2020

LOGEMAS

ANZSB

REGIONAL ABC - BRISBANE
AUSTRALIAN AND NEW ZEALAND
SOCIETY OF BIOMECHANICS

DECEMBER 3RD - 13 HUDSON ROAD

PROGRAM:

10:00-10:25AM	Coffee and Welcome	
10:25-10:30AM	Introduction	
10:30-11:30AM [SESSION 1] *(10+5 min presentations)*	10:30-10:45 - Basilio Goncalves (Griffith)	Changes in joint mechanics following repeated sprinting
	10:45-11:00 - Robert Shuster (UQ)	Establishing the relationship between foot form and function
	11:00-11:15 - Marco Giuseppe Branni (QUT)	Determining bone mechanical anisotropy in human femurs: image-based vs. micro-FE method
	11:15-11:30 - Evy Meinders (Griffith)	The deep hip stabilisers do not stabilise
11:30-12:30PM [SESSION 2]	Prof Peter Pinvonka & Dr Ashish Gupta	Towards patient specific Joint Biomechanics
12:30-1:30PM	Lunch	
1:30-2:30PM [SESSION 3] *(10+5 min presentations)*	1:30-1:45 - Edmund Pickering (QUT)	The missing link in Frost's mechanostat: Local strain and cortical adaptation in the mouse tibia
	1:45-2:00 - Patricio Pincheira (UQ)	Hamstrings muscle fascicle and sarcomere adaptations subsequent to eccentric exercise
	2:00-2:15 - Antonio Padilha Lanari Bo (UQ)	Design of FES control strategies for physical exercise using Opensim
	2:15-2:30 - Claudio Pizzolato (Griffith)	Neuromusculoskeletal model-based neurorehabilitation after spinal cord injury
2:30-3:00PM	Afternoon Coffee	
3:00-4:20PM [SESSION 4] *(5+2 min presentations)*	Corey Miller (QUT)	Development of a Simulation Platform for Cortical Bone Adaptation to Mechanical Loading in the Mouse Tibia Model
	James Williamson (UQ)	Passive Ankle Exoskeletons Influence Soleus Fascicle Dynamics During Unexpected Vertical Perturbations.
	Laura Hutchinson (UQ)	Shear wave tensiometry and the iliotibial band
	Maxence Lavaill (QUT)	An MRI-based musculoskeletal simulation framework for modelling shoulder kinematics and dynamics
	Eric Su (UQ)	Does the catch mechanism help us jump higher? An OpenSim simulation approach
	Alistair Quinn (Griffith)	Using digital twin in a two-step process of robotic manipulator control for orthopaedic applications
	Nikki Kelp (UQ)	Neuromechanical Determinants of Muscle Shape Change and Gearing
	Tamara Grant (Griffith)	Do hip biomechanics differ between surgical and conservative management of FAI syndrome?
	Ross Smith (UQ)	Energetic contributions of the foot and its muscles to deceleration
	Nataliya Perevoshchikova (QUT)	Image based 3D finite element modelling to investigate wrist ligament scaffold mechanics in the wrist
4:20-4:30PM	Closing remarks and Award Presentations	
4:30PM- evening	Social Event	

Queensland Regional ANZSB Conference 2020 – Abstracts

Changes in joint mechanics following repeated sprinting
Basilio Goncalves
(Griffith University)

To succeed in their respective sports, athletes often depend on their ability to sprint repeatedly. In this study we demonstrate a redistribution of work done by the sagittal hip and knee but not ankle joint moments following a repeated running protocol. The results suggest strategies to maintain sprint performance should focus on maintaining positive work done by hip extensors and negative work done by knee flexors during swing phase of running.

Establishing the relationship between foot form and function
Robert Shuster (University of Queensland)

Modern human feet are said to be unique, despite displaying a great deal of variation in both their external shape as well as their mechanical function. Based on this diversity, certain foot shape variations have been proposed to exhibit specific mechanical characteristics. However, accurately analysing the complex 3D external shapes of feet has only recently viable through advances in 3D scanning technology and statistical shape analysis. Combining these promising methods with classical biomechanical analyses of function may help to establish a more accurate relationship between foot shape and function.

Determining bone mechanical anisotropy in human femurs: image-based vs. micro-FE method
Marco Giuseppe Branni (QUT)

Cross-laboratory analyses shown variable accuracy across different finite-element (FE) models. Most protocols adopt isotropic material characterizations due to its simplicity. However, bone is recognized as an anisotropic material. This study aims to compare bone anisotropy determined using image-based method against corresponding micro-FE analysis. A total of 115 trabecular cubes were virtually extracted from micro-CT images of human femurs. Morphology and micro-FE analysis were investigated to determine anisotropic material constants. Preliminary results reveal a strong coefficient of determination between the two methods for cubes with bone volume fraction (BV/TV) of 10-40%. However, marked discrepancies are shown for lower values of BV/TV.

The deep hip stabilisers do not stabilise
Evy Meinders (Griffith University)

The deep hip muscles have long been considered hip stabilisers based on their line of action, however it remains unclear whether they can generate enough force to stabilise the hip. We defined hip stability as hip stiffness, calculated using an EMG-assisted neuromusculoskeletal model. Hip stiffness is compared between three model configurations: no deep hip muscles, deep hip muscles included and driven by EMG measurements, and deep hip muscles included and imposed by maximal activation. Preliminary results suggest that deep hip muscles are unlikely to contribute to hip stability and have only limited potential to increase hip stability under maximal activation.

Towards patient specific Joint Biomechanics
Prof Peter Pinvonka and Dr Ashish Gupta

In this session, we will hear from Prof Peter Pivonka (current ANZSB President, and Deputy Director of the ARC ITTC) who will be joined by Dr Ashish Gupta (Sub specialist Shoulder Surgeon and ARC ITTC Clinical Director). Abstract: The Industrial Transformation and Trainings Centre for Joint Biomechanics (ITTC-JB) is an Australian Research Council (ARC) funded research and trainings centre. The ITTC-JB is a multi-institutional collaboration between Queensland University of Technology (QUT), the University of Queensland (UQ), the University of New South Wales (UNSW), University of Stuttgart (Germany) and the University of Malaga (Spain) together with industry partners including Wright Medical, Zimmer Biomet, Materialise and Logemas. The ITTC-JB has officially commenced in August 2020 and is now operational. However, due to COVID many of the PhD and postdoctoral fellow positions still require recruiting. In this presentation I will provide an overview of the centre's four trainings/research pillars which encompass in-silico computational modeling, robotic simulators, tissue engineering and rehabilitation aspects of shoulder biomechanics. The clinical relevance of the programs is tightly linked to the guidance by our surgical directors. The vision of our centre is to serve as a nucleation point for biomechanists across QLD and engage in collaborative research for the future. Ashish is the founding Director of QUASR (Queensland Unit for Advanced Shoulder Research) and will discuss the 'Bridge between the Biomechanist and the Patient'. Peter will end the presentation with a brief overview of some of his current research projects on the mechanobiology of bone which feed into implant design, stress shielding and implant loosing.

The missing link in Frost's mechanostat: Local strain and cortical adaptation in the mouse tibia
Edmund Pickering (QUT)

Frost's mechanostat predicts a direct link between local strain and cortical bone adaption. However, may studies on bone adaption do not directly test this. Rather, most studies investigate the effect of total load (instead of local strain) and consider broad adaptive metrics (e.g. bone volume change, area change). Neither of these allow for direct testing of Frost's mechanostat. In this work we couple local strain predictions with an automatic cortical thickness change measurement technique (i.e. a local adaption metric). This allows us to directly explore the link between local strain and the adaptive response in the mouse tibia compression model.

Hamstrings muscle fascicle and sarcomere adaptations subsequent to eccentric exercise
Patricio Pincheira (University of Queensland)

In this study, we measured in vivo fascicle and sarcomere lengths in the human Biceps femoris long head (BFlh) before and after an eccentric training intervention. Three weeks of Nordic hamstring exercise led to an increase in both fascicle length and sarcomere length in the distal portion of the BFlh. However, no changes in sarcomere number were found. These findings provide new information about the early architectural adaptations of the hamstring muscles due to eccentric training.

Design of FES control strategies for physical exercise using Opensim
Antonio Padilha Lanari Bo (University of Queensland)

The design of controllers for active wearable devices may be time-consuming and risky. In this work, we have employed Opensim and Matlab to accelerate the prototyping of new control strategies for wearable assistive technology. In particular, we focus on systems to enable persons with spinal cord injury to practice physical exercise by means of electrical stimulation. Preliminary results include a comparison of performance in three exercises (cycling, rowing, and walking) and different conditions (varying mechanical load, muscle fatigue, assistance by passive and active orthoses, and others).

Neuromusculoskeletal model-based neurorehabilitation after spinal cord injury.
Claudio Pizzolato (Griffith University)

Efficacious multimodal therapies to restore function in people with chronic spinal cord injuries are becoming a reality. These include multiple stimulation (e.g., rehabilitation robotics and electrical stimulation) and sensor devices (e.g., EMG/EEG) that need to be appropriately orchestrated to maximize likelihood of motor and sensory restoration. In this presentation I will discuss the current evidence supporting these therapeutic approaches, and how neuromusculoskeletal modelling can be used to generate subject-specific rehabilitation paradigms.

Development of a Simulation Platform for Cortical Bone Adaptation to Mechanical Loading in the Mouse Tibia Model
Corey Miller (QUT)

Bones are known to adapt their form to changes in mechanical loading. Long bones are known to act mechanically like beams; bone's adaptation response can therefore be simulated by combining beam theory with bone cross-sectional properties taken from uCT imaging. Using this computationally efficient method allows for investigation and exploration of the effects of adaptation parameters such as input stimuli and formation response functions. Preliminary results of the simulation on mouse tibia uCT images are promising, with a gradient formation response to longitudinal strain providing qualitatively similar results to those found experimentally. This simulation will be further expanded on in future work, where it will be combined with a cell population model to provide a more realistic representation of bone adaptation.

Passive Ankle Exoskeletons Influence Soleus Fascicle Dynamics During Unexpected Vertical Perturbations.
James Williamson (University of Queensland)

The behaviour with which lower limbs store and return energy during steady gait has inspired the design of passive wearable assistive devices to aid walking (Collins et al., 2015), running (Nasiri et al., 2018) and hopping (Farris et al., 2013). However, we lack an understanding of how devices influence movement and neuromuscular function during tasks whereby energy must be generated or dissipated (i.e. an unexpected drop, uneven terrain or variable walking speeds). This incomplete understanding, regarding how the human body responds to exoskeleton assistance during variable gait conditions has limited our ability to improve wearable assistive technologies to be used in real-life scenarios.

Shear wave tensiometry and the iliotibial band
Laura Hutchinson (University of Queensland)

The human body has evolved many unique musculoskeletal specializations to enable bipedalism. Many of the adaptations (like a highly compliant Achilles tendon) have received much attention, the iliotibial band (ITB) however, has not. What role does this unique evolutionary adaptation have in locomotion? To understand this, we have spent a great deal of time looking at the technology required to do so. Using shear wave tensiometry our work aims to isolate and determine the function of the in-series musculature as they relate to force transmission in the ITB. This talk will focus on the methodology of adapting shear wave tensiometry for use in the ITB.

An MRI-based musculoskeletal simulation framework for modelling shoulder kinematics and dynamics
Maxence Lavaill (QUT)

Shoulder musculoskeletal models can provide insights into understanding shoulder muscle and joint function. Generic musculoskeletal models are commonly scaled to anthropometric measurements hence accounting for size differences. However, the skeletal geometry varies in a complex 3D manner. This work studies the differences between scaled-generic and MR-based models on joint angles and moments in a selected participant. Error between experimental and modelled markers appears lower with the MRI-based model and range of motion differs significantly between both models using the same inputs. Further experimental data and modelling analyses will be processed shortly.

Does catch mechanism help us jump higher?
Eric Su (University of Queensland)

Tendon elastic energy return have been thought to enhance human's work and power output. In our two-segment one-muscle model, we showed that increasing elastic energy storage and return via an external stop (physical catch mechanism) and accentuated eccentric loading (dynamic catch mechanism) does not improve muscle work and jump height. Therefore, the contribution of tendon's elastic energy recoil might not be effective in the single muscle. More complicated multi-segment, multi-muscle simulation is still needed to examine the potential role of tendon elastic recoil during a "human-like" jumping motion.

Using digital twin in a two-step process of robotic manipulator control for orthopaedic applications
Alistair Quinn (Griffith University)

Robotic manipulators are valuable orthopaedic research tools providing control, reliability, and (potentially) force generation exceeding human capacity. However, robust control systems are required to generate predictable motion and/or loading. Physics-based models (i.e., digital twins) are used in many engineering fields and help us understand system states, particularly when system linearization is intractable. We aimed to develop and validate a novel method for controlling a 6 degree-of-freedom robotic manipulator. We present a two-step calibration process whereby robot digital twin and control parameters governing the robotic are sequentially optimized, such that a simulation of an experiment well tracks the corresponding physical experiment. Further to this, the computational framework has been developed to operate in real-time, enabling optoelectric or inertial systems to assist control of motion, and software was written to enable extension to novel objects of interest (e.g., hand-wrist).

Neuromechanical Determinants of Muscle Shape Change and Gearing
Nikki Kelp (University of Queensland)

Muscle shape changes during a contraction extend the functional range of skeletal muscle by allowing the individual muscle fibres to shorten at different velocities than the whole muscle- a process defined as gearing. We aim to better understand the mechanisms underpinning in vivo shape change during submaximal contractions in synergistic muscle groups. Initial results suggest an interplay between the bulging of the Medial and Lateral Gastrocnemii, paving way to exciting avenues of research aimed at understanding how external constraints (ie. surrounding muscles) and internal constraints (ie. connective tissue properties and contractile forces) influence muscle shape change and gearing.

Do hip biomechanics differ between surgical and conservative management of FAI syndrome?
Tamara Grant (Griffith University)

Femoroacetabular impingement syndrome (FAIS) is a motion-related clinical disorder, whereby premature contact between acetabulum and femoral head/neck produces pain. FAIS has been associated with hip osteoarthritis development. Effective treatment may reduce symptoms and risk for osteoarthritis development. Common treatments include arthroscopic hip surgery, and conservative care (i.e., physiotherapy). However, after surgery, muscle activation and gait patterns are not restored to normal, and the comparative effect of different treatments on external biomechanics is unknown. Here, the effects of arthroscopic hip surgery and physiotherapy-led care between baseline measurements and 1months follow-up will be discussed.

Energetic contributions of the foot and its muscles to deceleration
Ross Smith (University of Queensland)

We examined the role of the foot (via Unified Deformable Segment model) and its muscles (via nerve block) in energy absorption/dissipation during landing. We found that at higher landing heights, the foot absorbed more energy, and its contribution to COM work remained constant (~11-16%). Without active contributions from foot muscles, the foot's energy absorption decreased (~3%). These novel results expand our understanding of human locomotion, and may inform future designs for exoskeletons and/or prosthetics.

Image based 3D finite element modelling to investigate wrist ligament scaffold mechanics in the wrist
Nataliya Perevoshchikova (QUT)

The wrist joint is a complex biomechanical structure. The bones of the wrist are interconnected by intrinsic and extrinsic ligaments forming at least 18 articulating surfaces. Among the carpal bones, the scaphoid and lunate are bound together by the strong scapholunate interosseous ligament (SLIL). The SLIL has a complex C-shaped structure. Anatomically, it can be divided into three distinct parts: dorsal; volar; and proximal each with different anisotropic mechanical properties. The dorsal part of the SLIL is the strongest and the primary stabiliser of scapholunate joint. Rupture of the SLIL is a common cause of dislocation of scaphoid and lunate bones and severely impairs wrist function. Typically, SLIL rupture is surgically treated. Overall, the aim of current surgical therapies for SLIL rupture is to restore wrist stability. A novel multiphasic bone-ligament-bone (BLB) scaffold 3D-printed of medical grade polycaprolactone (PCL) material is developed for the reconstruction of the dorsal part of the SLIL. This study focuses on the optimisation of the design of a scaffold to match the patient's anatomy that in turn stabilize the scapholunate joint and support regeneration of the ruptured SLIL. The construct surgical sites, number of fibers and their diameter together with length should ensure that during physiological wrist motions the scaffold stress is always less than the failure stress. Complex physiological wrist motions were combined with accurate scaffold material properties; feasible surgical installation sites and ranged of scaffold's lengths, used to compute the scaffold's stress using finite element analysis. In the current study a wrist motion was acquired using state-of-the-art dynamic medical imaging: tri-planar videoradiography that replicate realistic wrist motions (dynamic kinematics).