A forum to foster the growing interest in scientific work at the intersection of Motor Control and Biomechanics.

SYMPOSIUM OF THE ISB WORKING GROUP IN MOTOR CONTROL

MOTOR CONTROL IN BIOMECHANICS

TUESDAY 29 MAY 2018 | 9:00 AM TO 12:00 PM

2018 ANNUAL MEETING OF THE AMERICAN COLLEGE OF SPORTS MEDICINE

HYATT REGENCY MINNEAPOLIS • 1300 NICOLLET MALL, MINNEAPOLIS, MN 55403

ORGANIZERS: DR. PAOLA CONTESSA (USA) • DR. JOSEPH HAMILL (USA) • DR. WALTER HERZOG (CANADA) • DR. JIM RICHARDS (UK) • DR. IRENE DAVIS (USA)

INNOVATIVE TECHNIQUES TOWARDS A NEW APPROACH TO SPORTS AND EXERCISE

INVITED SPEAKERS

Dr. Darryl Thelen
University of Wisconsin-Madison
(USA)

Dr. João Paulo Vilas-Boas
University of Porto
(Portugal)

Dr. Angus Hunter
University of Stirling
(UK)

Dr. Ross Miller
University of Maryland
(USA)

Dr. Ezio Preatoni
University of Bath
(UK)

Dr. Jasper Reenalda
Roessingh Research and Development
University of Twente
(Netherlands)

Mr. Oladipo Eddo
George Mason University
(USA)

Who Should Attend: Researchers and students with an interest in Biomechanics and Motor Control should attend. Participants will have the opportunity to discover the latest developments at the intersection of these two fields and discuss with experienced investigators.

Registration and Fee: Participation is free for all ACSM attendees and breakfast will be served thanks to the generous support of the De Luca Foundation, MA. Register at: **mcg.isbweb.org/registration.html**

REGISTER

With the Support of the National Science Foundation (NSF): The symposium is supported by the Disability and Rehabilitation Engineering (DARE) program of NSF under Grant Number # 1821895. Any opinions, findings, and conclusions or recommendations expressed in this symposium do not necessarily reflect the views of the National Science Foundation.

NSF-SPONSORED STUDENT TRAVEL GRANTS

Ten travel awards will be offered to support the participation of students to the symposium. The awards consist of an amount of US $ 500. **Application:** Guidelines and application procedures can be found at **mcg.isbweb.org/award.html**

Deadline for application : May 20th 2018

Award Notification: May 25th 2018

A forum to foster the growing interest in scientific work at the intersection of Motor Control and Biomechanics.

SYMPOSIUM OF THE ISB WORKING GROUP IN MOTOR CONTROL

MOTOR CONTROL IN BIOMECHANICS

TUESDAY 29 MAY 2018 | 9:00 AM TO 12:00 PM

2018 ANNUAL MEETING OF THE AMERICAN COLLEGE OF SPORTS MEDICINE

PROGRAM

TUESDAY 29 MAY

9:00 AM - 12:00 PM	**Innovative techniques towards a new approach to sports and exercise**
9:00 AM – 9:05 AM	**OPENING**
9:05 AM – 9:30 AM	A Noninvasive Sensor of Tendon Loading during Dynamic Movement Dr. Darryl Thelen, University of Wisconsin-Madison, USA
9:30 AM – 09:55 AM	Assessing and understanding forces in swimming Dr. João Paulo Vilas-Boas, University of Porto, Portugal.
09:55 AM – 10:20 AM	Movement, coordination and their variability in sports skills monitoring: where we are and what is missing Dr. Ezio Preatoni, University of Bath, UK
10:20 AM – 10:45 AM	Predictive models are most useful when they are wrong Dr. Ross Miller, University of Maryland, USA
10:45 AM – 11:10 AM	Neuromuscular control in clinical and athletic populations: science of past, present and future Dr. Angus Hunter, University of Stirling, UK
11:10 AM – 11:25 AM	A Novel Approach To Investigate Differences In Knee Mechanics After ACL Reconstruction Using Inertial Sensors Dr. Jasper Reenalda, University of Twente, Netherlands
11:25 AM – 11:40 AM	Effects of Gait Modification on Lower Extremity Sagittal Plane Biomechanics Mr. Oladipo Eddo, George Mason University, USA
11:40 AM – 12:00 PM	**PANEL DISCUSSION AND CLOSING**

AMERICAN COLLEGE of SPORTS MEDICINE

65TH ANNUAL MEETING ACSM 2018
TUESDAY 29 MAY 2018
MINNEAPOLIS, MINNESOTA

info@mcg.isbweb.org
www.mcg.isbweb.org

ABSTRACT

A Noninvasive Sensor of Tendon Loading during Dynamic Movement

Darryl G Thelen, Emily M Keuler, Jack A Martin. The University of Wisconsin–Madison, Madison, WI, USA

The characterization of muscle forces is fundamental for investigating the control and mechanics of dynamic movements in sports and exercise. Motion analysis techniques are widely used to assess joint kinetics, but lack the specificity to assess loads at the tissue level. Computational models can provide estimates of muscle forces, but are reliant on many assumptions regarding muscle geometry and the coordination of redundant musculature. We have recently made exciting advances in noninvasively assessing muscle-tendon loading during movement based on shear wave propagation within the tissue (shear-wave tensiometry)[1].

Tendon tensiometers consist of a piezoelectric-actuated tapper and two in-series miniature accelerometers placed over a tendon of interest. The tapper induces shear waves by delivering micron scale impulsive taps at 50 Hz. The elapsed time between a wave's arrival at the two accelerometers is used to compute shear wave speed. We have previously shown both analytically and experimentally that wave speed varies in proportion to the square root of axial tendon stress at physiological loads[1]. We have subsequently demonstrated the use of tensiometers to assess tendon loads in the lower extremity during both walking and running activities. In an example running application, a tensiometer was placed over the patellar tendon while the subject varied cadence at a fixed running speed (3.35 m/s). A 10% increase from preferred step rate (84 steps/min) at a fixed running speed reduced patellar tendon wave speed from 63 to 57 m/s. This change corresponds to an estimated 18% reduction in the patellar tendon stress, which is within the range of prior modeling estimates[2]. In a second example, the system was used to tracked biceps femoris (lateral hamstrings) tendon wave speed over the gait cycle as a subject transitioned from jogging (2.7 m/s) to sprinting (8.0 m/s). The biceps femoris tendon wave speed exhibited a bimodal pattern over the gait cycle, with distinct bursts in late swing (85% of gait cycle) and early stance (15% of gait cycle). The data suggest that hamstring load was ~26% higher during stance than swing at the fastest speed, which contradicts prior conclusions about hamstring function based on computational models[3].

The potential to track tendon tissue loads during dynamic movement represents an exciting advance with numerous applications that involve biomechanics and motor control. For example, wave speed data may provide a quantitative metric for diagnosing and monitoring recovery following soft tissue injuries. In addition, the tensiometers can potentially be used to provide biofeedback when retraining movements to alter tissue loads. Future work will focus on repackaging the tensiometers into self-contained wearable devices suitable for field-based measurements.

Acknowledgements: NSF GRFP (DGE-1256259), NIH (HD092697).
References: 1 Martin et al. Nat Commun. accepted; 2 Lenhart et al. Med Sci Sports Exerc. 2014; 3 Chumanov et al. Med Sci Sports Exerc. 2011.

Assessing and understanding forces in swimming.

J. Paulo Vilas-Boas, Faculty of Sport, CIFI2D and Porto Biomechanics Laboratory (LABIOMEP), University of Porto, Porto, Portugal

Well before Newton, scholars perceived the importance of understanding the reasons behind movement and the "cost" of moving. In Biomechanics it is now perfectly clear that both external and internal forces are crucial for the characterization of human motion, associated load and corresponding energy cost. Indeed, forces are central in human Biomechanics, either in Sports or in Clinical areas of study and application. To analyze and prescribe exercise in both domains is mandatory to know how external forces are produced, how they are acting, and how they are expressed as internal load. At the same time, it is decisive to progress on the understanding of how the human body deals with those loads. This means gaining insight about the interplay of external kinetics and the function of both the human force production organs – the muscles – and the mechanisms of motor control.

Water motion and exercise are relevant parts of both Sports and Clinical forms of human activity. Water sports, as swimming for example, and water clinical exercise, such as hydrotherapy, raise crucial and specific problems to the biomechanicists. Underwater specificity is largely determined by the characteristics of external forces generated by the fluid surrounding, raising special problems to the assured implementation of most of the popular and exciting developments for dryland biomechanics to the study of human motion in the water, such inverse dynamics.

Recently, our research group had the chance of coming up with the first outcomes of inverse dynamics for the analysis of water human exercise. To achieve this goal, we firstly developed competencies on measuring propulsive and drag forces in swimming, both experimentally and numerically, we improved the use of dual-media motion capture procedures, and we had to solve problems related to body geometry extraction and realistic computer animation in order to allow running computation flow dynamics (CFD) solutions, with moving mesh, to continuously access external forces applied to moving segments.

In this talk we will go briefly through our history on dealing with forces' and EMG assessment in swimming, onto the most recent outcomes on internal load estimation through inverse dynamics in the water, aiming to explore further developments on muscle function and load characterization at the near future.

Movement, coordination and their variability in sports skills monitoring: where we are and what is missing.

Dr. Ezio Preatoni, University of Bath, UK

Learning a motor skill means becoming consistent in accomplishing the desired goal and achieving mastery in the way it is obtained. Movement, coordination and their variability play a fundamental role in this context as a repeated movement always exhibits some degree of variation in how it is implemented over subsequent attempts. Even the outstanding athlete cannot eliminate this. Consistency in performance outcome may not necessarily be the result of an equally-consistent motor strategy; in fact, a lack of variability in movement execution has been associated with pathologies, injuries or reduced motor skills.

Improvements in sport performance or injury prevention often rely on changing small details in movement execution. However, these changes may be subtle and involve mutual relationships between different elements of the motor system, which conventional analyses may fail to thoroughly characterize. A number of new data analysis techniques (e.g. dynamical system methods) have become more and more popular over the last three decades. These approaches have looked at human movement in a more integral way, and have shown that variance in movement execution while repeating the same task is not, or not only, the product of error in movement organization. In fact, it could represent a form of flexibility in the neuro-musculo-skeletal system in response to ever changing performer, environment and/or task constraints.

The introduction of novel analytical methods always warrants an effort to identify advantages and disadvantages and to establish common standards. Reference values can allow inference of sound conclusions and the transfer of comprehensible information to practitioners' use on the field. This talk will address these issues, discuss existing and missing knowledge in the field, and give some practical examples applied to the sports biomechanics area.

Predictive models are most useful when they are wrong

Ross H. Miller, University of Maryland, USA

Predictive simulations in biomechanics find the muscle excitations that cause a computer model to move in a way that minimizes (or maximizes) a cost function, with no explicit tracking of experimental data. These simulations are often used to test theories of human motor control and behavior under the umbrella-theory of optimal control. Greater emphasis has historically been placed on the prediction of accurate results, i.e. results that resemble human experimental data well without explicitly tracking these data. While accurate predictions are impressive, this presentation will argue that there is more to learn from inaccurate predictions, such as when a model does not perform accurately with an unambiguous cost function, when a seemingly-intuitive cost function produces an inaccurate result, or when two seemingly-different cost functions produce similar results. With an accurate prediction, the source of the accuracy can be difficult to determine, e.g. if an accurate prediction was due to an accurate theory or merely to a coincidental combination of model design and cost function. With an inaccurate prediction, the user has an impetus to investigate the source of the inaccuracy, be it the model design, the cost function, or the overall framework, and in the process learn something about the control of the real human system. The speed of modern optimal control methods such as direct collocation allows for these topics to be investigated more deeply than was possible in even the recent past. These topics will be demonstrated using optimal control simulations of human locomotion, including the prediction of maximum sprinting speed, the effect of limb loss and muscle strength on the metabolic cost of walking, and the prediction of knee flexion in the stance phase of walking.

Neuromuscular control in clinical and athletic populations: science of past, present and future.

Dr. Angus Hunter, University of Stirling, UK

Motor unit recruitment strategies are thought to produce safe, economic contraction of skeletal muscle via the Central Nervous System (CNS) to protect muscle integrity and whole-body health[1]. Extensive studies by colleagues and ourselves have provided further knowledge surrounding motor unit recruitment strategies employed under different environmental and pathological conditions; 1) Subconcussion studies demonstrate cortico-spinal inhibition[2] and altered motor unit recruitment strategies[3]; 2) Multiple Sclerosis patients demonstrated reduced motor unit recruitment with increased muscle fibre conduction velocity (MFCV)[4]; 3) exercise induced hyperthermia resulted in reduced motor unit recruitment and preserved MFCV[5]; 4) eccentric overload revealed reduced firing rates of high threshold motor units[6]; 5) damaging eccentric exercise showed recovery of force coupled with higher threshold motor unit firing[7]. These novel studies have provided greater information regarding motor unit recruitment strategies but the mechanisms of brain function, via the CNS, remain elusive.

The rapid evolution of mobile cognition technologies such as mobile; EEG, EMG; electrogoniometry; and foot sensors measuring force pressure are now providing further opportunities to explore brain function in relation to neuromuscular recruitment strategies. The benefit of these technological advances in our understanding are, for the time being, limitless particularly as there is now increasing evidence of a mismatch between data obtained in the lab versus that in the field. Understandably this has significant implications for translation of lab studies into that of the clinical and sports performance areas. This provides a wealth of applications and opportunities for neuromuscular science of the future.

References: 1 Noakes et al. Br J Sports Med. 2005; 2 Di Virgilio et al. EBioMedicine. 2016; 3 Di Virgilio in preparation; 4 Scott et al. Clin Physiol Funct Imaging. 2011; 5 Hunter et al. J Electromyogr Kinesiol. 2011; 6 Balshaw et al. Physiol Rep. 2017; 7 Macgregor & Hunter PLOS ONE (in press).

A Novel Approach To Investigate Differences In Knee Mechanics After ACL Reconstruction Using Inertial Sensors.

Jasper Reenalda[1], Erik Maartens[1], Jaap Buurke[1], Mary Lloyd Ireland[2], Brian Noehren[2]. [1]Roessingh Research and Development, University of Twente, Enschede, Netherlands. [2]University of Kentucky, Lexington, KY

Hop testing after an Anterior Cruciate Ligament reconstruction (ACLR) is a common functional test to determine return to play status. However, hop tests are not very sport specific, as they do not capture other tasks in sports like accelerating, decelerating, cutting and turning. A figure 8 running task is proposed as an alternative, involving these sport specific movements. Knee mechanics during this task can be objectified using inertial sensors. These sensors have been used previously to objectify hop tests and showed differences in knee kinematics in ACLR patients. PURPOSE: To investigate sagittal knee mechanics in ACLR patients during a 5 minute figure 8 running task, using inertial magnetic measurement units (IMUs). METHODS: 5 ACLR patients (2M 3F, 20.4 ± 2.1 yrs, 164.2 ± 10.7 cm, 69.1 ± 23.5 kg) one year post ACLR, and 10 healthy controls (7M 3F, 21.8 ± 2.0 yrs, 178.3± 10.2 cm, 73.5± 14.3 kg) performed a 5 minute figure 8 running task wearing a lycra suit equipped with 8 IMUs at the feet, tibia, upper legs, sacrum and sternum. Sagittal knee mechanics were determined at the straights since this is the most standardized part of the figure 8. The absolute difference in peak knee flexion (ADPK) during stance phase was determined between reconstructed and healthy leg for the ACLR group and between both legs for the healthy (HLTH) population. An independent Mann-Whitney U-test was used to test for a statistical difference in ADPK between ACLR and HLTH. RESULTS: ADPK was significantly higher ($p < 0.05$) for the ACLR group versus the healthy population. CONCLUSIONS: Subjects who have had an ACLR have a larger difference in peak knee flexion between their reconstructed and healthy leg (less flexion in the reconstructed knee) at the straights of a figure 8 Running task compared to healthy controls. The figure 8 test might serve as a new test to determine return to play and to assess re-injury risk. Future research should test this and include (frontal plane) knee mechanics during cutting and turning.

Effects of Gait Modification on Lower Extremity Sagittal Plane Biomechanics

Oladipo Eddo[1], Bryndan Lindsey[1], Shane Caswell[1], David Hollinger[1], Jessica Pope[1], Matt Prebble[1], Ana M. Azevedo[2], Nelson Cortes[1]. [1]George Mason University, Manassas, VA. [2]University of Lisbon, Lisbon, Portugal.

Gait modification (GM) via real-time biofeedback (RTB) is a conservative intervention that has shown positive outcomes in post stroke and diabetic patients. Results from a recent systematic review support the effectiveness of this approach for increasing peak internal knee extension moment (iPKEM). iPKEM is a resistive moment to peak external knee flexion moment (ePKFM), which is associated with altered joint loading. Scarce information exists on the comparative effectiveness of existing GM strategies. PURPOSE: To compare the effectiveness of trunk lean (TL), medial knee thrust (MKT), and foot progression (FP) on iPKEM. METHODS: 10 healthy individuals volunteered for this study (28.4±3.8 years, 1.73±0.1 m, 75.3±12.5 kg). Mean and standard deviation (SD) for iPKEM, trunk angle, knee angle (KA), and foot angle during stance were calculated from 10 baseline trials using a motion capture system (200Hz) and force plates (1000Hz). 10 trials completed for each strategy using RTB so that joint angles fell within a determined range (1-5 SD) relative to baseline. Visual 3D (V3D) was used to project visual RTB as a line graph displaying real-time joint angle during stance. V3D was used to calculate joint angles (º) and internal moments (Nm/kgm). Participants modified their gait based on strategy so the line fell within a highlighted bandwidth representing target ranges. Repeated measures ANOVA was used to assess differences in iPKEM between strategies. Dependent t-tests were conducted to compare joint angles between baseline and modification strategy ($p<0.05$). RESULTS: A significant difference between strategies was attained for iPKEM ($p=0.001$). MKT (.53±.24) had higher iPKEM than all other strategies (Baseline: .31±.2, FP: .34±.12, TL: .31±1.4). No other statistically significant difference was found ($p>0.05$). CONCLUSION: MKT gait increased iPKEM despite no significant differences in KA compared to baseline. The observed increase in iPKEM during MKT gait suggests that participants were successful at attenuating ePKFM during the absorption phase of stance. Lack of significant changes in joint angles across conditions suggests that overall gait kinematics were similar for all conditions. Future research employing greater values for kinematic change is needed to further understand the effect of GM on iPKEM.

NOTES

MOTOR CONTROL

A WORKING GROUP OF ISB

www.mcg.isbweb.org