International Society of
Electrophysiology and Kinesiology

ISEK 2018 Symposia

Ultrasound Elastography – What Are We Measuring in Muscle?

Chairs: **SABRINA LEE**, Northwestern University; **ERIC PERREAULT**, Northwestern University & **TOM SANDERCOCK**, Northwestern University

Overview:
Recent advances in ultrasound techniques allow the measurement of tissue material properties via noninvasive imaging. When applied to muscle, shear wave ultrasound elastography has the potential to measure muscle force and stiffness in healthy and diseased tissue. The fundamental principle is that the shear wave velocity is directly related to the local stiffness of the material. This relationship is well understood for homogeneous and isotropic materials, but muscle is neither. Rather, it is an anisotropic, heterogeneous, composite of active and passive elements. There is a need to understand the relationship between measurement obtained using ultrasound elastography and the structure and composition of muscle under passive and active conditions. This symposium will cover topics relating to 1) the relationship between shear wave velocity, muscle stiffness, and muscle force, 2) the activation-dependent relative contributions from the passive and active tissues within a muscle, and 3) theoretical limits to ultrasound elastography.

Neuromechanical Adaptations After Training and Exercise

Chair(s): **FRANCESCO NEGRO**, University of Brescia; **CLAUDIO ORIZIO**, University of Brescia

Overview:
Motor training and exercise develop adaptation mechanisms in motor neurons and muscle fibers that enhance the generation of movement. During different types of physical activity, specific neuro-mechanical transformations are induced in the motor system that result in the optimization of the neuromuscular output for the particular task. Neural adaptations involve changes in the intrinsic properties of the motor neuron pools and their synaptic input. On the other hand, mechanical adaptations comprise changes of the muscle fiber properties and their capacity to generate force. Recent developments in the analysis of motor unit behavior in human and animal preparations provide the possibility to track these mechanisms across different training and exercise methodologies. The focus of the symposium will be to provide an overview of these innovations and their importance in the study of the plasticity of the neuro-mechanical properties of the muscle.

Neuromechanics of Joint Stability After Anterior Cruciate Ligament Reconstruction

Chairs: **LUCA LAUDANI**, Cardiff Metropolitan University; **ANDREA MACALUSO**, University of Rome Foro Italico

Overview:
The symposium will focus on the most recent advances in neuromuscular control mechanisms underpinning dynamic stabilization of the knee joint following anterior cruciate ligament

reconstruction. Key topics will include: (i) neuromuscular control of the lower limb posture and movement during daily life as well as sport actions, (ii) anticipatory and compensatory postural adjustments in response to predictable and unpredictable perturbations, respectively, to the knee joint, (iii) innovative exercise interventions to specifically target the neuromechanical deficits following surgery for a safest and fastest return to normal. The present symposium will therefore represent a unique opportunity to critically discuss the most relevant surgery related changes in the neuromuscular control of the lower limb after anterior cruciate ligament reconstruction, for the contribution which they can make to a proper design of intervention protocols aimed at improving knee stabilization through early identification, quantification, and reduction of the neuromechanical deficits after surgery.

Why Are Muscles Weak After Stroke?

Chair: **WILLIAM ZEV RYMER**, Northwestern University

Overview:
The prevailing view about voluntary muscle weakness following hemispheric stroke is that disruption of the command signal resulting from ischemic damage to cerebral cortex or associated corticospinal tracts is the primary causal mechanism. While cortical damage is likely to be an important contributor, we now believe that disruption of spinal regulatory mechanisms, together with alterations in structure–function relations of skeletal muscle may also contribute.

Using a variety of motor unit recording techniques to assess spinal motoneuron regulation, coupled with advanced ultrasound methods to examine muscle properties, our group will review evidence supporting significant additional contributions towards stroke-related motor impairment at the spinal-cord and intrinsic muscle levels.

Multimodal Biomarkers of Motor Performance, Impairment and Recovery Derived from Physiological Measurements

Chairs: **DR. VINCENT C.K. CHEUNG**, Chinese University of Hong Kong; **DR. GIACOMO SEVERINI**, University College Dublin

Overview:
In neurological rehabilitation there is now a growing interest in developing more effective and patient-specific training procedures. One of the major factors limiting the personalization of motor rehabilitation is the difficulty in obtaining an in-depth neurophysiologically based assessment of motor impairment that would create a link between the functional and clinical scores (such as the Fugl-Meyer scales) and the neurological abnormalities. In this sense, deriving biomarkers that can give an objective indication of both the integrity of the motor system and the residual motor functions should facilitate further progress in rehabilitation research. In this symposium we will present an overview of some of the biomarkers that have been identified in the past few decades, and propose new frameworks of cross-level analysis of such markers that may allow the development of new useful tools. Such tools may eventually help clinicians, engineers and scientists evaluate the severity of neurological injuries, and design effective and patient-specific rehabilitation training protocols.

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Biomechanical and Clinical Challenges in the Shoulder from the Applied Perspective

Chair: **BIRGIT JUUL-KRISTENSEN**, University of Southern Denmark

Overview:
The symposium will cover aspects within sports and clinical interventions, in addition to methodological challenges in using ultrasound imaging as an outcome measure. The sports intervention includes scapula kinematics and glenohumeral dynamic control in handball players with and without pain. The clinical interventions include shoulder function in stroke patients before and after constraint-induced movement therapy, assessment of hand-held and isokinetic measures of shoulder rotator strength in tetraplegic wheelchair rugby players: a cross-sectional pilot study, and EMG activity of the upper trapezius muscle in patients with trapezius myalgia before and after dry needling. The topic covering methodological challenges includes ultrasound measurements of the subacromial space and its usefulness in treatment of shoulder tendinopathy.

High Density Surface EMG: A Non-Invasive Research Tool at the Transition to Clinical Applications

Chairs: **ALES HOLOBAR**, University of Maribor; **BERND LAPATKI**, University of Ulm; **HANS VAN DIJK**, University of Ulm

Overview:
High-density surface electromyography (HDsEMG) offers a realm of information that has not yet been fully exploited in clinical practice. This is mainly related to the complex and time-consuming HDsEMG signal acquisition. Currently, pre-gelled surface electrode arrays, wireless transmission systems and even epidermal electronics are developed to address this problem. The second reason for the long-lasting transition of HDsEMG to clinical practice lies in the high complexity of signal interpretation. In this symposium, we will present and discuss applications of HDsEMG for establishing fundamental anatomical and neurophysiological knowledge. We will also present recent achievements of (automatized) HDsEMG interpretation in various research fields and discuss the potentials and challenges when transferring these achievements to clinical practice and different populations with neuromuscular disorders. The main focus will be on extraction of peripheral nervous system properties of different skeletal muscles, although we will also address the central control strategies.

EMG Signal Decomposition: Validation and Impact In Our Physiological Understanding of Neural Control of Movement

Chair(s): **DARIO FARINA**, Imperial College London and **ALES HOLOBAR**, University of Maribor

Computer-aided identification of motor unit spike trains from electromyograms (EMG) provides in vivo analysis of relatively large motor neuron pools. Firing patterns of several tens of concurrently active motor units per investigated muscle can be identified with measurable accuracy. Different techniques for assessment of mutual information in extracted firing patterns and identification of neural control primitives in different muscle groups have also been developed. In this symposium, we will discuss the recent discoveries that changed our understanding of motor system in healthy and pathological conditions and offered novel insights into neurophysiology of human movement.

We will also illuminate current research trends and methodological challenges that need to be addressed in the near future.

Insights into Cognitive Processes from Motor System Measurements

Chairs: **SIMON KELLY**, University College Dublin; **MATHIEU SERVANT**, Vanderbilt University

Overview:
The cognitive brain mechanisms that allow people to translate sensory cues into goal-directed actions have long been of central interest to neurologists, psychologists, biomedical engineers and computer scientists alike. The principal method for studying these mechanisms has been to analyse the timing and accuracy of sensory-cued responses that subjects make under varying conditions. Simple, yet powerful, mathematical models can provide good quantitative fits to such data, but do not necessarily reveal algorithms really implemented by neural circuits. Recent work has demonstrated that electrophysiological measurements from the cortical and muscular systems for execution of movements in typical cognitive tasks (e.g. button presses and eye movements) can significantly enhance the level of insight gained into cognitive processes underlying simple sensory-motor translations. In particular, both EEG indices of cortical motor preparation dynamics and EMG indices of muscle activation have been shown to furnish strong constraints on models of sensorimotor decision making, thereby illuminating novel neural mechanisms that go undetected using behavioural modelling alone. The aim of this symposium is to showcase some of this work in the process of providing a general introduction of cognitive modelling strategies to account for sensorimotor decision behaviour.

Muscle Stiffness and Extensibility: How Do They Affect Muscle Function?

Chair: **MASSIMILIANO DITROILO**, University College Dublin

Overview:
Skeletal muscle stiffness, the relationship between applied load and elastic deformation, is an important neuro-mechanical component related to athletic performance and injury risk. This symposium will review some of the different methods of measuring stiffness. It will address the conflicting concepts of stiffness, extensibility and flexibility and how they affect muscle function to improve performance and reduce injury risk, with applications to the lower-limb amputee population. It will also expand on sex and age differences, fatigue responses and clinical populations. How stiffness relates to performance and injury is particularly interesting as there seems to be an ideal level of stiffness that optimises muscle performance, however too high or too low values may heighten the risk of injury. Equally interesting is the notion that females tend to exhibit a lower level of muscle-tendon stiffness than males and they are also more prone to lower limb musculo-skeletal injuries than males.

Moving Beyond the Physical: Addressing Musculoskeletal Injury Induced Neuroplasticity and Motor Control to Improve Patient-function

Chairs: **DUSTIN R. GROOMS**, Ohio University

Overview:
Musculoskeletal injury results in mechanical instability, local muscle adaptations and central nervous system neuroplasticity. This symposia will explore the spectrum of brain alterations after injury and their relationship to patient-function. Specifically, we will identify the neuroplasticity after injury and how the nervous system changes propagate reduced patient-reported outcomes and motor performance. This research also indicates new rehabilitation techniques (external focus, virtual reality, and sensory reweighting) that leverage the neuroplastic capacity of the nervous system can facilitate motor control changes, reduce recurrent injury risk, and improve patient outcomes. Information presented will help guide rehabilitation and return to work or sports following musculoskeletal injury.

Neuromechanics of LowerLimb Amputation and Prosthetic Gait

Chairs: **SILVIA CONFORTO**, Roma Tre University

Overview:
This symposium presents the results of a project funded by the Italian National Institute for Insurance against Industrial Injuries (INAIL) that investigates:

1. How amputation of a lower limb affects the locomotor control strategies
2. How the neuromechanical analysis of amputee's gait can inform physicians and engineers
3. How a proper quantitative assessment can help the procedures for functional recovery.

Technological improvements have led to the development of innovative prosthetic devices. During their rehabilitation process, lower limb amputees, both trans-femoral and trans-tibial, need to adapt their gait control schemes to completely different biomechanical demands on both the residual and contralateral limbs. Non-invasive muscle function assessment through surface electromyography, the evaluation of motor coordination with muscle synergy analysis, the study of dynamic stability, the analysis of kinematic and kinetic patterns during walking, when integrated among each other can make the therapeutic process more effective and improve the technical solutions used for developing and controlling the prosthetic devices. This symposium will encompass the major methodologies for neuromechanical and functional evaluation of walking after amputation, with the aim of developing novel methodologies to improve treatment and evaluation of lower limb amputees.

Design and Control of Advanced Prosthetic Limbs
Chairs: **RICHARD WEIR**, University of Colorado Denver and **LEVI HARGROVE**, Northwestern University

Overview:
Over the past decade, tremendous innovations have been made in the design and control of prosthetic arms and legs. For example, researchers have now used advanced EMG signal processing to control multiple hand and wrist movements, sometimes simultaneously, or use sensor fusion techniques to add additional information from other sources such as inertial sensors, force sensors or 3D cameras. Other researchers are a attempting to provide appropriate sensory feedback to improve patient outcomes, treat pain, and promote embodiment. Finally, new devices, for example powered prosthetic legs, and tools, for example Virtual Environments, are constantly being created

to push the field forward. This symposium will cover the technologies similar to those listed above to promote the design and control of advanced prosthetic limbs.

An Increased Reliance on Contralesional Cortico-reticulospinal Motor Pathways and Sensorimotor Impairments following a unilateral brain injury: Good or Bad?

Chair: **JULIUS P.A. DEWALD**, Northwestern University

Overview:
This session will discuss sensorimotor impairments following losses of corticofugal projections due to a unilateral brain injury in animal and human study participants. An increased reliance on contralesional cortico-reticulospinal motor pathways, following a loss of corticofugal projections due to a stroke, may be a maladaptive form of plasticity. Evidence from both animal and human work will explore the soundness of this argument. The presence of the flexion synergy, asymmetrical tonic neck reflexes, weakness, hyperactive stretch reflexes, loss of reflex modulation, reduced rate coding in flexor muscles and abnormal tonic motor unit firing will be linked to an increased use of contralesional cortico-reticulospinal resources. Conversely, evidence for the possible use of reticulospinal pathways as a useful backup system, especially for the recovery of hand function, will also be provided. State of the art quantitative animal and human approaches will be employed to answer this important question by experts in the field as it has a significant impact on the development of more effective neurorehabilitation approaches following a unilateral brain injury.

Novel Approaches to Enhance Recovery After Central Nervous System Injury

Chairs: **MONICA PEREZ**, University of Miami; **JOSE PONS**, Cajal Institute Spanish National Research Council

Overview:
Neuroplasticity contributes to the recovery of function after CNS injury. In this symposium, we will discuss current approaches used to enhance plasticity and promote recovery of sensorimotor function in animals and humans with spinal cord injury and Stroke. Dr. Guillermo Garcia-Alias will review the remarkable capacity of the spinal cord to adapt after injury. He will present novel evidence on how neural networks in the cervical spinal cord of mammals contribute to the control of forelimb function after spinal cord injury. The role of cervical epidural spinal cord stimulation as a promising technique for modulating the level of excitability and reactivation of dormant spinal neuronal circuits after spinal cord injury will be reviewed. Dr. Monica Perez will discuss contributions of the primary motor cortex, the corticospinal and reticulospinal pathways to the control of hand and arm function in humans with cervical spinal cord injury. Evidence indicate that excitatory inputs to corticospinal neurons activated by anterior-posterior induced currents in the brain are largely impaired and represent a novel target for enhancing the recovery of hand and arm function after spinal cord injury. Prof. Jose Pons will address recent work and results on associative neurorehabilitation in post-stroke patients where afferent feedback with rehabilitation robots is causally associated to motor planning and preparation, which is decoded out of EEG cortical activity. Dr. Antonio Oliviero will review and critically discuss the role of Non Invasive Brain Stimulation (NIBS) in the assessment of motor recovery in neurorehabilitation and the potential use of NIBS to boost rehabilitation.