3rd International Autumn School on Movement Science

Berlin, 3rd to 8th October 2016

Programme

BSMS
Berlin School of
Movement Science

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Hosted by

Humboldt-Universität zu Berlin, Institute of Sports Science
Charité - Universitätsmedizin Berlin, Julius Wolff Institute
Max Planck Institute for Human Development
Technische Universität Berlin, Department of Medical Technology
Zuse Institute Berlin (ZIB)

BSMS – Berlin School of Movement Science

Organisation

Scientific Coordination
Prof. Adamantios Arampatzis (Spokesperson)
Prof. Georg Duda (Deputy Spokesperson)

Administrative Coordination
Wiebke Hampel
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Executive Committee
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Alessandro Santuz (Student Representative)

Scientific Advisory Board
Prof. Vasilios Baltzopoulos (GBR)
Prof. Walter Herzog (CAN)
Prof. Paavo Komi (FIN)

General Information
Venues

The lectures will take place from Monday 3rd until Friday 7th of October.

Addresses (maps at page 33)

Humboldt-Universität zu Berlin (Campus Nord)
Department of Training and Movement Sciences
Philippstr. 13, Haus 11
Lecture Hall 5 (Room 1.26)
10115 Berlin
Web: www.tbw.hu-berlin.de

Campus Virchow Klinikum (Campus Virchow)
Föhrer Str. 15
Institutsgebäude Süd (IGS)
Auditorium
13353 Berlin
Web: jwi.charite.de

eduroam

The Wi-Fi network eduroam (education roaming) is available at both venues. Students, researchers and staff can obtain Internet connectivity across campus using the respective institutional credentials.

General Information

The Autumn School and the BSMS

The Berlin School of Movement Science (BSMS) is an interdisciplinary education programme based on scientific exchange and interaction, supporting PhD students to become highly skilled scientists in the fields of motor control and movement science. Our main research objectives are:

(a) to acquire knowledge about the fundamental principles of motor control in human movement,
(b) to investigate the effects of the musculoskeletal properties on the motor control strategies used during movement and
(c) to understand how the sensory-motor system controls biomechanical features and lead to adaptation on a structural level in tissues such as bone and muscle.

The BSMS organises yearly an International Autumn School on Movement Science for young scientists to give first-hand experience of the unique graduate training programme in the field of movement science.

In this Autumn School we want to provide an overview on movement viewed from different perspectives such as the brain, central nervous system, bone, muscle and spine as well as its associated diseases and therapeutic options using physical activity.

The participation to the Autumn School is free of charge. The BSMS provides 14 travel grants to invite Master's and PhD students from all over the world to participate in this Autumn School. The travel grants will cover travel expenses, accommodation and lunch for the whole duration of the Autumn School.

The Autumn School is of particular interest to those Master's and PhD students who are considering doing their doctoral or post-doctoral research in the field of movement science within the BSMS network. The 14 travel grants will be awarded depending on the quality of the application, merit and the relevance.

Sessions

Scientific Programme

Monday 3rd October (Campus Nord)

Locomotion and MTU function

09:30 to 10:30 **Glen Lichtwark** – *The University of Queensland*
11:00 to 12:00 **Andrew Biewener** – *Harvard University*
13:30 to 14:30 **Joseph Hamill** – *University of Massachusetts Amherst*
15:00 to 16:00 **Rodger Kram** – *University of Colorado (videoconference)*

Tuesday 4th October (Campus Nord)

Muscle and tendon adaptation

09:30 to 10:30 **Kiros Karamanidis** – *German Sport University Cologne*
11:00 to 12:00 **Markus Tilp** – *University of Graz*
13:30 to 14:30 **Brian MacIntosh** – *University of Calgary*
15:00 to 16:00 **Robert Schleip** – *University of Ulm*

Wednesday 5th October (Campus Nord)

Muscle and tendon pathology: prevention and regeneration

09:30 to 10:30 **Herbert Tempfer** – *Paracelsus Medical University Salzburg*
11:00 to 12:00 **Britt Wildemann** – *Charité - Universitätsmedizin Berlin*
13:30 to 14:30 **Wilhelm Bloch** – *German Sport University Cologne*
15:00 to 16:00 **Invited students' poster session**

Thursday 6th October (Campus Virchow)

Spine movement and loads

09:30 to 10:30 **Navid Arjmand** – *Sharif University of Technology*
11:00 to 12:00 **Babak Bazrgari** – *University of Kentucky*
13:30 to 14:30 **Alison McGregor** – *Imperial College London*
15:00 to 16:00 **Hendrik Schmidt** – *Charité - Universitätsmedizin Berlin*

Friday 7th October (Campus Nord)

Muscle synergies in neurophysiology and computational neuroscience

09:30 to 10:30 **Anderson Oliveira** – *Aalborg University*
11:00 to 12:00 **Vincent Cheung** – *The Chinese University of Hong Kong*
13:30 to 14:30 **Jens Bo Nielsen** – *University of Copenhagen*
15:00 to 16:00 **Niccolò Zampieri** – *Max Delbruck Center for Mol. Med. Berlin*

Sessions
Social Programme for invited students

The BSMS provides 14 travel grants to invite Master's and PhD students from all over the world to participate in this Autumn School. The travel grants cover travel expenses, accommodation, coffee breaks, lunch and a dense social programme for the whole duration of the Autumn School. The 14 awarded students will have the chance to join the following programme.

Monday 3rd October

18:30 to 20:30 **Get-together dinner**
Peter Pane Burgergrill & Bar
Friedrichstraße 101, 10117 Berlin – *Meeting point*

20:30 to 23:00 **Festival - Day of German Unity**
Peter Pane Burgergrill & Bar
Friedrichstraße 101, 10117 Berlin – *Meeting point*

Wednesday 5th October

19:30 to 21:00 **Jump House Berlin**
Miraustr. 38, 13509 Berlin – *Meeting point*

Thursday 6th October

18:45 to 20:30 **Museum of Sports & Olympic Park**
Hanns-Braun-Straße (Museum), 14053 Berlin – *Meeting point*

Friday 7th October

18:45 to 21:00 **Festival of lights - Walking tour**
Hotel de Rome, Behrenstr. 37, 10117 Berlin – *Meeting point*

Saturday 8th October

11:00 to 13:00 **East Side Gallery/DDR-Museum**
Weidendammer Brücke, 10117 Berlin – *Meeting point*

14:00 to 16:00 **87th International long distance rowing regatta "Quer durch Berlin"**
Haus der Kulturen der Welt, John-Foster-Dulles Allee 10, 10557 Berlin – *Meeting point*

20:00 to 23:00 **Closing dinner**
Brauhaus Südstern
Hasenheide 69, 10967 Berlin – *Meeting point*

Monday 3rd October
Locomotion and MTU function
Scientific Programme

Humboldt-Universität zu Berlin | Philippstr. 13, Haus 11 | Room 1.26

09:15 to 09:30	Welcome and introduction
09:30 to 10:30	Understanding muscle and tendon interaction in the human lower limb ***Glen Lichtwark*** – *The University of Queensland*
10:30 to 11:00	Break
11:00 to 12:00	Biomechanics of mammalian and avian terrestrial locomotion ***Andrew Biewener*** – *Harvard University*
12:00 to 13:30	Lunch break
13:30 to 14:30	Is changing footfall patterns beneficial to runners? ***Joseph Hamill*** – *University of Massachusetts Amherst*
14:30 to 15:00	Break
15:00 to 16:00	The energetic cost of running: speed, incline, footwear and age effects (videoconference) ***Rodger Kram*** – *University of Colorado*

Social Programme

18:30 to 20:30	**Get-together dinner** Peter Pane Burgergrill & Bar Friedrichstraße 101, 10117 Berlin – *Meeting point*
20:30 to 23:00	**Festival - Day of German Unity** Peter Pane Burgergrill & Bar Friedrichstraße 101, 10117 Berlin – *Meeting point*

Monday 3rd October
Locomotion and MTU function
Abstracts

Understanding muscle and tendon interaction in the human lower limb

Glen Lichtwark – The University of Queensland, Australia

It has long been recognised that the elastic properties of connective tissue may enhance muscle function in terrestrial locomotion. Tendons act to absorb and generate mechanical power to enable efficient locomotion, but also heavily influence the functional performance of muscles. This presentation will explore how tendon compliance might enhance, or detract from, human performance and provide descriptions of how muscles with very different functions in the human lower limb benefit from well-tuned tendon compliance. I will first focus on the well documented mechanical function of the triceps surae muscles during walking and running and provide a theoretical framework by which muscle function might be optimised through appropriately tuned tendon stiffness. In particular, I will focus on how tendon compliance might be well adapted to maximise muscle economy and/or minimise potential damage to muscles. Both experimental and theoretical manipulations of tendon compliance will be used to explore the importance of tendon compliance on muscle force generation and efficiency. I will then explore some recent findings on the dynamic function of lower limb muscles whose elastic behaviours are less well documented (e.g. tibialis anterior, tibialis posterior, intrinsic foot muscles), but which are still key for enabling both economical and safe locomotion. Innovative methods for measuring and understanding muscle-tendon interaction during dynamic movements, including musculoskeletal modelling and ultrasound image processing, will be described with insight into how they might be used to assess muscle and tendon interaction and understand the mechanics and energetics of human motion in various athletic or clinical populations.

Monday 3rd October
Locomotion and MTU function
Abstracts

Biomechanics of mammalian and avian terrestrial locomotion

Andrew Biewener – Harvard University, USA

Comparative studies of mammalian and avian locomotion provide key insight into the neuromuscular mechanics of movement. Indwelling electrodes implanted into the muscles of animal models enable their in vivo function (fiber strain, force and neural activation) to be recorded across a range of locomotor behaviors, revealing how force and work are modulated in relation to neural activation across movement tasks. Studies of avian bipeds and mammalian quadrupeds suggest the existence of a proximo-distal gradient in muscle function and control. Whereas proximal muscles function to modulate limb work through feedforward control, distal muscles utilize intrinsic F-L and F-V muscle properties reinforced by reflexive feedback to respond to perturbations for stability during running. Distal muscle-tendon units emphasize economy of force generation and elastic energy recovery from series elasticity, rather than work modulation. Postural changes in limb function dramatically affect musculoskeletal loading patterns. In vivo assessment of muscle function also provides an opportunity to validate Hill-type muscle model predictions, which are frequently used to model and evaluate human movement in both normal and pathological conditions. By evaluating the predictive accuracy of Hill-type muscle models, features of the model can be adjusted to improve performance. Improvement in the accuracy of time-varying force produced by muscle models can, in turn, improve their application to studies of human muscle function related to movement performance, rehabilitation and aging.

Monday 3rd October
Locomotion and MTU function
Abstracts

Is changing footfall patterns beneficial to runners?

Joseph Hamill – University of Massachusetts Amherst, USA

A question that has been asked recently in running circles concerns the style of running, barefoot or shod? A corollary of this concerns the type of footfall pattern to be used? The question that most ignore is on what surface is the running taking place. On a hard surface, a habitual rearfoot runner, when running barefoot, generally changes from their habitual pattern to a forefoot pattern to avoid the pain of landing on the heel. However, several running instructors and coaches have extended this concept of barefoot/forefoot running to suggest that the "optimal" footfall pattern to improve performance and reduce running injuries is the midfoot or forefoot pattern. Therefore, it has been suggested that runners, who use a rearfoot pattern, would benefit by changing their footfall pattern although there is little scientific evidence for suggesting such a change. The reasons often given for changing to a midfoot or forefoot footfall pattern are: 1) it is more economical to run with a midfoot or forefoot footfall pattern; 2) there is a reduction in the impact peak and loading rate of the vertical component of the ground reaction force (VGRF) in midfoot and forefoot footfall patterns; 3) there is greater use of the Achilles tendon; and 4) there is a reduction in the risk of a running-related injuries after changing to a midfoot or forefoot pattern. This presentation will critique these suggestions and provide alternate explanations and contradictory evidence against altering one's footfall pattern. We have concluded, based on results from studies in our laboratory and from examining the research literature, that changing to a midfoot or forefoot pattern does not improve running economy, does not eliminate an impact at the foot-ground contact, does not enhance the use of the Achilles tendon and does not result in reducing the risk of running-related injuries.

Monday 3rd October

Locomotion and MTU function

Abstracts

The energetic cost of running: speed, incline, footwear and age effects

Rodger Kram – University of Colorado, USA

Running over level ground involves weight support, forward propulsion, leg advancement, arm swing and balance. We have isolated those tasks and quantified the metabolic cost of each and then put the pieces back together again. We have also developed explanations for why running faster and uphill each require more metabolic power. Since shoes have mass that must be accelerated, they can increase metabolic cost but we find that lightweight, properly cushioned shoes can actually save metabolic energy. Yet, lightweight and resilient running leg prostheses do not seem to provide a net energetic advantage over biological legs. Finally, our recent studies of runners over 65 years of age show that lifelong running preserves running economy.

Tuesday 4th October
Muscle and tendon adaptation
Scientific Programme

Humboldt-Universität zu Berlin | Philippstr. 13, Haus 11 | Room 1.26

09:30 to 10:30	Muscle-tendon mechanosensitivity in ageing ***Kiros Karamanidis*** – *German Sport University Cologne*
10:30 to 11:00	Break
11:00 to 12:00	Effects of different stretching methods on muscle-tendon-unit properties ***Markus Tilp*** – *University of Graz*
12:00 to 13:30	Lunch break
13:30 to 14:30	How does a tendon minimize the energy cost of muscle contraction? ***Brian MacIntosh*** – *University of Calgary*
14:30 to 15:00	Break
15:00 to 16:00	Mechano-adaptation of fascial tissues ***Robert Schleip*** – *University of Ulm*

Tuesday 4th October
Muscle and tendon adaptation
Abstracts

Muscle-tendon mechanosensitivity in ageing

Kiros Karamanidis – German Sport University Cologne, Germany

The ageing tendon experiences a general deterioration in its structure and function, often characterized by a reduced capability to adapt to environmental stress as a result of declined tissue homeostasis. Exercise interventions of several months (3-4 months) have been shown to act against such degradations, demonstrating that tendons preserve their adaptability to mechanical loading in old age. However, older adult tendons have shown changes mainly in stiffness, but not in cross-sectional area, in response to mechanical loading. Furthermore, in younger adults, exercise-induced tendon hypertrophy is suggested to be a rather long-term effect, which might be more prolonged in the elderly. To our knowledge, there is limited information about the medium- (months) and long-term (years) mechanosensitivity of tendon biomechanical and dimensional properties in older adults.

This presentation will discuss some of our recent work which demonstrates that tendons of older adults preserve their mechanosensitivity and are capable of increasing their stiffness post physical exercise by adapting their material and dimensional properties. It will also be highlighted that the adaptive time-response relationship of tendons subjected to mechanical loading is nonlinear.

Moreover, an overview of some of recent data will be given, that indicate that ageing is not only associated with a reduction in muscle mass, but also that the shape of the M. triceps may be altered with ageing. Additionally, the effect of physical activity on muscle morphology will be presented.

Finally, the functional consequence of such exercise-related muscular changes on safety and effectiveness of human locomotion in the elderly will be outlined. Are older adults able to transfer their improved muscular capacities as a result of training interventions to repetitive motor tasks such as walking? Depending on the gait task, data from our longitudinal interventions suggest that medium-term interventions (several months) may not be sufficient for this purpose.

Tuesday 4th October
Muscle and tendon adaptation
Abstracts

Effects of different stretching methods on muscle-tendon-unit properties

Markus Tilp – University of Graz, Austria

The different stretching methods static, ballistic, and proprioceptive neuromuscular facilitation (PNF) stretching act differently on the muscle-tendon-unit (MTU) regarding applied force and level of muscle activation. While during static stretching the forces on the muscle and tendon are rather low, such forces increase during ballistic and even more during PNF stretching due to components of muscle activation. Therefore, one could also expect different effects on the MTU properties due to the different methods following a single stretching exercise or following repeated stretching training over several weeks or months.

While earlier studies in the past century could only determine the effects of various interventions on the whole joint or MTU respectively, modern methods like ultrasound or magnetic resonance imaging made it possible to study the muscle and tendon parts separately. Besides range of motion, passive resistive torque and stiffness of the joint, typical muscle and tendon properties analysed in stretching studies are fascicle lengths, fascicle pennation angles, muscle stiffness and tendon stiffness.

Due to different aims in training and therapy it is of great interest if the consistently observed increase in range of motion following different stretching interventions is accompanied with changes in the muscle and/or the tendon structures, respectively.

During the lecture, the current knowledge about changes in MTU properties due to stretching exercises and prolonged stretching training will be presented. Parameters describing the mechano-morphological properties of the MTU and methods to determine them will be critically discussed. Furthermore, the effect of the variation in stretching training regarding intensity and time will be reviewed.

Tuesday 4th October
Muscle and tendon adaptation
Abstracts

How does a tendon minimize the energy cost of muscle contraction?

Brian MacIntosh – University of Calgary, Canada

The energy storage and release in the Achilles tendon, during the stance phase of running has been carefully quantified and appears to be of some value. However, elite endurance runners are willing to sacrifice this energy in favor of a stiff Achilles tendon. Why is this? We know that the energy cost of running (E_{run}) correlates inversely with Achilles tendon stiffness and that if you can increase your tendon stiffness there is an associated decrease in (E_{run}). However, increased Achilles tendon stiffness is associated with decreased energy storage!

How does a decrease in energy storage translate to a decrease in (E_{run})? Any time that an increase in force can result in tendon energy storage, there must be a contraction by the muscle in series with that tendon. The energy cost of a muscle contraction can be estimated if the following are known: length of the muscle, average force, duration of contraction, muscle shortening. It is also important to know the shortening velocity to estimate the force per cross-bridge, according to the force-velocity relationship. With this information, the number of simultaneous cross-bridges and the turnover of cross-bridges can be estimated. Assuming a certain amount of energy per ATP hydrolyzed, the total amount of energy used by the muscle can be estimated.

This approach has allowed us to compare stiff and compliant Achilles tendons and calculate the corresponding energy cost of muscle contraction. The factor that is important in these estimations is that a compliant tendon will lengthen more during the early stance phase than a stiff tendon will. More lengthening of the tendon will require more shortening by the muscle. More shortening of the muscle will result in a higher turnover of the cross-bridges, and therefore more ATP hydrolysis. Our calculations show that the energy cost of muscle contraction exceeds the Achilles tendon energy storage. Therefore, the more energy you can store in the tendon, the higher will be your energy cost of running.

Tuesday 4th October
Muscle and tendon adaptation
Abstracts

Mechano-adaptation of fascial tissues

Robert Schleip – University of Ulm, Germany

Wolff's law does not only apply to bony connective tissues, but also to membranous fibrous connective tissues such as epimysia, perimysia, muscular septa, joint capsules and aponeuroses, which are summarized as fascial tissues in this lecture. Understanding more specifically how these tissues adapt to mechanical stimulation remains a promising field of investigation.

Lack of mechanical loading has been shown to induce an irregular fibre arrangement as well as reduction in the magnitude of crimp formation in these fibres. It also induces a reduction in passive joint mobility and a loss of shearing motion between adjacent tissue layers. Regular adequate mechanical loading, on the other side, seems to be able to revert at least some of these effects.

A more succinct understanding of these processes could be clinically relevant for chronic low back pain. Here a reduction of shearing motion of lumbar fasciae has been shown in patients compared with healthy controls, although the function of this tissue change in the aetiology of low back pain remains unclear. An increase in shearing motion could be demonstrated in lumbar fasciae by use of a foam roller self-treatment. The related quantitative assessment of this tissue change via ultrasound or MRI remains a challenging methodological task.

Recent cell culture as well as animal studies helped to understand the dynamics of altered cytokine expression in fibrous connective tissues in response to different mechanical loading protocols. We will review, to which degree these may also apply to the effect of exercise (or lack of it) in human fascial tissues.

Finally, a corollary Davis' law, a corollary of Wolff's law, will be discussed. Similar to Harold Frost's Mechanostat Model for bones, it attempts to describe the mechanical adaptation of fibrous connective tissues as a general remodelling process based on various control loops in response to the peak forces exerted on these tissues by muscles.

Wednesday 5th October
Muscle and tendon pathology: prevention and regeneration
Scientific Programme

Humboldt-Universität zu Berlin | Philippstr. 13, Haus 11 | Room 1.26

09:30 to 10:30	A high glucose diet affects tendon regeneration in rats ***Herbert Tempfer*** – *Paracelsus Medical University Salzburg*
10:30 to 11:00	Break
11:00 to 12:00	Patient specific characteristics of tenocytes ***Britt Wildemann*** – *Charité - Universitätsmedizin Berlin*
12:00 to 13:30	Lunch break
13:30 to 14:30	Crosstalk between extracellular matrix and muscle fibers – role for adaption and regeneration ***Wilhelm Bloch*** – *German Sport University Cologne*
14:30 to 15:00	Break
15:00 to 16:00	Invited students' poster session

Social Programme

19:30 to 21:00	**Jump House Berlin** Miraustr. 38, 13509 Berlin – *Meeting point*

Wednesday 5th October
Muscle and tendon pathology: prevention and regeneration
Abstracts

A high glucose diet affects tendon regeneration in rats

Herbert Tempfer – Paracelsus Medical University Salzburg, Austria

Metabolic disorders are frequently associated with tendon degeneration and impaired healing after acute injury. However, the underlying cellular and molecular mechanisms remain largely unclear. We have previously shown that human and rat tendon cells produce and secrete insulin upon glucose stimulation. Therefore, we now examine potential effects of a high glucose diet on tendon regeneration in a rat model.

Full-thickness Achilles tendon defects were created in female Lewis rats. Immediately after surgery animals were randomly assigned to three groups receiving different diets for 2 and 4 weeks (Diet C: control diet, n=25; Diet G: high-glucose diet, n=25; Diet F: high fat/low glucose diet, n=20). Gait analysis (Catwalk, Noldus) was performed at three time points.

The repair tissues of both treatment groups were significantly thicker compared to the control group ($p<0.001$) and one and two weeks p.op. Intermediate Toe Spread (ITS) was highest for animals receiving Diet G ($p<0.001$), indicating less pain. Repair tissue of animals receiving Diet G was significantly stiffer compared to the control group ($p<0.05$), whereas maximum tensile was unchanged. Also cell proliferation was increased by glucose rich diet, the proportion of Ki67+ cells in the repair tissue was 3.3% in the Diet C group, 9,8% in the Diet G group and 8.4% in the Diet F Group. Finally, gene expression analysis revealed chondrogenic marker genes to be upregulated by glucose diet.

A high-glucose diet improves gait pattern and tendon biomechanics, influences tendon thickness and cell proliferation. Gene expression analysis reveals an upregulation of chondrogenic marker genes. The molecular mechanisms underlying these effects on cells and extracellular matrix are currently under investigation, potentially revealing targets for developing a dietary intervention scheme to support tendon regeneration after trauma or tendon disease.

Wednesday 5th October

Muscle and tendon pathology: prevention and regeneration

Abstracts

Patient specific characteristics of tenocytes

Britt Wildemann – Charité - Universitätsmedizin Berlin, Germany

As we grow older, the risk of tendon degeneration and injuries increases, which can result in pain, disability, healthcare cost, and lost productivity. Even after surgical repair the results are often unsatisfactory and the cellular reasons for the differences in the healing potential are not well studied. To get a deeper insight into the biological characteristics of tenocytes-like cells from different patient groups we established a biobank with material from over 100 human donors. The patients/donors suffered from rotator cuff tears and were operated to restore the function. A proportion of the isolated cells showed stem cell-like characteristics and was able to differentiate into the osteoblastic, chondrogenic and adipogenic linage. Investigating the differentiation potential of the cells with regard to donor characteristics, we were able to demonstrate that age, sex but also the "degeneration" has an impact of the cellular potential. A possibility to stimulate the cellular activity is the application of growth factors, as already clinically used for stimulation of bone healing. Therefore, the responsiveness of the cells to the growth factors Bone Morphogenetic protein-2/7 (BMP-2/7) was analysed in vitro. Independent of the donor characteristics, the cells responded to the BMP-stimulation by increased proliferation and collagen-1 synthesis. However, cells isolated from donors with high fatty infiltration of the muscle or older females were less responsive. Looking into the intracellular signalling pathway, it seems as if the BMP-signal is mainly mediated by the canonical-pathway with samd8 playing a major role. With this presentation I will give you an insight into the impact of patient specific characteristics on tenocytes biology.

Wednesday 5th October
Muscle and tendon pathology: prevention and regeneration
Abstracts

Crosstalk between extracellular matrix and muscle fibers – role for adaption and regeneration

Wilhelm Bloch – German Sport University Cologne, Germany

Extracellular matrix (ECM) structure, proteins and cleavage products have been identified to be involved in different cellular process regulating skeletal muscle structural adaption and regeneration. Angiogenesis, myogenesis and muscle hypertrophy as well as changes of muscle fiber characteristic are dependent from crosstalk between ECM and muscle fibers beside of e.g. metabolic factors. Physical exercise and its potential to modulate the intramuscular ECM have become in the focus in recent years. Acute and chronic exercise can change the ECM structure and the proteins inside the ECM. Exercise mediated changes of ECM-Cell interaction can activate satellite cells and support muscle growth and regeneration. Vascular adaption is a further important goal of exercise mediated ECM processing. Different angio-modulatory cleavage products of basement membrane proteins (e.g. endostatin), their activation by proteases and inhibitors, such as matrix metalloproteases (MMPs), cathepsins, tissue inhibitors of MMPs are shown to be released by exercise. Cleavage products such as Endostatin can regulated the function of vessels relevant for muscle perfusion. The regulation of the ECM processing by physical training is highly dynamic and can be changed by chronic training and by a single bout of exercise in dependence of the kind of exercise stimuli, e.g. eccentric versus concentric training and intensity as well as volume of the training. The response seems to be dependent from age, diseases, training history and further factors. The understanding of these processes will help to develop training programs to optimize structural and functional skeletal muscle adaption by training.

Thursday 6th October
Spine movement and loads
Scientific Programme

Campus Virchow Klinikum | Föhrer Str. 15, Institutsgebäude Süd (IGS) | Auditorium

09:30 to 10:30	Biomechanical models of the upper trunk to predict muscle and spinal loads; applications in occupational biomechanics ***Navid Arjmand*** – *Sharif University of Technology*
10:30 to 11:00	Break
11:00 to 12:00	Spine Biomechanics – Whole body level experimental studies ***Babak Bazrgari*** – *University of Kentucky*
12:00 to 13:30	Lunch break
13:30 to 14:30	Understanding spinal function in the context of performance ***Alison McGregor*** – *Imperial College London*
14:30 to 15:00	Break
15:00 to 16:00	Dynamic response of intervertebral discs under loading and unloading cycles: on the role of fluid flow ***Hendrik Schmidt*** – *Charité - Universitätsmedizin Berlin*

Social Programme

18:45 to 20:30	**Museum of Sports & Olympic Park** Hanns-Braun-Straße (Museum), 14053 Berlin – *Meeting point*

Thursday 6th October

Spine movement and loads

Abstracts

Biomechanical models of the upper trunk to predict muscle and spinal loads; applications in occupational biomechanics

Navid Arjmand – Sharif University of Technology, Iran

Proper estimation of trunk muscle forces, spinal loads, and stability during physical activities is essential to evaluate risk of workplace injury, design effective prevention programs, and improve existing rehabilitation and performance enhancement programs. As a consequence and in absence of non-invasive in vivo approaches, biomechanical models are extensively used as the only viable means available. To facilitate use of such models of the multi-joint human spine for practitioners in the fields of ergonomics and rehabilitation, easy-to-use predictive equations, artificial neural networks, and commercial software have been developed. In biomechanical models of the spine, equilibrium of external moments (e.g., due to gravity, inertia, damping, and hand loads) and internal moments (e.g., due to trunk muscles and passive ligamentous spine), at one single joint (e.g., L4-L5) or at several joints, are commonly considered based on free body diagrams in each anatomical plane. Number of unknown muscle forces spanning a joint, however, outnumbers the equilibrium equations at that joint, causing a redundant system. Optimization or electromyography (EMG)-driven approaches are usually employed to resolve this redundancy. The former approach considers some cost functions to be optimized while solving the equilibrium equations for unknown muscle forces, whereas the latter exploits recorded EMG data of select trunk muscles. Comparative studies between optimization- and EMG-driven models indicate relatively large differences between their predictions. Practitioners in occupational biomechanics use biomechanical models with different degrees of complexity to evaluate risk of injury to the spine during occupational activities. As expected, the underlying assumptions and simplifications made in these models influence the accuracy of their predictions and hence their applicability in ergonomic, rehabilitation, and biomechanical applications.

In this presentation various biomechanical models including optimization- and EMG-driven models as well as some of the existing commercial software will be discussed. Predictions of six different biomechanical models (from different research groups in different universities) for the L4-L5 and L5-S1 compression and shear loads in twenty-six static activities with and without hand load will be compared. Each tool will be briefly evaluated to identify its shortcomings and preferred application domains.

Thursday 6th October
Spine movement and loads
Abstracts

Spine Biomechanics – Whole body level experimental studies

Babak Bazrgari – University of Kentucky, USA

Mechanical environment in the human lower back, specifically forces and deformations experienced by the lower back tissues when performing activities of daily living, has an important role in occurrence and recurrence of low back pain. Availability of quantitative information about the lower back mechanical environment is critical for management of the low back pain problem. Such quantitative information can be obtained from cell, tissue, and whole body level and using both computational and experimental studies. The focus of this talk will be on experimental studies of lower back mechanical environment at the whole body level.

Lower back mechanical environment is governed by the active and the passive mechanical synergy of lower back tissues for stability and equilibrium of the spine (SES). While all spinal tissues can contribute to SES passively, components of the trunk neuromuscular system can also contribute actively. The active contribution of the trunk neuromuscular system involves both motor and sensory contributions via reflexive, feedforward, and feedback components. Our recent methodological developments have enabled us to more accurately evaluate lower back mechanical environment, by comprehensive assessment of lower back tissues contributing to SES. In particular, the active contributions of lower back tissues are investigated using a displacement-control perturbation system, which quantifies: 1) intrinsic trunk stiffness, which is affected primarily by intrinsic/background motor contributions including muscle co-activation; 2) reflexive force, which represents reflexive motor contributions; and, 3) response latency, which represents sensory contributions. The passive contributions of lower back tissues are assessed using a stress-relaxation test. In this talk a review of changes in lower back mechanical environment with aging as well as exposure to prolonged flexed posture will be offered.

Thursday 6th October
Spine movement and loads
Abstracts

Understanding spinal function in the context of performance

Alison McGregor – Imperial College London, United Kingdom

This talk will examine spinal function and its assessment through the paradigm of performance and injury. The spine we know is an inherently stable structure yet it exhibits great strength and flexibility in certain conditions which allow humans to perform a range of functional activities. Whether we like it or not, over 80% of us will suffer with lower back pain at some point in our lives. Despite these high figures our ability to manage this epidemic is limited, with many treatments appearing ineffective, due in part to our limited understanding of how the spine works, its functional limits and why it goes wrong. This talk will use the context of elite rowing and how an understanding of spinal function can be used to enhance performance and potentially prevent and understand injury. We will explore how factors such as fatigue, and ability can alter the motion patterns of the spine during a task, how this links to spinal loading, and whole body mechanics. The role of the supporting spinal musculature will be included as well as how this links to spinal motion.

Thursday 6th October
Spine movement and loads
Abstracts

Dynamic response of intervertebral discs under loading and unloading cycles: on the role of fluid flow

Hendrik Schmidt – Charité - Universitätsmedizin Berlin, Germany

The primary function of the intervertebral disc is mechanical; it supports and transmits loads from one level to another while providing the spinal compliance required to perform various tasks. Over the course of daily activities, the disc fluid content continuously varies depending on loading (arising from the upper body weight, external loads, inertia and muscle activation), posture and the internal osmotic pressure (affected by the disc composition). Fluid flow within the disc is governed by this balance, causing fluctuations in the disc hydration and hence disc height. The time dependent mechanical behavior of the intervertebral disc has extensively been investigated by in vitro studies. Nevertheless, it remains yet unclear if conditions in in vitro studies properly emulate those in vivo. In view of long recovery periods in vitro, several studies have raised concerns on the fluid flow through the endplates that might be hampered by clogged blood vessels post mortem thus impeding diffusion in vitro. Studies on ovine, porcine, caprine and rat discs show that under constant compression, the disc height and nucleus pressure decrease due to fluid exudation. The recovery upon unloading is however very slow in time indicating an insufficient fluid inflow.

This talk aims to review and discuss the findings of reported studies as well as our ongoing in vitro investigations on the fluid flow mechanisms in intervertebral discs with special focus on creep and recovery in static and dynamic compression. Results of finite element model studies will also be presented and discussed in order to help identify the underlying mechanisms observed in vitro.

Friday 7th October
Muscle synergies in neurophysiology and computational neuroscience
Scientific Programme

Humboldt-Universität zu Berlin | Philippstr. 13, Haus 11 | Room 1.26

09:30 to 10:30	Modular control of motion: methodological considerations and applications for sports sciences ***Anderson Oliveira*** – *Aalborg University*
10:30 to 11:00	Break
11:00 to 12:00	Neuromotor modules as markers of diseased states and progress of motor recovery ***Vincent Cheung*** – *The Chinese University of Hong Kong*
12:00 to 13:30	Lunch break
13:30 to 14:30	Corticospinal function in the control of gait ***Jens Bo Nielsen*** – *University of Copenhagen*
14:30 to 15:00	Break
15:00 to 16:00	Motor neuron position and the assembly of motor circuits ***Niccolò Zampieri*** – *Max Delbruck Center for Mol. Med. Berlin*

Social Programme

18:45 to 21:00	**Festival of lights - Walking tour** Hotel de Rome, Behrenstr. 37, 10117 Berlin – *Meeting point*

Friday 7th October
Muscle synergies in neurophysiology and computational neuroscience
Abstracts

Modular control of motion: methodological considerations and applications for sports sciences

Anderson Oliveira – Aalborg University, Denmark

Objectively explaining the neural control of motion in humans was challenging in the past due to limitations in deinterlacing spatio-temporal aspects of muscular activity (EMG). Factorization algorithms, such as non-negative matrix factorization (NMF), have enabled the investigation of a wide range of motor control contexts from basic neuroscience to sports performance. One of the most investigated motion patterns is human ambulation, as EMG recordings from superficial lower limb muscles are reasonably easy, and there is a clear distinction between the silent and active periods of muscle activity.

Despite the fast-growing use of NMF to describe the neural control of motion, the use of limited number of muscles, recorded trials, and inadequate EMG post-processing methods might influence the outcomes. In a methodological study, we compared the outcomes from NMF applied on multi-muscle EMG gait datasets from different number of cycles and processing methods. Our results showed that it is necessary to include a considerable amount of gait cycles to accurately account for the EMG variability of human gait, and averaging EMG data prior to applying NMF might be an alternative approach in specific cases.

Factorization analysis has also been used to investigate the differences in human running overground in comparison to treadmill running. The use of several continuous running cycles has allowed the appropriated comparison of motor modules extracted in both conditions. Our results indicated that the use of traditional EMG processing is as sensitive as NMF to underpin changes in spatio-temporal properties of muscle activity. Moreover, the modular control of both running tasks is predominantly similar, but there are specific changes in the timing for modular recruitment to control swing and stance phases. Current and future applications of factorization analysis in sports sciences will be addressed in the presentation.

Friday 7th October
Muscle synergies in neurophysiology and computational neuroscience
Abstracts

Neuromotor modules as markers of diseased states and progress of motor recovery

Vincent Cheung – The Chinese University of Hong Kong, China

It has been suggested that combination of motor modules is a viable framework for understanding how the variety of movement patterns are generated by the CNS. A motor module consists of a set of time-invariant activation weights across muscles (a.k.a. "muscle synergy"), and a time-varying coefficient that scales the muscle weights across time. Many experiments have supported the neural origin of motor modules. Characterizing their deviations in diseased conditions should not only offer insights into the underlying pathology responsible for the impaired movement, but also suggest how an effective intervention may be rationally designed. Distinctive patterns of abnormal motor modules may be robust signatures of particular diseased states, and thus be used as markers for diagnosis, or for evaluating recovery progress. Here, we argue, with two examples, that abnormal patterns of either the muscle weights or temporal activations may serve as markers of diseased states. The first example concerns upper-limb modules in stroke survivors. Preliminary results from chronic survivors undergoing rehab indicate that enhanced post-rehab motor recovery is associated with the post-rehab activation of a specific module in the affected arm, one that can be regarded as a marker of post-training recovery. The second example concerns lower-limb modules in infants with delayed-onset locomotion, a condition with variable causes that affects 5-15% of newborns. We found in our pilot data that in these children, the temporal activation burst of one module was consistently time-shifted to the right relative to the burst of another module. Children responsive to therapy displayed a post-rehab temporal activation pattern similar to that observed in normal children. The above examples illustrate the potential of using either the muscle weights or temporal activations of specific modules for early detection and/or evaluation of recovery progress for different movement disorders.

Friday 7th October

Muscle synergies in neurophysiology and computational neuroscience

Abstracts

Corticospinal function in the control of gait

Jens Bo Nielsen – University of Copenhagen, Denmark

Human gait is regulated by integration of descending motor commands, rhythm generating networks and sensory feedback signals in the spinal cord (1). The primary motor cortex contributes through the corticospinal tract to the activation of muscles during uncomplicated treadmill walking and is of major importance in modulating and adapting gait to changes in the environment as well as in the visual guidance of gait (1,2,3). This corticospinal contribution to gait may now be evaluated non-invasively by electrophysiological techniques in healthy individuals and in individuals with spinal cord injury. Transcranial magnetic stimulation (TMS) during gait elicits a direct monosynaptic excitation of ankle plantarflexors, which is largest at the time of push-off at the end of stance (4). Oscillations in EEG and EMG recorded from ankle plantarflexors also show the most pronounced coupling (corticomuscular coherence; CMC) in relation to push-off. Individuals with corticospinal lesion show reduced activation of ankle plantarflexors by TMS with correlation to gait velocity. CMC and muscle activation by TMS recorded for ankle dorsiflexors are also reduced in individuals with lesion of the corticospinal tract, but with a correlation to foot drop (5). All TMS and CMC measures show correlation to regional atrophy of the dorsolateral quadrant of the spinal cord where the corticospinal tract is located (6). These observations indicate that corticospinal transmission to ankle plantarflexors contributes to forward propulsion and gait velocity, whereas corticospinal transmission to ankle dorsiflexors is mainly important for toe lift at the end of swing.

1.Nielsen JB. Neuroscientist. 2003 Jun;9(3):195-204

2.Drew T, Andujar JE, Lajoie K, Yakovenko S. Brain Res Rev. 2008 Jan;57(1):199-211

3.Barthélemy D, Grey MJ, Nielsen JB, Bouyer L. Prog Brain Res. 2011;192:181-97.

4.Petersen N, Christensen LO, Nielsen J. J Physiol. 1998 Dec 1;513 (Pt 2):599-610

5.Barthélemy D, Willerslev-Olsen M, Lundell H, Biering-Sørensen F, Nielsen JB. Prog Brain Res. 2015; 218:79-101.

6.Lundell H, Barthelemy D, Skimminge A, Dyrby TB, Biering-Sørensen F, Nielsen JB. Spinal Cord. 2011 Jan; 49(1):70-5.

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Supported by Ludvig and Sara Elsass Foundation

Friday 7th October
Muscle synergies in neurophysiology and computational neuroscience
Abstracts

Motor neuron position and the assembly of motor circuits

Niccolò Zampieri – Max Delbruck Center for Molecular Medicine Berlin, Germany

The selectivity with which proprioceptive sensory neurons and interneurons form synaptic connections with distinct subtypes of motor neurons is a crucial determinant of coordinated motor behavior. However, there has been slow progress in identifying the mechanisms that precisely control assembly of spinal sensory-motor circuits. Motor neurons are organized into anatomically and functionally discrete structures, termed pools, which occupy stereotypic and invariant positions in the spinal cord, suggesting the hypothesis that precise positioning may be a strategy to simplify the problem of connectivity. However, the mechanisms controlling motor neuron organization and its significance for the assembly of motor circuits are not clearly understood. By combining cellular and molecular analysis with mouse genetics we uncovered an important role for cell-cell adhesive recognition molecules in controlling motor neuron position and the assembly of spinal motor circuits.

Saturday 8th October

Social Programme

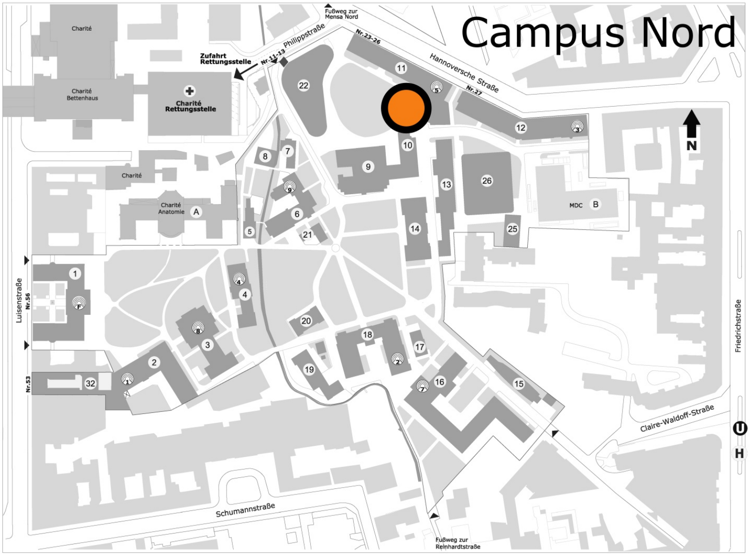
11:00 to 13:00 **East Side Gallery/DDR-Museum**
Weidendammer Brücke, 10117 Berlin – *Meeting point*

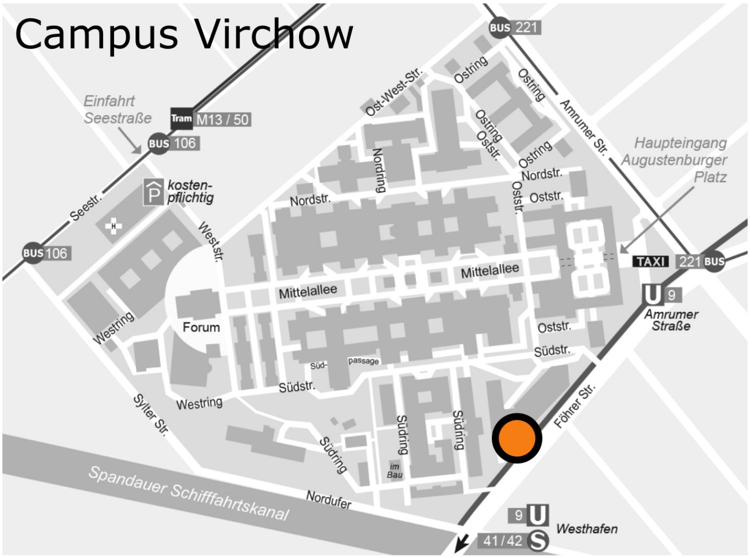
14:00 to 16:00 **87th International long distance rowing regatta "Quer durch Berlin"**
Haus der Kulturen der Welt, John-Foster-Dulles Allee 10, 10557 Berlin – *Meeting point*

This international long distance rowing regatta crosses 13 bridges of the inner-city from the Charlottenburg Palace to the Federal Chancellery. Around 150 boats will take part on the 7km course, trying to reach as fast as possible the finish line set at the Haus der Kulturen der Welt on the Spree river.

20:00 to 23:00 **Closing dinner**
Brauhaus Südstern
Hasenheide 69, 10967 Berlin – *Meeting point*

Lecture hall locations





3rd International Autumn School on Movement Science

Berlin, 3rd to 8th October 2016

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