College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**Noncontact 2D and 3D diffuse optical imaging of tissue blood flow distributions**
Author(s):	S. Mazdeyasna, Department of Biomedical Engineering, U of Kentucky C. Huang, Department of Biomedical Engineering, U of Kentucky M. Zhao, Department of Biomedical Engineering, U of Kentucky M. Mohtasebi, Department of Biomedical Engineering, U of Kentucky A. Bonaroti, Division of Plastic Surgery, U of Kentucky L. Wong, Division of Plastic Surgery, U of Kentucky G. Yu, Department of Biomedical Engineering, U of Kentucky

Abstract: A novel speckle contrast diffuse correlation tomography (scDCT) was recently developed in our laboratory as a noninvasive and noncontact optical imager for 2D and 3D imaging of blood flow distributions in relatively deep tissues (up to ~10 mm). The scDCT uses a galvo mirror to remotely deliver focused near-infrared point light to source positions and employs a sensitive scientific complementary metal–oxide–semiconductor (sCMOS) camera to rapidly quantify spatial diffuse speckle fluctuations resulting from moving red blood cells (i.e., blood flow). This system also integrates an innovative photometric stereo technique with the same camera to obtain tissue surface geometry. The scDCT has been tested in tissue-simulating phantoms, rodent brains, human burns, wounds, and mastectomy skin flaps. In a preliminary study using the scDCT and a commercial indocyanine green dye-based fluorescence angiography, we observed similar blood flow/perfusion patterns on mastectomy skin flap surfaces. Interestingly, lateral and depth heterogeneities in blood flow distribution were captured by our scDCT, suggesting the value of imaging the entire mastectomy skin flap volume. In addition, we also obtain 2D maps of tissue blood flow distributions. Compared to 2D mapping, 3D imaging quantifies blood flow distributions more accurately but needs more computation time for image reconstruction. We are currently testing scDCT in more patients with the expectation that intraoperative monitoring of ischemic tissues and their recoveries in mastectomy skin flaps will provide objective information for the assessment and management of skin flap viability to prevent skin flap necrosis and other complications.

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14th Annual CCTS Spring Conference
Monday, April 15, 2019 Lexington Convention Center

College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title: **Alterations in Lumbo-Pelvic Coordination from the Application of a Hip Orthosis**

Author(s): M. Gilliam, College of Engineering, U of Kentucky M. Ballard, F. Joseph Halcomb III, M.D. Department of Biomedical Engineering, U of Kentucky B. Bazrgari, F. Joseph Halcomb III, M.D. Department of Biomedical Engineering, U of Kentucky S. Sunderam, F. Joseph Halcomb III, M.D. Department of Biomedical Engineering, U of Kentucky

Abstract: Persistent abnormal lumbar movement has been observed in individuals who have a history of low back pain (LBP). This abnormality often presents itself as an alteration in the individual's lumbo-pelvic coordination. The rotation of the lumbar spine decreases, while pelvic rotation increases to compensate. This change in trunk movement patterns could contribute to further occurrences or more severe cases of LBP. This study makes use of a hip orthosis in an effort to increase lumbar rotation by restricting pelvic rotation. Seven asymptomatic participants were asked to perform three trunk movement tasks: forward bending, twisting, and lateral bending. The tasks were completed in a random order, both with and without the orthosis. Kinematic data was analyzed to determine the lumbar and pelvic contributions to total thoracic rotation. For the forward bending, twisting, and lateral bending tasks, the orthosis was shown to increase lumbar contributions by 15.5%, 21.4%, and 7.6%, respectively. Likewise, the orthosis decreased pelvic contributions in the forward bending, twisting, and lateral bending tasks by 28.9%, 11.2%, and 7.9%, respectively. Recruitment for asymptomatic participants is continuing, and results have been favorable thus far. As a next step, LBP participants will be recruited to determine if the hip orthosis could help to correct an abnormal lumbo-pelvic coordination in that population.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title: **Extraction of Heart Rate from Video of the Face**

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Abstract: Researchers have been working on non-contact measurement to improve telehealth and make vital monitoring accessible. One of the areas of development is extraction of heart rate (HR) from images of the face captured as part of video recording using digital cameras. Based on methods reported previously in the literature we implemented an algorithm to extract HR from video of subject's face. First, a region of interest (ROI) was manually selected and automatically tracked to minimize motion artifact from movement of subject. Then from the RGB image, the green frames were extracted. Spatial mean of all the pixels within the ROI was computed for each frame to obtain a raw photoplethysmograph (PPG) signal, which was band-pass filtered (0.02-0.7Hz) to produce final PPG. From the PPG, local peaks, i.e. beats, were detected which was followed by calculation of inter beat intervals (IBI). The HR was calculated from the IBI. The HR calculated using aforementioned method was validated against a contact measurement. Videos recorded during 40 one-minute trials from one subject were analyzed. The videos were downloaded from "DEAP: A Database for Emotion Analysis using Physiological Signals". The results show that, the mean HR within each of the 40 trials was similar to the mean HR computed from the contact PPG with an average difference of less than 5%. However, there were differences between HRs computed within each trial with largest deviation of about 11% suggesting that while the approach does a reasonable job of estimating the HR, further refinement would be helpful.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**Structure and Mechanical Properties of Streptococcus mutans by Atomic Force Microscopy**
Author(s):	J. N. Sandin, Department of Mechanical Engineering, U of Kentucky N. Korotkova, Department of Molecular and Cellular Biochemistry, U of Kentucky M. E. Grady, Department of Mechanical Engineering, U of Kentucky

Abstract: Poor oral hygiene continues to be a world-wide epidemic. Streptococcus mutans (S. mutans) are one type of bacteria that highly contribute to oral decay, causing plaque build-up, difficulty chewing, impaired speech, and cavity formation, contributing to over half the yearly dental visits in the United States. Specifically, patients with dental implants are at high risk for developing an oral biofilm which can cause pain, swelling, and possible loosening or loss of the titanium insert. S. mutans are highly resistant to antibiotics making infections due to the bacteria difficult to treat. As this issue remains persistent, it becomes important and necessary to study the mechanics of S. mutans to develop therapeutic targets for decreasing infection. One possible target is to evaluate cell wall modifications. Recent literature suggests that altering the biosynthesis pathways of the cell wall polysaccharides is a possible lead to achieving new therapeutic opportunity. Consisting of multiple peptidoglycan layers, wall teichoic acid (WTA) containing surface glycopolymers, and a polysaccharide capsule, the cell wall of S. mutans is complex. To study this high-functioning cell wall, atomic force microscopy (AFM) combined with fluorescent laser scanning confocal imaging is utilized to compare the cell wall deformation of mutant strains defective in WTA. In addition, S. mutans surface morphology will be studied by means of scanning electron microscopy to reveal and note differences in the wildtype and mutant strains. Our aim is to determine and characterize the mechanical properties of bacterial cell walls that contribute to antibiotic resistance to regulate such properties.

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Oral Presentation

Abstract Title:	**Early Autism Spectrum Disorder Detection From Visual Attention Behavior**
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Abstract: In this paper, recognition of certain behavioral cues in young children using machine-learning techniques has been investigated with the aim of early detection of autism spectrum disorder (ASD). The main objective of this study is quantification of the relation between ASD vs attention pattern, eye contact and involvement of a child in an interactive setting. Such a screening mechanism for early detection can facilitate the way for timely intervention leading to more effective autism management. Research has demonstrated that there is strong connection between ASD and visual attention for the measurement of which head pose and gaze pattern are good markers. We have applied deep learning techniques, which are a new class of machine learning methods, to detect clinically relevant behavioral features and social interactive cues from video which include facial expression, vocalization, direction of gaze. Several different kinds of features have been used including facial landmarks, head pose and eye gaze. The efficacy of these features for ASD detection has been demonstrated by existing research.The training data consists of videos of infants 0-12 months of age in an interactive environment with a caretaker and manually annotated by experts for various interactive behaviors. For data processing, child and partner frames are separately processed and visual features are extracted. The resulting features are then passed on to deep neural network for training. Relative performance of three different networks namely densely connected network, convolutional neural network and long short term memory (LSTM) network has been compared for the detection of above mentioned events.

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College of Engineering Biomedical Research Day

Oral Presentation

Abstract Title:	**Reduced Cerebral Blood Flow in Aging Adults with Down Syndrome: An Arterial Spin Labeling Study**
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Abstract: Introduction: Adults with Down syndrome (DS) develop extensive Alzheimer disease (AD) neuropathology very early in life, but they also exhibit protective cardiovascular traits like the absence of atheroma and hypertension. We used arterial spin labeling (ASL), a quantitative MRI technique that measures cerebral blood flow, to test the hypothesis that the progression of AD in adults with DS would result in compromised global cerebral blood flow (CBF) despite their otherwise healthy cardiovascular profile. Methods: Adults with DS (n=35, aged 26-65yrs) and age-matched control (n=15) were scanned using a pulsed ASL sequence on a Siemens 3T Prisma as part of an ongoing longitudinal study of aging in DS. Quantitative CBF maps were calculated in mL/100g/min and averaged over the entire brain volume. All subjects were also rated as having minimal, moderate, or severe residual arterial signal (RAS). Results: A plot of global CBF versus age reveals a clustering of DS participants over the age of 54 with drastically reduced CBF values. DS participants older than 54 had a 31% reduction in CBF (32.3± 9.6mL/100g/min) versus younger people with DS (46.7± 6.7mL/100g/min, p=0.011). No such pattern is observed in the control group (young= 45.9± 5.8mL/100g/min, old= 40.9± 4.1mL/100g/min). People with DS over the age of 54 also had a significantly higher proportion of severe RAS scores (50%) vs younger people with DS (7%, p=0.005) or non-DS controls (7%, p=0.016), and prevalence of diagnosed dementia (older DS=60%, younger DS=7% p<0.001, Ctl =0% p<0.001). Conclusion: This study has demonstrated that adults with DS exhibit deficits in perfusion that do not occur until the transition to dementia as opposed to other forms of AD where perfusion deficits precede dementia.

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Poster Presentation 243

Abstract Title:	**Noninvasive Noncontact Speckle Contrast Diffuse Correlation Tomography of Cerebral Blood Flow in Rats**
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Abstract: Continuous and longitudinal imaging of cerebral blood flow (CBF) variations provide vital information for investigating pathophysiology and interventions for a variety of neurological and cerebral diseases. An innovative noncontact speckle contrast diffuse correlation tomography (scDCT) system was downscaled and adapted for noninvasive imaging of CBF distributions in rat's brain through intact scalp and skull. Algorithms for 2D mapping and 3D image reconstruction of CBF distributions were developed and tested. The continuous imaging capability of the system was shown by imaging global CBF increases during CO2 inhalations and regional CBF decreases across two hemispheres during sequential unilateral and bilateral common carotid artery ligations. The longitudinal imaging capability was demonstrated by imaging CBF variations over a long recovery period of 14 days after acute stroke. Compared to the 2D mapping method, the 3D imaging method quantifies CBF distributions more accurately but needs more computation time for image reconstruction. Results from this study generally agree with those reported in literature using similar protocols to induce CBF changes. The scDCT enables a relatively large penetration depth (up to ~10 mm), which is sufficient for transcranial brain measurements in small animals and human neonates. Ultimately, we expect to provide a noninvasive noncontact cerebral imager for basic neuroscience researches using small animal models and clinical applications in human neonates.

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Poster Presentation 244

Abstract Title:	**A Wearable Optical Sensor for Noninvasive Measurements of Tissue Blood and Oxygenation**
Author(s):	X. Liu, Departments of Biomedical Engineering, U of Kentucky C. Huang, Departments of Biomedical Engineering, U of Kentucky Y. Cheng, Department of Biomedical Engineering, U of Kentucky Y. Gu, Department of Electrical and Computer Engineering, U of Southern California, CA G. Yu, Departments of Biomedical Engineering, U of Kentucky

Abstract: Quantification of tissue blood flow, oxygenation and oxidative metabolism provides vital information for diagnosis and therapeutic assessment of various diseases associated with tissue ischemia and hypoxia. We report an innovative, noninvasive, wearable, near-infrared diffuse speckle contrast flow-oximetry (DSCFO) technology for continuous monitoring of regional blood flow and oxygenation variations in relatively deep tissues (up to centimeter). A wearable DSCFO probe, consisting of small laser diodes at different wavelengths (@780 nm and 850 nm) as point sources and a tiny CMOS camera as a 2D detector array, was constructed and used to detect reflected spontaneous spatial fluctuations of laser speckles, resulting from the movement of red blood cells in deep tissues (i.e., tissue blood flow). The light intensity attenuations at the two wavelengths due to the absorptions of oxy-hemoglobin and deoxy-hemoglobin were detected for extracting tissue oxygenation information. The DSCFO system was tested and calibrated against established technologies in standard tissue-simulating phantoms and human forearm tissues with manipulated physiological changes. Consistent results were obtained between the concurrent measurements by different techniques. The wearable DSCFO technique has potential to be used for continuous monitoring of tissue blood flow and oxygenation in conscious, freely moving subjects including animals and humans. We are currently testing this innovative DSCFO system for continuous cerebral monitoring in rodents and newborn infants.

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Poster Presentation 245

Abstract Title:	**Changes in Activity of Abdominal Muscles While Using a Hip Orthosis**
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Abstract: Individuals with a history of chronic and acute low back pain (LBP) have exhibited a persistent abnormal lumbo-pelvic coordination, specifically a decreased use of the lumbar spine and an increased use of the pelvis in typical daily activities. These abnormal movement patterns could contribute to increased occurrences of LBP. A hip orthosis was recently shown to limit the amount of pelvic movement and increase the amount of lumbar movement in healthy subjects. While this device may encourage correct movement patterns it is important to consider any discomfort or difficulty it could add to the individual. This study has examined the activities of abdominal muscles in 7 healthy volunteers through normal movement and movement with a hip orthosis applied in an effort to gauge orthosis-induced alterations in muscle activation. Muscle activities were measured using surface electromyography (EMG) system. EMG signals were acquired from the rectus abdominis and transversus abdominis muscles through twisting, side bending, and forward bending tasks. Individuals showed slight decreases in EMG readings of 2.5%, 11.4%, and 5.6% for twisting, side bending, and forward bending, respectively, with the orthosis applied. An increase in EMG readings was expected with the orthosis; however, these measurements were obtained from healthy volunteers who may not experience the same resistance as individuals with LBP. These results indicate the hip orthosis could be a useful tool in encouraging healthy spine movement patterns. As a next step, participants with a history of LBP should be comparatively evaluated for any level of discomfort.

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College of Engineering Biomedical Research Day

Poster Presentation 246

Abstract Title:	**Lumbopelvic Coordination During Pregnancy: Differences Between Women With and Without Low Back Pain**
Author(s):	C. Drury, Department of Biomedical Engineering, U of Kentucky K. Jackson, College of Engineering, U of Kentucky F. Zachman, MD, Obstetrics and Gynecology, U of Kentucky S. Haynes, PT. UK Physical and Occupation Therapy, Good Samaritan L. Carney, PT. UK Physical and Occupational Therapy, Good Samaritan B. Bazrgari, PhD. Department of Biomedical Engineering, U of Kentucky.

Abstract: Low back pain affects between 50-70% of pregnant women and is the primary reason for them missing work during pregnancy. Biomechanical studies of low back pain often investigate how the movements of the lumbar spine and pelvis work together to achieve different motions (lumbopelvic coordination). Several physiological changes such as weight gain, increased abdomen size, and increased joint laxity due to hormones can change lumbopelvic movements, and it is suggested that this may be related to experiencing back pain during pregnancy. However, most research on lumbopelvic coordination during pregnancy uses non-pregnant women for comparison. This study will compare pregnant women with and without back pain. Subjects will perform simulated daily activity tasks: flexion-extension, picking up an object, sitting and standing, and walking. Using accelerometers placed on thorax, pelvis, and upper thighs, kinematic data will be collected. The data will be used to calculate range of motion (angular displacement) of the lumbar and pelvis, the relative contribution of each to total motion, and other measures of lumbopelvic coordination. This will be done at regular intervals throughout the pregnancy. Each time the subjects will take a questionnaire about their experience of low back pain during the pregnancy. The goal is to observe what differences in lumbopelvic coordination exists between women who experience back pain during pregnancy and those who do not. We are particularly interested in how these differences in motion change as the pregnancy progresses, and how this may be associated with the severity of back pain experienced.

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College of Engineering Biomedical Research Day

Poster Presentation 247

Abstract Title:	**Biofilm Adhesion Exceeds Cohesion in Laser Spallation Experiments**
Author(s):	K. L. Kearns, Mechanical Engineering, U of Kentucky J. D. Boyd, Mechanical Engineering, U of Kentucky N. Korotkova, Molecular and Cellular Biochemistry, U of Kentucky M. E. Grady, Mechanical Engineering, U of Kentucky

Abstract: Streptococcus mutans biofilm grows on the titanium surface of dental implants and often leads to cell death in the surrounding tissue after extended periods of growth. Sucrose from the patient's diet affects the growth of the biofilm by influencing the extracellular polymeric substance matrix, increasing the biofilm's ability to adhere to the titanium surface of dental implants. This study measures the adhesion strength of S. mutans biofilms grown in environments with varying levels of sucrose, tested using laser-induced stress waves to remove the biofilm from a titanium surface. We compared adhesion strength by measuring the area of biofilm removed at each loading site, called the spallation region. The data we collected shows a strong correlation between decreasing spallation region size and increasing adhesion strength at the same loading amplitude for each variant of biofilm. Furthermore, a positive correlation was found between increased loading amplitude and increased spallation region size for all biofilm variants. The S. mutans condition grown in 75 mM sucrose solution showed the greatest adhesion strength, with noticeable spallation only occurring at the two highest loading amplitudes. After identifying a likely set of circumstances at which adhesion strength is greatest, our next steps will be to study the material properties at those characteristics.

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College of Engineering Biomedical Research Day

Poster Presentation 248

Abstract Title:	**Effects of Dental Implant Textures on Biofilm Adhesion Strength**
Author(s):	J.D. Boyd, Department of Mechanical Engineering, U of Kentucky M. E. Grady, Department of Mechanical Engineering, U of Kentucky

Abstract: Peri-implantitis, a disease formed by subgingival biofilm between dental implants and surrounding tissue, can lead to gum necrosis or loss of implant. The development of an implant surface that deters bacterial biofilm adhesion while promoting implant osseointegration is paramount to prevent Peri-implantitis. A technique to quantify adhesion strengths of bacterial and cell biofilms is important to determine the optimal anti-bacterial, and pro-cellular implant surface characterizations. The laser spallation technique has been recently adapted to obtain quantitative measures of biofilm-implant adhesion. Laser spallation is ideal as it results in quantified film adhesion strength while using a non-contact high strain rate force. Using image analysis, dimensional wave analysis, and finite element analysis, a quantitative interface adhesion strength can be determined for the biofilm-implant interface. In this study, Streptococcus mutans, a gram-positive facultative anaerobe, was chosen. S. mutans is a common dental carry, cavity causing bacteria, which promotes the attachment and growth of other, more harmful, bacteria. The competition between oral bacteria and cell should also be considered when comparing implant surface characteristics. MG-63 was chosen as it closely mimics osteoblast adhesion. We will demonstrate the competition in adhesion between S. mutans and osteoblast like cells on dental implant mimicking surfaces through the adaptation of the laser spallation technique. This study will lead to the development of dental implant surfaces which promote osseointegration and inhibit biofilm formation. Furthermore, the laser spallation technique will be used to optimize other medical implant surfaces, and other surfaces, where biofilms have deleterious effects.

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Poster Presentation 249

Abstract Title:	**Modeling Spikes and Other Transients to Improve the Accuracy of Detection of High Frequency Oscillations**
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Abstract: High frequency oscillations (HFOs) are being actively investigated for their potential as biomarkers of epileptogenic brain tissue. True HFOs first need to be identified before using their region of activity to predict the location and extent of cortex that must be resected in order for a patient to become seizure-free. The purpose of this study is to develop an algorithm that is tailored to address this specific case. With IRB approval, eight epilepsy patients were monitored using intracranial EEG (iEEG). HFO candidates were first identified using a slightly modified version of a well-known algorithm (Staba et al., 2002), which tends to be highly sensitive to HFO activity but is not very selective and admits many spikes and other artifacts which, when filtered, may give the appearance of genuine HFOs. This deficiency is addressed here by modeling the baseline trend of the ECoG corresponding to a detection to identify and eliminate spikes. When a spike is fitted in this way and subtracted from the signal it will not produce a false ripple-like artifact when sent through a highpass filter. If an HFO is riding on the spike, it will remain in the residual after the spike is eliminated. If the baseline does not contain a spike, it is unaffected by the fitting process. This post-processing step serves to eliminate the confounding effect of spikes in the ECoG on HFO detection. The proposed method performed well in detecting highly rhythmic HFOs and rejecting spikes and other artifacts with a sensitivity of 80.5%, specificity of 81% and positive predicative value of 92.5%. Spikes and other transients in the ECoG can co-occur with HFO activity and significantly impair the ability of automated algorithms to detect them. Here we have proposed a simple algorithm to model and eliminate the transient baseline so that HFOs are more easily distinguished and used for diagnostic purposes.

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Poster Presentation 250

Abstract Title:	**Detection and Classification of Graded Movement using Electroencephalography**
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Abstract: Brain-machine interfaces (BMIs) are often designed to detect and act on changes in brain signals, termed event-related potentials (ERPs), associated with movement. The number of commands available for BMI operation is mostly limited by the number of distinct movements (e.g., right hand, left hand, tongue, foot, etc.) rather than variations within each movement. This severely restricts the usability and versatility of BMI function. Here we propose to model graded event-related potentials (GERPs) from the electroencephalogram (EEG), i.e., signals that reflect the level of effort associated with a movement task. This will make available a larger number of possible control signals to the user of the BMI. After giving informed consent, eight healthy human subjects participated in an IRB-approved protocol in which they responded to a cue by squeezing a hand dynamometer to different levels of pre-determined force guided by visual feedback. Offline, movement was detected in 86.33% (±4.76 SEM) and 88.09% (±6.10 SEM) of cues for dominant and non-dominant hand movements, respectively. Classification accuracies for the four different levels of effort ranged from 76% to 80% and all were above chance level. Early results suggest a model that provides interactive feedback to the subject on their intended level of movement effort is feasible. This may have utility as a rehabilitative intervention for those afflicted with neuromuscular impairments.

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Poster Presentation 251

Abstract Title:	**Work-Related Changes in Lumbo-Pelvic Coordination During Trunk Forward Bending and Backward Return Among Nurses**
Author(s):	M. McDonald, Department of Biomedical Engineering, U of Kentucky M. Ballard, Department of Biomedical Engineering, U of Kentucky C. Tyler, Department of Biomedical Engineering, U of Kentucky

Abstract: Timing and magnitude of flexion-extension activities are studied to identify the effects of occupational activities and diurnal changes on trunk kinematics and trunk stiffness. The physiological diurnal changes that occur throughout a day have a large impact on trunk stiffness and are especially affected by physical demands of a job, including the amount a person is seated or up and moving throughout a work shift. In this study, 30 nurses organized into groups based on physical demands and location of their 8-12 hour work shift are asked to come for data collection before and immediately following work shifts to monitor diurnal changes experienced. Participants are asked to stand on a force plate and complete three repetitions of a forward bending and backward return exercise at a self-selected pace and then repeat the exercises “as fast as possible”. Participants then repeat the exercise while lifting a weight from the ground to chest height. Magnetic inertial motion trackers are placed on the posterior thorax and pelvis, and left and right ankle and knee to record segment rotation data and monitor changes in magnitude and timing of flexion and extension. Using methods implemented by Stergiou, et al., 2001, data can be used to create continuous relative phase curves and obtain the mean absolute relative phase and deviation phase to evaluate timing of tasks. It is hypothesized that lumbar flexion-extension magnitude is greater, and timing is more synchronous following a work shift and in more demanding occupational activities, using a mixed ANOVA to find differences between groups.

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14th Annual CCTS Spring Conference
Monday, April 15, 2019 Lexington Convention Center

College of Engineering Biomedical Research Day

Poster Presentation 252

Abstract Title: **Work-Related Changes in Trunk Stiffness of Nursing Personnel**

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Abstract: Nurses, nursing assistants, and others working in similar careers experience varying degrees of physical activity in their jobs – some sit more during their shifts, while others stand more and perform strenuous activities during their shifts. These varying activities may produce different effects on the biomechanics of the lower back (e.g., trunk stiffness) of these nurses and others in similar careers. Given the important role of the biomechanics of the lower back in the occurrence of occupational low back pain, it would be beneficial to quantify the changes that occur in the biomechanics of their lower backs throughout their work shift. This study seeks to quantify these effects on the biomechanics of the lower back (specifically trunk stiffness). In order to collect the necessary data, this study will recruit approximately 30 nurses, nursing assistants, and others working in this profession (some who have more sedentary jobs and others who have more physically demanding jobs) to form three equal groups. Each participant will come in pre- and post-shift and will perform certain activities which will provide data related to trunk stiffness. This will allow for quantifying how the biomechanics of the lower back change over the course of a work shift and how the biomechanics of the lower back vary between the different levels of physical demand of the participants. In order to understand how trunk stiffness is affected by a work shift, the ratio of changes in moment over changes in angle will be calculated and appropriate analyses will be conducted.

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College of Engineering Biomedical Research Day

Poster Presentation 253

Abstract Title:	**Hyaluronate Injections after Anterior Cruciate Ligament Reconstruction Does Not Improve Running Mechanics**
Author(s):	N. P. Baumann, Department of Biosystems & Agricultural Engineering, U of Kentucky A. K. Johnson, Sports Medicine Research Institute, U of Kentucky N. R. Heebner, Sports Medicine Research Institute, U of Kentucky C. E-W. Conley, Department of Orthopaedic Surgery, U of Kentucky D. L. Johnson, Orthopaedic Surgery & Sports Medicine, U of Kentucky M. L. Ireland, Orthopaedic Surgery & Sports Medicine, U of Kentucky C Latterman, Harvard Medical School, Boston, MA J. P. Abt, Sports Medicine Research Institute, U of Kentucky

Abstract: Mitigating inflammation early after ACL reconstruction (ACLR) may help functional outcomes further in rehabilitation. The purpose of this study was to determine if hyaluronate injections (HI) administered early after surgery improves strength and running mechanics six months after ACLR. Nineteen individuals who suffered an ACL tear were enrolled in a randomized double-blind controlled trial to test a post-operative intraarticular HI compared to placebo one week after surgery (one patient screen failed, one withdrew after surgery). Six months post-surgery individuals completed isokinetic quadriceps strength (IKQS) and a biomechanical analysis of overground running using motion capture and force plates. Bilateral lower extremity biomechanics including knee excursion (KEX), peak vertical ground reaction forces (VGRF), internal peak knee abduction moments (KAM), and peak knee extension moments (KEM) were calculated. A repeated measures analysis of variance was used to determine differences between groups (HI vs control) and limb (involved vs uninvolved). Alpha value set at 0.05. There were no significant differences between the HI group and control group in peak IKQS or running mechanics, and there was no significant group x limb interaction. In both the HI group and the control group, the involved limb exhibited significantly lower IKQS (Control-Univolved:217.20±48.14Nm/kg; Control-Involved:128.31±35.33Nm/kg p=<0.001,HI-Uninvolved:221.54±61.28Nm/kg;HI-Invovled:143.05±60.74Nm/kg,p=<0.001) and KEM(Control-Uninvolved:4.08±0.83Nm/kg;Control-Involved:1.93±0.75,p=<0.001;HI-Uninvovled:3.80±0.36,HI-Involved=2.48±0.39,p=<0.001), less KEX(Control-Uninvoled:27.89±6.28°,Control-Invovled:18.36±3.73°,p=0.007;HI-Uninvolved: 26.74±0.82°,HI-Invoved:21.93±1.52°,p=0.039), and lower peak VGRF(Control-Uninvolved: 3.32±0.65xBW,Control-Involved:2.99±0.57xBW,p=0.001;HI-Uninvolved=3.13±0.36,HI-Involved: 2.95±0.35,p=0.007) compared to the uninvolved limb. Individuals who received the HI post-surgery did not present with improved strength or running mechanics six months post-ACLR compared to control subjects. Future research should investigate benefits of neuromuscular and physiological factors from a HI.

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College of Engineering Biomedical Research Day

Poster Presentation 254

Abstract Title: **Cryogenic Formation of Multi-Layered Hydrogel Scaffolds with Tunable Interfaces**

Author(s): A. Najarzadeh, and D.A. Puleo

Abstract: Spatiotemporal control of mechanical properties and (bio)chemical cues is a critical design element in the engineering of scaffolds to mimic and maintain the complex structure and signal patterns of tissues. Scaffolds with gradient properties may provide a path to achieve spatiotemporal control of signal distribution. In the present study, layered systems of three different hydrogels were fabricated to exhibit gradient interfaces with tunable mechanical properties that may be used to design complex tissue structures with different anatomic zones for tissue engineering applications.

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College of Engineering Biomedical Research Day

Poster Presentation 255

Abstract Title:	**Automated Selective REM Sleep Restriction Through Non-invasive Somatosensory Stimulation**
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Abstract: The role of REM sleep in normal physiological function and health is widely studied, most commonly by selectively interrupting the state in question. Many protocols developed for experimental REM sleep restriction (RSR) are stressful to the animal or affect its normal behavior. To address these limitations, we have developed an automated system that tracks sleep stages in real time and applies non-invasive vibrotactile stimulation to induce a state change. Here, we assess the ability of this system to accomplish RSR. With IACUC approval, eight C57BL/6 mice (4M/4F) were instrumented for EEG/EMG monitoring. Custom software classified signals as Wakefulness, REM sleep, or Non-REM in real time. Upon detecting REM, a waveform of specified frequency and amplitude actuated a cage-mounted stimulator (MouseQwake; Signal Solutions, LLC) to interrupt REM. Each animal underwent four trials with unique stimulation frequency/amplitude. When compared to baseline, low intensity stimulation had no clear effect on REM, but higher intensity settings reduced mean REM bout duration by 50-70% depending on stimulation setting. Furthermore, a setting-dependent reduction in REM proportion (up to 40%) was observed during the first 4 hours of stimulation, after which a compensatory REM rebound occurred. The system used here has the potential to non-invasively alter sleep on a state-specific level, and stimulation parameters can be tuned to suit experimental conditions and compensate for circadian/homeostatic changes in response thresholds – difficulties inherent to most sleep restriction protocols. Ongoing efforts include automatic adaptation of stimulation parameters to combat rebound, as well as transitioning to sleep classification through non-invasive signals.

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College of Engineering Biomedical Research Day

Poster Presentation 256

Abstract Title:	**Noninvasive Screening of Epilepsy Onset in Small Animal Models Using a Piezoelectric Sensor**
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Abstract: Outcomes in preclinical models of epilepsy can be very variable. In most cases, it is desirable for experimental therapies and/or monitoring to take place once animals' seizure rates stabilize. However, quantifying the latency to epilepsy onset is complicated by the diversity of seizure-related behaviors and the unpredictability of seizure recurrence. While invasive electroencephalography (EEG) allows for accurate seizure detection, it is difficult to know which animals to implant beforehand. Visual observation or video analysis, while non-invasive, is labor-intensive and time-consuming. Thus, convenient non-invasive automated methods for seizure screening are desirable. Here, we investigate the utility of a piezoelectric ("piezo") motion sensor for noninvasive seizure screening in two rodent epilepsy models. Mice and rats (n=4/group) of both sexes were treated with pilocarpine i.p. to induce acute status epilepticus (SE). In this model, seizures typically subside in 1-2 hours and spontaneously recurring seizures—the hallmark of chronic epilepsy—may emerge after a latent period of several weeks. Animals that survived SE were monitored continuously for 12 weeks in individual, piezo-equipped cages. An algorithm based on piezo signal features significantly deviating from a moving baseline was used for seizure detection. Video review of the detections revealed variable seizure outcomes, which guided us in choosing animals to implant for a further validation. This demonstrates the feasibility of noninvasive epilepsy screening without exhaustive review of video. However, approximately 8-10 detections needed to be reviewed for every true seizure, so our next priority is to optimize the detection algorithm to increase detection specificity.

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College of Engineering Biomedical Research Day

Poster Presentation 257

Abstract Title:	**Examining Kinematic Changes of the Trunk Following a Standardized Chiropractic Treatment Plan**
Author(s):	A. Elliott-Rosenberger, Department of Biosystems Engineering, U of Kentucky

Abstract: Americans are increasingly using manual therapies as a complimentary or alternative method to conventional medical care. Among different types of manual therapies, spinal manipulation has become a widely practiced technique amongst chiropractors, osteopathic physicians, and physical therapists. Approximately 22 million Americans visit chiropractors annually, 35% of which are seeking relief from back pain. This submission details a designed feasibility study to examine kinematic changes of the trunk resulting from a four-week standardized chiropractic treatment plan for low back pain. Twenty patients with low back pain will be recruited from the current clientele of a local chiropractor. The chiropractor will also define the treatments available for use in the study. Subjects will be expected to visit the chiropractor two to three times per week, for four weeks. Two data collection sessions will be performed in the chiropractor's clinic; one before the subject's first treatment session, and one after their final treatment session, following the four-week period. During the data collection sessions, subjects will complete the Oswestry Low Back Disability Questionnaire, and then perform simple tasks such as trunk forward bending, axial twisting, and lateral bending. Kinematic changes will be evaluated using a multi-directional force plate and inertial measurement units (IMUs). We expect to see distinct differences in biomechanical outcome measures (i.e. range of motion, lumbopelvic rhythm) in subjects following completion of the four-week treatment plan. The study will begin once Institutional Review Board approval is granted.

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College of Engineering Biomedical Research Day

Poster Presentation 258

Abstract Title:	**Dynamic Sequence Alignment Identifies AKI Trajectory Phenotypes Associated with Increased Inpatient Mortality**
Author(s):	T. D. Smith, Department of Computer Science, Institute for Biomedical Informatics, University of Kentucky J. A. Neyra, Department of internal Medicine V. Ortiz Soriano, Department of Internal Medicine J. Chen, Institute for Biomedical Informatics, Departments of Internal Medicine and Computer Science

Abstract: Acute kidney injury (AKI) occurs in about 50% of ICU patients and is strongly associated with hospital mortality. Current approaches to model AKI severity focus on the maximal absolute or relative change in serum creatinine (SCr) in reference to baseline. While changes in SCr represent activities of a wide range of pathophysiologic processes, current models rely on single changes in SCr which ignore critical factors, such as duration of AKI or multiple hits, strongly associated with the risk of hospital mortality. We develop a new machine learning algorithm called TAKI (Trajectory of Acute Kidney Injury) to model AKI trajectory phenotypes by leveraging a large amount of ICU patient data with SCr values obtained over time. In TAKI, a population-based Dynamic Time Warping (DTW) algorithm is presented to align patients' SCr records while preserving critical clinical features such as the duration and relative severity of AKI. Similarly, a population-based distance function is presented to compare aligned SCr records between patients, followed by hierarchical clustering to identify final AKI trajectory sub-phenotypes. Experimental results on 6,816 ICU patients at the University of Kentucky Albert B. Chandler Hospital indicate that TAKI is better than existing trajectory clustering algorithms regarding the association between AKI trajectory sub-phenotypes and hospital mortality and the association between trajectory sub-phenotypes and AKI progression. Next steps will include identifying and extracting key trajectory features most highly associated with inpatient mortality to aid in the development of a new tool stratify patients with AKI in the ICU by risk of inpatient mortality.

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Poster Presentation 259

Abstract Title:	**Noninvasive Diffuse Correlation Spectroscopy for Cerebral Blood Flow Measurements in Frontal and Occipital Corties**
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Abstract: Cerebral vascular disease (CVD) is a common problem in aging populations. Quantification of cerebral blood flow (CBF) is essential for diagnosis and therapeutic monitoring of CVD. Near-infrared diffuse correlation spectroscopy (DCS) is a relatively new technology enabling noninvasive measurements of CBF in cerebral cortex. In previous studies with DCS, a fiber-optic probe was placed on the subject's forehead for CBF measurements in frontal cortex. CBF levels at other regions are also valuable, but difficult to measure due to hair influence and low signal-to-noise ratio (SNR). We report a modified DCS system with a fast software correlator technology to improve the sampling rate from 3 Hz to 20 Hz. Two optimized fiber-optic probes with long and flexible fiber tips placing between hairs were fixed with a velcro band and medical tape and covered with wrapping bandage for detecting CBF signals from both frontal and occipital cortices. We test the improved DCS system in two volunteers, including a young volunteer (32 yrs) with more hairs and an older subject (83 yrs) with less hairs. Resting CBF indces in each subject were continously measured for 3 minutes. Results demonstrate the feasibility of simultaneous measurements of CBF indices from both frontal and occipital cortices. More subjects are being recruited to further validate this innovative technique in aging populations with the goal of applying this noninvasive portable device for screening and assessing of CVD.

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Poster Presentation 260

Abstract Title:	**Simultaneous Measurements of Cerebral Blood Oxygenation and Metabolism using Noninvasive Near-infrared Spectroscopy**
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Abstract: A subject is in danger when there is a prolonged lack of oxygen delivery to brain for meeting cerebral metabolic demand. Thus, there is an urgent need for real-time measurements of cerebral tissue oxygenation and metabolism. Near-infrared spectroscopy (NIRS) is a noninvasive, continuous, and portable tool for bedside monitoring of dynamic changes of oxygenated and deoxygenated hemoglobin concentrations ([HbO2] and [Hb]) in cerebral microvasculature. However, these measurements do not directly reflect cerebral oxidative metabolism at the cellular level. Changes in the oxidation state of Cytochrome-C-Oxidase (oxCCO) are indicative of CCO redox state changes within mitochondria, and therefore represent oxygen utilization in cells. In this study, a frequency-domain multiple-wavelength (690, 750, 780 and 830 nm) NIRS probe was fixed on the subject's forehead to measure simultaneously dynamic changes in [HbO2], [Hb], and [oxCCO] during a protocol of breath holding. These dynamic changes in chromophore concentrations were extracted with the modified Beer-Lambert law from the measured light attenuations due to chromophore's absorptions. After lying supine on the bed for 5 minutes, the subject was asked to take a deep breath and hold it as long as he/she can. After 5-minute recovery, this procedure was repeated one more time. Increases in Δ[oxCCO] and [HbO2] and a decrease in [Hb] were found during breath holding. Simultaneous measurements of [HbO2], [Hb], and [oxCCO] provide more a comprehensive evaluation of brain health state compared to a single-parameter measurement. Future studies will apply this system in patients with cerebral vascular/cellular diseases affecting brain oxygenation and metabolism.

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College of Engineering Biomedical Research Day

Poster Presentation 261

Abstract Title:	**Development of An Innovative Optical Tissue Flow-Oximetry System**
Author(s):	Yanda Cheng, Department of Biomedical Engineering, University of Kentucky Yutong Gu, Department of Electrical Engineering, University of Southern California Xuhui Liu, Department of Biomedical Engineering, University of Kentucky Chong Huang, Department of Biomedical Engineering, University of Kentucky Guoqiang YuDepartment of Biomedical Engineering, University of Kentucky

Abstract: We report an innovative near-infrared diffuse speckle contrast flow-oximetry (DSCFO) system for simultaneous measurements of blood flow and oxygenation variations in relatively deep tissues. In DSCFO, two small laser diodes at wavelengths of 785 nm and 830 nm are used as point sources and a tiny CMOS camera as 2D detector array to detect reflected spontaneous spatial fluctuations of laser speckles, resulting from motion of red blood cells (i.e., blood flow). Tissue blood oxygenation is calculated from the measured light intensities at two wavelengths. A current driving circuit with feedback is designed and controlled by a graphical interface based on LabView to actively stabilize output powers of the laser diodes. The CMOS camera is connected through a commercial control board (NanoUSB2.2, Awaiba) to a laptop and controlled by C# program. The laser diodes and camera are synced through an internal trigger based on the Transmission Control Protocol (TCP) communication technology. Innovatively, connections between the DSCFO probe and a control laptop are all flexible electrical wires (i.e., fiberless) that offer wearable flexibility for continuous cerebral monitoring in freely moving subjects. The DSCFO system is tested and calibrated against established technologies in standard tissue-simulating phantoms and human forearm tissues with manipulated physiological changes. Results show that the DSCFO can continuously measure and display rapid changes in blood flow and oxygenation with a fast sampling rate of 5 Hz. The wearable DSCFO has potential to be used for continuous monitoring of tissue blood flow and oxygenation variations in conscious, freely moving subjects.

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College of Engineering Biomedical Research Day

Poster Presentation 262

Abstract Title:	**Extracting Multiple Tissue Optical Properties from Speckle Contrast Diffuse Correlation Tomography (scDCT) Measurements**
Author(s):	M. Zhao, Department of Biomedical Engineering, U of Kentucky C. Huang, Department of Biomedical Engineering, U of Kentucky G. Yu, Department of Biomedical Engineering, U of Kentucky

Abstract: Objective: We recently developed an innovative speckle contrast diffuse correlation tomography (scDCT) system for 3D imaging of blood flow (BF) distributions in relatively deep tissues. One limitation with this technique is the potential influence of other unknown tissue optical properties such as tissue absorption coefficient (μa) on BF measurements. In this abstract, we report a new algorithm to extract both μa and BF from the measured light intensities and speckle contrasts at multiple source-detector (S-D) distances. Methods: The new algorithm was tested using tissue-simulating phantoms with varied values of μa (0.04 to 0.13 cm-1) and BF index (6.5e-9 to 1.1e-8 cm2/s) created by ink titration and phantom temperature changes, respectively. Light intensities measured at multiple S-D distances were used to fit μa, and speckle contrasts were used to fit BF with the μa as input. Results were compared against established technologies including a diffuse correlation spectroscopy (DCS) for BF and a near-infrared spectroscopy (NIRS) for μa. Results: Significant correlations were found between scDCT measurements with our new algorithm and DCS/NIRS measurements of μa ($R2 = 1.00$, $p < 0.01$) and BF ($R2 = 0.89$, $p = 0.01$). Discussion and Conclusions: We have developed a new algorithm enabling simultaneous extraction of μa and BF from scDCT measurements. Results from phantom tests demonstrated good performance of our new algorithm in the normal range of μa and BF variations for biological tissues. We are currently testing this innovative technique/algorithm for in vivo measurements of optical properties and hemodynamics in human tissues.

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