Exoskeletons for Health

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Background: Maintaining an ad equate level of physical activity is considered vital during both leisure time and working hours. For that purpose, technical aid such as exoskeleton devices can be used to promote physical activity. These devices are divided in active and passive exoskeletons depending on the source of energy.Aim: The objective of this symposium is to give a state of the art concerning the use of passive and active exoskeletons in population at risks of being either too little or too much physically active, i.e., among older people or workers.Relevance: The symposium is of relevance for a major portion of the audience present at the ISEK 2024 congress as the topics encompass ageing, ergonomics, physical activity, exoskeletons, and physical performances. The symposium will have four speakers with different background that will focus on both laboratory and field studies assessing both the biomechanical effects of wearing exoskeletons and the implementation of exoskeletons in real life.Novelty: The novelty lies in the fact that the symposium will show case how passive and active exoskeletons impact the level of physical activity in activities of daily living like walking and working among older adults and workers. The symposium will offer for the first-time ways to ensure a successful implementation of exoskeletons.
Format: Moderated symposium with focus interaction with the audience – we will organize a quiz (using e.g., Kahoot) to underline the take home messages as well as a round table after the presentations.

Motor unit analysis of surface EMG for precision rehabilitation: advances and challenges

Yingchun Zhang, University of Houston; Chengjun Huang, University of Health and Rehabilitation Sciences; Xiaoyan Li, Medical College of Wisconsin; Xu Zhang, University of Science and Technology of China

1. Background, aims and relevanceDisease or neurological injury can cause numerous pathological changes including but not limited to muscle weakness, spasticity, and contracture that contribute to motor impairment and disability. The mechanisms behind such changes are multifactorial, involving altered processes in both central and peripheral nervous systems. Regardless of the underlying mechanisms, it remains very important to examine how the motor unit responds, given that it is the final common pathway for neuromuscular control. The aim of this symposium is to provide a forum for in depth discussion on recent advances and challenges in motor unit analysis of surface EMG and their applications in neuromotor rehabilitation.2. Justification for why the proposed topic is novelSkeletal muscle is the primary organ for force generation and often contributes to disability. Much research in patients has focused on examination of whole skeletal muscles using a variety of techniques including medical imaging, electrical impedance myography, and global surface EMG, etc. Relatively less attention has been devoted to using surface EMG to examine motor unit function in patients undergoing neuromotor rehabilitation. This symposium will focus on motor unit analysis of surface EMG, covering both novel developments and applications for patients with neurological disease or injury. Understanding the changes in different motor unit components (such as motor unit number, size, control properties, etc.) may help identify mechanisms contributing to motor impairment, and thereby guide development of appropriate interventions that target specific motor unit properties. This is particularly important given the diverse origins of neurological injury, the induced neuromuscular changes, and specific patient needs. 3. Brief outline of the proposed format for a moderated, interactive scientific exchange with the audienceThe symposium will include four to five individual presentations. Each presentation will be followed by a question & answer session. An open discussion session will be provided at the end of the symposium for a moderated, interactive scientific exchange with the audience. Stimulating questions will be provided to the audience as a starting point for facilitating an in-depth discussion.

Enhancing Physical Function in Aging and Hospitalized Populations with Neuromuscular Electrical Stimulation

Toshiaki Miyamoto, Kansai Medical University; Brian Caulfield, University College Dublin; Nicola Maffiuletti, Schulthess Clinic

In recent years, neuromuscular electrical stimulation (NMES) technology has emerged as a potential alternative to exercise. While its scientific application has mainly focused on athletes and young adults, a growing body of research suggests that NMES may induce numerous exercise-related benefits, including enhanced skeletal muscle strength, aerobic capacity, and glucose metabolism, in clinical populations. Nevertheless, recent systematic reviews have shown inconclusive results in clinical settings, mainly due to the heterogeneity in study populations and NMES use. It is well recognized that the physiological response to NMES depends on stimulus parameters, pulse frequency in particular. NMES at < 12 Hz frequencies (sub-tetanic NMES) yields effects akin to those induced by voluntary aerobic exercise, whereas NMES at ≥ 20 Hz frequencies (tetanic NMES) mimic the outcomes of voluntary resistance exercise. Despite the respective potential of tetanic NMES and sub-tetanic NMES to enhance neuromuscular function and physical fitness, NMES is often used without due consideration of stimulus characteristics. Furthermore, NMES protocols need to be tailored to the specific needs of individuals with pathological conditions such as sarcopenia and chronic/critical illnesses, yet comprehensive protocols for these specific populations remain underdeveloped.Exploring alternative exercise methods using NMES technology represents a novel approach to overcome the declining physical function in both elderly and hospitalized populations. While organizing the current evidence, systematically developing optimal NMES protocols to address the specific needs of individuals with pathological conditions has the potential to significantly impact the field and improve clinical practice. Ultimately, this could lead to an extension of healthy life expectancy among these vulnerable populations.This symposium brings together three researchers who have actively contributed to NMES research with the aim to highlight the potential of NMES strategies for enhancing physical functions. The symposium addresses current issues in the NMES research field, providing insights into the establishment of NMES protocols to enhance physical function. Each of the four speakers will present their research findings during 15-minute sessions. Dr. Maffiuletti will discuss the importance of NMES parameters for enhancing neuromuscular function. Dr. Caulfield will present an updated systematic review of NMES studies. Finally, Dr. Miyamoto will discuss potential NMES protocols as alternatives to aerobic exercise. The symposium will conclude with a 15-minute interactive discussion with the audience, facilitating a moderated scientific exchange.

International Motoneuron Society: non-invasive methods to understand human motoneuron physiology in health, disease, and training

Jakob Skarabot, Loughborough University; Duane Button, Memorial University of Newfoundland; Helio Cabral, Università degli Studi di Brescia; Sophie Jenz, Northwestern University

BACKGROUND: All human movement is achieved via activation of alpha motoneurons, which integrate and transform synaptic inputs into force output. For this reason, analysis of the excitability and discharge properties of motoneurons is an effective way of gleaning information about the generation and control of movement in humans. Advances in stimulation techniques and analysis of motor units identified from high-density EMG have revealed important contexts in which physiological properties of motoneurons differ. The culmination of this work has dramatically improved our understanding of motoneuron physiology in humans and its relation to force generated by the contractile properties of muscles in health and disease.AIMS. This symposium will highlight contemporary analysis and interpretation of human neurophysiological studies to achieve unprecedented insights into human motoneuron physiology.RELEVANCE. Presenters will provide recent analysis of human neurophysiological studies that have dramatically improved our ability to estimate essential properties of human motoneurons. They will address the importance of considering neurological impairments; biological sex and circulating sex hormones; intensity of contraction; training status; and the behavioural context of the task, when estimating motoneuron properties. The symposium will strengthen the synergy between the ISEK and International Motoneuron society and all invited speakers are members of the International Motoneuron Society.Justification for the novelty of the topic: Interdisciplinary collaboration is a key step for connecting the end applications of EMG to the basic molecular and cellular mechanisms of motoneuron function. We anticipate that EMG end-users will enhance their understanding of the basic properties of motoneurons through the interactive exchange of knowledge between International Motoneuron Society and ISEK members.OUTLINEIntroduction (Gregory Pearcey)Presentations:1) Allison Hyngstrom (Marquette University)Title: Fatigue matters – force regulation and motor unit firing behavior in fatiguing contractions post stroke2) Sophie Jenz (Northwestern University)Title: Sex matters – sex-related differences and hormonal effects on estimating motoneuron properties in humans3) Jakob Škarabot (Loughborough University)Title:Intensity matters – training and ageing-induced adaptations in the discharge behaviour of human motor unit populations4) Duane Button (Memorial University)Title: Training status matters – chronic training-induced plasticity of the human cortico-motoneuronal pathway5) Helio Cabral (Università degli Studi di Brescia)Title: Behavioural context matters – motor unit discharge behavior during isolated and synergistic finger movementsDiscussion (moderated by Francesco Negro): presenters will engage in an open discussion about the topics presented and the importance of the interaction between the ISEK and International Motoneuron societies.

Estimating Mechanical Behavior of Skeletal Muscles Using Imaging and Modeling Modalities

Silvia Blemker, University of Virginia; Vickie Shim, University of Auckland; Yasuo Kawakami, Waseda University, Tokyo, Japan; Geoffrey Handsfield, Auckland Bioengineering Institute, Auckland, New Zealand

To understand musculoskeletal changes in aging, exercise, or diseases, it is essential to characterize in vivo muscle material properties across diverse populations. This is a challenging area of research and a ‘golden fleece’ in the musculoskeletal research community. While a single in vivo technique for soft tissue characterization does not yet exist, the clever integration of advanced non-invasive techniques might offer critical quantitative knowledge. Shear wave elastography (SWE), an imaging-based method that can characterize mechanical properties, has shown promise in illuminating the force production capacity of human muscles and detecting muscular changes in specific conditions. However, SWE is presently limited to providing two-dimensional information. For a comprehensive but static three-dimensional (3D) perspective, diffusion tensor imaging (DTI) can be employed to visualize the microstructural organization of muscle fibers. To fully take advantage of multiple data acquisition techniques, image-based models of musculoskeletal tissues can be built and probed to gain insights into anatomical function. Finite element modeling (FEM) is a standard technique for mesoscale and macroscale modeling of skeletal muscles and offers an understanding of tissue deformation and stresses under prescribed loading conditions. Integration of FEM with DTI data and shear wave velocities from SWE may be the best way to determine the feasible sources of shear wave velocity differences that are observed empirically. This symposium aims to facilitate discussions on how non-invasive experimental approaches and computational modeling can advance our understanding of muscle mechanics. Additionally, it explores (i) methods for validating SWE information and (ii) the integration of these techniques into finite element modeling to estimate muscle force production in 3D.These in vivo approaches offer a comprehensive view of skeletal muscle structure and mechanics and their use in simulating muscle behavior is relevant in research areas and clinical applications such as orthopedics, sports science, and the management of muscular diseases.The novelty of the symposium lies in its focus on the integration of diverse methodologies. This multidisciplinary approach not only enhances the depth and precision of our understanding but also represents a groundbreaking step in the field of musculoskeletal research.The symposium will feature five presentations: i) the SWE method for material characterization, ii) Finite element models for musculoskeletal mechanics, iii) 3D structural insights from DTI MRI, iv) 3D musculoskeletal modeling using DTI MRI, and v) Musculoskeletal tissue behavior simulation and validation. Each presenter will have a 12-minute talk followed by a 3-minute Q&A. The session will conclude with a moderated audience-speaker discussion.

Neuromechanical characterisation of muscles and their functional units using ultrasound imaging methods: State-of-the-art and future perspectives

Robin Rohlén, Lund University / Umeå University; Emma Lubel, Imperial College London; Alberto Botter, Politecnico di Torino; Martino Franchi, University of Padova

Force production in skeletal muscles results from electrochemical and mechanical events in the neuromuscular system. Specifically, myofibrils translate the neural excitation from spinal motoneurons into tensile forces, transmitted to tendons and the skeleton. Although classic tools for electrophysiological and biomechanical assessments can describe the neuromechanical determinants of force production, they provide a limited view of the complex interactions between muscle excitation and contraction.In biomechanics, there is an increasing interest in ultrasound imaging due to its ability to assess muscle structure and musculoskeletal properties and, more recently, neuromechanics via identifying neural discharges of motoneurons. Ultrasound enables such studies to be done non-invasively, in vivo, and with great spatial and temporal resolution, opening exciting avenues for investigations in health and disease.In this Symposium, we will present various novel ultrasound imaging methods to analyse neural or musculoskeletal characteristics, many of which have not been analysed before. The speakers will present state-of-the-art methods to update the audience on the latest developments in these fields and provide awareness of the potentialities of these techniques in different applications. To open the session, the Symposium Chair will present the format of the session, the sequence of speakers, and introduce possible open issues or points of discussion that may arise. After this introduction, each Speaker will present their contribution in a 12-minute presentation. After each Speaker's presentation, 5 minutes of moderated Q&A between the Speaker(s) and the audience will occur.The first speaker, Christer Grönlund, will lay the groundwork for those in the audience unfamiliar with the ultrasound technique and the relevant biomechanics, enabling everyone present to get the most out of the following talks. After this, follow three talks on the current state-of-the-art methods in the field. Martino Franchi will present novel methods to detect and analyse the muscle-tendon unit and its behaviour in static and dynamic conditions through ultrasound imaging along the muscle fibre direction. This enables analysis of muscle thickness, pennation angle, fascicle length, aponeuroses and muscle gearing. Then, Alberto Botter will discuss the integration of ultrafast ultrasound and high-density surface electromyography for the neuromechanical characterisation of the muscle. Then, Emma Lubel will talk about ultrafast ultrasound imaging perpendicular to the muscle cross-section and the recent developments from the subtle local motions of single muscle units to decomposing the ultrasound image sequences for identifying motoneuronal spike trains located superficially and deep in the muscle.The final talk is from Robin Rohlén, who will bridge the state-of-the-art to future perspectives and translational capabilities, including 3D imaging and wearable systems.

Back in Action: muscles, mechanics, and movement in Adolescent Idiopathic Scoliosis

Ryan Graham, University of Ottawa; Juha-Pekka Kulmala, Motion Laboratory, New Children's Hospital, Helsinki, Finland; Phoebe Ng, The University of Queensland; Phoebe Duncombe, The University of Queensland

Background: Adolescent idiopathic scoliosis (AIS) occurs in 2-4% of adolescents with otherwise healthy musculoskeletal structures. AIS develops rapidly during adolescence and has no known cause or cure. The three-dimensional spinal deformation in AIS is associated with progressive wedging, translation, and rotation of multiple vertebrae, and can have lasting detrimental effects on physical function, quality of life, and socio-emotional health. The current best predictors of future curve progression are severely limited to knowledge of recent curve progression, current curve angle and skeletal maturity. There are no known specific musculoskeletal indicators to guide targeted interventions for individuals with AIS. There are many independent research groups around the world working to advance our understanding of the impact of AIS and what we might be able to do to slow or stop progression. However new ideas and collaborations are needed to advance this important field of research.Aims: To facilitate discussions, collaborations and sharing of ideas that will lead to meaningful discoveries that will one day (soon) influence outcomes for adolescents with scoliosis.Symposia hot-topic titles: (i) Asymmetrical paraspinal muscle size and quality in Adolescent Idiopathic Scoliosis. (ii) Maximal and asymmetrical submaximal paraspinal muscle activation in Adolescent Idiopathic Scoliosis during simple back extension tasks. (iii) Paraspinal muscle activation during gait in Adolescent Idiopathic Scoliosis. (iv) Novel technology and methods for the assessment of deformity and function in Adolescent Idiopathic Scoliosis. (v) Panel discussion with audience participation on how to support best practice in scoliosis research across the globe.Relevance and Novelty: ISEK is a multidisciplinary organization composed of members from all over the world with a common desire to study human movement and the neuromuscular system. By bringing together researchers and clinicians who have diverse perspectives and a keen interest in adolescent spine health, scoliosis, movement control, spine biomechanics, spine modelling, we will begin to ask more complex questions and could rapidly advance the field.Format: Our moderator will encourage interactive scientific exchange with the audience and facilitate a panel discussion to address questions at the end of the talks. We will have an online platform to encourage ongoing exchange of ideas that will remain open for the duration of the ISEK congress. This symposium includes speakers from Australia, Singapore, Canada and Finland, with high diversity in background and experience. We look forward to an informative exchange of ideas.

From Lab to Living Room - Opportunities, Challenges and Potential using Smart Textiles and Wearable Solutions to facilitate Self-administered Home-based Rehabilitation

Yohann Opolka, University of Borås; Xi Wang, University of Borås; Leif Sandsjö, University of Borås; Elisa Romero Avila, Institute of Applied Medical Engineering

Background, Aims, and Relevance:With an aging population and increasing demands on healthcare, finding ways to provide efficient, self-administered, easy-to-use rehabilitation methods is essential. Smart textile solutions can contribute to new rehabilitation measures that can be performed by patients in the comfort of their homes. This symposium aims at describing recent results and insights from textile-based interventions, their applicability in different settings, as well as methodological developments emphasizing the potential in healthcare.Justification for Novelty:Rehabilitation is central to the fields of electrophysiology and kinesiology. Various smart textile-based solutions offer novel ways to monitor, administer, and enhance therapeutic interventions. This not only presents alternatives to current practice but also advances patient experience, convenience, and outcome, as rehabilitation measures can be fully self-administered and performed “anytime - anywhere”.Proposed Format: Welcome (5 mins): A brief introduction of the symposium objective.Presentations (75 mins): Each of the five topics is scheduled for 12 minutes plus Q&A (1-3 questions). Short descriptions of the presentations are in the supplemental file. Presentation 1: Phantom Limb Pain Treatment at Home Facilitated by a Textile Electrode System – A Case StudyPresentation 2: Easy-to-Use sEMG Wearable Device to Monitor Muscle Activity at the Clinic or at Home. Presentation 3: Co-creation of a Smart Textile Intervention for Hand Rehabilitation after Stroke – A Case Study Presentation 4: Textile Electrode System for Improved Signal Quality and Usability in Surface ElectromyographyPresentation 5: Effect of Electrolyte Amount and Concentration on Neuromuscular Electrical Stimulation (NMES) – Towards Near-Dry Textile Electrodes Concluding Discussion (10 minutes): The symposium will hopefully lead to discussions on the potential role smart textiles can play in (home-based) rehabilitation and encourage networking and collaboration among attendees.

Factors influencing neuromodulation of motoneurons and/or PICs: What do human studies tell us and what are the applications?

Anthony Blazevich, Edith Cowan University; Lucas Orssatto, Deakin University; Francois Hug, Université cote d'azur; Greg Pearcey, Memorial University of Newfoundland

Background: Spinal motoneurons have a remarkable ability to amplify and prolong synaptic input, causing non-linearities between the input that a motoneuron receives, and its recruitment and firing characteristics. A major source of this non-linearity is due to brainstem pathways that form connections with motoneurons and release the monoamines serotonin (5-HT) and noradrenaline (NA). Monoamines modulate motoneuronal intrinsic properties and are hence commonly classed as "neuromodulators". Animal studies indicate that 5-HT and NA exert significant effects on motoneuron excitability by facilitating voltage-gated persistent inward currents (PICs). PICs provide an intrinsic source of depolarization for motoneurons, and hence motoneurons can maintain steady firing rates with minimal excitatory drive when PICs are active. The amplitude of the PIC is proportional to monoaminergic drive, whereby more 5-HT and NA release to motoneurons results in larger amplitude PICs. Hence, estimating PIC amplitude in humans may estimate the magnitude of monoaminergic drive to the spinal cord, thus potentially revealing how neuromodulators shape the output of motoneurons during motor behaviour.Aims: In this symposium, we aim to present recent human work concerning neuromodulatory inputs and/or PICs, and how they are affected by drugs, pain, aging, fatigue, muscle stretching and more. Through a question/answer platform and panel discussion, we also aim to generate conversation regarding the role that neuromodulators and PICs play in motor behaviour, and future directions for this line of work.Relevance: The work presented within this symposium will (primarily) involve the use of high-density surface electromyography (HDsEMG). HDsEMG is an increasingly popular technique employed by ISEK attendees, and the use of HDsEMG (including associated analyses) to study the intrinsic properties of motoneurons will be of interest to a large portion of conference attendees. Likewise, a symposium detailing emerging work in the control of human motoneuron excitability will be relevant for any attendee wanting to better understand the neural mechanisms underpinning muscle activation.Novelty of proposed topic: The neuromodulatory control of motoneurons and PICs has not been a topic of a stand-alone symposium at previous ISEK congresses. This symposium will provide an opportunity for each presentation to build upon the previous, to maximise our opportunity to disseminate the latest work in this area.Brief outline for moderated, interactive scientific exchange with the audience: We plan to use the educational technology Padlet so that the audience can submit specific questions to the presenters that arise during the individual presentations. Padlet will also enable the audience to ask more general (i.e., big picture) questions to all presenters, which will be answered during an interactive panel Q&A at the end of the individual presentations.

Unique engineering approaches to modify neuromotor activity through human-robot intention and perception

Yuichi Kurita, Hiroshima University; Jinwoo Lee, Dongguk University; Minoru Shinohara, Georgia Institute of Technology

Modifying neuromotor activity during intended movements via human-robot interaction can enhance motor performance capability and physical activity in individuals, both disabled and non-disabled. This symposium aims to introduce and discuss recent unique engineering approaches that can modify the neuromotor activity of the muscles by leveraging human-robot intention and perception. The symposium will discuss: 1) Controlling movements of detached artificial hands through intended synergistic torso muscle activity with visual and auditory perception to augment the neuromotor activity in the real human hand in healthy and post-stroke individuals (Minoru “Shino” Shinohara, Georgia Institute of Technology, USA); 2) Developing an intelligent upper-limb exoskeleton system that deploys cloud-based deep learning to predict human intention, providing strength augmentation (Jinwoo Lee, Dongguk University, South Korea); and 3) Developing training support technology in which individuals perceive simultaneous visual and force feedback in a virtual reality environment through small, lightweight, and easily detachable pneumatic gel artificial muscles (Yuichi Kurita, Hiroshima University, Japan). These engineering approaches can be applied to rehabilitation in clinical populations, such as individuals with stroke and spinal cord injury, and to training for healthy aging. The topic is novel as it incorporates recent and distinct engineering techniques. Each presentation will be followed by a short Q&A session for clarification, and the entire panel will convene for interactive exchange at the end of all presentations.

Characterizing and targeting muscle stiffness to improve treatment and rehabilitation

Benjamin Binder-Markey, Drexel University; Preeti Raghavan, Johns Hopkins Medicine; Ridhi Sahani, Northwestern University; Taylor Dick, University of Queensland

Increased muscle stiffness contributes to dysfunction in several neuromuscular disorders and conditions, e.g., stroke, muscular dystrophy, and aging. Quantifying changes in muscle stiffness and developing treatment and rehabilitation programs to mitigate pathological alterations would greatly improve mobility and quality of life. However, it is challenging to measure meaningful values of stiffness across muscles, due to their complex structural arrangements and transient mechanical loading states. Further, muscles generate both active contractile forces and passive forces that must be considered when characterizing material properties. Skeletal muscle has a hierarchical structure where muscle fibers group into muscle fascicles that form whole muscle. The extracellular matrix (ECM) surrounding and within muscle is a key contributor to its passive properties, but the role of ECM amount on stiffness is debated. Mechanical properties do not scale uniformly between muscle fibers and whole muscle, making it difficult to relate conclusions across scales. Individual muscles also have unique macroscopic architectures, including variations in shape, such as length and physiologic cross-sectional areas, as well as the arrangement of muscle fibers. Muscle stiffness is often measured with ex vivo mechanical testing within animals, but it is difficult to replicate in vivo loading patterns and three-dimensional deformations experimentally within humans. Thus, it is challenging to relate measured properties from isolated muscles to whole muscles in vivo and across muscles or species. Mechanical interventions that passively lengthen muscle, e.g., intermittent stretching and casting, focus on reducing stiffness, but their effectiveness is questionable at the tissue level. Therapies such as anti-fibrotics often target a reduction in ECM components such as collagen to reduce stiffness, but collagen amount and muscle tissue stiffness are not well correlated. To optimize targets for treatment and rehabilitation programs, we must consider what physiological characteristics relate to stiffness and develop robust methods to measure stiffness. The goal of this symposia is to showcase methods for characterizing muscle stiffness across multiple scales and discuss considerations for future treatments aiming to reduce stiffness. We will bring together experts in the fields of human movement, muscle function, and rehabilitation. Speakers will deliver 15-minute presentations followed by audience questions and we will conclude with a moderated panel discussion. Topics will include complex relationships between ECM microstructure, mechanical properties, architecture, and three-dimensional deformations in skeletal muscle, as well as the role of treatments such as hyaluronan on muscle stiffness. This discussion is important for understanding how and why muscle stiffness progresses in health and disease and is relevant in many conditions where stiffness contributes to dysfunction.

Neurorehabilitation pipeline for upper extremity motor paralysis after stroke: xR, non-invasive brain stimulation, and Constraint-induced movement therapy

Michiyuki Kawakami, Keio University School of Medicine; Takashi Takebayashi, Osaka Metropolitan University; Fuminari Kaneko, Tokyo Metropolitan University

Stroke is the second leading cause of death and a major cause of disability worldwide. One of the most serious disabilities that occur after stroke is paralysis of sensory and motor functions. Among these, paralysis of the upper extremity (UE) is known to be difficult to repair. While at least 60% of survivors will regain the ability to walk, it has been shown that UE motor function is not restored to a practical level in as many as 80% of patients. In this symposium, we will focus on neurorehabilitation for repair of paralysis in UE motor function.In the treatment of post-stroke UE motor paralysis, constructing a step-by-step personalized treatment strategy according to functional status of individuals is important. Liu et al. (2012) summarized the treatment strategies for UE paralysis in individuals with stroke as follows: if electromyography (EMG) of finger extensors is not detectable, motor imagery-based training is an option (Level 1). If EMG of finger extensor muscles is detectable, functional electrical stimulation (FES) therapy is feasible (Level 2). Constraint-induced movement therapy (CIMT) may be indicated if the patient is at a level where actual joint motion occurs, not just EMG (Level 3). In stroke treatment guidelines in many countries, CIMT is recommended as a treatment for Level 3 of post-stroke UE motor paralysis. Similarly, guidelines also recommend functional assistance systems using electrical stimulation delivered by the EMG-feedback system as a treatment for people with Level 2 function. As a treatment of motor imagery-based training, passively induced kinesthetic illusion with visual stimulation (passive-KNVIS) is one option for people with Level 1 function.A treatment pipeline that provides graduated treatments tailored to an individual's motor function can be realized by seamlessly providing a series of treatments as described above. This treatment pipeline is called “neurorehabilitation pipeline.” In this symposium, we will discuss the individualized therapies used in neurorehabilitation pipeline and present examples of actual seamless delivery of treatment series.Dr. Kaneko first talk about passive-KNVIS. During KINVIS therapy, patients have the feeling that their paralyzed real body has been replaced by an artificial body with enhanced motor functions. In the next step is the therapy that repetitively the patient voluntarily controls artificial body movements using a system driven by EMG-feedback. This therapy leads further to the exercise with FES. Dr. Takebayashi will talk about CIMT combined with transcranial direct current electrical stimulation for improving motor function and activities of daily living in people with roughly level 3 function. Dr. Kawakami will talk about non-invasive brain stimulation therapy such as combination of repetitive transcranial magnetic stimulation (TMS) and passive-KINVIS. Furthermore, the impact of quadripulse stimulation using TMS will also be presented.

Advances in the analysis and interpretation of the muscle compound action potential (M wave) in humans: implications for the study of muscle fatigue

Javier Rodriguez-Fal, Public University of Navarra; Nicolas Place, University of Laussane

Background:The compound muscle action potential (M wave) has been commonly used to assess the peripheral properties of the neuromuscular system. More specifically, changes in the M-wave features are used to examine alterations in neuromuscular propagation that can occur during fatiguing contractions. The utility of the M wave is based on the assumption that impaired neuromuscular propagation results in a decrease in M-wave size. However, there remains controversy on whether the size of the M wave is increased or decreased during and/or after high-intensity exercise. The controversy partly arises from the fact that previous authors have considered the M wave as a whole, i.e., without analyzing separately its first and second phases.Aims:The present review is aimed at 4 main objectives: (1) to describe the mechanistic factors that determine the M-wave shape; (2) to analyze the various factors influencing M-wave characteristics; (3) to demonstrate that the electrical origin of the first and second phases of the M wave is intrinsically different(4) to show that the first and second phases of the M wave behave in a different manner during fatiguing contractionsRelevance:+ The proposal emphasizes the need to analyze separately the first and second M-wave phases to adequately identify and interpret changes in muscle fiber membrane properties.+ The proposal shows that only the amplitude of the M-wave first phase, but not the second, can be used reliably to monitor possible changes in membrane excitability.+ The proposal advances the hypothesis that it is an increase (and not a decrease) of the M-wave first phase which reflects impaired sarcolemmal membrane excitability.+ The proposal revisits the involvement of impaired sarcolemmal membrane excitability in the reduction of the force generating capacity Justification for why the proposed topic is novel+ The analysis of the M wave has been kept invariant for the last 50 years, and essentially consists on calculating the peak-to-peak amplitude of the M wave. This practice is inaccurate and leads to misinterpretation of the results. Here, we propose an alternative analysis for the M wave base on the separate evaluation of its first and second phases.+ There is a widespread assumption that decreased membrane excitability causes a depression of the M wave. However, we demonstrated that, when membrane excitability is reduced, the amplitude of the M-wave first is increased, and not decreased. Brief outline of the proposed format for a interactive scientific exchange with the audience+ First, describe previous results in the literature about the M-wave changes during fatigue.+ Second, ask the audience to report their previous results related to the M wave.+ Third, inquire about the methods and technical aspects that the audience followed to record their M waves.+ Summary main findings and propose recommendations.