13th Annual CCTS Spring Conference
Friday, April 13, 2018 Lexington Convention Center

College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title: **A Possible Link between R-wave Amplitude Alternans and T-wave Alternans to Improve Positive Predictive Value of Arrhythmia Risk**

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Abstract: Alternans of the T wave in the ECG (TWA) has been widely investigated as a potential predictor of ventricular arrhythmia. Large clinical trials show a very high negative predictive value for TWA, but with a low positive predictive value. The link between TWA and arrhythmia is considered to be functional conduction block that results from increasing amplitude oscillations of repolarization duration, i.e. alternans of action potential durations (APD). Alternans of APD causes TWA in the ECG. However, some subsequent studies show that rather than alternans of APD, spatial discord in alternans of APD may be a better indicator of block and subsequent arrhythmia. Prior studies from our group showed that alternans of the rate of depolarization of an action potential also can occur when APD alternans occurs and the relationship between the two alternans has the potential to affect formation of spatial discord. These results suggest that exploration of the co-occurrence of the alternans of depolarization and repolarization phase has the potential to stratify the outcome of TWA tests. Using mathematical models, we observed that alternans of rate of depolarization can manifest in ECG as alternans of the R wave amplitude. In consideration of these studies, our overall objective is to explore the use of R Wave Amplitude Alternan (RWAA) as a complement to the TWA in order to improve positive predictive value of arrhythmia risk. The specific aim of this study is to verify the existence of R wave amplitude alternans in clinical grade ECGs.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**Trunk muscle forces and spinal loads in persons with unilateral transfemoral amputation during sit-to-stand and stand-to-sit activities**
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Abstract: Alterations and asymmetries in trunk motions during activities of daily living are suggested to cause higher spinal loads in persons with unilateral lower limb amputation (LLA). Given the repetitive nature of most activities of daily living, knowledge of the amount of increase in spinal loads among persons with LLA is important for designing interventions aimed at prevention of secondary low back pain due to potential fatigue failure of spinal tissues. The objective of this study was to determine differences in trunk muscle forces and spinal loads between persons with and without LLA when performing a common activity of daily living, sit-to-stand and stand-to-sit tasks. Three-dimensional kinematics of pelvis and thorax, obtained from ten males with unilateral (transfemoral) LLA and 10 male uninjured controls when performing five repetitions of sit-to-stand and stand-to-sit activities, were used within a non-linear finite element model of the spine to estimate trunk muscle forces and resultant spinal loads. The peak compression force, medio-lateral (only during stand-to-sit), and antero-posterior shear forces were respectively 348N, 269N, and 217N larger in person with vs. without LLA. Persons with LLA also experienced on average 171N and 53N larger mean compression force and medio-lateral shear force, respectively. The spinal loads for both groups were generally smaller than the reported threshold of spinal tissues injury. However, tasks like sit-to-stand and stand-to-sit, with a peak compression force of ~ 2.6kN in persons with LLA, if performed following a highly repetitive activity like walking will impose >50% risk of fatigue failure for spinal tissues.

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13th Annual CCTS Spring Conference
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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title: **Developing a Multi-scale Finite Element Model of Myocardial Contraction**

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Abstract: The finite element method is a powerful tool that is becoming increasingly popular at modeling cardiovascular materials and system under stress. Understanding the behavior of a healthy heart is crucial to be able to move forward and develop predictive models for any of the numerous ways the heart can fail. The goal of the current ongoing study is to incorporate a novel systolic contraction model into a 3D nonlinear finite element code of the left ventricle. This new contraction model aims to provide a multi-scale model by capturing cellular level mechanisms of cross-bridge cycling and inter-filamentary movement. Specifically, this model expands on our current active contraction model by incorporating a novel low-energy detached state for myosin heads. The transition from this state into a detached state that can interact with binding sites includes force-dependence. The addition of this state in previous work has been shown to reproduce length-dependent activation of muscle fibers on the cellular level (K. S. Campbell). To validate this approach, an optimization of contractile parameters is being performed using experimentally obtained ventricular geometry and pressure profiles from five healthy rats. The model predicted end systolic strains and circumferential-longitudinal shear angles will then be compared to those obtained via magnetic resonance imaging data of the same five rats. This model could capture length-dependent activation of myocytes and in turn more accurately capture phenomena seen in the heart, such as the Frank-Starling mechanism. The results to be presented are preliminary as the optimizations are still ongoing.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**The Effect of Sucrose on Streptococcus Mutans' Adhesion to Titanium via Stress-wave Loading**
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Abstract: Current treatments are inefficient at eradicating biofilm-forming infections associated with implants in part because these biofilms remain well-adhered to the implant surface. Modern techniques for measuring biofilm adhesion associate the level of adhesion with bacterial count, or fail to measure macro-scale strength of bacterial biofilm-implant adhesion. The laser spallation technique has been adapted to compare the macro-scale adhesion strength of biofilms formed on titanium, the industry standard for dental implants. Oral biofilms composed of Streptococcus mutans were used for its association with human dental caries. Biofilms were cultured directly onto commercially pure titanium within our custom substrate assembly. Todd Hewitt Yeast broth, with varying sucrose concentrations, was used in order to obtain the effect sucrose has on biofilm adhesion. Each biofilm was loaded at multiple locations with increasing loading pressure waves. Amplitude of the loading pressure wave was controlled by adjusting laser fluence. As sucrose was initially added to the media, the adhesion of the biofilm monotonically increased, before reaching a saturation point at a sucrose concentration of 75 mM, resulting in a monotonically decreasing biofilm adhesion measurement. The laser spallation technique has been used previously to measure the adhesion of several different thin film-on-substrate systems. This study is the first to measure biofilm-substrate adhesion. This initial study shows promise for the further study of many other biofilm-surface adhesion studies. Future work in this area looks towards correlating the complex relationship between bacteria species and different surface characteristics and how this relationship impacts biofilm adhesion.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**Non-invasive Characterization of Sleep Architecture in an Animal Model of Alzheimer's Disease**
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Abstract: Alzheimer's disease (AD) is a neurological condition in which patients experience progressive changes in personality and deficits in memory and cognitive function. While sleep disturbances accompanying AD were once thought to be solely a consequence of the disease, there is accumulating evidence suggesting that disordered sleep could actually accelerate AD progression, warranting further research. Tracking sleep in preclinical models requires surgical implantation of sensors for electroencephalogram (EEG) and electromyogram (EMG) measurement and manual scoring of these data – tedious procedures that are not feasible for high-throughput, longitudinal studies. In the present study, we investigate the ability of a non-invasive piezoelectric motion sensor to differentiate sleep and waking states in wild-type and AD animals, and the feasibility of using it to identify AD-related differences in sleep compared to experimental controls. Six C57BL/6 and five 5XFAD mice, instrumented with EEG/EMG headmounts, were monitored for 24 hours each. Manual scoring of the EEG/EMG revealed significant changes in sleep architecture between the two groups, especially during the light-off period. The piezoelectric sensor signal was recorded in parallel with EEG/EMG, and its features used to build an unsupervised hidden Markov model to quantify sleep-wake state dynamics. The significant differences seen between sleep metrics derived from EEG/EMG scores of AD and control data were mirrored by the piezo-modelled data, with strong agreement between manual and automated scores (Kappa: 0.78-0.85). Overall, this system provides a means to automatically identify and track changes in sleep accompanying AD, alleviating the need for extensive experience and resources to perform sleep research.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title: **A wearable optical sensor for continuous monitoring of cerebral blood flow in mice**

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Abstract: Continuous and longitudinal monitoring of cerebral blood flow (CBF) in animal models provides information for studying fundamental mechanisms and interventions of versatile brain diseases such as ischemic stroke, traumatic brain injury and brain cancer. Since anesthesia may affect brain hemodynamics/function, researchers are seeking wearable devices which can be installed on the head of conscious animals. We present a wearable ultra-small diffuse speckle contrast flowmeter (DSCF) sensor enabling noninvasive and continuous measurement of CBF in the mouse brain (up to 8 mm depth). The DSCF sensor consists of a small laser diode and an ultra-small CMOS camera chip, which are glued on a mouse head. The movement of red blood cells in the brain (i.e., CBF) produces continuous fluctuations of laser speckles, which are captured by the CMOS camera. Measurements of CBF variations in mice during transient ipsilateral arterial occlusions or forepaw electrical stimulations by our DSCF sensor are compared to standard laser Doppler flowmetry (LDF) and diffuse correlation spectroscopy (DCS), respectively. Significant correlations ($R2 > 0.77$, $p < 10\text{-}5$) and excellent linear relationships are observed among these measurements. Compared to conventional LDF and DCS sensors which commonly use rigid optical fibers for light delivery and detection, our DSCF sensor can be placed directly on the tissue surface without using any optical fiber. The connections between the DSCF sensor and a control unit are all flexible electrical wires/cables, which offer the potential for continuous monitoring of CBF variations in freely moving conscious rodents.

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College of Engineering Biomedical Research Day

Poster Presentation #265

Abstract Title:	**Seizure Prediction with Autonomic Measurements versus Intracranial EEG in Patients with Refractory Epilepsy**
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Abstract: There is resurgent interest in the role played by autonomic dysfunction in seizure generation. Advances in wearable sensors make it convenient to track many autonomic variables in patient populations. The purpose of this study is to assess peri-ictal changes in surrogate measures of autonomic activity in epilepsy patients. Three patients admitted for invasive presurgical evaluation using intracranial EEG (iEEG) were monitored. Additional sensors for fronto-central EEG, EKG and submental EMG were applied and variables relevant to autonomic function (AV), specifically electrodermal activity, heart rate, blood volume pulse and skin temperature measured by a wrist-worn device. The mean of each AV was computed in 5-second epochs. Several one hour-long interictal and preictal segments were extracted for analysis. Sleep and wake data were verified using video-EEG and analyzed separately. Several electrophysiological variables (EV) were estimated in 5-second epochs from the iEEG in the seizure onset zone, and a naïve Bayes classifier was trained on these features and tested using five-fold cross-validation to determine whether preictal and interictal sleep (or wake) epochs could be distinguished from each other using AV or EV features. Of 16 EV features, beta power, gamma power, line length, and Teager energy were sometimes significantly different for preictal and interictal sleep (or wake) data in each patient ($p < 0.001$). Using AV features, the classifier labeled preictal sleep epochs with 84% sensitivity, 79% specificity, and 64% kappa; and 78%, 80% and 55% respectively for preictal wake epochs. Using EV, the classifier labeled preictal sleep epochs with 69% sensitivity, 64% specificity, and 33% kappa; and 15%, 93% and 10% respectively for preictal wake epochs. This result suggests that autonomic measurements, which can be conveniently measured using noninvasive devices, have some predictive value for epileptic seizures in certain individuals.

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College of Engineering Biomedical Research Day

Poster Presentation #266

Abstract Title:	**Intraoperative imaging of blood flow distributions in mastectomy skin flaps using speckle contrast diffuse correlation tomography**
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Abstract: Flap necrosis is the most common complication after tissue transfer and following mastectomy. Knowledge of flap blood flow level and variation during surgery may enable predicting necrosis and failure of flaps. A novel noncontact CCD-based speckle contrast diffuse correlation tomography (scDCT) was recently developed in our laboratory for 3D imaging of tissue blood flow distribution. This system has been recently modified to obtain both surface geometry information via photometric stereo technique and boundary blood flow data via speckle contrast measurement using a single CCD camera. Specifically, four 2D images obtained from the camera perspective with four different illuminations provided by four LEDs are used to obtain the surface geometry. The extended scDCT system was first used to image forearm blood flow responses to a cuff-occlusion paradigm for validation. Spatially heterogeneous response in blood flow distribution was observed in the forearm, which agreed with the expectation of physiological change due to the occlusion. The scDCT instrument was then moved to the surgical room for intraoperative imaging of mastectomy with the goal of predicting the area/volume of mastectomy skin flap necrosis for resection. Nine patients were imaged and large spatial variations in blood flow distributions were observed in these patients. This study demonstrates the feasibility and safety of our novel noncontact imaging modality for intraoperative monitoring blood flow distributions and variations. Since none of these patients had mastectomy skin flap necrosis, more patients are being measured to verify the capability of scDCT imaging for intraoperative prediction of mastectomy skin flap necrosis area/volume.

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College of Engineering Biomedical Research Day

Poster Presentation #267

Abstract Title: **Effects of Spinal Fusion Surgery on Lumbo-pelvic Coordination**

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Abstract: Abnormalities in lumbo-pelvic coordination play a role in occurrence/recurrence of low back pain (LBP). The lumbo-pelvic coordination before spinal fusion surgery and its changes following the surgery are not understood. A repeated measure study was designed to investigate timing and magnitude aspects of lumbo-pelvic coordination in a group of patients (n = 5) with LBP before and after a spinal fusion surgery. Participants completed a forward bending and backward return task at their preferred pace in the sagittal plane. The ranges of thoracic and pelvic rotations and lumbar flexion (as the magnitude aspects of lumbo-pelvic coordination) as well as the mean absolute relative phase (MARP) and deviation phase (DP) between thoracic and pelvic rotations (as the timing aspects) were calculated. Thoracic, pelvic, and lumbar rotations/flexion were respectively 3.4° larger, 16.7° larger, and 13.3° smaller after the surgery. Also, MARP and DP were smaller during both bending (MARP: 0.049; DP 0.041) and return (MARP: 0.078; DP: 0.019) phases of the motion after surgery. The alterations in lumbo-pelvic coordination after surgery can be the result of changes in lumbar spine structure due to vertebral fusion and/or new neuromuscular adaptations in response to the changes of lumbar spine structure. The effects of altered lumbo-pelvic coordination on load sharing between passive and active components of lower back tissues and the resultant spinal loads should be further investigated in patients with spinal fusion surgery.

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College of Engineering Biomedical Research Day

Poster Presentation #268

Abstract Title:	**Dynamic Sleep Modulation in Mice through Ambient Temperature Control**
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Abstract: Sleep disorders are increasingly common and can negatively impact human health. Understanding sleep-thermoregulation interactions could lead to novel strategies for the treatment of disordered sleep. As a first step toward this goal, we characterized ambient temperature (Ta) effects on mouse sleep, and then dynamically altered Ta to manipulate sleep quality. Following IACUC approval, ten C57BL/6 mice were instrumented for EEG/EMG monitoring. In “static” experiments, Ta was elevated from the baseline (~21-23C) to 27, 30, and 33°C from 11 a.m.–5 p.m. on different days. Vigilance state was scored manually from the EEG in 4-sec epochs as Wake, REM, or NREM. Mice exposed to elevated Ta spent more time in NREM and REM and less in Wake ($p < 0.05$). Following static trials, three dynamic strategies were investigated: 1. Ta was manipulated to force the proportion of sleep time to approach a target value (n=2); 2. Ta was manipulated to enhance sleep depth based on the error between Q, the instantaneous EEG delta/theta bandpower ratio, and a preset target value of Q typical of deep sleep (n=2); and 3. The setpoint for Q was programmed to exponentially decay (30?min) and then grow (60?min) in cycles to approach values typical of Wake and NREM respectively, to see if the timing of the ultradian sleep-wake cycle could be controlled (n?=?7). With sleep modulation, mice had more REM and deep sleep, states that are less likely to foster seizures in epilepsy patients. To further investigate this possibility, Ta effects were assessed in epileptic mice (n=4). Results showed that elevated Ta promotes sleep. Thus, active manipulation of Ta may serve as an adjunctive therapy for seizure control.

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College of Engineering Biomedical Research Day

Poster Presentation #269

Abstract Title: **Noncontact Imaging of Flow and Fluorescence Contrasts**

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Abstract: Our lab recently integrated nonconctact speckle contrast diffuse correlation tomography (nc_scDCT) and diffuse fluorescence tomography (DFT) techniques into a single noncontact reflectance-mode multimodal instrument for imaging of 3D flow and fluorescence contrasts in deep tissues. This multi-parameter data set is made available with a shared framework and operation enabling simplified data acquisition and analysis. A galvo-mirror enables directing polarized light to a tissue-like phantom surface. Reemitted light passes through a filter and cross polarizer for collection by CCD camera. To evaluate the system, a solid phantom cube (flow contrast) and liquid-filled tube (fluorescence and absorption contrasts) were submerged in a liquid phantom background. Stepwise increases in the tube indocyanine green (ICG) concentrations ranged from 0.0625 to 4 ?M in doubling fashion. The tube shape, orientation, and localization were recovered in general agreement with actuality by measured fluorescence and absorption. Relative fluorescence changes neared expected values with large deviations at the highest concentrations. The flow heterogeneity localization was successfully extracted and its average relative flow values in agreement with previous studies. Increasing ICG concentrations induced notable disturbances in the tube region (? 0.25/1 ?M for 785/830 nm) suggesting the graduating absorption (340% increase at 785 nm) introduced errors. We observe that 830 nm is lower in the ICG absorption spectrum and the correspondingly measured flow encountered less influence than 785 nm. We conclude then that the instrument proved successful with the recommendation of using a flow laser source in the low ICG absorption range in practice.

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13th Annual CCTS Spring Conference
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College of Engineering Biomedical Research Day

Poster Presentation #270

Abstract Title: **Diurnal Changes of Lumbo-Pelvic Coordination: Sedentary vs. Active Nurses**

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Abstract: Prevalence of low back (LBP) among nurses is ~ 60% higher than that of the average worker in the United States. Abnormalities in lower back mechanics can impose excessive stress and strain on lower back tissues leading to development of LBP. Such abnormalities can be due to accumulated diurnal changes (i.e., net disturbance and recovery) of lower back mechanics experienced by nurses during their workdays. It is, however, unclear how/if differences in nursing activities impact the diurnal changes of lower back mechanics. The objective of this study is to determine the effects of nursing activities on lower back mechanics via measures of lumbo-pelvic coordination during activities of daily living. Forty-eight nurses between 20-60 years old with two different levels of nursing activities (i.e., sedentary vs. active nurses) are planned to be recruited from the University of Kentucky Health Care system. The nurses will complete two data collection sessions (i.e., before and after their work shifts) including trunk forward bending and backward return, conducted at preferred and fast paces, as well as manual material handling tasks. Thoracic and pelvic rotations will continuously be recorded using wireless inertial measurement units and magnitude and timing aspects of lumbo-pelvic coordination will be analyzed and compared between sedentary and active nurses using statistical models. We expect to observe distinct differences in diurnal changes of lumbo-pelvic coordination between sedentary and active nurses and, therefore, different levels of risk for long-term abnormalities in lower back mechanics. Some preliminary results will be reported during the Biomedical Research Day.

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College of Engineering Biomedical Research Day

Poster Presentation #271

Abstract Title:	**Cardiac-synchronized EEG: The Effects of Tempo and Cognition of Songs using Eigenvalue Analysis of Covariance Matrix**
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Abstract: It is over 150 years that the intimate interaction between the heart and the brain was realized by Claude Bernard, and of all the organs in the human body, the heart is among the ones that have the most extensive neural connection with the brain. So considering the cardiac cycle in analyzing EEG could be useful and it may show the changes in neural oscillations triggered by internal or external stimuli differently. In this study, we introduced the idea of using cardiac-synchronized EEG to investigate the effects of tempo and cognition of auditory stimuli. For evaluating the effects of tempo, two songs of slow and fast tempo were chosen, and for cognition factor, the subjects' favorite song was presented. For cardiac synchronization, the ECG was used, and the EEGs correspond to last 300-millisecond segment of cardiac cycles were considered. Six EEGs were recorded form two spots in each of frontal, temporal and parietal lobes. The eigenvalue analysis of covariance matrix of 14-subject synchronized EEG to the end of cardiac cycle showed that, P3 has better ability of discriminating between songs. All the songs lowered the second and the third biggest eigenvalues compared to control among which the slow tempo song induced more significant changes in T3, T4 and P3. Also, in slow song, all six EEGs could be presented in the lowest number of eigenvalues if they were representing 80% of total sum of all eigenvalues and in the subjects' favorite song this number was the highest.

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College of Engineering Biomedical Research Day

Poster Presentation #272

Abstract Title:	**Recovery of Hand Function in Spinal Cord Injury Patients Augmented by BCI-driven Afferent Nerve Stimulation**
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Abstract: Individuals with cervical spinal cord injury (SCI) can retain sensory and motor function in the upper limbs, albeit with severe impairment. Development of increasingly efficient rehabilitation techniques is necessary to help patients regain their independence. Peripheral nerve stimulation (PNS) applied to sensory fibers prior to motor therapy is known to augment rehabilitation. However, the role of PNS timing, when applied in conjunction with volitional motor tasks, has not been adequately explored. In this IRB-approved feasibility study, patients received up to four weeks of median nerve PNS while engaged in an interactive cue-driven hand grip task. A brain-computer interface (BCI) was developed to trigger PNS in real time based on motor intent-related electroencephalogram (EEG) features. One group of subjects (n=8) received BCI-driven PNS while the other (n=12) received “open-loop” PNS, uncorrelated with movement initiation. Changes in cortical motor map volume (MMV) and hand grip force (HGF) were assessed relative to baseline. Subjects receiving volition-dependent PNS had mean HGF changes of 62.3±4.6% and 86.2±10%, and mean MMV changes of -0.8±0.3 and 3.2±0.3 units for the left and right hand, respectively. In contrast, subjects receiving open-loop PNS had mean HGF changes of 3.0±6.8% and 25.5±7.2%, and mean MMV changes of -1.1±0.4 and 0.2±0.3 for the left and right hand, respectively. Subjects with volition-dependent PNS showed greater increases in HGF in both hands (though significant only for left hand, $p<0.05$) than the other group. These results suggest that BCI-driven protocols with fine control of PNS timing could accelerate rehabilitation of patients with SCI.

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College of Engineering Biomedical Research Day

Poster Presentation #273

Abstract Title: **Immediate Effects of a Hip Orthosis on Lumbo-Pelvic Coordination**

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Abstract: Persistent abnormal lumbo-pelvic coordination has been observed in patients with non-chronic and chronic low back pain (LBP). Whether such persistent abnormality plays a role in transition to chronic stage or recurrence of LBP is not known. These questions are likely addressable using clinical trials involving a combination of physical and psychological treatments aimed at correction of lumbo-pelvic coordination. As the first step toward designing such clinical trials, a repeated measure study has been designed to investigate the immediate effects of an external orthosis on lumbo-pelvic coordination of asymptomatic and symptomatic volunteers during forward bending and backward return tasks. Specifically, given the observed increased contribution of pelvic rotation and decreased contribution of lumbar flexion to thoracic rotation in patients with LBP, a hip orthosis will be used to limit pelvic rotation and motivate lumbar flexion during the tasks. Participants will complete bending and return tasks of different pace (preferred and fast) and loading condition (no load and load in hand) with and without the orthosis while their lumbo-pelvic coordination will continuously be collected. The effects of the orthosis on lumbo-pelvic coordination and its potential interactions with other factors will be investigated using statistical models. The preliminary results obtained from an asymptomatic participant were promising indicating a 17.5% decrease in pelvic rotation, 21.0% increase in lumbar flexion, and no changes in thoracic rotation when using the hip orthosis. The observed acute effects support design of future interventions aimed at developing persistent change in lumbo-pelvic coordination.

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College of Engineering Biomedical Research Day

Poster Presentation #274

Abstract Title:	**Noncontact Speckle Contrast Diffuse Correlation Tomography for 3-D Blood Flow Imaging of Burn Wounds**
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Abstract: Objective: Healing of burn wounds depends highly on blood flow/perfusion of the burned tissue. Imaging of tissue hemodynamics may provide critical information for the prediction of burn healing and management of burn wounds. This pilot study was designed to explore 3-D imaging of blood flow distributions in burn wounds using a novel noncontact speckle contrast diffuse correlation tomography (scDCT) technique developed in our laboratory. Methods: Three patients with burn wounds were imaged before surgery and after dressing taken down. Patients lay supine or on their sides to expose their burn wounds. A noncontact scDCT probe was aligned above burn wounds and focused on a region of interest (ROI). The scDCT system projects near-infrared coherent light through optical lenses and detects moments of red blood cells (i.e., blood flow) using an EMCCD camera. The measured boundary blood flow data were used to reconstruct 3-D blood flow images. Results: Reconstructed 3-D blood flow distribution images show large spatial variations in each individual before and after the treatment. Relatively lower baseline blood flow levels before the treatment were found around the wounded tissues, which agreed with the visual observations from the tissue surfaces of ROI. Discussion and Conclusions: This pilot study demonstrates the feasibility and safety of scDCT for noncontact 3-D imaging of blood flow contrasts in burn wounds. Future study will recruit more subjects and correlate the imaging results with clinical outcomes to determine the effectiveness of scDCT for predicting wound healing.

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Poster Presentation #275

Abstract Title:	**Relationship between Bone Microcracks and Mechanical Properties of Bone in Osteoporotic Women Undergoing Bisphosphonate Treatment**
Author(s):	C. Tyler, Department of Biosystems Engineering, U of Kentucky E. Davis, Department of Biosystems Engineering, U of Kentucky D. Pienkowski, Department of Biomedical Engineering, U of Kentucky

Abstract: Bone quality refers to the ability of bone to endure physiologic loads and resist fracture. Several key material and structural factors govern bone quality, e.g., bone mineral composition, cortical thickness and porosity, and microdamage. Microdamage classifications include diffuse damage (< 30 microns) or microcracks (> 30 microns). Bone microcracks are repaired by the process of bone turnover, but various medications and pathologies may reduce the rates of bone turnover and of microcrack repair. When this occurs, bone microcracks may grow, coalesce, and form macro-cracks that lead to gross clinical fracture. Bisphosphonates are the most widely used class of drugs for treating patients with osteoporosis, but use of this drug for excessive durations may lead to suppressed bone turnover and inhibited microcrack repair. This in turn may predispose bone to macro-cracks and clinical fracture. Evidence supporting this hypothesis exists in the literature. The purpose of this study is to determine whether the duration of bisphosphonate drug use is related to the number, length, and area of microcracks in bone from osteoporotic women who were treated with bisphosphonates. The relationship between duration of bisphosphonate treatment and the mean area of bone microcracks will be shown from a cross-sectional study of bone samples from post-menopausal women. This information is important because it will allow estimates to be made of the microcrack-induced changes in clinically-relevant mechanical properties of bone, such as Young's modulus, yield strength, fracture toughness, and fatigue life. This data will also help guide physicians regarding the optimal duration for bisphosphonate treatment.

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College of Engineering Biomedical Research Day

Poster Presentation #276

Abstract Title: **Trabecular Bone Parameters in Women with Osteoporosis Taking Biphosphate Drug**

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Abstract: Data was collected from the trabecular bone in women with osteoporosis taking bisphosphonate (BP) drug treatment over a twenty year span using Fourier-transform infrared spectroscopy (FTIR). The parameters collected from the trabecular bone using FTIR included the mineral to matrix ratio, carbonate to phosphate ratio, c-axis mineral crystal length, crosslink type, and carbonate/Amide-I ratio. The goal of this study is to compare these parameters with the time span of the BP drug treatment and the location(s) on each woman's trabecular bone structure. The raw data will be seperated first into subsections denoted by one of the corresponding five parameters listed above using the programming language, R. The data will then be divided into a second subsections corresponding to the time and date the measurements were taken and will enclose all the measurements on the trabecular bone corresponding with the initial parameter. The second subsections will be averaged and plotted onto a normal distribution curve. The averages that fit the normal distribution curve will be separated from the averages that do not. These two new subsections will be plotted against time and compared. The raw data will also be divided up corresponding to patient number and to an individual parameter. This data will then be plotted against the duration of treatment and compared with all other patient numbers. A statistical z-test will also be ran on this subset of data to help find other correlations. This will be done for every parameter to determine patterns in the data.

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Poster Presentation #277

Abstract Title: **Mathematical Modeling of Ultradian Sleep-Wake Cycles in Mice**

Author(s): H. Wang, Department of Biomedical Engineering, U of Kentucky
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Abstract: Mathematical models can be of great potential utility in the study of sleep and its underlying dynamics. Physiologically-based mathematical models, validated through experimental data, will not only strengthen our understanding of existing theories, but also test hypotheses regarding the neural circuitry governing sleep dynamics. Experimental studies in rodents, and mice in particular, provide useful insights into human sleep due to the similarities in brain circuitry and electrophysiological rhythms. But unlike humans, mouse sleep is polyphasic, and contains multiple bouts of sleep and wakefulness during the course of a day. And on a shorter timescale within each prolonged bout of sleep, there are multiple cycles between REM sleep, non-REM sleep and brief arousal, each phase lasting seconds to minutes in duration. Existing mathematical models successfully replicate mouse sleep metrics on the shorter timescale, but not the long one involving prolonged sleep and wakefulness. Here, we present a hierarchical model that captures vigilance dynamics on both timescales, and therefore reproduces all essential features of the ultradian sleep-wake cycle. Simulation of the hierarchical model successfully reproduces the proportion of time and the mean bout duration of each vigilance state, their trends along the circadian rhythm, and the effect of external photic stimuli.

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College of Engineering Biomedical Research Day

Poster Presentation #278

Abstract Title: **Alpha Rhythm Detection Using Tri-Polar Concentric Ring Electrodes**

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Abstract: Electroencephalography (EEG) is commonly used in the clinical evaluation of brain health but the technology has remained unchanged for nearly 100 years. Our collaborators at the University of Rhode Island have developed a method for recording EEG in which the single disc-shaped metal electrode is replaced with a tri-polar lead comprised of a central disk, middle ring, and outer ring, each of which records electrical potential with respect to a reference. Potentials at these concentric poles are combined to approximate a focal Laplacian measurement with high spatial selectivity and reduced muscle artifact. To benchmark performance of this tripolar EEG (tEEG) system, we measured the extent to which the alpha rhythm—an 8-13 Hz oscillation found in the EEG when the subject's eyes are closed—is modulated by opening the eyes in simultaneous tEEG and EEG recordings. Our preliminary study comprised eight independent sessions on five subjects. In each session, the subject opened and closed the eyes five times for 30s at a time. Opening the eyes dropped alpha power by an average of 66.5% and 59.1% in tEEG and EEG recordings, respectively. A within-session comparison using the Wilcoxon signed-rank test showed that alpha modulation was greater in the tEEG than in the EEG by 12.5% ($p = 0.11$; $n = 8$), a difference that was almost statistically significant. These findings suggest that the dynamical changes in brain rhythms may be more easily detected by tEEG than by conventional EEG. This could have implications for clinical diagnosis and neurofeedback applications.

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Poster Presentation #279

Abstract Title: **Peak Lower Extremity Joint Moments during Squat and Stoop Lifting Techniques**

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Abstract: Different lifting techniques affect moment demand on lower extremity joints, leading to differences in stress and stress experienced by joint tissues. The purpose of this study is to investigate whether differences in lower extremity joint moments exist when using squat (SQ) versus stoop (ST) lifting technique. Considering the amount of joint excursions, we hypothesized that the magnitude of moment demand at knee joints will be greater during SQ lifting and greater in hip and ankle joints during ST lifting. Four participants (Height:1.65±0.14m; mass:70.44±17.48kg) completed a lifting task using two techniques: 1) a SQ lift wherein they predominantly bent at the knees and 2) a ST lift wherein they predominantly bent at the hips, to lift a 4.5kg box placed on the floor. Whole body kinematics were captured using a camera tracking system and ground reaction forces were collected using a force plate. The kinematics data as well as the ground reaction forces were used in an inverse dynamic model to calculate joint moments. Paired t-test were used to determine within subject differences between the lifting techniques. There was significant differences in the right hip moment (SQ:-1.07±0.18Nm/kg; ST:-1.54±0.09Nm/kg, p=0.012). Also, there was significant differences in moment demand on knees between SQ and ST tasks (right knee: SQ:1.07±0.22Nm/kg; ST:-0.73±0.18Nm/kg, p=0.0001) (left knee: SQ:1.18±0.23Nm/kg; ST:-0.56±0.11Nm/kg, p=0.001). The observed increased hip moment during ST lifting likely requires large muscle forces (to offset the moment) that, in turn, put the lower back under greater susceptibility to injury during this lifting technique.

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College of Engineering Biomedical Research Day

Poster Presentation #280

Abstract Title: **Mechanical Testing of Proximal Sesamoid Bones in Racehorses**

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Abstract: In Thoroughbred racing, proximal sesamoid bone fractures has been a frequently reported cause of fatal breakdowns in the industry. While the amount of fatal breakdowns is decreasing, further investigation into these fractions is wanted in hopes to help prevent them. While studies have examined the micro and macro structural properties of proximal sesamoid bones (PSB), very little research has been done on the mechanical properties of the bones. With mechanical testing, specifically done by reference point indentation (RPI), different mechanical properties of the bone such as yield stress and strength will be tested. For this study, 96 PSBs from three groups will be tested. The control group consist of PSBs from horses with no race training. The second group will consist of horses who are in race training but were euthanized for reasons separate from skeletal failure. The third group will be horses in race training who are euthanized for PSB fractures. PSBs in both limbs will be examined. The bones will be placed in PMMA and polished. The bones will then be clamped, marked where to indent, and indented 5 times per sample with each indent deeper than the last. RPI uses a 375 micron diameter probe to indent the bone with a force up to 4 N. Data is recorded by transducers and used to calculate nine different material property parameters. The goal with this research is to be able to use the information to better understand why the PSBs fracture.

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Poster Presentation #281

Abstract Title: **Parathyroid hormone analog for bone fracture treatment**

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Abstract: Introduction: Osteoporosis is a bone pathology that afflicts up to 24 million Americans. Forteo is a parathyroid hormone analog commonly used in treatment for patients with osteoporosis. This study aims to analyze the efficacy of Forteo to help prevent bone fractures in patients with prior bone fracture history. Methods: This was an observational case series with retrospective chart review of patients with a history of bone fractures that were treated with Forteo. All patient data was collected from patients with a history of multiple bone fractures that had undergone treatment with Forteo. Patient data ranged from ages 19-85 years old with a mean age of 58.73 years. Results: statistical analysis of patient data samples

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College of Engineering Biomedical Research Day

Poster Presentation #282

Abstract Title:	**Diurnal Changes of Trunk Stiffness: Sedentary vs. Physically Active Nurses**
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Abstract: Lower back pain (LBP) affects between 35-80% of nurses throughout their career, causing 12% to leave the profession. Individuals with reduced trunk stability have been recognized as being at-risk for developing LBP. Trunk stability is usually indirectly evaluated using measures of trunk stiffness. Because trunk stiffness is provided by viscoelastic passive tissues of lower back and active components of trunk muscles, it can be affected by activities that individuals perform over the course of the day. However, the effects such activities have on trunk stiffness is not well understood. The purpose of this study is to determine and compare changes in trunk stiffness of two groups of nurses with different levels of work activities. Forty-eight nurses from the University of Kentucky Health Care system, involved in sedentary or physically active tasks, will be recruited to complete two data collection sessions prior to and after their work shift. During each session, trunk stiffness tests will be conducted on each participant using a custom-made rigid frame assembly. During the tests while participant's thorax and pelvis are constrained using a harness-connected rod assembly and straps, respectively, the participant's legs will be raised to a specific angle to obtain a passive flexed posture. The angle will be 70% of the subject's maximum flexion angle, found from an early flexion-extension task. Using an in-line load cell, the rod's force and the corresponding lower back moment demand will be estimated at each flexion angle and the instantaneous stiffness of the trunk will be calculated. We expect to observe distinct differences in changes of trunk stiffness between sedentary and physically active nurses. Some preliminary results will be presented during the biomedical research day.

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Poster Presentation #283

Abstract Title:	**Quantification of papillary muscle motion and mitral regurgitation after myocardial infarction**
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Abstract: Change in papillary muscle motion as a result of left ventricular (LV) remodeling after posterolateral myocardial infarction is thought to contribute to ischemic mitral regurgitation (Wenk et al., 2010). A finite element (FE) model of the LV was created from magnetic resonance images acquired immediately following myocardial infarction and 8 weeks later in a cohort of 13 sheep. Severity of mitral regurgitation was rated (scale 1-4) by two-dimensional echocardiography. Of the cohort, 6 animals (DC) received hydrogel injection therapy shown to limit ventricular remodeling after myocardial infarction (Rodell et al., 2016) while the control group received a similar pattern of saline injections. LV pressure was determined by direct invasive measurement and volume was estimated from MRI. FE models of the LV for each animal included both healthy and infarcted tissue regions as well as a simulated hydrogel injection pattern for the DC group. Constitutive model material parameters for each region in the FE model were assigned based on results from previous research (Dorsey et al., 2016, Guccione et al., 1991, 1993). Invasive LV pressure measurements at end diastole and end systole were used to drive model simulations for each animal. Passive stiffness (C) and active material parameter (Tmax) were adjusted to match MRI estimations of LV volume at end systole and end diastole. Nodal positions of the chordae tendineae (CT) were determined by measurements obtained from the excised heart of each animal at the terminal time point. Changes in CT nodal displacements between end systole and end diastole at 0 and 8-week time points were used to investigate the potential contribution of changes in papillary muscle motion to the progression of ischemic mitral regurgitation after myocardial infarction.

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College of Engineering Biomedical Research Day

Poster Presentation #284

Abstract Title: **Cerebral Microhemorrhage Volumetric Method using Susceptibility Weighted Imaging**

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Abstract: Cerebral micro-hemorrhage (CMH) is a small dark signal that can be seen in T2*-weighted MRI images, like susceptibility weighted imaging (SWI). CMH can be found in patients with Alzheimer's disease, dementia, stroke. It may cause either by cerebral amyloid angiopathy, diffuse axonal injury, hypertension, and small vessels disease. Volumetric quantification of CMH can help for diagnosis cerebrovascular disease for clinical trial. In this study, we utilized a method to quantify CMH using SWI images. Images for two random subjects, who recruited by Sanders-Brown Center on Aging, were used in our method as preliminary data. Most of the steps used in our method are from a published research1. Briefly, T1-weighed and T2-weighed images were registered to each other, then segmented to four different tissue masks, Grey-matter (GM), White-matter (WM), CSF and misclassified tissue. The SWI image registered to the subject space and cleaned from the non-brain and CSF tissue signal. The mean and standard deviation were driven from the previous step to threshold the SWI mask using 4xSD as maximum and one as a minimum. Manual editing is required to remove the unwanted voxels; the remaining is the CMH total volume. Our method takes about 20-30 minutes. The time-consuming is due to the manual editing, which is mostly to clean the lower brain slices. The small size of some CMH, ~1 voxel, makes filters inapplicable to use for smoothing the CMH mask, which leads to a noisy mask. Future work, increase the number of the subjects to refine the method.

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