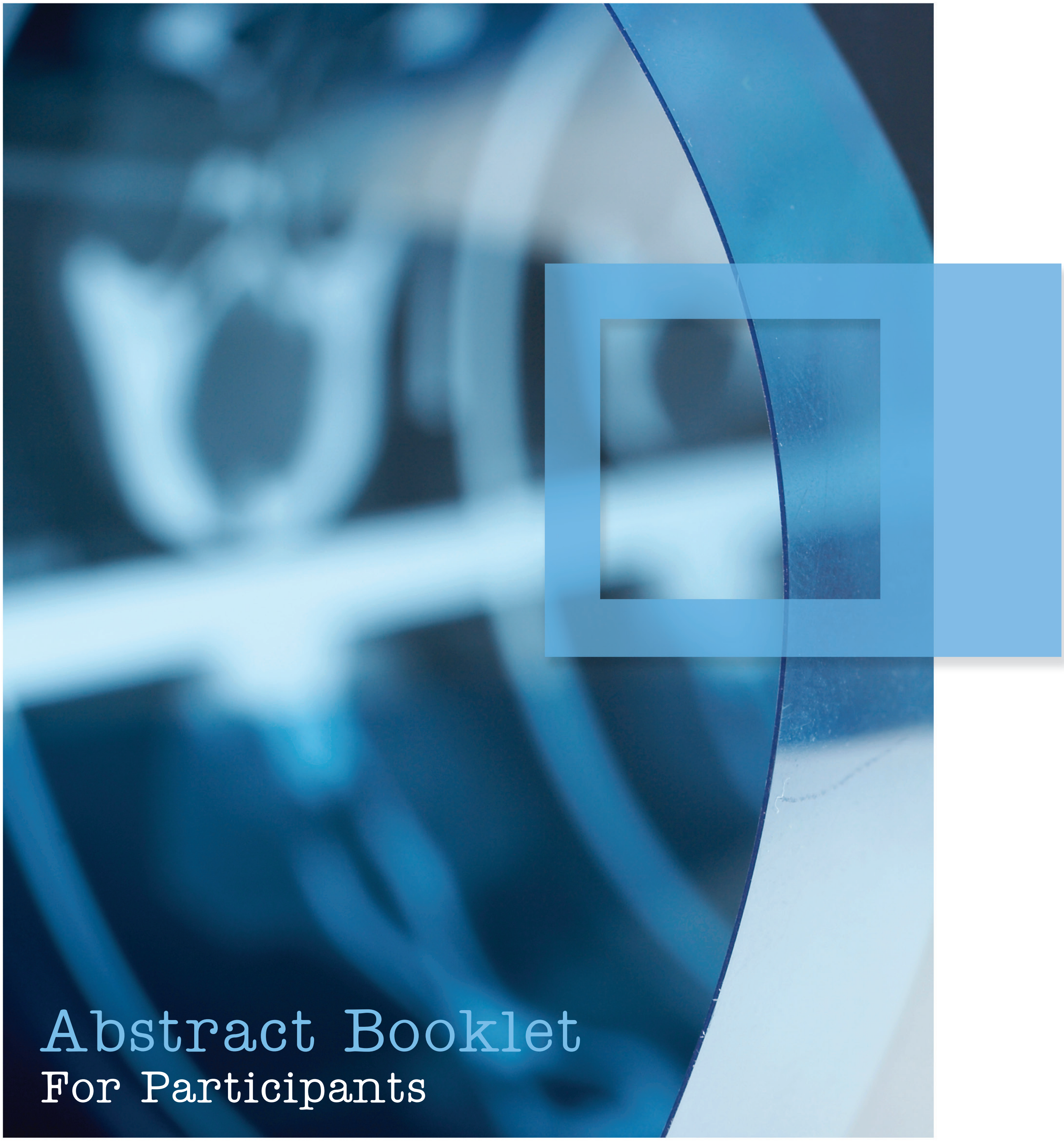

# Abstract Booklet

## For Participants

SHEPHERD CENTER AND HOCOMA

# NEUROREHABILITATION SYMPOSIUM

AUGUST 27-28

ATLANTA, GA

NANRS2010.COM

# Contents

## KEYNOTE SPEAKERS

### Neurorehabilitation Pilot Studies Suggest Efficacy, Randomized Clinical Trials Reveal Little
### Bruce Dobkin, M.D.

A review of recent RCTs that often followed years of pilot studies reveals rather disappointing results. How will we avoid finding the same lack of high efficacy for trials of robotic assistive devices and other alternative therapeutic strategies to improve motor control after stroke, spinal cord injury, and other disabling diseases?

**Learning Objectives:**

1. Describe the results of 3 upper and 3 lower extremity randomized clinical trials to improve outcomes after stroke, spinal cord injury, or multiple sclerosis.
2. Describe potential flaws in pilot studies that aim to gather evidence for RCTs.
3. Describe potential flaws in translating pilot studies of robotic assistive devices into RCTs. That can prove efficacy of an experimental intervention.

### Future of Robotics in Neurorehabilitation
### David Reinkensmeyer, Ph.D.

Most robotic therapy devices for neurorehabilitation are currently designed to physically assist the patient in making desired arm, hand, or gait movements, mimicking the approach of "active assistance" used by rehabilitation therapists. In this talk, I will review data from my laboratory and others that indicate that the way the motor system responds to physical assistance is diverse rather than uniform, and depends on the task, the way the assistance is provided, and the initial skill level of the patient. In some situations, assistance may help create a safer, more motivating, or more effective training environment, but, in others, it may add little to training or even encourage slacking by the motor system, reducing the therapeutic benefit of time spent training. Given this diverse response, I will suggest possible approaches to improving the next generation of robotic therapy devices.

**Learning Objectives:**

1. To understand that the way the motor system responds to physical assistance from robotic therapy devices is diverse, and depends on the task, the way the assistance is provided, and the initial skill level of the trainee.
2. To be able to explain clinical and motor learning experiments that indicate that assistance may motivate patients and enhance motor learning in some cases, but may add little to training or even decrease therapeutic benefit in other cases.
3. To be able to identify three ways that the next generation of robotic therapy devices might be improved.

## ARMin Meets Armeo
## Robert Riener, Ph.D.

Robots can serve to assist and assess the rehabilitation of upper extremity function. Furthermore, the use of additional audiovisual displays can increase patient motivation. This presentation will provide an overview of existing robotic devices and strategies that can support the movement therapy of the upper extremities in subjects with neurological lesions. We will distinguish between passive and active robotic devices. Passive devices such as Hocoma's Armeo, can support the movement against gravity, while the patient still has to generate the movement with sufficient voluntary effort. In contrast, active devices such as ARMin can support also weaker patients, even if they cannot produce enough force. Furthermore, due to the active function of ARMin it allows for a patient-cooperative training of a large variety of different tasks and activities as well as assessment of different structural, functional and task-related issues.

**Learning Objectives:**

1. Get overview about existing robotic technologies for upper extremity therapy.
2. See main differences about active vs. passive and exoskeletal vs endeffector based approaches.
3. Learn about the challenge of developing therapy defices from the idea to the commercial distribution.

## Robotics and Motor Learning
## William Zev Rymer, M.D., Ph.D.

Rehabilitation Robotics is a highly promising technology, whose application has shown benefit in several disabling neurological illnesses, particularly in stroke and Spinal cord injury. There are also promising signs that robotics will be useful for treating cerebral palsy, multiple sclerosis  and traumatic brain injury as well. While early benefits are measurable, the magnitude of long-term improvements resulting from robot use has been quite limited to date, for reasons that we do not fully understand. Accordingly, the central problem we face is our uncertainty about the appropriate way to use these devices.

In the beginning, robots were designed to emulate the actions of therapists, which included several key features:

1. Range of motion exercises to increase, preserve, or maintain joint motion and muscle length changes.
2. Voluntary muscle activation to preserve and increase voluntary muscle force generation.
3. Assisted motion to help patients achieve desired tasks, such as activities of daily living.
4. Repetitive practice, to restore lost movements, such as locomotion patterns, or manual skills (linked to 3).
5. Development of compensatory strategies so that new muscles or movements are substituted for missing functions.

Currently, robotic devices are able to assist with objectives 1 and 2, and sometimes with objective 3, but they are less suited to accomplish, 4 and 5. The cited limitations are not really attributable to deficits in robot design or implementation. Our major deficits are in the development of an optimal framework for learning by the injured brain or spinal cord. These issues will be discussed.

**Learning Objectives:**

1. Establish a working knowledge of common rehabilitation robotics systems currently in use world wide for treatment of major neurological disorders.
2. Learn current indications for use of specific robotic systems for particular neurological disorders.
3. Learn about new strategies for improving performance of robotic systems for enhancing neurological rehabilitation.

## Traversing the Translational Trail for Trials
John Steeves, Ph.D.

It is difficult to develop optimal clinical trial protocols and clinical endpoints for a disorder, like SCI, which has yet to validate a treatment with a clear clinical benefit. Past clinical trial efforts provide valuable lessons and knowledge (e.g. natural history of SCI recovery) for future prospective human studies. There are number of potential confounding factors that can influence trial outcomes. Broad inclusion criteria (e.g. mixing different levels and severities of SCI) can limit the ability to detect a subtle, but meaningful clinical benefit. The ability to detect a therapeutic effect depends on the sensitivity, accuracy, and reliability of appropriate trial outcome measures. The most rigorous SCI clinical trial is a prospective double blind randomized control study, utilizing appropriate placebo control subjects, but this is not always possible as different trials have different goals and constraints. The presentation will briefly outline different trial factors and protocols with discussion of the impacts on clinical results.

## SPEAKERS

### Progress in Rehabilitation Science and Engineering in SCI
### Deborah Backus, PT, Ph.D.

The synergy between rehabilitation science and engineering is leading to exciting and promising advance in technology and clinical approaches that will advance the field of spinal cord injury rehabilitation. This presentation will highlight recent basic and clinical science advances, including technological developments, focused on improving motor control and function after spinal cord injury. The presenter will also address issues related to translating and utilizing evolving evidence and technological advances into clinical practice.

**Learning Objectives:**

1. Define the current clinical standard for rehabilitation in SCI;
2. State key benefits and barriers to translation of recent advances in technology for advancing SCI rehabilitation;
3. Discuss issues related to investigation of motor control and functional recovery in SCI.

### The Role of Virtual Reality and Interactive Games in Upper Extremity Rehabilitation
### Paolo Bonato, Ph.D.

Virtual reality tools have been widely used in physical medicine and rehabilitation to facilitate the implementation of rehabilitation interventions. Two major applications of this technology are the use of interactive games to motivate 1) patients required to performed repetitive movements for a large number of times and 2) patients (e.g. children) who find it challenging to undergo intensive rehabilitation interventions. This talk will present an overview of ongoing studies that leverage existing systems for robotic-assisted rehabilitation that benefit from the use of interactive games. It will also present preliminary work aimed at developing new rehabilitation interventions combining motor and cognitive training using an interactive multi-touch table. These technologies have been tested in pilot studies in various patient populations including children with cerebral palsy, children undergoing burn rehabilitation, adults who suffered a stroke, and adults who suffered a traumatic brain injury.

**Learning Objectives:**

1. To gain an understanding of the mechanisms underlying the increased effectiveness of rehabilitation interventions that leverage virtual reality and interactive games compared to traditional interventions.
2. To gather information about new technologies (e.g. interactive multi-touch table technology) that are expected to provide opportunities to enhance the effectiveness of rehabilitation interventions.
3. To gain an understanding of the technology needed to implement rehabilitation interventions targeting upper limb function according to the level of impairment and functional ability of patients undergoing rehabilitation.

## The ArmeoSpring and ArmeoBoom at UPMC – Clinical Application and Research Questions
## Michael Boninger, M.D.

Rehabilitation robotics hold promise for improved outcomes in patients with physical and sensory impairments of the upper limbs. The ArmeoSpring and Boom are clinical robotic devices used for the restoration of arm function following disabling conditions like stroke. The UPMC Institute for Rehabilitation and Research has been using an ArmeoSpring for our inpatient program since the spring of 2009. In the fall of 2009 UPMC received the ArmeoBoom, a lower cost device than the ArmeoSpring designed to be used in the outpatient and possibly home setting. At first the ArmeoSpring and ArmeoBoom were used next to each other in an acute inpatient rehabilitation facility. The Boom was then transitioned to an outpatient facility for use with an outpatient group. In this talk the experience with both devices will be detailed as well as the clinical protocols put in place for their use. Future clinical and research direction related to rehabilitation robotics for the upper limb will be discussed.

**Learning Objectives:**

1. Be able to list the characteristics of robotics that make them an ideal rehabilitation tool.
2. Be able to cite specific clinical examples when robotics may lead to improved outcomes in upper limb function.
3. Be able to discuss the research literature that supports robotics usage for upper limb training.
4. Be able to discuss future research and clinical directions in the area of upper limb rehabilitative robotics.

## Moving Robotics from Research to Industrial Development on to Clinical Application
## Gery Colombo, Ph.D.

In the last 15 years we have seen a fast growth and development in the field of research in rehabilitation robotics. The number of universities working in this field has increased to more than hundred and a lot of new technologies and devices are being developed. The ultimate goal must be an effective and efficient clinical use of the new technologies but only few devices have become clinically applied and widely accepted yet. With the new devices, clinical research has to be done, to find the short comings of the existing approaches. Before large trials are initiated, the results of the testing should lead to iterative improvements of the technology. Intensive testing can only be done if the devices are already safe, run reliably and ideally can be tested in different conditions and pathologies. The most important aspects for a successful device development and market introduction will be discussed.

**Learning Objectives:**

1. To receive a rough overview about developments of robotics devices for neurorehabilitation in the past 10 years.
2. To identify the difficulties of providing evidence based data based on large clinical trials for a new developed rehabilitation device.
3. To learn about important cornerstones for a successful development and deployment of a rehabilitation device.

## Sensorimotor deficit in Cerebral Palsy
## Debbie Gaebler-Spira, M.D.

Cerebral Palsy is a result of an injury to the Central Nervous System (CNS) in young children before the brain has matured. The impairments related to CNS injury in children are superimposed on a background of growth and development. This presents unique challenges for management and treatment. The primary deficits such as spasticity, weakness and impaired motor control respond to physical therapy. Adjuncts to physical therapy include medical management, orthotic management and innovative robotic intervention. The use of robotics introduces repetitive practice and motivation in functional settings. The lecture will review the sensorimotor deficits of CP and present the use of robotics in the context of improving outcome in children with neurologic disorders.

**Learning Objectives:**

1. The learner will recognize the primary and secondary impairments or deficit of CP.
2. The learner will  be able to identify  the contraindications for use of a Lokomat therapy for ambulation in children with CP.
3. The learner will be able  use easy objectives measures for outcomes in children with cp and ambulation.

## Wearable robotics for gait assistance and rehabilitation
## Michael Goldfarb, Ph.D.

Robotic gait assist devices have been shown to facilitate gait retraining and rehabilitation in neurologically impaired individuals. Recent advances in robotics technology (including significant improvements in battery, motor, and microelectronics technologies) now offer the possibility of self-contained, wearable robotic gait assist devices. A self-contained, wearable robotic gait assist device would have the ability to provide similar gait retraining capability to stationary, treadmill-based robotic gait assist devices, but would also provide the added benefits of enabling overground locomotion (presumably with a stability aid, such as Canadian crutches) and in-home use (at appropriate stages of rehabilitation). The presenter will describe collaborative efforts between Vanderbilt University and the Shepherd Center to develop a robotic lower limb exoskeleton for gait assistance in spinal cord injured individuals, and also for gait retraining in neurologically impaired individuals. The exoskeleton design will be presented, and preliminary results will be presented demonstrating its potential for gait assistance.

**Learning Objectives:**

1. Provide survey of recent developments in wearable gait assistance and retraining devices.
2. Provide survey of emerging (commercial) devices in this field.
3. Describe challenges and technological limitations in implementing wearable robotic gait assist devices.

## Insights from a walking spinal cord on the role of sensory feedback in locomotion and establishing appropriate sensory regulation
## Heather Brant Hayes, BE

Sensory feedback wields powerful influence over spinal locomotor circuitry and can refine, reinforce, and even elicit locomotion. To investigate the neural mechanisms underlying this interplay, we developed a novel spinal cord-hindlimb preparation (SCHP) in the neonatal rat that combines intact sensory feedback and behavioral observability with the neural accessibility of more reduced preparations. Essentially, a walking spinal cord. As in human studies, we can monitor kinematics, kinetics, and EMG and apply mechanical perturbations, while directly measuring the neural effects of our mechanosensory interventions. Using the SCHP, we investigated how sensory feedback can be used to reinforce and refine weak locomotor patterns in the absence of brain input. First, we demonstrated the ability of mechanosensory manipulations to reinforce spinal locomotion. Second, we investigated how sensory feedback is dynamically regulated during locomotion. Our studies indicate that contralateral limb loading plays a major role in selectively regulating sensory input on the ipsilateral side, suggesting that contralateral limb loading may be an important parameter for restoring sensory regulation during walking and enhancing spinal cord injury patients' ability to selectively gate sensory inputs.

**Learning Objectives:**

1. Understand emerging methodologies in spinal cord research and how they apply to locomotor rehabilitation.
2. Describe the pharmacology of presynaptic inhibition.
3. Identify one major mechanism underlying sensory regulation during walking and how it can be modulated by the mechanical condition of the lower limbs.

## Role of Robotics in Gait Rehabilitation in SCI and Stroke Patients
## Joseph Hidler, Ph.D.

Over the last 10 years, we have seen the proliferation of robotics-based rehabilitation strategies that have centered on improving walking ability following neurological injuries. Widespread acceptance of robots in the clinical setting has yet to get traction, perhaps because early research studies have produced mixed outcomes and it is still unclear how robotic devices should interact and 'cooperate' with patients. While various robot control strategies have been implemented, none have become the gold standard. The focus of this seminar will be to present an overview of studies to date that have focused on gait rehabilitation using robotics and discuss possible next steps for the field. Topics will include training activities that should be supported by these devices, ways of interacting with patients, and the barriers to clinical acceptance. Data from clinical trials involving the Lokomat and ZeroG overground gait and balance training system will be presented.

**Learning Objectives:**

1. To learn about how robots can be used to deliver mass-practice gait training.
2. To identify the barriers to clinical acceptance of rehabilitation robotics.
3. To learn about new strategies being developed to enhance gait training in individuals following neurological injuries.

## State of the Art in Traumatic Brain Injury Rehab
## Darryl Kaelin, M.D.

This discussion of the "State of the Art in Traumatic Brain Injury Rehabilitation" will review the evidence based standards of care in the acute stages of recovery including timing, location and intensity of treatment. Evidence for motor and cognitive interventions particularly in robotics will be reviewed. As cognitive deficits and spasticity both impact rehabilitation, medication effects on these conditions will be described.
The clinical algorithm for spasticity management will be explained and correlated to known and theoretical outcomes in performance.

**Learning Objectives:**

1. Outline the evidence based standards of care for acute Traumatic Brain Injury Rehabilitation.
2. Describe the known effects of common drugs on spasticity, cognition and neurorecovery.
3. Explain clinical methods of managing spasticity and their theoretical effects on motor control.

## Lokomat training to improve gait in multiple sclerosis and freezing of gait in Parkinson's disease
## Albert C. Lo, M.D., Ph.D.

**Introduction**

The purpose of this presentation is to discuss the use of robot-assisted treadmill training (Lokomat) for individuals with multiple sclerosis (MS) and Parkinson's disease (PD). The majority of persons with MS experience problems with gait, which are disabling and adversely impact quality of life. We have previously investigated Lokomat training as an intervention for ambulatory MS patients. A follow-up study was conducted to determine if Lokomat training combined with body weight-supported treadmill training (BWSTT) within the same session would be effective for improving gait in MS. Similarly, PD is a neurodegenerative disease characterized by gait abnormalities, such as freezing of gait (FOG). FOG is reported as one of the most disabling and distressing parkinsonian symptoms. There are no specific therapies to treat FOG; however, some external physical cues may alleviate these motor disruptions. The primary purpose of this study was to examine the effect of sensorimotor gait training (Lokomat) on reducing FOG and improving gait.

**Methods**

*Multiple Sclerosis:* Seven MS participants (EDSS 3.5-6.0) completed 16 sessions of combination Lokomat & BWSTT gait training. Outcomes included velocity, cadence, double support time, the timed 25-foot walk test (T25-FW), the 6 minute walk test (6MW), and the functional reach test (FRT).

*Parkinson's Disease:* Four individuals with PD and FOG symptoms received ten 30-minute sessions of Lokomat training. Outcomes included the FOG-Questionnaire, a blinded clinician-rated FOG score, spatiotemporal measures of gait, and the PDQ-39 quality of life measure.

**Results**

*Multiple Sclerosis:* Combination gait training resulted in significant improvements in 6MW and FRT, and trends in improvements in T25FW compared to a usual care control group. Significant longitudinal improvements following combination gait training were found in 6MW, FRT, and double support time and trends towards improvement were found in T25-FW time, velocity and cadence.

*Parkinson's Disease:* All participants showed a reduction in FOG frequency and severity, both by self-report and clinician scoring upon completion of training. Improvements were also observed in gait velocity, stride length, rhythmicity, coordination, and quality of life.

**Conclusion**

These results demonstrate that combination gait training is well tolerated by individuals with MS and can improve walking ability. Additionally, robot-assisted gait training may be a feasible and effective method of reducing FOG and improving gait in individuals with PD. These studies extend the knowledge of potential clinical therapeutic strategies and outcomes used to treat and monitor gait abnormalities present in individuals with MS and PD.

## Financial Feasibility of Robotics in Neurorehabilitation
## Sarah Morrison, PT

Evidence suggests that the use of robotic devices can improve function and/or promote neuroplasticity for persons with neurological disorders. More specifically, use of the Lokomat® driven gait orthosis has been shown to improve walking function in persons who have been diagnosed with spinal cord injury, stroke, brain injury and multiple sclerosis. However, these robotic devices are often viewed as cost prohibitive to many clinical programs. This presentation will examine the financial feasibility of using robotics in a neurorehabilitation setting. A break even analysis will be examined using the Lokomat® for improved walking function. In addition, financial feasibility of the robotic device will be compared to other non-robotic body weight supported systems for improving walking function.

**Learning Objectives:**

1. Understand how financial projections and cost-benefit analysis can guide business decisions.
2. Become familiar with the process for performing financial projections for using robotic devices in your clinic.
3. Discuss the various costs associated with robotic devices versus non robotic devices for locomotor training.

## Robotic Gait Training Post-stroke – more than going through the motions
## Carolynn Patten, PT, Ph.D.

The efficacy of rehabilitation robotics remains controversial and many misconceptions regarding the actual therapeutic effects induced through robotic assistance remain. One significant misconception is the assumption that robotic training is a passive phenomenon. Work conducted in our laboratory reveals that robotic-guided locomotion involves significant, patterned neuromotor activity and task-dependent differences in motor activation with adjustments in robotic parameters, and normalization of the bilateral sensorimotor state in persons post-stroke. While training in the robotic environment enhances overground locomotor function in terms of walking speed, spatio-temporal symmetry and inter-joint coordination, these effects appear to be mediated by changes in the non-paretic limb without significant improvements in paretic limb function. Our recent work conducted in the robotic environment reveals a subject-specific range of walking speeds within which both the magnitude and temporal patterning of paretic limb activity is significantly enhanced. Identifying and training within the critical speed range may optimize locomotor training.

**Learning Objectives:**

1. The activity and task-dependent differences attainable within the robotic environment.
2. Bilateral characteristics of locomotor dysfunction in persons post-stroke.
3. The relevance of speed to normalizing the bilateral sensorimotor state in persons post-stroke.

## Functional Electrical Stimulation Therapy for Grasping for Individuals with Incomplete Spinal Cord Injury: Randomized Control Trial
## Milos R. Popovic, Ph.D.

The objective of this single site randomized control trial (RCT) was to assess the efficacy of functional electrical stimulation (FES) therapy over conventional occupational therapy, in improving hand function in individuals with sub-acute traumatic incomplete C4-C7 spinal cord injury (SCI). 22 individuals with sub-acute traumatic incomplete spinal cord injury (SCI) (less than 6 months post-SCI) were recruited. All of them received treatment for both upper extremities. Irrespective of group allocation all participants received 60 minutes per day of conventional occupational therapy for hand function. Over and above 12 of the 22 individuals received an additional hour of conventional occupational therapy (control group) while the remaining 10 participants (intervention group) received an hour of FES hand therapy while performing activities of daily living. Therapies were delivered 5 days a week for 8 weeks (40 hours of therapy in total). The primary outcome measure was Functional Independence Measure (FIM). The secondary outcome measures were Spinal Cord Independence Measure (SCI) and Toronto Rehabilitation Institute Hand Function Test (TRI-HFT). Assessments were performed at baseline, upon therapy completion and at 6 months following baseline assessment. The participants who received FES therapy improved their upper limb function significantly compared to controls as measured by FIM self-care component ($p=0.0194$), SCIM self care component ($p < 0.0001$) and TRI-HFT ($p=0.053$). For the control group the FIM and the SCIM score changed from 8 and 3 to 18 and 6 post therapy respectively whereas for the intervention group the FIM and the SCIM changed from 8 and 2 to 28 and 12 post therapy respectively. The current randomized control trial has shown that FES therapy significantly reduces the degree of disability and improves function in individuals with tetraplegia as compared to conventional occupational therapy. FES therapy can be easily implemented by occupational therapists in a clinical setting, and we recommend its use in rehabilitation settings.

**Acknowledgements:**
Physicians' Services Incorporated Foundation, Christopher and Dana Reeve Foundation, Toronto Rehabilitation Institute, and Ontario Ministry of Health and Long-Term Care.

**Learning Objectives:**

1. The audience will become familiar with the FES therapy, how it is delivered and what is its actual purpose.
2. The audience will be informed about the most appropriate measures to assess FES therapy for hand function in SCI population.
3. The audience will become familiar with the most recent randomized control trial results in SCI population pertaining to the FES therapy for grasping.

## Motor control in the upper extremity and its implications for neurorehabilitation

Boris I. Prilutsky, Ph.D.

Understanding the motor control and musculoskeletal mechanics of the upper extremity is critical for developing effective methods of neurorehabilitation. Many aspects of the musculoskeletal mechanics of the human arm are well established and several comprehensive computer programs have been developed that allow for accurate predictions of ranges of joint motion, moments of muscle forces at the joints and other functional measures. However, there is no consensus on a single motor control theory that would explain generation of voluntary movement in able-bodied individuals and in individuals with spinal cord injury (SCI). One difficulty in all computational models of neuromechanical control is the incorporation of musculoskeletal redundancy permitting multiple motor strategies. Traditionally, the musculoskeletal redundancy has been viewed as a factor complicating motor control. Recent data obtained on SCI individuals who performed multi-joint control tasks by the arm suggest that muscle redundancy may in fact be useful in allowing alternative motor solutions to be explored.

**Learning Objectives:**

1. Review recent developments of motor control theories and discuss their implications for neurorehabilitation.
2. Review software programs recently developed for musculoskeletal and neural control modeling of the upper extremity.
3. Discuss selected experimental and modeling studies on motor control of upper extremities in individuals with SCI that suggest the importance of considering musculoskeletal redundancy.

## Muscle synergies during walking in healthy and post-stroke individuals
## Lena H. Ting, Ph.D.

Evidence suggests that the nervous system controls motor tasks using a low-dimensional modular organization of muscle activity. Here I will present data demonstrating the robustness of such motor modules, or muscle synergies, in both standing balance and locomotor tasks in humans subjects. We have found that each muscle synergy is organized to produce a consistent biomechanical task, allowing the nervous system to functionally reconfigure the multiple degrees of freedom of the body to robustly and flexibly perform tasks. Specifically, a consistent set of muscle synergies underlie the temporal variations in muscle activation patterns across different walking speeds. Moreover, these same muscle synergies are identified in subjects with post- stroke hemiplegia. Functional differences across subjects are related to the number of motor modules that subjects are able to independently control. Our results suggest a common modular organization of muscle coordination underlying walking in both healthy and post-stroke subjects.

**Learning Objectives:**

1. To introduce current concepts about muscle synergies.
2. To present evidence for the functional nature of muscle synergy organization.
3. To demonstrate commonalities and differences in muscle synergy organization in individuals with post-stoke hemiplegia compared to age- matched controls.

## Stroke Rehabilitation: Developing a Logical and Defensible Approach to Upper Extremity Management
## Steven L. Wolf, Ph.D., PT

There is a critical need to better determine the relationship between magnitude of impairment, relative chronicity and appropriateness of intervention during the rapidly constricting interval available for the treatment of the hemiplegic upper extremity following stroke. This brief presentation is designed to suggest ways in which we can better use available evidence to change the recovery slope and delay the plateauing of function so often seen in these patients. An effort is made to link evidence for successful “improvement” in movement capability with relative severity of upper extremities symptoms and to suggest new approaches for both clinical practice and scientific exploration. Concepts such as augmented movement with enhanced stimulation (AMES), robotics, and constraint-induced movement therapy are placed in the context of their timing and relevance within the rehabilitation process.

# Expert Roundtable Discussion
# Robotics in Neurorehabilitation – what is needed in 2020

**Participants:**

William Zev Rymer, M.D., Ph.D (Chairman)
Bruce Dobkin, M.D., Ph.D.
Keith Tansy, M.D., Ph.D.
Michael Boninger, M.D.
Steven L. Wolf, Ph.D.

Robotic rehabilitation devices are widely used to treat neurological impairments and are known to allow high intensity, task specific and reproducible therapy. Its application has shown benefit in several neurological pathologies like stroke and spinal cord injury, cerebral palsy, multiple sclerosis and traumatic brain injury. The participants of this roundtable are experts in the field of neurorehabilitation and will discuss the future of rehabilitation robotics. Based on the knowledge and experience of already existing robotic devices, the requirements for future developments will be outlined. The importance of motivational exercises, provision of feedback and the optimal level of task difficulty will be addressed among others aspects. The audience will have a chance to actively participate by asking questions and share opinions.

**Learning Objectives:**

1. Understand the status quo of robotic devices in neurorehabilitation.
2. Learn about the requirements of future robotic devices for enhancing the treatment of major neurological disorders.
3. Learn about the future potential of rehabilitation robotics.