemoral amputations, due to dysvascularity or trauma, were included. Comparisons of TUG between sex, and cause of amputation were obtained by independent t-test for transtibial and transfemoral amputations. Results: 336 Timed “Up and Go” samples were analysed from 232 participants (mean age 61.3, standard deviation 14.4 years and 77.2% male). Of these 80% (269/336) were transtibial and 20% (67/336) transfemoral amputations, with 78% (211/336) caused by dysvascularity. There were significant differences in TUG between all comparison groups for both transtibial and transfemoral levels of amputation: sex ( $P=0.017$ ,  $P=0.007$ ), cause of amputation ( $P<0.001$ ,  $P<0.001$ ), with higher values of TUG for female and dysvascular participants. Conclusions: Using this data it will be possible to develop Timed “Up and Go” normative values for lower limb prosthetic users and provide valuable baseline data for clinicians

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Richard W Bohannon. Reference Values for the Timed Up and Go Test: A Descriptive Meta-Analysis. *Journal of Geriatric Physical Therapy*; 2006; 29, 2; Health & Medical Complete

Schoppen MD, Boonstra A, Groothoff JW, et al. The timed "Up & Go" test: reliability and validity in persons with unilateral lower limb amputation. *Arch Phys Med Rehabil* 1999; 80:825–828.

Condie E, Scott H, Treweek S. Lower limb prosthetic outcome measures: a review of the literature 1995 to 2005. *Journal of Prosthetics and Orthotics*, 2006; 18:1S:13-45.

Title: **Does Elevated Vacuum Suspension Improve Limb Health?**  
Authors: M Wernke, M Haynes, A Albury, J Colvin  
Presenter: Matthew Wernke PhD  
Affiliation: The Ohio Willow Wood Company  
E-mail: [mattw@owwco.com](mailto:mattw@owwco.com)

## **Abstract**

Qualitative reports on the basis of self-reported questionnaires, clinical outcomes scales, and wound closure studies have documented claims for elevated vacuum suspension (EVS) dependent improvements to limb health. Previously, our team developed in- and out-of-socket measurement techniques to quantify changes in skin barrier function, blood perfusion, and oxygen concentration within the skin tissues of the residual limb. A randomized crossover study found that 16 weeks of EVS use resulted in a promotion of skin barrier function, improved blood perfusion during activity, and a reduction in reactive hyperemia following doffing the prosthesis compared to 16 weeks of non-EVS use. Building upon this study, the purpose here is to investigate the effect of vacuum pressure setting on limb motion and skin health using quantitative analyses. Fifteen lower extremity amputees with existing EVS prostheses participated in this study. Subjects completed 1 month in high, medium, and low vacuum pressure settings based on their randomized order. Limb health and limb motion data was collected at the end of each month. The results found significant correlations when limb health data was compared to limb motion data, showing that a reduction in limb motion resulted in improved limb health. There was not a relationship between limb health and the vacuum pressure setting, suggesting the optimal vacuum pressure setting is where limb motion can no longer be reduced with increased vacuum pressure. This result contradicts

beliefs by many prosthetists that maximum vacuum pressure is the best for the limb and prosthetic suspension.

### **Acknowledgement**

This work is funded by the United States Department of Defense.

Title: **Monitoring socket fit for children with lower limb absence**  
Authors: J.Tang, L.Jiang, D.Moser, J.McCarthy, S.Zahedi, J.Head, M.Twiste, E.Morley  
Presenter: Dr. Jinghua Tang  
Affiliation: Faculty of Engineering and Physical Sciences, University of Southampton  
E-mail: [Jinghua.tang@soton.ac.uk](mailto:Jinghua.tang@soton.ac.uk)

## **Abstract**

Children with lower limb absence frequently require new prosthetic sockets due to residuum growth. Monitoring socket fit would help to determine the appropriate time to fit a new socket, which is critical for the development and mobility of the child. The aim of this work is to develop a Proof-of-Concept (PoC) Socket Interface Monitoring System (SIMS) for children with lower limb absence based on loading profiles at the residuum/socket interface. A lab-based residuum/socket interface simulator was manufactured based on a residuum model (from a 3D scan of a child's residuum)<sup>1</sup>, embedded in sockets with different fit levels. Southampton's tri-axial pressure and shear sensors<sup>2</sup> (<http://tripssensor.co.uk/>) were then placed at the residuum/socket interface to provide dynamic loading outputs at defined anatomical landmarks (see Figure 1, below). The correlation between the interface sensor outputs and different socket fits were subsequently explored to develop a pilot App-based SIMS (some screens shown in Figure 2). These results demonstrated that a PoC SIMS can be developed using the interface loading outputs, which could potentially be adapted within a personalised monitoring system benefiting children, family carers and clinicians. However, current socket fit evaluation has not yet been extended to a real-world setting, making it important to conduct longitudinal studies with children and family carers in any future work.

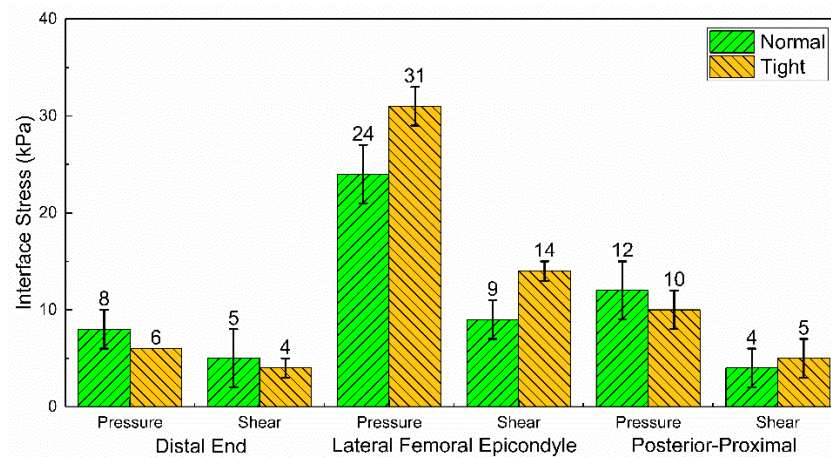


Figure 5: Mean and one standard deviation of peak pressure and shear stresses obtained at three interface locations.

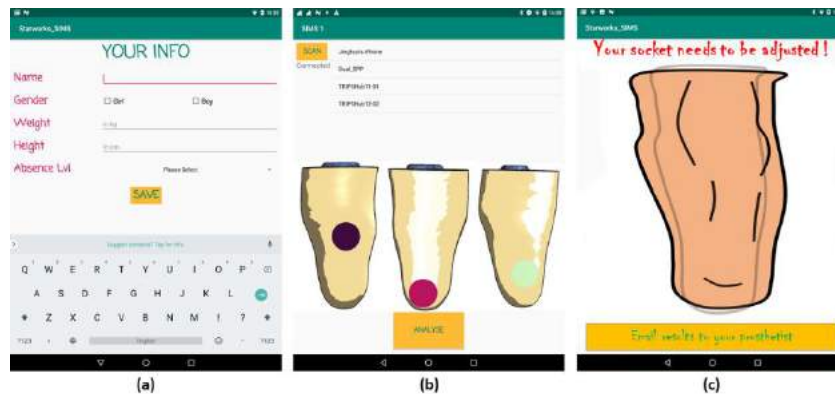


Figure 6: Typical screenshots of the SIMS App: (a) demographic data collection, (b) interface load visualisation and (c) socket fit assessment.

## Acknowledgements

We would like to thank the NIHR Device for Dignity HTC (D4D) STARworks for funding this project.

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## Posters

Title: **User experiences of digital prostheses in daily functioning in people with an amputation of thumb or finger**

Authors: V.G. van Heijningen,

Presenter: Vera G. van Heijningen, Occupational Therapist CHT-NL

Affiliation: Rijndam at Erasmus Medical Center, Rotterdam, the Netherlands

E-mail: [vvheijningen@rijndam.nl](mailto:vvheijningen@rijndam.nl)

### Abstract

Digital prostheses are rarely used, and little is known about the experiences of traumatic finger amputees with digital prostheses. When advising digital prostheses, it is crucial for professionals to understand the meaning of digital prostheses and experiences of users thereof. The aim of this study is to explore and understand the meaning of digital prostheses in users' daily functioning. The objectives are as follows: analyse users' experiences with digital prostheses in semi-structured interviews; perform content analysis to categorise and identify relationships in the data; and provide recommendations that may assist in the process of application requests for digital prostheses. Qualitative research design was chosen using interpretative phenomenological analysis (IPA) to interpret users' experiences with digital prostheses. Semi-structured one-on-one interviews were conducted, recorded, and transcribed. The written interview texts were analysed using IPA guidelines. Participants experienced the prostheses as valuable additions to their daily functioning. Three different reasons for wearing and using digital prostheses emerged from in-depth analysis of the data: improved grip, reduced overload on unaffected side and restored body image. In conclusion, this study provides a deeper understanding of what features are important to people with digital amputations who use prostheses. The most important finding is that a prosthesis was of crucial importance for participants to be able to act independently and autonomously as

well as to participate in family, work and social environments. The use of a digital prosthesis helps to improve the quality of life.

Title: **Neural correlates of hand augmentation**

Authors: D. Clode, P. Kieliba, G Salvietti, D Prattichizzo, T. R. Makin

Presenter: Danielle Clode

Affiliation: Institute of Cognitive Neuroscience, University College London, UK

E-mail: [d.clode@ucl.ac.uk](mailto:d.clode@ucl.ac.uk)

## **Abstract**

In the recent years there has been increased interest in augmentative technologies that extend the physical and cognitive abilities of able-bodied individuals. Supernumerary robotic fingers are an example of such technology, designed to allow the user to single-handedly perform normally bimanual tasks. However, these new devices introduce various theoretical and practical challenges: (i) what resources could one's brain employ to control a body part that has never been there before? (ii) what are the risks and benefits of modulating one's body representation in order to support and enhance supernumerary robotic fingers usage? Here, using human somatosensory cortex as a model, we investigate neural correlates of hand augmentation. We train healthy able-bodied participants to use a supernumerary robotic finger over the course of one week. During the training participants have to complete a set of normally bimanual tasks from daily life using only the augmented hand. A separate group of controls wears the robotic finger for the same duration of time but without using it. We use pre- to post- comparison measures to assess the outcomes of the training and see whether hand augmentation affects the representation of body in the brain. We track neuronal changes in the somatotopic hand representation using 3T fMRI and a set of well-defined behavioural tasks. By studying the neural correlates of hand augmentation, we hope to probe the boundaries of brain plasticity and see how it could be harnessed to improve usability and control of traditional and augmentative prosthetic devices.

## References

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Ejaz N, Hamada M, Diedrichsen J. Hand use predicts the structure of representations in sensorimotor cortex. *Nat Neurosci*. 2015;18(7):1034–40.



Title: **Innovative methods and materials used to produce trans-radial SSOS prosthetic sockets that can be easily used by under-resourced communities.**

Authors: C. Liu, J. Schull and S. Day

Presenter: C. Liu

Affiliation: University of Strathclyde, Glasgow, UK.

E-mail: [c.liu.2015@uni.strath.ac.uk](mailto:c.liu.2015@uni.strath.ac.uk)

## **Abstract**

CAD and 3D printing technologies have made it possible for non-clinically trained volunteers to design and deliver prostheses to people with limb losses at the trans-radial level. However, due to the lack of clinical training, the sockets delivered are often rudimentary in design, using bulky humeral cuff suspension for shorter residual limbs or poorly suspending skin friction for longer ones. The authors would like to present two innovative methods of creating self-suspended trans-radial sockets for under-resourced communities. These methods both make use of pre-fabricated flexible elbow caps, in physical and digital forms, that contain all of the casting and rectification around the elbow anatomy required to create a Strathclyde Supra Olecranon Suspension (SSOS) Socket. The physical pre-fabricated elbow cap is made from hot glue, and soda bottles are thermoformed around this and the cast to create a structurally sound semi-customised socket. (Figure 1) The elbow caps come in different shapes and sizes for users with congenital and amputated limb losses. The materials needed in these methods are also mostly easily sourced and cheap, in an attempt to reduce clinically-used materials as much as possible, so as to truly make these sockets accessible to under-resourced communities all around the world. The digital elbow cap stl files are combined with the 3D-scans of residual limbs using free softwares such as Meshmixer and Sculptgl, and subsequently digitally modified and 3D-printed. (Figure 2) A mixture of flexible materials, e.g. Nylon/ TPU/ PC, and non-flexible materials, e.g. PLA/ PETG/ ABS, can be used to make flexible inner liners

and hard outer sockets. The remaining connector piece, forearm piece, and prosthetic hand can also be digitally adjusted and 3D-printed.



*Figure 7: SSOS socket made from thermoformed soda bottle and hot glue elbow cap*



*Figure 8: 3D-printed SSOS socket*

Instructions manuals on the both of the above processes are available for volunteers and users to have step-by-step guidelines and troubleshoots on the above fabrication methods. By simplifying the processes of producing customised trans-radial sockets in terms of materials, time, and specialised labour, a lot more people around the world with trans-radial limb losses will be able to benefit from the use of a prosthesis.

### **Acknowledgement**

Thanks to e-NABLE for funding the summer internship that made this project possible, to mentor and co-innovator Dr. Jon Schull, and to lecturer Dr. Sarah Day for her guidance.

Title: **The Play Attachment Project**

Authors: M.Tulloch

Presenter: Marjorie Tulloch

Affiliation: Prosthetist, Steeper Group, Harold Wood Long Term Conditions Centre

E-mail: [marj.tulloch@steepergroup.com](mailto:marj.tulloch@steepergroup.com)



### **Abstract**

It is often difficult to make a good case for split hooks for paediatric upper limb prostheses; although they offer good functional capabilities, many parents and children are unwilling to accept them. This is mainly because of the appearance of the split hook, and associated fears of stigmatisation. These issues led the rehabilitation team at Harold Wood to investigate the creation of a child-friendly and customisable cosmetic attachment that would make the split hook more attractive and desirable. Initial designs used a combination of Lego blocks, screws and glue to build a Lego platform on top of the split hook as well as colour sheaths on the hooks so that the prosthesis could become part of a child's play habits. This Play Attachment

produced consistently positive results. The next challenge was to make the play attachment affordable, simple and open-source. Through collaboration with a 3D printing company with an interest in prosthetics (Team Unlimbited), 3D printed Play Attachments were developed that could snap easily onto a split hook, and a grant awarded by the National Institute for Health Research following the Starworks campaign. The grant was used to further develop the computer modelled design. This information is presented for consideration as a poster at TIPs 2019; the poster will contain images of each stage of the “Play Attachment Project” development, the positive results that have been achieved within the limited number of local case studies, the obstacles encountered and the future plans for the development of the project.

### **Acknowledgement**

The Play Attachment Project has been funded by the National Institute for Health Research (Devices for Dignity).

Title: **Occupational therapy for children after amputation of hand**  
Authors: D. Brezovar, M. Bugar, A. Križnar, H. Burger  
Presenter: Darinka Brezovar  
Affiliation: University Rehabilitation Institute  
E-mail: [helena.burger@ir-rs.si](mailto:helena.burger@ir-rs.si)

### **Abstract**

Occupational therapist (OT) is an important member of rehabilitation team for children after hand amputation. We reviewed medical and OT records of all children who have visited our Clinic for rehabilitation of children with congenital or acquired amputation after 1996, specially the activities of OT team members. Since 1996, we have treated 20 children (12 boys, 8 girls) after amputation (16 congenital, 4 acquired) of part of their hand (three had amputation just distal to the wrist joint, five had part of the palm, six had thumb and six had two fingers amputated). Ten children were fitted with prosthesis (4 with passive, 3 myoelectric and 3 with silicone one). Eight children got one to three different devices for activities (three for cycling, two for playing a musical instrument – one drums and one violin, one for eating, typing, writing, phone and skiing). Those fitted with myoelectric prosthesis had regular checks and OT treatment; the others received explanation about the possibilities and various advices, including coming back if the child encounters problems at any age with an activity or would like to have prosthesis. The two main roles of the OT were teaching the children how to use the prosthesis and making devices for different activities.

**Title:** De Hoogstraat Xperience Prosthesis; an unique innovative test-prosthesis

**Authors:** F. M. de Backer-Bes, I. E. M. Roeling, E. P. H. Mooibroek-Tieben,  
M-L. Vestjens, M. A. H. Brouwers, I. van Wijk

**Presenter:** Femke F.M de Backer-Bes (CP) and Ingrid E.M. Roeling (OT)

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## **Abstract**

De Hoogstraat Xperience prosthesis is an unique innovative test-prosthesis and an important tool in the decision making process in providing patients with an upper limb prosthesis. It is the first individual adjustable armsocket that is ready to use in Occupational Therapy for children and adults with a trans radial congenital or acquired limb deficiency. De Hoogstraat Xperience Prosthesis has a 3D printed adjustable socket, available in 4 different sizes and is re-usable. The patients are able to test a static terminal device, myo-electric or body-powered control. Therapists are able to fit patients with the test-prosthesis within 15 minutes without the intervention of a technician. De Hoogstraat Xperience prosthesis helps patients to have more realistic expectations of the wearing and usage of a prosthesis; does the patient want a prosthesis or not, which terminal device and which control system, myo-electric versus bodypowered complies best with the request. Besides the availability of videos, written information and experienced patients, who demonstrate their prosthesis and its possibilities, potential users lack the possibility to experience different types of prostheses. Therefore a De Hoogstraat Xperience Prosthesis was developed. Experiences with De Hoogstraat Xperience Prosthesis will be shared. Further experiences should reveal whether the De Hoogstraat Xperience Prosthesis may help to reduce the high rejection rates of upper limb prostheses.

Title: **Assessing embodiment in elite prosthesis users and expert tool users**  
Authors: H. R. Schone, R. O. Maimon Mor, C.I. Baker and T.R. Makin  
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## **Abstract**

Advancements in robotics and information technology have led to the development of highly innovative artificial prosthetic limbs. Despite these advancements, low rates of prosthetic hand usage and even complete device rejection are commonplace amongst amputee populations (1). While significant efforts are being taken to develop technological solutions to combat these issues, little attention is given to potential neurocognitive bottlenecks, such as embodiment (2). Recent evidence from our lab has shown that the more amputees use a prosthesis, the less their brain represents the prosthesis as either tools or hands. However, because the nature of a prosthesis is to act as a hand substitute, it should have a greater propensity to be embodied. Therefore, we designed a study around individuals with the most successful prosthesis usage, elite prosthesis users, to investigate if a prosthesis is represented as an expert tool or a hand substitute. We included two control groups: able-bodied expert tool users (litter-pickers) and able-bodied novices. Using fMRI, we evaluate the representation structure of hands, tools and prostheses, across the body-representation and tool-use networks. To activate these representations, we presented first-person perspective videos depicting actions performed by either a hand, a prosthesis, a litter-picker or an unknown tool. Using a large battery of well-defined cognitive and motor tasks, we further evaluate the level of embodiment and expertise of the prosthesis and tool users. By contrasting elite prosthesis

users with tool experts, our results help to elucidate the challenges and benefits of prosthesis usage on brain organisation and embodiment.

### **Acknowledgements**

This research is funded by the European Research Council (ERC).

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Title: **Abstract Myoelectric Control in Amputees**  
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### **Abstract**

We recently proposed an abstract myoelectric decoder based on motor learning (1). At TIPS2019 we will present corroborating evidence obtained from eight amputee participants demonstrating equivalent performance to that previously shown in the case of limb intact participants. In these experiments the decoder was controlled by muscles of the forearm or upper arm depending on the participant's level of limb loss. All participants were initially trained on a four target interface and progressed to an eight target interface once sufficiently proficient. Two control conditions were tested, use of a manually selected pair of surface electromyography sensors and the use of a data driven weighting of multiple electrodes. Performance rates demonstrate that all eight participants tested were able to learn the control task. As in our previous work, gains in performance were mirrored by improvement in a range of measures indicative of motor learning. Our results suggest that participant performance on a four target interface generalises quickly to the use of an eight target interface. Current results show no significant enhancement in performance when using spatially weighted sensors on a four target interface, however performance during use of an eight target interface was significantly improved when using the multi-sensor approach.

## Acknowledgements

This work has been supported by the Engineering and Physical Sciences Research Council (EPSRC), UK, for funding via grants [EP/R004242/1](#) and [EP/M025594/1](#).

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Title: **Reimagining prosthetics services, combining limb fitting and co-creation**  
Authors: G. Pullin, J. Gooding, and A. Cook  
Presenters: Graham Pullin and Jo Gooding  
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## **Abstract**

*Hands of X* ([www.handsofx.co.uk](http://www.handsofx.co.uk)) is a reimagining of a prosthetics service that augments a clinical limb fitting centre with a fashion-led service in which wearers choose materials from which their hand is made. So the 'X' stands for both *what* a hand could be made of and also for *whom* it is made and whether they feel a deep sense of ownership of it. Since our first participatory workshops with wearers and prosthetists were presented at TIPS in 2016 as 'Exploring everyday materials and prosthetic hands', we have gone on to prototype a radical fashion-led customer service within an eyewear retailer in London's Kings Cross. At TIPS 2019 we will present this prototype and show extracts from a professionally-made documentary film showing the installation and featuring conversations with wearers in which they reflect on their feelings (or lack) of ownership of their prostheses. Now we are looking ahead to how Hands of X could have impact within NHS rehabilitation services, both in terms of the drivers and hurdles that would be involved in its adoption and adaptation locally and nationally, and also the influence it might have in seeding discussion about future services, as part of the National Prosthetics Review and beyond. Co-design and co-creation—and with these perceptions of 'co-ownership', if we can call it this—are currently of interest across the NHS. Our intent at TIPS is to seed discussion with further prosthetists, wearers, manufacturers and healthcare professionals who might be interested in joining us in effecting change.



Figure 1 (left): part of *Hands of X* installation, Cubitts eyewear, June 2017 (photo: Hands of X)

Figure 2 (right): Eddie Small experiencing the *Hands of X* service in Glasgow, September 2017 (photo: Jared Schiller)

### Acknowledgement

Funded by EPSRC as 'Socio-technical materials for prosthetic hands' (Pullin; Co-I Mark Miodownik with Sarah Wilkes, UCL) and by AHRC / NPIF as a Design for Health Interactions Fellowship (Gooding).

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Gooding J. Investigating the adoption of co-design for prosthetic limbs within a social model of Healthcare. *Report, AHRC and LDoc Centre for Design*, 2018 (forthcoming).

Title: **Patient Specific Canoe Limb**  
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Presenter: S.Baker  
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### **Abstract**

A 43 year old female with a left-sided congenital through elbow limb absence presented in clinic wanting an upgrade to her existing canoe limb. The patient travels for canoe based holidays with her husband, mainly paddling tandem. The patient requested a review of the design of the limb with the aims of increasing ROM at the elbow to give her more freedom when paddling and also to prevent compensatory movements / overuse injury of the contralateral shoulder and arm. The patient also reported the socket tendered to rotate about the pin causing interfering movement.



*Figure 9: Existing fixed flexion socket and wrist*

The patient was kept on a pin lock liner for the positive suspension. Having recently attended a course on the use of pressure casting sockets, this option was discussed with the patient and it was decided to change the design of the socket to a pressure cast socket to reduce /

eliminate unwanted rotation, the patient was a suitable candidate due to soft tissue consistency and good length of residuum. It was also discussed that the socket trim was to be kept higher than her previous socket to distribute pressure over a larger surface. This poster describes the stages involved in design and manufacturing and the positive outcome on her rowing technique and reduction of compensatory movement in the contralateral limb.



*Figure 10: Completed limb with design changes*

### **Acknowledgements**

Many thanks go to Dan Keeping, prosthetic technician and workshop manager, whose technical knowledge made these changes achievable and for the patient's enthusiasm and patience throughout the process.

Title: **Motion Capture Analysis & Plotting Assistant: An Opensource Framework to Analyse Inertial Sensor-based Measurements**

Authors: R.Cheng, V.H.Nagaraja, J.H.Bergmann, and M.S.Thompson

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## **Abstract**

Literature suggests a lack of widespread clinical-adoption of motion capture-based (mocap) objective prosthetic evaluation, especially for prosthetic arms, partially due to such analysis requiring coding in computing languages that an average clinician might be unfamiliar with. A few opensource applications have been developed to help researchers deal with marker-based mocap data e.g., MoKka, Biomechanical ToolKit, C3Dserver, MOtoNMS, etc. Although, there are no similar packages for inertial-sensor based measurements facilitating translation of mocap beyond the lab. Some research groups might likely have developed their own packages that may not be available to those outside these groups. This might prove as a hindrance in reproducibility of results and collaboration, consequently, slowing advancement of this field. *Motion Capture Analysis & Plotting Assistant* (MCAPA) wants to address this gap by offering an opensource-framework for data post-processing/visualisation involving inertial sensor-based measurements for user-friendly analyses. MCAPA eliminates the need for coding, making movement analyses more feasible for clinicians. MCAPA (Figure-1; <https://github.com/runbei/mcapa>) is coded in MATLAB® R2018a and compiled as a standalone executable-application powered by MATLAB® Runtime. Following mocap for select functional task execution using a full-body Xsens system via *MVN Analyze* 2018 software, this data is exported to \*.MVNX filetype which is compatible with our app. Among other kinematic information provided by the MVN biomechanical model, the joint angles

calculated per Z-X-Y Euler angle sequence and ISB-guidelines [1] can be analysed using MCAPA facilitating an array of qualitative and quantitative assessments. The future version of MCAPA will be made compatible with lower-extremity outputs and \*.c3d filetype.

Fig. 1: Screenshot of MCAPA App compatible with Inertial-sensor based measurements

## Acknowledgement

The work was supported through a Wellcome Trust Affordable Healthcare in India award 103383/B/13/Z.



Title: **The Impact of Provision of Multi Articulating Hands in Scotland**  
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## **Abstract**

The Scottish Specialist Prosthetic Service (SSPS) was introduced in 2014, and designated to provide assessment, prescription and fitting of technologically complex prostheses, including Multi Articulating Hands (MAH) to any prosthetics service user resident in Scotland who are approved by the Specialist Prosthetics Multi Disciplinary Team. Forty people in Scotland have been provided with a MAH through SSPS in the past four years. The mean age of this cohort was 47 years (SD 20.4) and 68% were males with the majority having a Trans-Radial Amputation (TRA). 40% of the cohort had their upper limb amputation due to trauma and 35% were congenital upper limb absence. Outcome Measures were recorded pre-provision and again at 6 months post SSPS provision. These included patients reported measures, objective measures and qualitative feedback. The majority of the cohort has improved in their patient reported measures with a mean improvement in the Southampton Hand Assessment Procedure (SHAP) of 12% at 6 months after provision of an MAH. Improvements were observed in all of the other outcome measures such as the Disabilities of the arm, shoulder and hand (DASH), Quality of Life measure (EQ-5D-5L) and the TAPES-R. However, the main improvements were seen in the qualitative feedback from users when they talked about how much of a positive impact their MAH had on their everyday life which can't necessarily be measured by the conventional outcome measures (Fig 1).

*“My posture is definitely better and I’m not having to contort my body into various positions when I am doing something – I notice a difference already in my neck pain. This can only be of benefit as I get older”*

*“It’s the wee things really which seem really silly but add up to a lot – being able to put toothpaste on my toothbrush, going out for a meal with friends and not being reliant on my wife cutting up my food or serving food onto my plate at a buffet. I just see it as given me so much more options to do what I do but easier or try other things”*

*“I am really surprised how quickly my new prosthesis has become part of me. I no longer think about what I need to do to change grips – I just do it”*

*“My friends have said how much more expressive I am with my hands now during conversation  
“*

Figure 1: User Feedback on MAH

### **Acknowledgements**

The Scottish Specialist Prosthetics Service is funded through NHS National Services Scotland.

Title:           **Effective experiment design for myocontrol**  
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## **Abstract**

Despite decades of research, pattern-recognition-based myocontrol has only recently moved out of the laboratories and into the clinics. Indeed, one facet of the problem is the lack of *effective* experiments – myocontrol as an academic topic is still, by and large, removed from the clinical reality. Data are collected while subjects perform overtly simple tasks and examined offline; the experimental setup is unrelated to real prosthetic hardware; patients are hardly involved (when they are at all); and so on. To bridge this gap we plan to issue a set of guidelines on how to design effective experiments for myocontrol. Myocontrol should be *dexterous, reliable, flexible and natural*; these four characteristics pave the way to *trust* in the prosthetic hardware, foster man-machine *adaptation* and in the end provide *acceptance* and *restoration of the lost functions*. And in fact, to reach these goals much can be done already when a novel myocontrol system is tested in an academic lab. We argue that experiments in myocontrol should involve patients since the start and resemble daily life, which implies, for instance, using wearable hardware and real-time control; online tests enforcing complex tasks needing bodily movements, real-life objects and realistic environments; evaluation of performance not only on the speed of execution and/or the success rate, but also on co-adaptation; and so on. We will discuss these aspects in detail and provide a set of guidelines to design more effective academic experiments for myocontrol.

## **Acknowledgements**

This work was partially supported by the German Research Agency project *TACT-HAND: improving control of prosthetic hands using tactile sensors and realistic machine learning* (DFG/SNSF Sachbeihilfe CA1389/1-1).

Title: **User satisfaction with upper limb prosthesis and service in Slovenia**  
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## **Abstract**

The team for the rehabilitation of people after the upper limb amputation at the University Rehabilitation Institute, republic of Slovenia (URI Soča) note that the satisfaction of the people after the amputation of the upper limb with prosthesis is very different. Some users are happy with prosthesis, others are less and third are completely dissatisfied. The data on the acceptance rate of upper limbs prosthesis vary from 5% to 61% (1). We decided to evaluate the situation with the Slovenian version of the Quebec User Evaluation of Satisfaction with assistive Technology (QUEST) (2). The purpose of the study was to assess satisfaction with our products and services. We sent the questionnaire to all adult persons (18 years and more) who received the upper limb prosthesis from January 2014 to June 2017 at the Centre for Orthotics and prosthetics of URI Soča. 159 questionnaires were sent. 63 (40%) were sent back fully completed. Patients rated satisfaction with device with average score 4.0, satisfaction with service with average score 4.3 (total QUEST score was 4.2). The most important satisfaction items as identified by the users were comfort, durability/endurance and ease of use. The users mainly commented on durability and quick staining of the cosmetic gloves, problems with impact of the weather features on the temperatures in the socket, and not enough sustainable prosthetic components for heavy duties and sport. Many also highlighted that the administrative process is long and unclear.

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Title: **Extension of the Target Achievement Control Test to an Immersive 3D Virtual Environment**

Authors: J. Leestma, R. Woodward, and L. Hargrove

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## Abstract

The Target Achievement Control (TAC) Test is a Fitts Law style developed to evaluate pattern recognition control systems [1]. The primary benefit of using this test is that it allows control performance of multiple degrees of freedom to be characterized while the user receives real-time feedback from a virtual limb moving on a computer screen. We have shown TAC test scores correlate strongly with several outcomes measures, including the Southampton Hand Assessment Procedure taken when users are controlling physical prostheses, whereas only weak, or no correlation is found with offline measurements such as the classification error-



Figure 1: A subject wearing the EMG arm-cuff (blue), with the attached tracking puck (green). The immersive environment is rendered through the virtual reality headset (red).

rate [2]. A limitation of prior implementations of the TAC test is that it was implemented on a 2D display. Furthermore, there are no restrictions on where the residual limb needed to be positioned in a functional workspace to acquire target postures. Here, we have created a 3D version of the TAC test using the HTC Vive Virtual Reality System (Figure 1). Using motion tracking we can track the user's residual limb position and enforce that they move through a reasonable workspace to reach 3D-rendered target postures. We

tested this system with 8 intact limb control subjects using a dual task control test and

compared results to performance achieved with a single task control test. We found significantly lower target completion rates ( $p<0.05$ ) when completing the dual task test. This is presumably because of higher difficulty in holding the residual limb in a target location while simultaneously commanding the virtual limb into a target posture.

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Title:           **Developing Self-Advocacy: the McGann Client Feedback Form**  
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## **Abstract**

As healthcare professionals and providers, it is incumbent upon us to provide client-centered care. The consumer demands it, the healthcare industry requires it and our professional ethics mandates it. Patient satisfaction has long been a buzzword and in the prosthetic industry, it includes satisfaction with service delivery as well as with technology. Existing surveys and feedback forms often appear inadequate; and the information is often provided late in the process, hampering functional outcomes and at times does not allow the clinician with the opportunity to rectify dissatisfaction. At Handspring, we have partnered with our adult and pediatric clients to create a feedback loop which speaks to all phases of the prescriptive prosthetic process. We initiate use of the feedback document during the pre-prosthetic phase and extend it through follow-up after delivery of the definitive technology. Items on the form are relevant to comfort, aesthetics, ease of donning/doffing, tolerance to weight, length, socket and harness as appropriate; control systems, reliability, pain and functionality of the technologies. The user grades each item using a 3-point color-coded system that is easy to use by children and adults. It has been translated to Spanish for more seamless use with other measures. This information is further substantiated with other standardized outcomes measures, particularly those that relate to quality of life and self-perceptions of ability vs disability. *Subjects:* Individuals with upper limb acquired loss or congenital deficiency who present for prosthetic technology.

*Apparatus:* Use of McGann Client Feedback Form at different stages of development of prosthetic technology and training. Additional assessment using outcomes measures including the QuickDASH, Box and Blocks Test and tests of prosthetic function as appropriate to technology developed. *Data:* Scores are derived from the diverse tools, correlated by subject as they relate to prosthetic satisfaction, function and self-perception of disability or quality of life. Clients are given the opportunity to rate their satisfaction with various factors of the prosthesis. Of interest are the relationships between prosthetic satisfaction and self-perception of disability and between prosthetic satisfaction and function.

Final outcomes will be reported at this event as the subject continues to participate in prosthetic rehabilitation. This presentation specifically describes the feedback form and its implementation during the prosthetic fabrication and rehabilitation process. Case studies offer insight to its correlation to scores derived from measures such as the Quick DASH and the SF-36, changes to the prostheses and impact on functional performance of the client. Murray (1, 2) cites the importance of consumer perceptions, input and self-advocacy to the design of prosthetic technologies. He speaks of the social meanings of prosthesis use and the value of this as it relates to prosthetic satisfaction and integration to the community. By actively engaging the client, as well as input from the family and/or case manager, the prosthesis user is able to offer feedback immediately. This information is communicated to the entire team and ultimately contributes to changes in the prosthesis, user acceptance of the device, and to beneficial functional outcomes as measured by tools such as the UNB, SHAP and APMC.

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### **Disclosures**

The Author is an occupational therapist with private practice; and has business relationships with several companies within the prosthetic industry, including the prosthetic provider where this tool was developed.

Title: **VVITA – Validation of the Virtual Therapy Arm**  
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## **Abstract**

Phantom Limb Pain (PLP) occurs in 60-85% of cases [1] where people suffer from upper-limb impairment. To treat PLP we developed the Virtual Therapy Arm (VITA). The system has been tested with able-bodied and impaired subjects and is based on our experience and research in prosthetic hand control [2-4]. We have transferred our machine learning based control algorithm to Virtual Reality (VR) in order to control a virtual hand. A prerequisite for successful PLP treatment is a high level of immersion. To achieve this we deem the following properties important: intuitivity, proportionality (the ability to modulate the force level) and interactivity (the ability to updating the control algorithm at any given time). Furthermore, we believe the same methods can be transferred to stroke patients, e.g. people suffering from neglect. In this work we propose the validation of the functionality of the VITA System. We planned and developed a multicentre study involving rehabilitation centres specialised in treating amputees and stroke survivors. We will provide each centre with a VITA setup, which will be used in rehabilitation sessions. The specific scenarios in VR will be developed in close cooperation with rehabilitation experts and VR designers to ensure a purposeful implementation. Over the period of one year we will monitor the rehabilitation progress of the patients comparing it to the progress using conventional approaches. Through the feedback from not only the rehabilitation expert and physician, but also the patients we expect a successful and effective treatment for manifold applications.



Figure 11 The VITA Prototype; used by an able-bodied person

## Acknowledgements

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4. Nissler C, Connan M, Nowak M and Castellini C Online tactile myography for simultaneous and proportional hand and wrist myocontrol. *Proceedings of MEC - Myoelectric Control Symposium*, 2017

Title: **A Content Analysis of factors associated with embodiment of upper limb prostheses**

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## **Abstract**

Some prosthesis users report feeling their prosthesis to be part of them, rather than a tool.<sup>[1]</sup> This feeling is known as 'prosthesis embodiment'<sup>[2]</sup>, and whilst encouraging this has been proposed as a goal of rehabilitation, the benefits of embodiment are largely unexplored in the literature. Further, to understand why some experience embodiment, whereas others do not, the factors influencing this process need to be understood. There have been few qualitative studies in this area, and hence the full range of factors associated with prosthesis embodiment remains unclear. In addition, several questions remain unanswered, including how embodiment may change over time, and the impact of embodying a prosthesis on the individual. Thus, a qualitative study was designed to explore these areas. A Directed Content Analysis was conducted on in-depth email interviews with 10 upper-limb prosthesis users (resulting from amputation or congenital limb loss) from various countries. Five of the participants experienced embodiment, with this feeling more commonly fluctuating over short periods of time rather than changing gradually. Salient factors believed to influence embodiment included type of prosthesis and satisfaction with / awareness of the prosthesis. Short-term fluctuations in embodiment resulted from the prosthesis being broken, removed, or noticed by others. Some respondents who experienced embodiment reported feeling incomplete when the prosthesis was absent. Outcomes of embodiment included increased use of the prosthesis, better proficiency, and less need to plan tasks in advance.

## **Acknowledgements**

Research supported by a Pathways to Excellence PhD scholarship from University of Salford.

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Title: **Learning to control prosthetic fingers with an intuitive myoelectric interface**  
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## **Abstract**

Pattern recognition-based myoelectric control creates associations between muscle co-activation patterns and prosthesis movements that aim to simulate the physiological pathways existing in the human upper limb, thus providing the user with an intuitive control scheme. Nevertheless, there has been increasing evidence that user experience with classification-based myoelectric interfaces leads to motor adaptation, which in turn results in improved performance over time. In this study, we investigate the effect of motor learning when using a surface electromyography (sEMG)-based, intuitive, continuous finger position controller. We recruited ten able-bodied and two transradial amputee subjects and instructed them to modulate their muscular activity to control the six degrees-of-freedom (DOF) of a robotic hand, including flexion/extension of all fingers and thumb abduction/adduction. We demonstrate that despite using a biomimetic control scheme, learning still occurs and leads to task performance improvement within a short period of time. Moreover, we find evidence that learning to control the prosthetic hand induces changes in the statistical properties of the recorded muscle signals. Finally, we demonstrate that offline analysis cannot reliably predict real-time control performance, thereby reiterating the need for putting the human in the loop and testing myoelectric control strategies with real-time experiments.



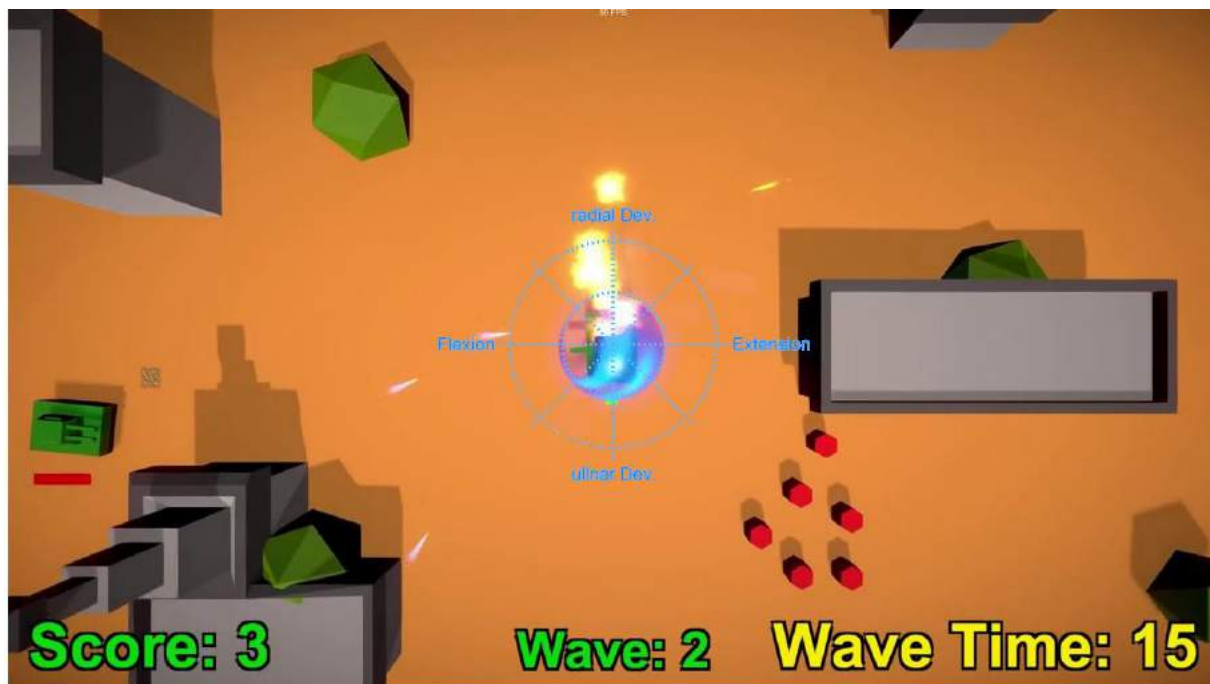
## **Acknowledgements**

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Title: **Game-based training for EMG decoding algorithms**  
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## **Abstract**

Despite increasing sophistication in machine learning and easier and easier ways to implement state-of-the-art algorithms in a variety of fields, the art of data generation has been severely neglected in prosthesis users. To train algorithms, practitioners rely on physiotherapy to isolate promising pattern candidates and single repetitions of these patterns to train a classifier. However, it is a well-known problem that data recorded in a stress-free office environment does not translate into good classification during everyday life. In order to bridge the gap between the data recording environment and the prosthesis usage environment, games may offer a promising avenue for research. By presenting conditions of motivation and stress that are similar to what users experience in everyday life, while also retaining structure that allows for label inference, it may be possible to acquire more relevant data with less inconvenience to the end user. We present here one idea for how this could be done using a so-called “turret shooter” game, in which the player controls a stationary turret that can rotate and fire projectiles at incoming objects. Drawing from Hahne et al. [1], this setup allows for the natural use of 2 degrees of freedom, and can be calibrated to vary between generating fully and partially labelled data. We hope that data gathered in this way, in comparison to data gathered normally, better fits the use case of patients in their homes and every day environments.



**Figure 1:** Mock-up of how 2 DoF will be mapped to the movement of a turret. Co-contractions could control the firing.

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Title: **Prosthetics and Orthotics facilities in Uganda**

Authors: A. Cockroft, P. Graham, L. Ackers, J. Head, R. Ssekitoleko and L. Kenney

Presenters: Alan Cockroft & Paul Graham

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## **Abstract**

The University of Salford is working with other UK partners, the University of Jordan and Makerere University (Uganda) to develop low cost, but appropriate upper limb prostheses, together with digital tools to evaluate the effectiveness of the new design(s) (EPSRC grant EP/R013985/1). To inform the manufacturing aspects of the project and building on a recent scoping report by the research team, it was agreed that a brief review of P&O facilities in public hospitals in Uganda should be carried out. The lead authors (AC and PG) are UG students on Salford's P&O programme, but with previous industry experience, were ideally placed to take up this opportunity and spent August 2018 with our project partners in Uganda. We found that the government-funded hospitals of Mulago, in Kampala, and Buhingo, in Fort Portal are currently not well-placed to manufacture and fit upper limb prostheses. Reasons include limited finances, lack of specialised production materials and componentry, insufficient machinery to produce laminated sockets and lack of support when machinery breaks down. The Orthopaedic Technologists have the skills to manufacture and produce an upper limb prosthesis, but further specialised training would likely be required for these limbs to be consistently manufactured, to a good standard. While there are other, better equipped workshops in other areas of Uganda, the demand for good quality prostheses far outstrips current availability. To help address these issues, the project team is working towards designs which may be easier to produce.

## **Acknowledgements**

This work was supported by the Engineering and Physical Sciences Research Council and National Institute of Health Research under grant number EP/R013985/1. Funding from B.P.O is also gratefully acknowledged.

Title: **Long term use of embroidered EMG electrodes**  
Authors: S.S.G. Dupan, S. Pitou, M. Dyson, M.J. Howard, K. Nazarpour  
Presenter: S.S.G. Dupan  
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### **Abstract**

Embroidered EMG electrodes can be integrated into wearable surfaces, such as clothing. This offers the possibility of measuring muscle activity non-intrusively, in a variety of environments and over long periods of time. Previously, the functionality of these electrodes has been shown in both laboratory tests, and incorporated into a pair of jogging leggings (1,2). However, when considering the use of these electrodes to monitor daily activities, for instance as part of a prosthetic device, it is important to quantify the long term properties of these electrodes. At TIPS2019, we will present the results of a study in which participants wear two sets of embroidered electrodes during twenty 1-hour sessions over the course of four weeks. During these sessions, participants will continue their normal activities. The EMG signal will be characterized in both the time and the frequency domains. Additionally, the resistance of the electrodes will be measured after each session. We hope that the results of this study can indicate whether the use of embroidered electrodes is feasible for long term, repeated use, especially in the context of limb prosthetics.

### **Acknowledgements**

Authors would like to acknowledge Engineering and Physical Sciences Research Council (EPSRC), UK, for funding via a Healthcare Technology Challenge Award ([EP/R004242/1](https://doi.org/10.1016/j.epsc.2019.04.001)).

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Title: **Experiences with a novel Pattern Recognition System used in a below-elbow prosthesis with a multiarticulating Hand**

Authors: M.Schaefer, F.Muders and K.Laasidi

Presenter: Michael Schaefer

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## **Abstract**

State of the Art prosthetic components offers you a function and shape that is much more obvious to nature than the conventional traditional myoelectric prostheses.

Thus multi-articulating hand systems can already achieve added value through the realization of various types of grip [1]. While traditional myoelectric prosthetic systems rely on 2-electrode control, switching to different grip modes requires more complex controls with reliable signal detection (Fig.1). The first systems available on the market initially required frequent recalibrations [2], recent developments have made detection more reliable. In the house of the authors different system configurations of a novel Pattern recognition system could be successfully tested with the use of up to 8 electrodes on different test persons (Fig.2). The following lecture will report on the first application experiences of this novel system. After an initial familiarization and practice of the new system, it were tested by two of our patients in activities of their daily living. The patients involved reported a noticeably more intuitive approach, which made everyday activities much easier. Recalibration rates could be extended to a very large extent, with the same reliability of the system. The functional outcome of the patients is very promising. Movements are executed much faster, more coherently and more intuitively, which could give the users a significant benefit in everyday life. In the next steps the different clinical conditions and the subjective-positive should be tested here

The positive Outcomes has to be examined and approved by appropriate assessments.





**Fig.1**



**Fig.2**

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Title: **Relationships between upper limb prosthesis use, embodiment, and balance confidence**

Authors: K. Turner, E. Moore, A. Spells and M.J. Major

Presenter: Kristi Turner

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### **Abstract**

Loss of an arm can cause severe disability, affecting work and leisure activities and even basic independence. Without the ability to access arm dynamics required to successfully regulate balance, individuals with upper limb loss/difference (ULL/D) are at an increased risk of falls and fall-related injuries (1). These Individuals report a similar number of falls as individuals with lower limb amputation (1). Other factors that may affect balance and fall likelihood are balance confidence, prosthesis use, and prosthesis embodiment. For instance, lower balance confidence was a strong retrospective predictor of frequent falls in persons with ULL/D (1), and higher levels of upper limb prosthesis embodiment has been reported to improve postural control (2). The purpose of this study is to evaluate the relationship between prosthesis use and embodiment, balance confidence, and falls in individuals with ULL/D. If individuals with ULL/D who have a high risk of falling can be identified, it may be possible to implement rehabilitation interventions to minimize fall risk and prevent fall-related injuries. Participants with ULL/D at or proximal to the wrist completed a survey using an online platform or over the telephone. Collected data included limb loss, prosthesis use, health characteristics, fall history and circumstances, balance confidence, fear of falling, and prosthesis embodiment. The strength and significance of relationships between measures will be analysed through relevant statistical correlational analyses.

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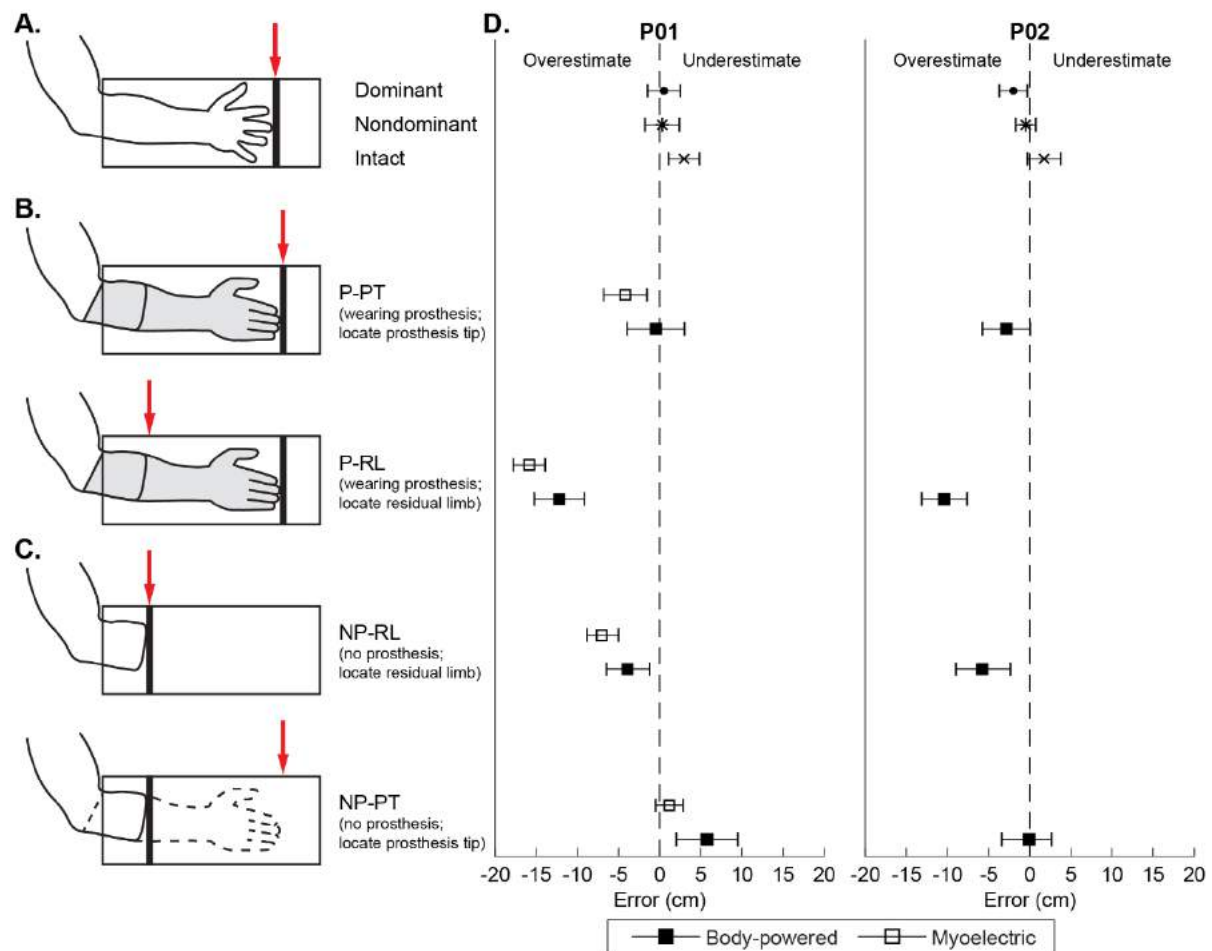
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Title: **Limb Length Estimation in Body-Powered and Myoelectric Prostheses Users**  
Authors: S.M.Engdahl and D.H.Gates  
Presenter: Susannah M. Engdahl  
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E-mail: [sengdahl@umich.edu](mailto:sengdahl@umich.edu)

## **Abstract**

If the spatial representation of the body is expanded to include a prosthesis, the prosthesis is “embodied.” Since embodiment is related to the integration of multisensory inputs (especially visual and proprioceptive) (1), the degree to which a prosthesis is embodied may depend on the availability of sensory feedback. Prior work has demonstrated that children often overestimate their residual limb length when wearing a myoelectric prosthesis (2), suggesting that the prosthesis is embodied. A similar trend may exist among body-powered prosthesis users given the greater availability of proprioceptive feedback through those devices, but this has not been tested. In this study, two adults with transradial limb loss performed limb length estimation tasks (Figure 1). P01 (32 year-old male) had 10 months of experience with a body-powered prosthesis and 5 months of experience with a myoelectric prosthesis. P02 (52 year-old female) had 7 months of experience with a body-powered prosthesis. Age- and sex-matched controls (34 year-old male and 48 year-old female) without upper limb loss also participated. Although estimation error was small when prosthesis users estimated the length of their intact and prosthetic limbs, they overestimated their residual limb length when wearing both body-powered and myoelectric prostheses. Interestingly, they also tended to overestimate their residual limb length when not wearing the prosthesis. They could also accurately determine where the end of the prosthesis would be, even when they were not

wearing it. Taken together, these results may be interpreted as evidence that prosthesis users can embody both body-powered and myoelectric prostheses.



**Figure 1:** Participants reached inside an opaque tube using the intact limb (A), prosthetic limb (B), or residual limb (C) until they touched a plate. They indicated where they perceived the end of their intact limb, prosthesis (P-PT), residual limb (P-RL, NP-RL), or where the prosthesis would be if they were wearing it (NP-PT). Error between the plate position and indicated position was averaged across 10 trials (D). Prosthesis users performed this procedure using their body-powered prosthesis (filled squares), myoelectric prosthesis (open squares) and intact limb (x). Controls performed this procedure with their dominant (•) and nondominant (\*) limbs.

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Title: **The influence of practice on SHAP task performance when using a body-powered prosthesis.**

Authors: A. Chadwell, L. Kenney, D. Howard, and R. Ssekitoleko

Presenter: A. Chadwell

Affiliation: University of Salford, Salford, UK

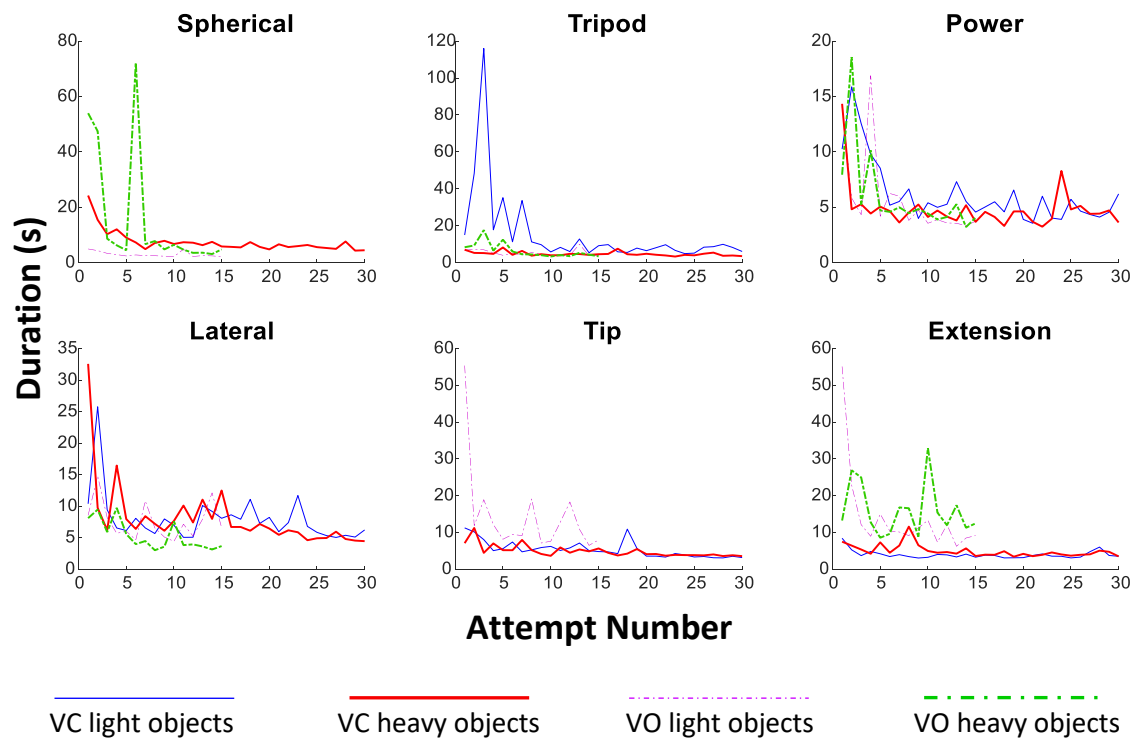
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## **Abstract**

The Southampton Hand Assessment Procedure (SHAP) has been widely used in upper limb prosthetics research since 2002. The assessment consists of 26 tasks assessing 6 types of grip. The protocol states “Prosthesis users should be encouraged to practice each task, prior to timing it, in order to determine the most appropriate technique” <sup>[1]</sup>, however, it is unclear how many attempts should be given prior to assessment and the amount is rarely reported. In novice users with no practice, repeated administration of SHAP results in learning effects <sup>[2]</sup>.

Here we present a short case study evaluating change in task duration from first introduction to each task during a single testing session. All tasks were performed by an anatomically intact subject using a TRS body-powered simulator with a TRS Voluntary Closing (VC) prehensor, and a Hosmer 5XA Voluntary Opening (VO) hook. Using the VC device, each task was attempted 30 times before moving on to the next task (order of tasks as per SHAP guidelines); total testing time exceeded 6.5 hours. For most tasks, duration began to plateau after 3-10 attempts. Therefore, using the VO device, the number of repeats were halved, reducing the testing time to  $\approx$  3 hours 20 minutes. Figure 1 shows results for the 6 abstract tasks. The duration fluctuated for some tasks where objects were fumbled or dropped.

Findings suggest studies using SHAP should report number of practice trials and consider using average performance on more than a single attempt. Further work is needed to establish how many attempts would be appropriate.



**Figure 1.** Task durations for the 12 abstract SHAP tasks (6 heavy objects, 6 light objects). For the VC device 30 repeats were undertaken (solid lines), for the VO device 15 repeats were undertaken (dashed lines). Using the VC device, the light spherical object could not be released (no results presented), and using the VO device, the subject was unable to complete the heavy tip task (no results presented).

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Title: **Unlimbited Wellness: A Unifying Telehealth Program**

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### **Abstract**

Individuals with upper limb loss/difference often require specialized services that may be difficult to access. In addition, these individuals are likely to experience secondary conditions that include pain, overuse and perceptions of isolation, and social stigma. A needs assessment specifically focused on the challenges experienced by this population offered insight to program needs to improve access and interventions to overcome these obstacles. The program was held during 10 sessions over a 12-week period of interactive telehealth experiences. Topics, such as physical overuse, medical visits, self-advocacy and awkward social situations were provided in advance of the group meetings. Participants interacted with each other to create tip sheets and other self-help tools with strategies toward prevention. This program includes relevant information for intervention that engages peer support and addresses psycho-social and physical secondary conditions. All participants demonstrated health behavior changes following participation.

### **Acknowledgements**

Handspring Clinical Services, Middletown, NY, USA supported the pilot program.



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<https://doi.org/10.1016/j.apmr.2011.06.026>

Title: **EMG control in a virtual reality environment and the effect on phantom limb pain**

Authors: D.M. Pressney, L.A. Miller, R.B. Woodward , L.J. Hargrove

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## Abstract

Causes of phantom limb pain (PLP) and sensation are poorly understood and treatments are often ineffective.(1) Other than pharmaceutical treatment, mirror box therapy is one treatment that has shown promise. Extending the idea of mirror box therapy, recent research has indicated that immersion in a virtual reality (VR) environment may also have a positive impact on phantom limb pain and sensation.

(2) In our study, six subjects with upper-limb amputation (3 transradial, 3 transhumeral) completed various pain surveys (Visual Analog Scale [VAS], Short-form McGill Pain Questionnaire [SF-MFQ] and two

study-specific surveys) before and after using a commercial VR system (Vive, HTC Corp.) with a customized virtual environment developed in Unity. Subjects wore a headset and an arm tracker attached to an adjustable EMG cuff (Figure 1). EMG signals from the residual limb were used to control a virtual arm using pattern recognition control. Subjects completed surveys immediately before and after six VR sessions, each lasting approximately 1 hour. Within the



Figure 1: Subject with a transradial amputation wearing the headset and the arm tracker mounted to a custom six channel EMG cuff to control the virtual arm using pattern recognition control.

VR, subjects completed a variety of target achievement control (TAC) tests and participated in custom games.

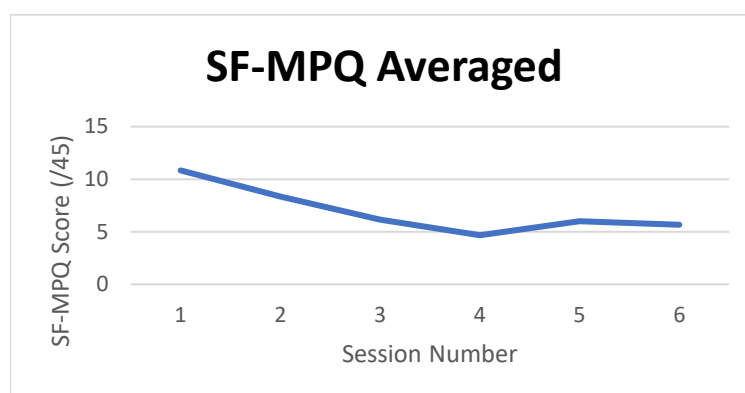


Figure 2: Average SF-MPQ across six sessions for six subjects, three transhumeral and three transradial. The SF-MPQ was administered prior to the start of each VR session

Phantom limb pain decreased across the six sessions for all three VAS measures (current PLP, average PLP, and worst PLP) and for the SF-MPQ (Figure 2). There was also a decrease in the impact of PLP on sleep. Subjectively, subjects

also reported more control over the positioning of the phantom limb, and those with a powered prosthesis reported improved control and endurance after the final session.

## Acknowledgements

The National Institute on Disability, Independent Living, and Rehabilitation Research (NIDILRR # 90RE5014) and the Department of Defense Joint Warfighter Medical Research Program (W81XWH-15-2-0035).

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Title: **An audit to examine the prevalence of psychological distress amongst patients with digit or finger-tip amputations.**

Authors: M.Jacobs, L.Byles and R.Nicholson

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### **Abstract**

At present there is limited evidence relating specifically to the psychological impact of digit amputations. Anecdotal evidence indicates that the prevalence of psychological difficulties in this population is high. The aim of this audit was to examine the incidence of reported and/or observed psychological distress within this client group. Information was retrospectively collected from patient notes, for patients attending Queen Mary's following either single digit or finger-tip amputation, over an 18 month period. Additionally, the team aimed to explore the effect of the provision of high definition silicone prostheses, from both a psychological and functional perspective. 19 patients were identified for the audit. Of these, 16 presented with psychological difficulties related to the amputation. Symptoms included; hiding the affected hand, avoiding informing family and friends about the amputation, significant emotional distress and reduced participation in previous activities of daily living. Two patients reported no psychological difficulties however, both of these patients reported a significant functional impact. There was no information available for one patient. The time since amputation ranged from several weeks to 20+ years. The information will be presented using a table of results and statistical graphs. Furthermore, a selection of 4 case studies will be used to illustrate the impact and severity of psychological distress experienced by many of these patients.

Title: **Characterising compensatory movements of Upper Limb Prostheses**  
Authors: C. H. Chua.  
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## **Abstract**

Current upper limb prostheses are not able to replace the lost Degrees of Freedom (DoF) from limb loss. The musculoskeletal structures of the upper body, trunk and arms contain redundant degrees of freedom, which allows a user to orientate their prosthesis into more favourable operating positions. Nonetheless, these unnatural and awkward compensatory movements may cause increased stress at other joints. The majority of upper limb prostheses are evaluated using a series of timed tasks, which can be used to quantitatively assess functionality. However these tests do not reveal the compensatory movements when using the prosthesis. This work measures and characterises the compensatory movements of prosthesis users performing the Southampton Hand Assessment Procedure (SHAP) using a motion capture system. The prostheses which are to be tested include but are not limited to: Split Hook, enAble Raptor Hand, and Boreham Hand. Able-bodied volunteers are tasked with completing the SHAP using each device via a prosthesis simulator. It is expected that the prostheses with a posable thumb, such as the Boreham Hand, will result in fewer compensatory movements. This research aims to introduce a feedback loop into the design process, where the design of an upper limb prosthesis reduces the compensatory movements instead of the user having to modify their motor strategies.

Title: **Groupwork For Children With Limb Loss**  
Authors: L. Barker  
Presenter: Lindsey Barker  
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## **Abstract**

Harold Wood prosthetic service has a history of running groups for children with acquired upper limb amputation and congenital limb deficiency. These groups provide children and their families with an opportunity for peer support, enabling them to share experiences, practical ideas and advice. Alongside this, they also provide the opportunity for children to use their prosthesis with fun, practical play activities alongside their peers. For children uncertain whether they wish to pursue having a prosthesis, an observational experience such as this can be really helpful. Additionally in recent months, we have used these groups as an opportunity to develop ideas around a play attachment for the child's split hook. The service is keen to understand the value of these groups as perceived by its service users, both children and their parents/carers, and to consider ways to develop them in the future. For example recent consideration has been given to the introduction of paediatric mindfulness groups, practising a range of mindfulness exercises and activities, techniques for the child to reduce worry and deal with stress. It was decided to undertake an audit in the form of an anonymous survey, with a view to eliciting perceptions around the groups to evaluate current service delivery and ideas for improvement. This presentation will describe in further detail some of the paediatric groupwork being carried out within the prosthetic service already; share the results of the survey and make conclusion as to the direction paediatric groupwork will take in the future within this service.

Title: **A Bi-Manual Evaluation Setup for Upper Limb Prostheses in Real-Life Settings**

Authors: A. Gigli, A. Gijsberts, C. Castellini

Presenter: Andrea Gigli

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### **Abstract**

Research on myoelectric control for upper-limb prostheses often fails to transfer from the laboratory to the everyday life of amputees. Among the causes for this difficult transition is that clinical short-term evaluations do not sufficiently reflect the performance during subsequent real world use. To bridge this gap, we propose an evaluation setup for upper-limb myoelectric prostheses for intact subjects, consisting of sEMG sensors, two state-of-the-art commercial hand prostheses (left and right) and a bi-manual evaluation protocol that is executed in a domestic setting. Orthotic splints are used to fix the prosthetic hands via a standard quick-release unit at the extremity of the arms or stumps. This makes the method suited for both able-bodied as well as amputated subjects and it prevents unilateral amputees from using the intact limb to compensate for a lack in dexterity of their prosthetic hand. The evaluation protocol requires users to perform everyday bilateral manipulation tasks in different areas of their reachable workspace. Specifically, subjects must, e.g., make a phone call, unscrew a jar lid, pick up objects from shelves at different heights, fold clothes, and clean the floor (Figure 1). Furthermore, our myoelectric setup can also be used in virtual reality with simulated prostheses. This allows fast prototyping of new prosthetic hands, novel tasks, as well as new environments that simulate a wide variety of possible use-cases of end-users.



Figure 1: Examples of the bimanual manipulation tasks defined in the evaluation protocol.

### Acknowledgement

This work was partially supported by the Swiss National Science Foundation Sinergia project #160837 "Megane Pro".

### References

<https://www.youtube.com/watch?v=y6ul5FLB9Q4>

<https://www.youtube.com/watch?v=aVWqX02nqj8>



Authors: **Investigating the use of 3D printing as a method to produce upper limb sports prosthesis**

Authors: J.Head, L.Kenney, B.Jones

Presenter: Bronwyn Jones

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## **Abstract**

Sports participation for Upper limb absent individuals may often be limited to specific activities that require limited upper limb involvement. Only a small number of specialist upper limb prosthetic devices are available for transradial prosthesis users who wish to undertake sports, and even fewer for those undertaking minority sports, such as fencing. Those that do exist are also extremely expensive. This project investigates the prescription and usability of specialist, inexpensive 3D-printed transradial prosthetic devices that may be employed for fencing. A mixed methods approach uses semi-structured interviews with leading private practice or retired upper limb prosthetists in the UK to explore existing prescription options and clinical practice. Concurrently, a Qualisys motion analysis evaluation exploring the effectiveness of specially designed 3D-printed fencing devices fitted within a bespoke forearm prosthesis simulator is also being undertaken. The participant is a qualified fencing instructor, who is adept at performing specialist fencing moves, such as 'lunging'. The effectiveness of the use of 3D-printed prosthetic devices during a 'lunge' will be compared to a 'gold standard' 'lunge' employed by the dominant natural hand, using a comparison of movement trajectories, plus a target score. The non-dominant hand will also be evaluated in a similar fashion, and contrasted to the 'gold standard'. The combined qualitative and quantitative results for this evaluation should help prosthetists to determine whether a 3D-printed prescription option is viable, or if training 'on the non-dominant side

would be a preferential option. Results are currently being collated, and will be available for publication by December.



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