

1<sup>ST</sup> ASSEMBLY OF THE INTERNATIONAL CONSORTIUM ON

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MOTOR DEVELOPMENT RESEARCH

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July 6 – 9, 2015

Auboulard, Ouroux-en-Morvan, France

## Research Abstracts

Opening address: Jill Whitall, University of Maryland-Baltimore

### The past, present and future of Motor Development

Throughout history a variety of approaches have been taken in the study of human motor development. In general, the conceptual approach has dictated the questions asked, the research design and methodology and the interpretation of the results. This talk will provide a brief overview of these approaches and related questions and concepts, beginning historically and drawing on a paper co-written with Jane Clark (Clark & Whitall, 1989; Quest). The main section will be an emphasis on more contemporary theoretical and methodological approaches drawing on more recent papers (Whitall, 2007; 2008). The remainder of the talk will focus on the future. From one perspective, the field of motor development researchers is shrinking and research hard to fund; but from another perspective one could argue that the time has never been better for interdisciplinary research that is valued by the wider community and policy makers (and not just other scientists).

Closing Address: Jane Clark, University of Maryland-College Park

### The Future of Motor Development Research

# Participants & Research Agendas

## **Farid Bardid**

*Department of Movement and Sports Sciences, Ghent University, BELGIUM*

Our research group of Ghent University, led by prof. Matthieu Lenoir, focuses on motor competence and motor development within different contexts. Four lines of research can be distinguished: cycling, talent identification, obesity and general pediatric population. Within the research of cycling, the role of visual information and motor competence in the steering behavior of cyclists are examined as well as the relationship with their behavior in traffic. Our research on talent identification investigates the predictive value of motor competence and physical fitness in the performance levels of youth players. Within the context of obesity prevention, research is conducted on the relationship between obesity and motor competence as well as the underlying mechanisms. Within the general population, we also investigate the role of motor competence in children and the link with other health-related factors. Each research line has its intervention component to stimulate motor competence and contribute to a healthy and active lifestyle.

My research focuses on motor development in early and middle childhood. Three topics can be distinguished in my investigation: motor assessment, motor skill interventions, underlying mechanisms of motor competence. First, I'm examining motor assessment by evaluating the construct of motor competence, exploring the convergent validity between popular test batteries and comparing motor competence cross-culturally. Second, I'm investigating the effect of fundamental motor skill interventions in children with and without motor problems. Third, I am exploring the relation between children's actual motor competence, perceived motor competence and prior physical activity experience. Newell's *Constraints model* (Newell, 1986) and Stodden et al.'s *Conceptual model* (Stodden et al., 2008) provide the framework for this research.

## **Lisa Barnett**

*School of Health & Social Development, Deakin University, AUSTRALIA*

I originally completed a Bachelor of Social Science majoring in youth work. Working in 'frontline' crisis services encouraged me towards preventative health. I transitioned into health promotion and worked for over 10 years (1994–2005) designing and implementing health promotion interventions. During this time I completed a Masters' in Public Health. From 2006 - 2008 I completed my PhD, a six year follow up of children who had participated in a past health promotion project. I commenced at Deakin University in 2009 and completed a competitive early career fellowship from 2011-14. Currently I am a Senior Lecturer on a Research Fellowship. I have over 60 peer reviewed research publications and close to 900 Scopus research citations. My research agenda is:

- Understanding the prevalence of adequate motor competence in children and adolescents
- Understanding the correlates and determinates of motor competence using a social ecological approach

- The relationship between motor competence and health behaviours and outcomes (physical activity, fitness, healthy weight status)
- Perceived physical competence and perceived motor competence and the relationship between these constructs and health behaviours and outcomes
- Interventions to improve motor competency in children and adolescents
- The investigation of Active Video Gaming as a mechanism to increase motor competence
- Sustainability and maintenance of physical activity and movement skill interventions
- Measurement in actual and perceived motor competence assessment

Whilst most of my research has been in typically developing populations, lately I have also become involved in projects focusing on children with Autism.

## **Tricia Biancone**

*Department of Human Sciences, the Ohio State University, USA*

## **Ali Brian**

*Department of Physical Education and Athletic Training, University of South Carolina, USA*

I am an Assistant Professor of Physical Education at the University of South Carolina. My research focuses on the relationship between motor competence (MC), perceived motor competence (PMC), and physical activity (PA) of children with and without disabilities. My past research examined the feasibility of preschool teachers implementing the SKIP (T-SKIP, or teacher-led SKIP) motor skill intervention with on-going coaching and support. In addition, I sought to determine the effectiveness of SKIP/T-SKIP on improving the OC skills of preschoolers both in Head Start and public early childhood centers. The results of the series of SKIP/T-SKIP studies are in review. Presently, I am examining: (a) the relationship between socio-economic status, MC, PMC, and body composition in preschoolers from a rural setting, (b) modifying and validation the Pictorial Scale of Perceived Competence and Social Acceptance for use on children with visual impairments, (c) examining the relationship between levels of visual acuity, PA, MC, and PMC in you children who are visually impaired, and (d) examining the validity of various activity monitors to measure moderate to vigorous physical activity as well as step counts. My future research includes: (a) interventions to develop preschool teachers' motor development and physical education pedagogical content knowledge, (b) exploring the relationship between MC, PMC, and PA in children who are visually impaired, (c) examining the validity of activity monitors in physical education for children with and without disabilities, and (d) continuing to implement motor skill interventions for children with and without disabilities.

## **Priscila Caçola**

*Department of Kinesiology, University of Texas – Arlington, USA*

My research agenda seeks to further our understanding of the nature of motor planning & execution across the lifespan. More specifically, I am interested in exploring links between cognitive and motor behavior, with particular emphasis on how motor and space representations develop and how problems associated with those representations cause motor skill difficulties in vulnerable populations (e.g., children with low motor ability and the elderly). During my four years working at the University of Texas at Arlington, I have sought to continue this work by studying the mechanisms of space and motor development and by exploring how the issues of children with Developmental Coordination Disorder (DCD) are associated with problems in motor planning. Some of my early findings state that children with DCD seem to have difficulties integrating tool use with spatial judgments for reach actions and suggest that rehabilitation protocols should take this issue into account. From this, my work is currently expanding to include paradigms that explore motor and space representations in dynamic settings (for example, coincident timing ability) and the issue of motor skill intervention/rehabilitation protocols for children with DCD. I believe that working with children with DCD provides a research environment for addressing important motor development research and applied questions. Along with my current work with children with DCD, I continue to explore issues related to environmental opportunities and infant motor development, by working with a tool that measures the quantity and quality of affordances in the home environment, created by me and collaborators. The Affordances in the Home Environment for Motor Development – Infant Scale (AHEMD-IS) offers many opportunities for the understanding of infant motor development – currently, it is being used to investigate the longitudinal effects of the home environment in cognitive and motor development of high-risk infants as well as a clinical tool for early intervention.

## **Jane Clark**

*University of Maryland – College Park USA*

Dr. Jane E. Clark was appointed dean of the University of Maryland School of Public Health on July 1, 2012. Clark is a professor of kinesiology in the School of Public Health and previously served as chair of the Department of Kinesiology for ten years. Her research focuses on development of motor skills in young children, with a special focus on those with movement difficulties. Her passion is to help children achieve the competence and confidence to be physically active throughout their lives.

## **Ann De Meester**

*Department of Movement and Sport Sciences, Ghent University, BELGIUM*

Despite the well-known positive health effects of regular physical activity, an increasing number of children and adolescents do not meet the daily recommendations of at least sixty minutes of moderate to vigorous physical activity. To develop interventions aiming at increasing children's and adolescents' physical activity levels, it is necessary to identify underlying mechanisms that promote PA engagement and sports participation. I started with investigating whether after school sports could be used as a vehicle to promote lifelong engagement in physical activity. Gradually, my interest grew in two underlying mechanisms of physical activity, namely the role of motor competence and motivation for physical activity /sports.

With regard to motor competence, the research I've done so far reveals that, among adolescents, actual and perceived motor competence are positively but only moderately correlated. Further analyses indicated that a large proportion of 12- to 14-year olds either under- or overestimate their skills. Adolescents with the lowest actual motor competence who overestimate their competence (i.e., have high perceived competence), demonstrate positive motivation for physical education and have high physical activity and sports participation levels, while adolescents characterized by low actual and perceived motor competence display significantly lower levels of physical activity and motivation.

My future research plans include conducting similar research in younger age groups (early, middle and late childhood) and, based on cross-lagged panel modeling, integrating the concept of motivation in the conceptual model developed by Stodden et al. (2008).

## **Guido Fumagalli**

*Research Center on Motor Development, Department of Public Health & Community Medicine  
University of Verona, ITALY*

### **Building motor skill competences**

Our research questions are:

- a) What is the role of the environment in developing motor skills in preschool children?
- b) Is development of motor skills a general process or is task-specific?

We have assembled a playground where instruments were tested and selected for the motor skill that each preferentially trained; the instruments were then distributed in three areas each exercising one basic motor skill: manuality, mobility and balance.

We investigated the effects on motor skills of a training period consisting in 10 visits occurring once per week over a period of 10 weeks. During each visit, children were exposed to 30 minutes of free play combined with 30 minutes of structured activities. A set of tests was used to measure changes in some of the gross- and fine-motor skills

We found that limited training is sufficient to increase performances in some of the tests analyzing gross-motor skills and not in tests dedicated to fine-motor skills.

By analyzing the data from gross-motor tasks exploring and training balance, we found that increased competence is associated to training of the task while transfer of competence between different balance tasks is very limited; transfer of competence both within a same domain (e.g. balance or manually) and between different domains occur when training is expected to modify physical fitness parameters (e.g. muscle strength).

Open questions:

Definition of physical activity programs for generalized development of motor skills in preschoolers.

Education of care-givers in kindergartens

## **Nancy Getchell**

*Department of Kinesiology and Applied Physiology, University of Delaware, USA*

My research agenda focuses on ways to understand and improve the ability of children to move successfully in their everyday lives. I study the development of motor coordination and competency in typically and atypically developing children. In my research, I examine perceptual-cognitive-motor relationships in young children and those with learning disabilities and autism spectrum disorder, with the long term goal of quantifying relationships that allow for earlier identification of their disease/disorder state. Since 2010, I have been in a major transition from my previous research approach (behavioral, with quasi-experimental designs) towards more contemporary approach to motor control (neurobehavioral, with randomized, controlled designs). I have adapted my research methodology to include functional near infrared spectroscopy (fNIRS), a non-invasive neuroimaging technique that measures hemodynamic changes in the cortex that is associated with neural activity, so that I can examine executive function and motor planning within these populations.

## **Jackie Goodway**

*Department of Human Sciences, Ohio State University, USA*

My work focuses on providing young children with an active start to life. I provide motor skill interventions to promote motor competence, perceived motor competence, fitness and enhance physical activity levels among young children, specifically disadvantaged children. My work contributes to the FIC mission by enhancing the quality of life of young children and their families by providing them with the skills, knowledge and behaviors to engage in a healthy lifestyle.

## **Susanna Iivonen**

*Department of Sport Sciences, University of Jyväskylä, , FINLAND*

Research Group: S. Iivonen, A. Sääkslahti, A. Laukkanen, & P. Rintala

Childhood motor skills are examined for different purposes at the University of Jyväskylä mainly aiming to show possible effects of interventions: First, the APM-Inventory (Numminen, 1995) was used to investigate the effects of an eight month preschool physical education curriculum in 4-to 5-year-olds (Iivonen et al. 2011). Second, the KTK (Kiphard & Schilling, 2007) was used to examine the effect of a family based physical activity intervention in 4- to 7-year-olds (Laukkanen, under review) and relationship between motor coordination and accelerometry-derived physical activity interpreted by metabolic and neuromuscular loadings (Laukkanen et al., 2014). Third, locomotor and object control skills and the validity of observations were in focus in the study, which collected Finnish reference values for The TGMD-3 test battery with 379 children (Ulrich, 2013). Motor skill activities of preschoolers are of interest in the study where general observation software (Iivonen et al., 2009) will be used to determine time spent in different activity types during free play and machine learning techniques to predict activity type from accelerometer data. Cross-sectional study to measure associations of motor skills with child temperament, perceptions of physical competence, and physical activity will start in August in 2015 within the Skilled kids -project (Sääkslahti et al.). Funding was gained to investigate by APM how Finnish children's motor skills have changed during 25 years. International comparisons using the TGMD-3 and the KTK are also planned. From the Finnish perspective we see that encouraging physically active play of young children is the most important focus.

## **Samuel W. Logan**

*College of Public Health and Human Sciences, Oregon State University USA*

The aim of this presentation is to provide an overview of past, present, and future research through the lens of bridging the fields of kinesiology and disability in pediatric populations. There are three themes of my past, present, and future research including 1) the use of dynamic systems theory as a framework to design and implement research studies, 2) a measurement of behavior, and 3) an emphasis on children. Past research has focused on understanding the relationships amongst fundamental motor skills, physical activity, weight status, and skill-based interventions in typically developing populations. Current research focuses on providing novel toy-based technology to children with disabilities to use for exploration and play (known as Go Baby Go). Go Baby Go is a national, community-based research, design and outreach program that provides modified ride-on cars to children birth to age three who experience limited mobility. Another current research focus includes understanding how children with and without disabilities use physical movement to engage in play interactions with peers. Future research interests include facilitating inclusive play environments for children with and without disabilities through innovative playground structures, studying the daily lives of children, and establishing collaborations with engineering faculty to develop other

## **Vitor Lopes**

*Research Center in Sports Sciences, Health Sciences and Human Development, Sport Science Department, Polytechnic Institute of Bragança, PORTUGAL*

My main research interests are on acquisition and development of fundamental motor skills and motor coordination, and the association of motor skill competence (MSC) / motor coordination (MC) with physical activity (PA), physical fitness (PF), perceived motor competence, and healthy weight across the lifespan.

In the past my research focused mainly on PA, PF and MSC/MC characteristics in children and adolescents (Lopes, Maia et al. 2003, Lopes, Vasques et al. 2006, Lopes, Vasques et al. 2007). In 2002, with other colleagues, we started a 5 years longitudinal study following children between 6 to 10 years on PA, MC, PF and somatic growth. The group then studied the relationship between those variables. We found out that MC and PF were predictors of PA and body fat/BMI (Martins, Maia et al. 2010, Lopes, Rodrigues et al. 2011, Lopes, Maia et al. 2012, Michele Caroline de Souza 2014).

After the publication of the Stodden et al model (2008), my interest also focuses on perceived motor competence and its relationship with actual motor competence and PA. We currently have a mixed longitudinal study running (5 years) to investigate the relationship between perceived and motor competence, PA, PF and healthy weight. We also have interest in the relationship between motor competency and academic achievement / cognitive function (Lopes, Santos et al. 2013).

Future research will include efforts to answer the question: “is there a critical level of movement proficiency that facilitates physical activity and sport participation in children and adolescents or even in adults?” This is the hypothesis of the proficiency barrier postulated by Seefeldt (1980).

## **Ilaria Masci**

*InterUniversity Center BOHNES, University of Rome “Foro Italico” ITALY*

*Research group: Giuseppe Vannozzi, Rosalba Marchetti, Caterina Pesce*

### **The joint role of motor and cognitive development for a holistic view on childhood physical activity.**

Since the works by Barnett et al. (2008) and Stodden et al. (2008), motor skill development is increasingly recognized as a public health issue, given that motor proficiency acquired in childhood is predictive of physical activity (PA) levels and fitness later in life. Neuro-developmentalists have highlighted the relevance of motor development for the public health issue from a mental health perspective, showing that motor and cognitive development are linked by

joint gains in the brain regions supporting them. Both paths converge on the need to go beyond a conceptualization of childhood PA as mere means to counteract obesity that allows only a limited exploitation of the potential of ‘whole child’ initiatives of PA promotion.

Nevertheless, several aspects must still be investigated before a transfer into good practices of children’s health care through quality PA may occur. First, while there is a growing evidence base on the positive impact of quality PA experiences in kindergarten and primary schools on motor and cognitive development, it still to be proven if the positive impact of PA on children’s cognitive functioning is mediated by improvements in performing coordinated motor skills. Second, to translate this interrelated, holistic view on child development through PA into local practices, we need more translational research for evaluating how public health researchers can facilitate such transfer, addressing characteristics of interventions, target settings, and implementation fidelity issues.

### **Leah Robinson**

*Child Movement, Activity, and Developmental Health Lab, Department of Kinesiology, University of Michigan, USA*

My research agenda takes a developmental perspective to three complementary areas: *motor skill acquisition, physical activity, and physical health and development* in preschool and school-age children. First, my research seeks to understand the developmental process of motor skill acquisition along with the underlying factors that shaped or that are influenced by a child’s ability to move. Then, I seek to maximize physical activity, motor skills, and physical health and development in pediatric populations, both typical developing and those at-risk of developmental delays through the design and implementation of evidence-based interventions that are grounded in Achievement Motivation. Finally, my research inquiry seeks to understand how these interventions contribute to other domains of child development - school/academic readiness (cognitive health) and self-perceptions/confidence (affective health). The overarching goal of my research is to promote movement while motivating children to be physically active and ensure that they enter school healthy, active, and ready to learn.

### **Luis Paulo Rodrigues**

*Research Center in Sports Sciences, Health Sciences and Human Development, Portugal School of Sports and Leisure, Polytechnic Institute of Viana do Castelo, PORTUGAL*

Just after my PhD my research interests centered on the affordances for motor development in early childhood. With Carl Gabbard we developed a research, clinical, and educational instrument to assess the home environment of 18-46 months’ children (AHEMD, affordances in the motor environment for motor development). Up to now, the AHEMD has been translated for more than

eight different languages, and the age scope has been extended by a new inventory for 3-18 months by Priscila Caçoila.

From about 2008, in association with Vitor Lopes, we aimed our research interests in the longitudinal predictors of physical activity and health correlates (mainly adiposity). At this point, and given our analyses of two longitudinal growth studies in the early 2000's (Azores, and Viana do Castelo), we started focusing on the role of children motor competence as a main predictor of health and fitness correlates for children and adolescents. In 2011 we started a fruitful collaboration with Dave Stodden and published several research papers analyzing our longitudinal data within the scope of the Stodden et al. model. Around this same theme, I have been working on the biosocial determinants of motor competence in preschool children (with Linda Saraiva); in the relationship between motor competence and physical fitness in cognitive and academic performance (with Carlos Luz, and Rita Cordovil).

At this time my main interests are: (1) the analysis of developmental trajectories of development (individual pathways) of motor competence, physical fitness, and physical activity; and (2) the establishment of a motor competence assessment model that could be used along all different developmental ages.

## **Nadja Schott**

*Institute of Sport and Exercise Sciences, University of Stuttgart, GERMANY*

In my lab we have four main research interests:

### **1 Assessment of motor and cognitive development**

In a joint effort with the computer science department at the University of Stuttgart we are developing sensor-based forms of qualitative and quantitative forms of assessment of motor skills (key words: Kinect; sensors in clothing). Furthermore, we develop several computerized protocols of age-adjusted assessments of cognitive functions, focusing on hot and cold executive functions (key word: age-adjusted task difficulties).

### **2 Relationship of motor and cognitive performance across the lifespan**

It is well known, that for learning, planning and performing such complex motor skills (FMS) like throwing, catching or kicking a ball, cognitive abilities like executive functions (EF) are required. The main objectives of our studies are (1) the investigation of age- and gender-specific courses of development of qualitative and quantitative parameters of FMS and for EF as well as (2) testing the interrelations between and the predictive power of FMS and EF among each other.

### **3 Development of motor representation across the lifespan**

Because the body and brain are subject to physical, physiological and cognitive changes across the lifespan it can be expected that the representation of the own body and therefore action representations change. This leads to the assumption that the ability to mentally represent actions and the different dimensions of MI should be more or less affected by these changes. The aims of our studies are to examine how age influences different dimensions of the ability to imagine motor actions, how this process is mediated by working memory, and how this changes of motor representation influences skill learning.

### **4 Cognitive-motor interference during fine and gross motor tasks**

Recent studies suggest that motor and cognitive development is more closely related than previously assumed, depending on movement experiences, skills, age, and gender. Especially gross-motor performance such as functional goal-oriented locomotion is not a merely automatic process, but requires higher-level cognitive input, highlighting the relationship existing between cognitive function and walking even in young adults. An elegant approach to assess the interdependence of motor and cognitive function comes from the motor-cognitive interference research using dual task (DT) conditions. Our studies aim to further examine factors such as the prioritization of posture/walking, the sensorimotor-cognitive interactions, the exercise-induced activation of resources, the type of tasks combined (peripersonal system vs. the extrapersonal system), the structural and functional changes of the brain, and the automatization deficit to characterize how performing concurrent cognitive task of different loads interfere with fine and gross motor performance.

### **Dave Stodden**

*Department of Physical Education & Athletic Training, University of South Carolina, USA*

My research agenda focuses on promoting the acquisition and development of fundamental motor skills and the association of motor skill competence with physical activity, health-related physical fitness, perceived competence, and obesity across the lifespan. My research emphasizes the need to address and understand developmental mechanisms and casual pathways related to youth physical development trajectories. In addition, research addressing ballistic skills allows me to further explore the behavioral and mechanical nature of multijoint ballistic motor skills and apply this knowledge to skill acquisition, youth physical development and assessment validation.

### **Patrizia Tortella**

*Research Center on Motor Development, Department of Public Health & Community Medicine University of Verona, ITALY*

The main question relates to the links between training of motor skills and development of executive functions (EFs) Levels of motor competence influence amount, intensity and level of physical activity performed by children. Physical activity is related to health and executive functions (EFs, Diamond, 2013). Different physical activities produce different outcomes on EFs but it is still debated which kind of physical activity and motor skills are fundamental for development of cognitive skills (Best, 2010). We analyzed how children exposed to a difficult balance task (walking on a unstable balance beam supported by springs) behave and acquired the skill required to perform the task. Experimental variables included type of support and teacher behavior. Time and number of errors were measured before and at the end of a training period consisting of one hour once-a-week visits to the park for ten consecutive weeks. On the same children an estimation of possible changes in EFs induced by the training was done with the day-and-night test; the test was administered before and at the end of the ten weeks training period.

Our preliminary data indicate that teacher-mediated experiences promote child expansion of body scale and affordances. The data also suggest that successful experiences encourage autonomous child training thus further expanding perception of motor skill competence. Preliminary data also indicate that teacher-mediated experiences promote EFs development.

Open questions: Organization of physical activities in schools for promoting both motor skill and EF development, Which kind of scaffold contribute to develop motor skills and cognitive processes?

## **Giuseppe Vannozzi**

*InterUniversity Center BOHNES, University of Rome “Foro Italico” – Italy*

*Research group: Ilaria Masci, Eleni Grimpampi, Ilaria Pasciuto, Rosalba Marchetti, Caterina Pesce*

### **Quantitative assessment of motor skill development through inertial sensor measurement.**

Development of Fundamental Movement Skills (FMS), typically divided in locomotor and object control (ballistic and manipulative) skills, is crucial for motor development in children. This has a clear impact on cognitive and social personality development as well as on health promotion and fitness later in life. This evidence supports the research in improving objectivity and field applicability of current assessment methodologies. In this respect, quantitative human movement analysis could overcome the limitations of the current qualitative observations, mostly used to assess FMS. While traditional biomechanical approaches are limited to laboratory assessments, wearable inertial sensors allow to measure movement-related quantities in ecological settings.

Current activity of two projects of the BOHNES group is, therefore, focused on proposing and validating quantitative methods for in-field assessment of FMS development in kindergarten and primary school children. This objective is pursued by: i) defining feasible multi-sensors set-ups for each locomotor or ballistic skill; ii) identifying a set of parameters able to sensitively detect changes in each skill by joining the use of inertial sensors to the use of common in-field evaluation tests; iii) testing the suitability of the identified parameters for an in-depth investigation of skill developmental trajectories and to detect subtle changes due to physical activity interventions. As outcome, it is expected that the proposed methodologies could highlight the role of enhanced physical activity program in impacting the individual motor competence as well as children's cognitive development and mental health.

## **Jill Whittal**

*Department of Physical Therapy, University of Maryland – Baltimore, USA*

*1. Determining the sensorimotor characteristics of children with and without developmental coordination disorder in order to understand how to design effective interventions. Through lack*

of new funding, this focus has diminished with only papers on previously collected data continuing to be published.

2. *Developing and testing novel interventions for individuals with stroke in conjunction with investigating the underlying mechanisms of recovery.* This focus has included applying principles of motor learning and control to the design of two novel interventions. Current funded grants include two with industrial partners working towards home-based tools for stroke rehabilitation (one recently patented). A long collaboration on the use of UE robots has resulted in a recent successful Co-I application where we will systematically look at determining predictors of outcomes in chronic stroke survivors after a combined robot and task-based intervention. There are five current agenda items related to this work:

(i) Determine the relationship between the timing and intensity of standard rehabilitation delivery and the functional outcomes across countries for stroke survivors using a retrospective followed by a prospective multicenter longitudinal study.

(ii) Compare the effectiveness of a web-based UE rehabilitation program in sub-acute stroke to standard home-based exercise programs in US and UK.

(iii) Determine the effectiveness of adding a rhythmic auditory cue to treadmill and overground gait training in chronic stroke survivors.

(iv) Design and validate a test of bilateral arm function for individuals with stroke.

(v) Design and validate a test of cognitive-motor function using dual-task methodology for stroke survivors.