16th Annual Regional National Occupational Research Agenda (NORA) Young/New Investigators Symposium

University of Utah's Rocky Mountain Center for Occupational and Environmental Health (RMCOEH) and The Department of Mechanical Engineering

April 19-20, 2018

Welcome Address

We are delighted by your attendance this year at our Annual NORA Young and New Investigators Symposium. This year commemorates our 16th Annual NORA Symposium and is attended by students, researchers, and professionals from around the country. We want to thank each of you for attending our symposium and bringing your expertise, knowledge, and vision to our group. We invite you to ask questions of the speakers, network with one another and develop new friendships and collaborations.

We would also like to thank Drs. Ken d'Entremont and Don Bloswick for reviewing abstract submissions, and Liz Reiser for her efforts in taking care of everything else. Please contact Liz.Reiser@mech.utah.edu if you need anything during the symposium.

This symposium is made possible in part through the generous support of the Rocky Mountain Center for Occupational and Environmental Health, the Department of Mechanical Engineering, and funding from NIOSH (NIOSH Education and Research Center training grant T42/CCT810426-10).

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Thursday, April 19 - Keynote

Keynote
19-Apr
8:45

NIOSH, NORA and Robots

Brad Husberg, BSN, MSPH
National Institute for Occupational Safety and Health

The National Institute for Occupational Safety and Health (NIOSH) seeks to develop new knowledge in the field of occupational safety and health and to transfer that knowledge into practice. A large part of NIOSH activities involve providing leadership, conducting relevant research activities, and recommending public health interventions for the occupational safety and health community to advance worker well-being.
NIOSH accomplishes many of these activities by working with stakeholders through the National Occupational Research Agenda (NORA). The NORA is a partnership program to stimulate innovative worker safety and health research and improved workplace practices. The national agenda is developed and implemented through NORA Councils. Each council develops and maintains an Agenda. Participation in NORA is broad, including stakeholders from universities, large and small businesses, professional societies, government agencies, and worker organizations. One of the common themes of the different NORA agendas is emerging technologies.
One of the common emerging technologies is the use of robots in the workplace, beyond the industrial robots that have been around for decades. These emerging robotic technologies include: Collaborative robots designed to work alongside human workers; mobile robots that move alongside and in the same space as human workers; wearable robotics designed to decrease physical loads on human workers (i.e., powered exoskeletons/exosuits); and remotely controlled and autonomous ground and aerial vehicles, such as tractors, rescue vehicles, commercial trucks, and drones. In 2017 the Center for Occupational Robotics Research was created within NIOSH. The centers mission is to provide scientific leadership to guide the development and use of occupational robots that enhance worker safety, health, and wellbeing.

Thursday, April 19 - Session 1

Estimating Trunk Postures in Manual Material Handling Using Simple and Complex Wearable Measurement Systems

Oral
19-Apr
10:20

Molly Jean Hischke, Jose Arroyo, John Rosecrance
Colorado State University

Introduction: For decades, low back disorders (LBDs) have been recognized as major causes of injury among many occupational populations (NRC, 2001; Marras et al., 2009). Tasks like manual material handling (MMH) routinely demand workers to engage in awkward trunk postures (Coenen et al., 2013; Putz-Anderson and Bernard, 1997; Marras; 2010). Tasks involving awkward trunk postures has been associated with low back disorders in numerous occupations (Lavender et al., 2012; Marras et al., 1993; van Dien et al., 2010; Zurada, Karwowski, and Marras, 2004). Wearable devices are becoming more common to assess motion as an occupational tool, and limited research exists comparing their performance. The purpose of the present study was to evaluate the comparability and agreement between a simple wearable measurement system (Bioharness 3), and a complex wearable system (XsensTM) for estimating trunk postures during simulated MMH.

Methods: Thirty healthy participants were recruited from Colorado State University. Each participant was fitted with both a ZephyrTM Bioharness 3 (Zephyr Technology Corporation, USA), and XsensTM (Xsens Technolgoies, NL). Participants wore the two systems simultaneously during simulated tasks in the laboratory that involved reaching, lifting, lowering, and pushing a load for ten minutes.

Results: Results indicated that the Bioharness 3 and Xsens systems were comparable for strictly estimating trunk postures involving flexion and extension of 30 or less. The Bioharness also exhibited moderate to strong agreement and correlations with the Xsens system for measuring common exposure assessment metrics, including amplitude probability distribution functions and percent time spent in specific trunk posture categories. However, the large root mean square difference, and Bland Altman limits of agreements suggests poor agreement and lack of comparability. More research is needed to determine if the differences between the two systems impact clinical applications.

Conclusion: Wearable technology has improved to the point where measuring physical exposures in industry is more attainable than ever. However, limited research exists comparing common exposure assessment metrics between different wearable devices. Furthermore, if the Bioharness is able to measure common exposure metrics comparably to Xsens, the simplicity of the Bioharness may be more realistic for occupational professional to utilize in the field.

Fuzzy Logic Approach to Improve The Accuracy of Rapid Entire Body Assessment(REBA) Method

Oral
19-Apr
10:40

Chuan Zhao, Carisa Harris-Adamson, Sui Huai Yu
Northwestern Polytechnical University/University of California Berkeley

Introduction: Work-related musculoskeletal disorders (WMSDs) are a significant problem and associated with physical exposures such as force, awkward posture, and repetition. Effective and efficient exposure assessment is critical to mitigating ergonomic risks associated with WMSDs. Observational methods, such as the Rapid Entire Body Assessment (REBA) are commonly used by practitioners since they are easier to use, less costly and more flexible when it comes to collecting data in the field. However, estimating posture angles accurately and reliably can be challenging. The visual ambiguity in estimating those posture angles often makes it difficult for a human observer to obtain accurate inputs, leading to inaccurate analysis outcomes. The purpose of this study was to assess the application of a fuzzy logic approach to the REBA. to improve the precision of ergonomic assessment inputs, caused by human intuition in field observation.

Methods: A fuzzy system uses a collection of fuzzy membership functions and if-then rules to improve the accuracy of the REBA. Trapezoidal membership functions are used to represent the angle ranges of the inputs as well as the weight imposed on the worker, and triangular membership functions are used for intermediate variables which represent the REBA intermediate scores. The final output variable, REBA total score, is also represented by triangular membership functions. To validate the Fuzzy REBA model, 10 participants took part in a manual material handling (MMH) lifting task (100 cm and 150 cm height; 1 kg and 5kg weight). Electromyography (EMG) recorded muscle activity of the right extensor digitorum communis (EDC), deltoid(DLT), and upper trapezius (UT); videos recorded the lifting task. Spearman's correlation coefficients estimated the relationships between the study variables.

Results: The result shows that the Fuzzy REBA score was highly correlated with the traditional REBA result($r=0.85$, $p<0.01$), EMG activities on RD($r=0.85$, $p<0.01$), REDC($r=0.69$, $p<0.01$), and RUT($r=0.76$, $p<0.01$). Significant correlations were also found between REBA score and EMG activities on RD ($r=0.71$; $p<0.01$), REDC($r=0.64$, $p<0.01$) and RUT($r=0.62$, $p<0.01$). But the correlations between the Fuzzy REBA results and the EMG data were higher than that of traditional RULA.

Conclusion: The Fuzzy REBA outperformed the traditional method when addressing discrepancies the results of traditional tools, caused by human perception with respect to discrete input boundaries. This study thus provides a more reliable field tool to identify worker postures in manual operations, and consequently reduce the rate of WMSDs in basic industry.

Ergonomic Assessment and Abatements to Reduce Risk of Musculoskeletal Disorders in Production Line Workers in Utah

Oral
19-Apr
11:20

Reg Beales, Robert Chestnut, Isaiah Merriam, Christopher Moore, Melynda Schreiber, Andrew Merryweather

Rocky Mountain Center for Occupational and Environmental Health

Introduction: Musculoskeletal disorders (MSDs) related to Manual Material Handling (MMH) performed in the workplace are associated with high medical costs, absenteeism, and presenteeism. Multiple ergonomic tools have been developed to objectively evaluate MMH activities that increase risk of MSDs. A Utah manufacturer has recorded multiple MSDs in production line workers during the past year. A new packaging process may have put workers at increased risk of MSDs.

Methods: An overview of the new packaging process including production requirements was obtained from safety and management personnel. Production line workers were observed, photographed, and video recorded while performing this process. The process was divided into five primary tasks and the following ergonomic tools were selected to assess the individual tasks for risk of MSDs: Task Hazard Abatement Worksheet (THA), Utah Revised Back Compressive Forces, Rapid Upper Limb Assessment (RULA), Shoulder Moment, Metabolic Rate Predictive Method, Strain Index (SI), and the NIOSH Revised Lifting Equation (RLE). The OSHA 300 log from the prior year and respective financial records were obtained and evaluated for trends of injury type, location, and costs.

Results: Direct observation and completion of THA revealed frequent non-neutral movements. Back Compressive Force and Shoulder Moment worst case estimations were 695 lbs and 41.5% respectively, neither of which is considered to increase the risk of MSDs. This was likely due to relatively low weight of load (3.2kg). RULA and SI identified Loading, Staging, Boxing, and Stacking as tasks that increase the risk of MSDs. The RULA and SI scores for these tasks were greater than four and seven respectively, representative of immediate change being recommended. The tasks Loading, Boxing, and Stacking were found to exceed the recommended level for metabolic rate of 261 kcal/hour. The NIOSH RLE yielded a score of 5.4 and revealed the chief process aspects in need of abatement were lift frequency, asymmetry, and height, which are present in Boxing, Loading, and Stacking. Review of the OSHA 300 log revealed that 71% (n=15) of the 21 OSHA-reportable injuries in 2017 were MSDs. 53% (n=8) of the MSDs were Upper Extremity MSDs (UEMSDs) that occurred primarily in the production line areas. These UEMSDs resulted in three days of absenteeism and 233 days work restriction (proxy for presenteeism). The direct employer cost for these injuries was $84,303 (median=$2,302).

Conclusion: A 1:1 ratio of workers per task was recommended in order to reduce lift frequency. Moveable task fixture arrangements were proposed for reducing task asymmetry. Recommended use of permanent or mobile pallet jacks with adjustable height to reduce vertical displacement. Recommended that production line workers and supervisors receive relevant training to increase adherence to neutral body positions. The OSHA 300 log review demonstrated significant MSDs reported in the production area and significant cost incurred by the employer. Data collected in this review may be used to formulate an economic justification for the proposed abatements.

Pilot Study Predicting Body Core Temperatures in Hot Work Environments Using Thermal Imagery

Oral
19-Apr
11:20

Jacob Thomas, Leon Pahler, Rod Handy, Matthew Thiese
University of Utah

Introduction: Heat stress can lead to various health issues including heat rash, heat exhaustion, heat syncope, cramps, and heat stroke. Heat stroke can lead to death or serious injury if not treated quickly. One of the most reliable ways to assess heat stress is by measuring the core body temperature. The gold standard procedure for assessing core body temperature has been rectal thermometers, which are so invasive that many workplaces choose to forgo their use. The goal of this study was to investigate a more convenient method of assessing heat stress for workers in hot work environments by comparing temperature measurements from transmitting thermometer pills to temperature measurements of an employees face using an infrared camera.

Methods: Eight volunteers working in a hot work environment were selected for this study. Temperature measurements were taken with four employees on August 28, 2018 and four employees on September 1, 2018. All eight employees ingested a thermometer pill (CorTemp Ingestible Core Body Temperature Sensor) four to six hours before their body core temperature measurements were taken. Worker temperature measurements were recorded approximately every 30 minutes throughout their normal daytime work schedule. An infrared camera (TiS 65 Fluke Infrared Camera) temperature measurement was taken immediately after the thermometer pill temperature measurement was recorded. The infrared camera temperature measurements included a frontal face measurement and a measurement of the left side of the head, near the ear. The left side was chosen due to the passage of the external carotid artery through this area. A linear regression model was used to evaluate the correlation between the two measurements. Outside temperature measurements were obtained from the National Weather Service so temperatures could be evaluated with the worker measurements. Workplace temperatures were measured using a Wet Bulb Global Thermometer (WBGT) instrument (Quest Technologies QUESTemp 36 Thermal Environment Monitor).

Results: Correlation between temperature measurements recorded from the thermometer pills and the infrared camera was different by group. Group 1 had a much higher correlation compared to Group 2. The R^2 values were as high as 0.847 and two of the eight employees measured a very low R^2=0.004. The combined R^2 value for group 1 was 0.56 and the combined R^2 value for group 2 was 0.076. A possible reason for this could have been differing temperatures both outside and in the workplace. When group 1 temperatures were measured, the outside temperature measurements ranged from 96-99°F. When group 2 was sampled four days later, the outside temperature measurements ranged from 84-90°F. Temperatures were also different in the worksite on these two given sampling days. For group 1, the temperatures were globe=109.5°F and WBGTin=86.8°F. For group 2, the temperatures were globe=106.7°F and WBGTin=89.1°F. The effect of the combination of these differences merits further investigation.

Conclusion: Although the statistical results didn't demonstrate strong correlations for these two groups, more research should be conducted to determine how workplace temperatures affect the accuracy of the infrared camera facial temperatures compared transmitting thermometer pill body core temperatures. Group 1 temperature statistics showed a much more encouraging correlation (R^2=0.56). Group 1 outside and inside work temperatures were considerably warmer during this study. The results of this study merit more rigorous research with warmer indoor/outdoor temperatures and more participants.

Cardiovascular Strain Among Hotel Room Cleaners

Oral
19-Apr
11:40

Abdullah Khafagy, Duyen Dinh-Dang, Carisa Harris-Adamson
University of California, Irvine

Introduction: There are about 500,000 people who work in cleaning hotel rooms in the United States. Most hotel room cleaners are from immigrant populations with low socioeconomic status (SES), low job control, and low cardiovascular fitness, which are consistently associated with increased risk of cardiovascular disease. High levels of occupational physical activity and high-energy expenditures at work are also associated with increased risk for cardiovascular diseases. We aimed to evaluate the impact of high occupational physical activity on the physiology of the cardiovascular system of hotel room cleaners.

Methods: In a cross-sectional study, sixteen hotel room cleaners between 33 and 55 years had baseline measurements and cardiovascular fitness testing and completed background and psychosocial work stress surveys. They were trained on wearing a 24-hour ambulatory heart rate (HR), blood pressure (BP) and activity monitors. We recorded heart rate and blood pressure for 4 days- divided into 2 workdays and 2 off days- using a 24-hour ambulatory heart rate and blood pressure monitors for measuring aerobic workload [%HR reserve (%HRR)], as well as movement activity using an activity monitor. Participants filled a daily diary with wake/sleep times, eating times, and both work and leisure activities.

Results: Of the 16 hotel room cleaners, 50% were Spanish and 50% were Chinese with an average years working as hotel room cleaners of 11.4 (SD±8.6). When comparing Pre-Work HR and BP to the same time on the rest day, we found significant difference in HR [86.2±16.4 vs. 70.3±9.8, $P<0.02$], Systolic BP [119.9±17.5 vs. 114.1±13.8, $P<0.04$] and Diastolic BP [78.2±8.1 vs. 72.5±10.0, $P<0.01$]. For the first hour of work vs. same time on rest day, we found significant difference for HR [90.7±9.9 vs. 74.7±9.9, $P<0.00$] but not for Systolic [120.8±17.8 vs. 116.2+/-16.4, $P<0.06$] or Diastolic [76.9±12.9 vs. 75.9±11.1, $P<0.32$] BP. And for the last hour of work vs. same time on rest day, we found significant difference for HR [94.9±12.4 vs. 82.9±20.3, $P<0.03$] and Diastolic BP [78.0±9.5 vs. 72.7±10.9, $P<0.00$], but not for Systolic BP [120.4±17 vs. 117.0±18.5, $P<0.10$]. Average METs for a work period across all subjects during a workday was 2.57 METS (classified as moderate intensity) and peak METs was 4.88 METs (classified as high-intensity). Heart rate elevation occurred over the course of a work shift.

Conclusion: Preliminary analysis shows hotel room cleaners are working at an increasing relative workload as the day progressed based on average and peak heart rate and diastolic blood pressure, and may be at increased risk for cardiovascular disease.

Thursday, April 19 - Session 2

Effectiveness of Biocide Substitution and Management Plan Implementation for the Control of Legionella pneumophila in Cooling Tower Waters

Oral
19-Apr
1:00

Adelmarie Bones, CIH, Rene Salazar, PhD, CIH
University of South Florida

Introduction: After the notorious outbreak and discovery of Legionella bacteria in 1976, the waterborne pathogen was added to the list of disease-causing agents associated with the built environment. Legionella pneumophila was discovered when it was identified as the agent that caused 34 deaths and an outbreak of pneumonia-like symptoms in several attendees of the 1976 American Legion Convention held in Philadelphia (OSHA, 2017).
Recently published data from the year 2015 reported more than 6,000 Legionnaires cases identified in the United States (CDC, 2016). This is a concerning number given that one in every ten infected persons will die of the disease. It is believed that case numbers are likely under-reported, given that Legionnaires disease is very difficult to diagnose.
Legionella species live naturally in bodies of water, including lakes and rivers. Legionnaires disease has been associated with the introduction of Legionella into manmade water systems. The presence of Legionella has been reported in cooling towers, domestic hot-water systems, humidifiers, decorative fountains, grocery spray misters, spas, whirlpools, and dental water lines, among other systems housing stagnant water (CDC, OSHA, 2017). From an occupational exposure standpoint, cooling towers are considered the most concerning source of Legionella pneumophila exposures, based on data from previous cases (Principe et al., 2017).
The purpose of this research was to measure the effectiveness of biocide substitution and maintenance management in evaporative condensers. Such condensers were previously identified as having high counts of Legionella pneumophila in the water and/or on surfaces. The study sites were in the states of Florida and Georgia. Initial water testing for Legionella was carried out between July and August of 2016.Results from 2016 showed high counts of colony forming units (CFU) per millimeter (mL) at baseline assessment. An intervention of biocide substitution and enhanced management planning was recommended in order to lower or eliminate L. pneumophila from the water basins of the evaporative condensers. Follow-up results of water sampling conducted between July and August 2017 showed a significant reduction of CFU counts after the intervention plan had been implemented for an entire year.

Methods: Water Sampling of Evaporative Condensers, Statitiscal analysis of differences in levels from 2016 and 2017

Results: Significant reduction of Legionella counts was achieved after continuous biocide application and the implementation of a management plan

Conclusion: Use of biocide and an implementation of a management plan helps reduce the levels of Legionella in cooling tower waters.

Characterization of CO and NO2 Exposures of Ice Skating Rink Maintenance Workers

Oral
19-Apr
1:20

Aaron Cox, Darrah Sleeth, Rodney Handy, Victor Alaves
University of Utah

Introduction: Air quality issues are common among indoor ice rink facilities due to the use of gasoline/propane ice resurfacing equipment. Although previous studies have investigated spectator, guest and skater exposures, none in the published literature have evaluated ice maintenance employees exposures. Ice maintenance includes edging and resurfacing. The resurfacer is commonly referred to as a Zamboni®. Edging is almost always followed by resurfacing, but resurfacing frequently happens independently of edging.

Methods: Employees from four (4) ice rinks in Salt Lake County, Utah were sampled during routine ice maintenance activities. Maintenance was divided into four (4) activities: 1) Edging only, 2) Resurfacing after edging (not including edging), 3) Edging and resurfacing (Activities 1 and 2 combined), and 4) Resurfacing only (independent of edging). Activities 1, 2 and 3 were sampled twenty-four (n=24) times. Activity 4 was sampled eight (n=8) times. Sampling results were analyzed using Analysis of Variance and T-tests to find differences between activities and rinks.

Results: CO results indicated differences between Activity 2 (resurfacing after edging) and Activity 4 (Resurfacing only), and between Activity 3 (edging and resurfacing) and Activity 4 (resurfacing only, all $p<0.001$). For specific activities at different rinks, there were differences for Activity 1 (edging only) between all rinks except 3 and 4 (all $p\leq 0.002$); for Activity 2 (resurfacing after edging) between rinks 1 and 3 ($p=0.007$); and for Activity 3 (edging and resurfacing) between rinks 2 and 3 ($p=0.008$). NO2 samples indicated minimal exposure at all four rinks (only gasoline powered equipment was used).

Conclusion: Results confirmed that gasoline edgers significantly contribute to indoor CO levels. Indoor ice rink facilities should monitor employees CO exposures and implement procedures to limit exposures. This may be achieved by limiting the number of laps taken with the edger or replacing gasoline powered edgers with electric edgers.

Temperature Inversion and Ultrafine Particulate Matter Concentrations in the Salt Lake Valley

Oral
19-Apr
1:40

Danielle Mecate, Rod Handy, Leon Pahler, Darrah Sleeth, Joemy Ramsay
University of Utah

Introduction: Exposure to particulate matter (PM) is associated with a multitude of adverse health effects, including increased mortality rates and respiratory complications, some of which show dependency on particle size. Ultrafine particulates (diameter ¡100nm) are of particular concern due to their small size which allows them to penetrate more deeply into the lungs and potentially cross directly into the bloodstream. Although some associations have been established between ultrafine particle (UFP) exposure and adverse health outcomes, significant gaps still exist surrounding the potential health risks posed by these exposures. Additionally, monitoring for UFPs is still a fairly recent technology leaving the scientific community with a lack of studies on UFP exposures in either occupational or environmental populations. In this study we contribute to the growing body of knowledge about UFP exposure by assessing differences in UFP concentration and fraction during inversion and noninversion episodes in the Salt Lake Valley. Inversions are a common wintertime occurrence in the Salt Lake Valley. They result from the bowl- like geography of the area which allows pollutants to become trapped in the valley when temperature conditions invert, creating a warm air layer over the colder air in the valley. Knowing if there is a significant difference between UFP concentration and fraction during inversions compared to noninversion episodes can help characterize exposures as well as contribute to understanding of the health risks posed by inversions to individuals residing in the Salt Lake Valley.

Methods: In this study, two types of particle counters, the Enmont and the Grimm 1.109, were used to define UFP concentrations in the Salt Lake Valley during inversion and noninversion episodes at 7 sampling sites. Ultrafine particulate concentrations were log-transformed and assessed using t- tests and mixed effects linear regression models to determine if concentration or fraction UFP differed significantly between inversion and noninversion episodes as well as by length of inversion.

Samples were collected from 7 sites throughout Salt Lake City, Utah. A total of 10 samples were collected at each site, 5 during inversion days and 5 during noninversion days. We defined a route prior to any sample collection to ensure that samples were collected from each site at the same time of day and under similar traffic conditions for the surrounding area.

Results: A total of 70 measurements were collected across 5 inversion and 5 noninversion days. However, 3 were excluded due to missing meteorological data. Relative to noninversion days, the geometric mean UFP concentration was 2.97-fold higher during inversions (95% CI 1.924.58). Conversely, the percent UFP declined by 0.29 percentage points on average during inversions relative to noninversions (95% CI -0.43 -0.15). We observed significant differences in the concentration of UFP as well as the ratio of UFP to total PM during inversion episodes.

Conclusion: Results obtained in this study could have serious implications for the health of individuals living in the Salt Lake Valley as well as other areas prone to inversions. Our results indicate that the health risks posed by inversions in the Salt Lake Valley could be due, in part, to the drastically higher exposures to UFP, nearly threefold increase in GM concentration, that we observed during inversion episodes. Length and intensity of inversions could play a significant role in predicting prevalence of adverse health outcomes in the immunocompromised.

Development of an Empirical Formula for Describing Human Inhalability of Airborne Particles at Low Wind Speeds and in Calm Air

Oral
19-Apr
2:00

Alexandra Land Cox, Darrah Sleeth, Rod Handy, Matthew Thiese, Gran Lidn
University of Utah

Introduction: The current International Organization for Standardization (ISO) convention modeling human aerosol inhalability (i.e., aspiration efficiency) is not valid when wind speeds are less than 0.5 m/s. Data from experiments performed in this wind speed range were not included when the convention was created. Additionally, the convention is based only on mouth breathing data and aerosols with aerodynamic diameters smaller than 100 μm. Since the convention was developed, inhalation data at wind speeds lower than 0.5 m/s for nose, mouth, and oronasal breathing have been produced for a wide range of aerosols sizes (6-135 μm).

Methods: To address the weaknesses of the current convention, nose, mouth and oronasal data were gathered from 9 studies which determined experimental aspiration efficiencies in low wind speed (>0 m/s to <0.5 m/s) and calm air (0 m/s) conditions. Once compiled, data was modeled using least squares regression with the intention of developing a simple convention to represent the inhalable fraction when wind speeds are <0.5 m/s. All equations developed related aspiration efficiency (AE) to aerodynamic diameter (dae).

Results: Linear, exponential decay, logistic, and polynomial models were fit to the data. The polynomial model, AE=1+0.000019dae$\hat{2}$-0.009788dae, was found to have the best fit.

Conclusion: This equation will be recommended as a convention to represent aspiration efficiency in low wind speed and calm air conditions to the ISO Technical Committee (TC) 146, Subcommittee (SC) 2, Working Group (WG) 1 (Particle Size Selective Sampling and Analysis) as it relates to standard 7708 and the European Committee for Standardization (CEN) TC 137, WG 3 as it relates to CEN Standard EN 481.

Traumatic life events and development of Post-Traumatic Stress Disorder among female factory workers in a developing country

Oral
19-Apr
2:20

Fitch Taylor, Hasanat Alamgir

Department of Public Health, School of Health Sciences and Practice New York Medical College

Introduction: Healthcare professionals and researchers have become more aware about Post-Traumatic Stress Disorder (PTSD) as a health condition with the availability of more screening tools and treatment options. Type of trauma, number of traumatic events, and health disparities have been found to be associated with the development of PTSD. This health issue may be more prevalent and burdensome in developing countries, yet the evidence from there is largely unavailable.

Methods: A survey was administered to a convenient sample of 607 lower socio-economic status working women in Bangladesh 310 of who were garment workers. The primary outcome PTSD was measured by the Post-traumatic Stress Disorder Checklist and the Life Events Checklist determined the number and type of traumatic events. Data on their demographics and health profile were also obtained.

Results: The prevalence of PTSD was found to be 17.79%: 7.25% in garment workers and 21.55% in the comparison group. In terms of traumatic events participants experienced or witnessed natural disasters (71.83%), fire/explosions (43.33%), and exposure to sudden accidental death (30.15%). In multivariate analysis, PTSD was found to be significantly associated with age, income, chronic pain, and number of stressful events. Participants aged 45-50 had the greatest odds of getting PTSD by 15.68 folds (95% CI = 4.08, 60.29) compared to those aged younger than 24. PTSD was more common in those with lower income (2,000-4,000 taka) [OR = 1.60; 95% CI 0.79-3.26], chronic pain [OR = 2.48; 95% CI 1.51-4.07], and who experienced over 3 traumatic life events [OR = 11.25; 95% CI 4.59-27.59]. Furthermore, the mean number of traumatic events experienced by this entire population was 4.9 with PTSD being more likely in those who experienced physical assault [OR = 6.35; 95% CI 4.07-9.90], caused serious harm or death to someone else [OR = 4.80; 95% CI 1.36-16.87], and had exposure to combat or war [OR = 4.76; 95% CI 1.17-19.34].

Conclusion: Traumatic events and resulting PTSD are common among working lower SES women in Bangladesh. This study demonstrates associations of number and type of trauma, medical conditions like chronic pain and other social determinants of health such as income with PTSD. Undiagnosed and untreated PTSD impact the quality of life and wellbeing of working age adults as well as decreasing worker productivity.

Thursday, April 19 - Poster Session

Indoor Marijuana Grow Operations: Estimation of Fungal Burden Utilizing the Environmental Relative Moldiness Index (ERMI)

Poster
19-Apr
2:40

Kyle S. Root, Julia L. Sharp, Sheryl Magzamen, Stephen J. Reynolds, Michael VanDyke, Joshua W. Schaeffer

Colorado State University

Introduction: The recent legalization of marijuana and indoor marijuana grow operations (IMGOs) across a number of states has highlighted the need for increased understanding of potential occupational exposures. One relevant exposure is the potentially increased fungal burden of IMGOs due to high humidity and temperature levels. However, it has long been a challenge to accurately measure and assess human exposure to airborne mold. Mold specific quantitative polymerase chain reaction (MSQPCR) was developed as a quantitative method for the identification of 36 specific mold species. Subsequently, MSQPCR was used to create the Environmental Relative Moldiness Index (ERMI), which is a moldiness scale based on the abundance of those 36 species. These species are divided into groups: those associated with water damage (Group 1; n=26), and those commonly found inside homes (Group 2; n=10). ERMI values can typically range from -10 to 20 (low to high) with 0 indicating the 50% mark of moldiness.

The ERMI score was developed using approximately 1,000 homes from a specific geographical range. Given the inherent variability in fungal species and levels, it may not be appropriate to use the current ERMI algorithm to describe fungal burden in locations other than a residential structure such as a typical single-family home. Furthermore, extreme or unique environments such as IMGOs may contain mold species at quantities atypical to the average home. For this reason, it is important that the ERMI algorithm and subsequent score be evaluated in a variety of settings to ensure its applicability. The purpose of this study is to examine the use of the ERMI index in describing the fungal burden of IMGOs. We hypothesize that while MSQPCR is an acceptable method for measuring fungal species, the ERMI algorithm may not provide an accurate index of fungal burden in IMGOs.

Methods: Sixty-two MSQPCR and 320 culturable samples were collected from 24 IMGOs for a total of 382 samples. Culturable samples were collected at 28.3 liters per minute using a 400-hole impactor (Standard BioStage, SKC, Inc., Eighty-Four, PA.) connected to a QuickTake 30. Using two different kinds of agar/media (malt extract and DG-18), samples were collected in duplicate in each location. MSQPCR samples were collected using 25 mm styrene cassettes loaded with PVC filters.
Data were analyzed for differences in concentration between Group 1 and 2. Differences in species detected between the ERMI and culturable methods were also evaluated using a mixed-effects model for each species. Method was set as the fixed effect and IMGO as a random effect because both culturable and ERMI samples were collected from each IMGO.

Results: The average ERMI score was 3.65 across all IMGOs with a range of -3 to 18. Higher ERMI scores were primarily driven by A. pollulans, A. sidowii, W. sebi, and A. flavus, which have been demonstrated to be capable of allergenic/pathogenic effects. Using separate mixed effects models for each species (i.e. those species present in both the ERMI and culturable methods), Group 1 species A. versicolor, E. (A.) amstelodami, C. sphaerospermum, P. variotii, S. chartarum, and W. sebi, and group 2 species P. chyrsogenum had statistically significant higher odds of being detected in the ERMI method than the culturable method. However, the majority of species analyzed did not reach convergence due to relatively small numbers detected and did not allow for a comparison between each method.

Conclusion: Given the IMGO conditions, allergenic/pathogenic fungal taxa are present at concerning levels. These results indicate that the ERMI method is detecting some species more often than the culturable method and that MSQPCR may be better suited for detecting some species. Additional research is needed to further address the applicability of the ERMI method in IMGOs and possibly other unique environments.

The Art of Sound: Sound Exposures of School Musicians and Conductors

Poster
19-Apr
2:40

Baylee Schell, William Brazile, David Gilkey
Colorado State University

Introduction: In many school districts, students can learn how to play a musical instrument when they reach middle school. Learning musical instruments requires many hours of practice individually and in ensembles; student ensembles include, but are not limited to, bands, percussion ensembles, and orchestras. Throughout their middle school and high school years, many students become passionate about music and their instrument. After K-12 graduation, they may play their instrument for fun, continue music at the university level, and/or decide to pursue a music degree. Some people who earn music degrees become school conductors and continue the cycle of musical passion for next generations.

Unfortunately, musicians of all genres and levels are susceptible to developing noise-related health effects. This study aims to identify whether musicians and conductors at university, high school, and middle school levels are exposed to high sound levels during their practice sessions. Musician sound exposure is dependent on the repertoire, the duration of practice, the type of group, the environment in which the music is practiced, and whether the musicians take preventative measures to decrease their individual sound exposures.

Methods: With IRB approval, sound measurements were taken from music ensembles using a Larson Davis 831 sound level meter (SLM). Measurements were taken around the perimeter of each group the closest measurements being about three feet away from any individual. The SLM was pointed directly at the conductor at all sound measurement locations. At each location, the largest integrated one second average of sound level in dBA (LAeq(1s)) was recorded on a gridded practice room map at the respective location. LAeq(1s) measurements and scaled maps were input into NoiseAtWork software to generate sound contour maps for each ensemble.

Results: No matter the music level of students, similar ensembles produced similar LAeq(1s) ranges. For instance, the sound level range for middle school, high school, and university string orchestras was about 65 dBA to 85 dBA and that of bands was about 85 dBA to 95 dBA. A percussion ensemble had a sound level range of 95 dBA to 100 dBA.

Conclusion: According to OSHA and ACGIH standards, musicians and conductors at all studied musical levels were exposed to high sound levels, especially in bands and percussion ensembles. This is concerning for respective conductors who may teach music classes for their entire workday. In the future, noise dosimetry, reverberation, and possibly hearing tests will be performed to classify the problem fully. Then, appropriate preventive measures will be implemented for each musical ensemble to reduce damaging sound exposures while also increasing ensemble sound quality.

USF Health Faculty & Staff, Health & Well-being Assessment: Highlighting The Current

Poster
19-Apr
2:40

Carli, Rita DeBate
University of South Florida

Introduction: It is reported in the World Economic Forum that an employee wellness program plays an important role not only reduce the burden of chronic illness and health cost but also increase employees productivity.1 For every 1$ spent on employee wellness programs, the company could achieve the ROI for $2.71.2 Furthermore, OSHA Act of 1970 emphasized employer to assure a safe, healthy working condition.3 Since, the USF campus is a workplace for its faculty and staff, an effective wellness programs is needed. In addition, the objective of this study was to evaluate the health & well-being status of USF faculty and staff.

Methods: The participants were full-time faculty and staff from USF Health. By using $\alpha = 0.05$, 95% CI, 5% margin of error, and 50% of estimated response then the sample size should reach at least 315. The CDC worksite questionnaire was used for assessment and spread through the listserv.

Results: The total sample size of the study was n= 383. 82.5% participants got into analysis process (n=316). Most of the participants were female (81.96%) and about $>$ 50 years old (32.91%). The staff overwhelmingly represented the majority of USF Health employees. In terms of works duration, the majority of participants worked for less than 5 years (164 participants, 51.90%). Around 50% of the participants were in good health condition (46.52%) and without a history of any disease (41.1%). Alarmingly, 82% of participants answered that the pain affects their daily activities (18%). Some of the preventive health services were being well utilized by staff while some areas need to be improved such as medical check-ups (65.19%), blood cholesterol measured (60%), and blood sugar levels monitored in the past 3 years (60.32%). Beneficial behavioral change programs could be implemented to elevate the participation of USF Health employees with a focus on physical activity and healthy eating even though majority of the participants have already been in the fifth stages of change. It could be concluded that for the most participants, they have good mental well-being. Most participants reported being most interested in information about nutrition or healthy eating, weight management, onsite fitness/physical activity, managing stress, and ergonomics (62.94%, 53.99%, 73.80%, 51.76%, 56.87% respectively).

Conclusion: Metabolic syndrome is a hidden majority causal for low health and well-being status among the USF Health Faculty & Staff. Almost 65% of participants suffered from at least one out of four conditions such as hypertension, hypercholesterolemia, hyperglycemia, and musculoskeletal problems. The first three factors are the predispose for metabolic syndrome. Prevention and treatment should be done, such as healthy eating, increasing physical activity, and weight loss.

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Ergonomic Concerns at a Leading Manufacturer of Medical Imaging Equipment

Poster
19-Apr
2:40

Aaron Cox, Kyle Christian, Devin Owens, Charlotte Robison-Hanchett, Andrew Merryweather
University of Utah

Introduction: A leading supplier of medical x-ray tubes and image processing solutions located in the Salt Lake City area has requested a thorough ergonomic evaluation and subsequent abatement strategies for several specific ergonomic concerns related to manufacturing and testing of equipment produced at their main manufacturing facility. The on-site analysis was notable for risk factors including awkward postures, heavy lifting, high force, pinch grips and repetitive motions.

Methods: Evaluation of ergonomic hazards was accomplished using standardized assessment tools to include the NIOSH Recommended Lifting Equation (RLE), Rapid Upper Limb Assessment (RULA), Strain Index (SI), Hand Activity Level (HAL), and Rogers Muscle Fatigue Analysis. Each of these tools is suited to specific ergonomic concerns and hazards. They were applied judiciously to the identified hazards.

Results: For the microscope analysis, it was determined that the hands/wrists/fingers were the biggest area of concern according to the Rodger's and there was a concern found with the duration and intensity of the task. In the panel analysis, three panels (CBI, DXI, HE) were analyzed with the RLE, RULA and Rodger's. The CLI for the CBI was 1.43, for DXI was 2.34, and the HE was 1.0. This meant that the CBI and DXI would be difficult for some workers to do at the current weight of the panels. The RULA performed on the CBI and DXI indicated that the tasks were hazardous and needed further investigation. The Rodger's also identified additional areas of concern, such as the posture of employees, and the time spent on their feet. For the pressure testing hoses, a RULA, Rodger's SI and HAL were performed. All of the performed analyses indicated that this area was hazardous and needed investigation and remediation to reduce the hazard.

Conclusion: In the microscope area, there were two separate remediation recommendations. The first was to install a tool that has two tines that the workers can place the small part on that operates on a gimbal to move the part as needed. It was also proposed that all employees in the clean room be trained on all tasks to allow for rotation. For the panel clean room, it was proposed that clamps be installed as well as sit/stand desks. With the hose pressure testing, it was suggested that hooks to hold the control hoses be placed on the side of the wall to allow for attachment from one direction.

Health Hazards in a Personal Hygiene Manufacturing Facility

Poster
19-Apr
2:40

Alex Cox, Benjamin Heaton, Danielle Mecate
University of Utah, RMCOEH, Occupational Medicine

Introduction: A large personal hygiene manufacturing company collaborated with the Rocky Mountain Center for Occupational and Environmental Health (RMCOEH) Occupational Health and Safety Solutions Class and faculty members to measure employee noise and dust exposures. Employees responsible for measuring and mixing various chemical ingredients work in a dusty and sometimes noisy environment. The dust in the mixing area is a concern since amorphous silica is one of the ingredients. Additionally, employees involved in the production of instrument tips by an automated robotic process are exposed to various types of dust. The companys packaging area consists of five manufacturing lines and noise was of concern when multiple lines are running simultaneously.

Methods: Personal noise dosimetry was conducted on four individuals working on multiple manufacturing lines. A fifth sample was collected from an individual who oversaw the mixing of ingredients by large machinery. Samples were collected using 3M The Edge personal noise dosimeters. Total sample times ranged from 4-7 hours. A Larson Davis LxT Sound Level Meter was used to monitor 54 noise level measurements mapped on a grid in the packaging area. NoiseAtWork V4 was used to construct a noise isopleth map of the packaging area from these measurements. A Grimm 1.109 was used to measure particulate matter in another location where ingredients are measured in a walk-in hood. NIOSH methods 7501 and 0600 sampling procedures were followed to obtain personal respirable and amorphous silica dust samples from three employees working in the mixing rooms. These samples were sent to DCM Science Laboratory, Inc. for analyses. A ventilation survey of the walk-in hood located in the measuring area was performed using a TSI Velocicalc (thermal anemometer). Air velocities were recorded across the hood face in twelve equal squares and an average face velocity was determined.

Results: The personal noise dosimetry sound level for the individual who oversaw the mixing of ingredients was 87.5 dBA for an 8-hour time weighted average. All other personal dosimetry sound levels from the packaging and production areas were below the 85 dBA limit set by OSHAs Hearing Conservation Standard. The noise level measurements used to construct the noise isopleth map of the packaging area ranged from 70-82.2 dBA; however, only 2 of the 5 lines were running. Area measurements for particulate matter concentrations were below personal Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) for total dust (15 mg/m3) and respirable dust (5 mg/m3). Personal amorphous silica samples from two individuals working in the mixing rooms were found to exceed the OSHA PEL (80 mg/m3)/(% silica) for respirable amorphous silica. The average face velocity of the walk-in hood was 21.2 feet per minute.

Conclusion: Noise dosimetry conducted during this study suggests that individuals responsible for mixing ingredients should be enrolled in the companys hearing conservation program due to results that indicated worker noise exposure levels were above 85 dBA. Verification of these results is recommended. It is also recommended that personal noise sampling of employees in the packaging area be repeated when more than two lines are running to provide more accurate worst-case noise exposure estimates. Because two of the respirable amorphous silica samples exceeded the OSHA PEL, one by a factor of five, the company should implement a formal respiratory protection program for employees who mix ingredients. This program should ensure compliance with requirements set forth in the OSHA standard 29 CFR 1910.134.

Health Hazards in a Composite Components Manufacturing Facility

Poster
19-Apr
2:40

Jesse Zmoos, Ben Borsh, Cody Jackson, Michael Fitch, Naomi Riches
University of Utah

Introduction: A composites manufacturing facility had multiple ongoing processes with potential occupational exposures. The manufacturing involved the work of drilling carbon composites, use of solvents and painting the composites. These manufacturing processes had the potential for worker exposure to isocyanates, naphtha, carbon-based dust, synthetic fibers as well as other exposures that had already been evaluated by the company. Isocyanates are known to be powerful irritants to the eyes, skin, and respiratory tract. Isocyanates are also a sensitizing agent that can result in asthma. The exposure to naphtha can also be an irritant. Carbon-based dust health hazards include respiratory damage, bronchitis, decreased lung function, myocardial dystrophy, pulmonary fibrosis, and pneumoconiosis. Finally, synthetic fibers are also an irritant to the eyes, skin, nose, and throat, and, with chronic exposure, can lead to a granulomatous lung disease similar to that of chronic beryllium disease.

Methods: Sampling was performed for isocyanates, naphtha, synthetic fibers, and carbon dust within the manufacturing facility. Utilizing the NIOSH 1550 method, two passive samples for naphtha were collected over a 4-hour period using 3M badges that were attached to the lapels for the employee working directly with the Naphtha containing chemical. Isocyanates were collected on the paint booth employee utilizing a personal sample pump for one cycle of painting. The fully validated ISO 17734-1:2013 technique was used. For synthetic fibers, NIOSH 7400 total fibers method was used. An employee working directly with synthetic fibers through one cycle of the task wore a personal sample pump. Samples for naphtha, isocyanates and synthetic fibers were sent to ALS for laboratory analysis. Carbon-based dust sampling results were collected as area samples using Grimm and Enmot particulate counters over a 6 hour period. Data were downloaded directly from those devices for analysis.

Results: Isocyanates exposure results were below the level of detection (LOD) and thus below permissible exposure limits (PEL) and action levels. The average result for naphtha exposure was 10 ppm which is well below the PEL of 100ppm. The synthetic fibers exposure result was 0.15 f/cc, which was below the ACGIH TLV of 1 fiber/cc and the OSHA PEL of 5 mg/m3. For carbon-based dust, the area exposures from the Grimm were 3.37 mg/m3 and 0.012 mg/m3 for total and respirable dust, respectively. The Enmot result was a respirable dust count of 1.29 mg/m3. All results were below the exposure limits.

Conclusion: Due to the controls already in place at the manufacturing facility, the exposures assessed were below occupational exposure limits. Workers assigned to the jobs that were evaluated need to continue to follow all standard operating procedures including the use of proper personal protective equipment.

Dual-task interference during gait on irregular terrain in people with Parkinsons disease

Poster
19-Apr
2:40

Hang Xu, K.Bo Foreman, Andrew Merryweather
University of Utah

Introduction: Gait impairments and balance limitations are common among people with Parkinsons disease (PD). The purpose of this study was to understand gait alterations on irregular terrain with dual-tasks in persons with PD. A combination of surfaces (regular and irregular terrain) and tasks (single and dual-tasks) were evaluated. Specific hypotheses include: 1) gait parameters will differ from irregular to regular terrain with dual-task for PD; 2) gait parameters will differ between single-task (gait only) and dual-task on irregular terrain for PD; 3) gait parameters will differ between persons with PD and healthy-matched adults (HA) on irregular terrain with dual-task.

Methods: Nine persons with PD and nine HA controls were recruited. All participants signed an informed consent document. Walking trials were collected at self-selected speeds for both PD and HA using a 24-camera motion capture system at 100 Hz. The irregular terrain was simulated using faux rock panels. Persons with PD were in an on medication state during the activities. A serial 7 subtraction task was added as the concurrent task during walking on regular and irregular terrains. The spatiotemporal variables, lower limb kinematic variables (range of motion (RoM) for the hip, knee and ankle joints) and stability variables (trunk RoM and center of mass (CoM) acceleration root mean square (RMS)) were determined using Visual 3D software. Paired t-test was used to test hypotheses 1 and 2 and independent t-test was used to test hypothesis 3.

Results: Persons with PD showed significant differences for speed (p=0.015), cadence (p=0.043), step length (p=0.031) and step width (p=0.023) when comparing different terrains with dual-task (Fig.1). Speed and cadence were smaller in dual-task than single-task on the irregular terrain for PD (p=0.007/0.049), which was also seen for cadence in HA (p=0.036). When comparing between PD and HA with dual-task, differences were found for speed (p=0.005/0.004), cadence (p=0.015/0.021) and single limb support (p=0.033/0.028) on regular and irregular terrains. A decreased step length was also observed for PD than HA on irregular terrain with dual-task (p=0.024).

Ankle transverse RoM was significantly different between terrains with dual-task for both PD and HA (p=0.010/0.006). HA showed larger hip and knee sagittal RoMs on irregular terrain than regular terrain with dual-task (p=0.015/0.049). Both PD and HA showed similar hip, knee and ankle joint RoMs between single and dual-task on irregular terrain, except hip frontal RoM and knee sagittal RoM for HA (p=0.015/0.041). When comparing the dual-task condition, different knee sagittal RoM was found between groups on two terrains (p=0.002/0.006). Hip sagittal RoM was also different between two groups on irregular terrain (p=0.029).

The trunk sagittal RoM and mediolateral (ML) CoM acceleration RMS were different between terrains with dual-task for PD (p=0.017/0.001) and HA (p=0.047/0.009). Additionally, PD showed a larger ML CoM acceleration RMS in dual-task than single-task on irregular terrain (p=0.014).

Conclusion: Reduced gait speed, cadence and increased ML CoM acceleration RMS were the main gait characteristics affected for persons with PD on irregular terrain with dual-task. Training PD with kinematic strategies that increase hip and knee sagittal plane motion should be considered to reduce fall risk on irregular terrain.

Risk Analysis for Occupationally-Acquired Bloodborne Pathogens among Medical Trainees at the University of South Florida: Application of the WHO model

Poster
19-Apr
2:40

Kourtni L. Starkey, Rachel H. Williams
University of South Florida

Introduction: Sharps injuries present a major occupational hazard to healthcare workers (HCWs) who may be exposed to bloodborne pathogens (BBPs) such as HIV, Hepatitis B and Hepatitis C. Infection with bloodborne pathogens can have serious and lifelong consequences including chronic illness, financial strain, disability and in some cases death. Medical trainees (medical students and residents) historically have a higher rate of sharps injuries than attending physicians, which is often attributed to inexperience and limited procedural skillsets.

Methods: Here, we estimate the risk for occupationally-acquired infection by bloodborne pathogen in medical trainees at the University of South Florida (USF) using the World Health Organization (WHO) model for assessing burden of disease.

Results: Effective vaccination against Hep B (90% effective), antiviral treatment of Hep C (90% effective), and PEP for HIV (89% effective) reduces the likelihood of a USF medical trainee by orders of magnitude.

Conclusion: Based on this model, decreasing sharps injuries in HCWs, vaccination of HCWs, and appropriate treatment of sharps injuries significantly reduce the likelihood of seroconversion in the HCWs.

Compliant Flooring Surfaces Study Aimed at Reducing Fall Injuries in Hospitals and Elderly Homes

Poster
19-Apr
2:40

Rohan Srinivas, Nathan Leddige, Andrew Merryweather
Ergonomics and Safety Laboratory, University of Utah

Introduction: Falls and injuries related to falls are a prevalent problem in hospitals and nursing homes. The aftermath of a fall often leads to additional treatment and extended hospital stays. Thus, there is an urgent need to address this issue and reduce injuries in hospitals related to falls. Many toolkits and hospital staff training programs have been established to reduce falls. Most of the existing measures focus on an interdisciplinary approach to care and a highly routinized system catering to each patients specific risk profile. There is still a factor of difficulty and complexity involved in completely preventing falls as all existing fall prevention programs do not completely eliminate the problem. This research study and experimental analysis aims to modify traditional Vinyl Composition Tile (VCT) to reduce impact forces on the human body from a fall, thus lowering the likelihood of sustaining an injury.

Methods: Existing literature related to flooring design, hospital falls, fall prevention devices, finite element analyses and experimental analyses on compliant flooring and hip injury prevention was studied. ANSYS Workbench and SolidWorks were used to model and simulate a fall. An explicit dynamics analysis was conducted with the model to understand how the forces are distributed across different surface configurations. The results of the simulation gave the stresses on the object, which were then used to calculate the equivalent impact force and time of impact. Experimental testing was performed using an Instron Dynatup Impact tester which provides consistent values in a highly controlled environment. The dropping heights of the indenter to the floor surface were based on anthropometry data such that the drops were similar to falling from a standing position and impacting the floor at the hip bone. The first set of tests used a fixed dropping height and a second set of tests used varying dropping heights.

Results: The results of the simulation ran in ANSYS Workbench were compared to results found in literature for impact on a single VCT tile. By comparing these results to the literature, our simulation provided us with confidence that the model was acceptable for this study. Initial empirical testing showed that when dropped from the same height, the metal impactor on the Instron Dynatup Impact tester had a much greater impact force when it struck a single VCT tile. When the study was conducted with the implementation of Sorbothane, the impact force was reduced by up to 60%.

Conclusion: New approaches to reduce injury risk from falls in hospitals represent an important topic. The research reported here shows that Sorbothane could be a good option to reduce the impact force from a fall. A computation model was developed and evaluated as well as experimental testing. All results show a reduction in impact force with Sorbothane over standard VCT tile alone. However, further testing is required to determine if Sorbothane would be an appropriate choice for use as a compliant flooring material in hospitals. This would include additional empirical testing with a bone like impactor and durability testing of the floor. A biomechanics study to determine how Sorbothane effects gait and balance would also be necessary.

A Testbed to Study Neck Stiffness and Concussion Risk following Acoustic Warnings

Poster
20-Apr
2:40

Mohammad Homayounpour, Andrew Merryweather
Department of Mechanical Engineering, University of Utah

Introduction: The role of neck muscles in reducing the risk of concussion has been questioned in several studies. Gender difference was investigated and shows that neck muscle strength and anticipatory cervical muscle activation may decrease the risk of concussion. In this project, a testbed was designed, fabricated, and tested to achieve the following: 1) Investigate the effect of neck muscle activation on head acceleration. 2) Find the optimal time to deliver a stimulus to minimize impact. 3) Investigate the effect of directional acoustic stimulus on response. 4) Improve musculoskeletal model results using experimental data. 5) Investigate the effect of muscle clench training on the reaction to impact.

Methods: In this study, we expect to determine the effect of directional awareness and neck muscle clenching on reducing head acceleration from an impact. A control strategy was developed for the testbed (Figure 1). A directional acoustic stimulus, is played prior to an impact. The sound is played at a frequency of 4-16 kHz and 85 dB for a duration of 50ms. We plan to study how a warning to initiate muscle clenching (100ms, 150ms and 200ms), affects head acceleration during impact.

To simulate the impact, a testbed was designed and fabricated in the Ergonomics & Safety Lab at the University of Utah (see Figure 1). The testbed was modeled after. Impacts are delivered using 4 dropping masses (1250g) that free fall for 20cm and pull the head using a string. After free fall, the mass travels 10cm and provides an impulse to the head before striking a safety stop. The major advantage of using this design is the inherent safety of this mechanism. The testbed can only produce a predetermined force (100N) to pull the head. Electromagnets hold the masses in place until the release command is given.

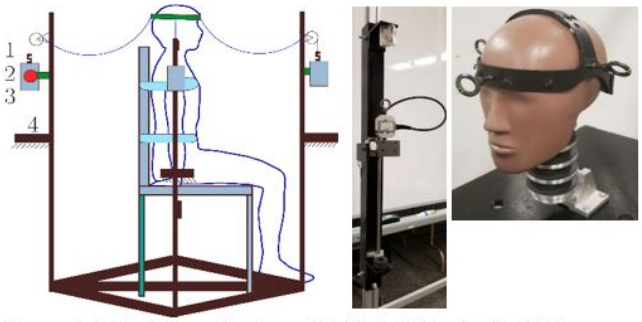

Figure 1: Left: Schematic view of Testbed. 1) Load cell, 2) Magnet, 3) Mass, and 4) Safety stop. Middle: close up view of the pulling system, Right: Dummy head, headband and attached cables.

The amount of force that is applied depends on the placement of the head and the amount of slack in the cable. To measure the precise amount of force delivered through the cable, a load cell is used (50lb, S type PCB Piezotronics) in line with the mass. The sound is played to warn the subject about the impending impact. One of the goals of this project is to find the optimal time to provide an auditory stimulus before an impact to maximize the muscle contraction and eventually minimize the amount of head acceleration. The relative time between the impact and the time the sound plays, should be precise. LabVIEW and a cDAQ are used to control the testbed and acquire data. To synchronize the data between multiple systems, a trigger signal is sent to start data collection. The EMG (TrignoTM Wireless DELSYS), Accelerometers, Vector (MouthGuard, Athlete Intelligence), Load Cells, and Electromagnets are all synchronized using the cDAQ.)

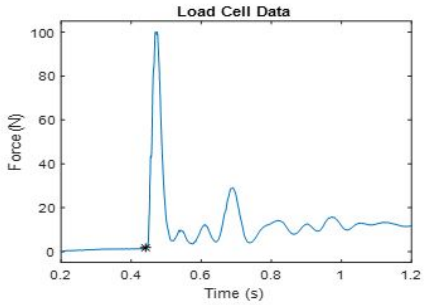

Figure 2: Sample result of load cell for flexion response of the dummy head.

Results: Results from trials in the testbed demonstrate that we are able to deliver a controlled sound stimulus followed by a precise impulse force to a Hybrid III head form using the testbed (see Figure 2). These results are promising and provide us with confidence to move forward with the study. Future work will be conducted to calibrate the testbed and confirm repeatability and reliability prior to human subject studies.

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Biomechanical Characterization of the Hand Touch Corrective Behavior of the Frail Elderly During Bed Egress

Poster
20-Apr
2:40

Dorothy Taylor, Alex Tatom, Janice Morse, Andrew Merryweather
University of Utah

Introduction: According to the National Council on Aging, within the United States, falls are the leading cause of fatal and non-fatal injuries among the elderly[1]. Studies indicate that the elderly are most likely to fall during weight transitioning, such as during sit-to-stand. While studies have been done to determine what factors (both intrinsic and extrinsic) may influence the likelihood that an elderly person may fall[2-4], these have often been a simulated fall in a laboratory with healthy adults which have been shown to be quite different from a real-world fall[5]. A better understanding of biomechanical factors of real-world falls, including any attempts at correcting balance before or during a fall, could assist in predicting the conditions just prior to a fall. This knowledge would provide the ability not only to identify falls in a laboratory setting, but also would provide a basis for more appropriate interventions to prevent falls of the frail elderly in their living environments. Thus, there is a critical need to understand the balance recovery strategies in frail elderly and their role in fall prevention.

Methods: This study looks at the specific task of sit-to-stand to walk from a hospital bed. Corrective behaviors (CBs) are defined, biomechanically characterized, and identified for each trial. The data set consists of 88 elderly subjects with over 1400 unique trials. An 18-camera motion tracking system was used to track full-body biomechanics. Participants exited an adjustable, instrumented hospital bed with three bed rail conditions and three bed height conditions. Each subject performed a sit-to-stand to walk transition from bedside. A corrective behavior (CB) was defined as a behavior which establishes a Point of Contact (POC) with a stable surface to regain or maintain stability. Specifically, for this study the hand touch CB is the movement of the hand, including touching chair armrests, bed rail, or mattress, to maintain or regain stability.

A random sample of thirteen subjects was used from the large data set for this pilot study. Key biomechanical stability metrics were calculated for each trial, as follows: BOS area, COM proximity to the BOS perimeter, COM Time to Contact (TtC) the BOS perimeter, and COM Jerk.

Results: From the 13 subjects trials, we identified 209 hand touch CBs. Initial results from this indicate Hand CB/POCs are readily identifiable when the velocity of the wrist is equal to approximately zero. The Jerk of the COM was found to be zero at all key BOS transitions. However, a significant jerk occurred during IS. We anticipate that the additional biomechanical attributes we will review will also be indicators of a fall/near fall, such as a threshold value for the COM proximity to the BOS perimeter. These biomechanical attributes will then be used to establish an automated process to review the remaining trials.

Conclusion: The sit-to-stand transition is a challenging task for the frail elderly. Strategies typically employed by the frail elderly to achieve standing require the implementation of corrective behaviors to maintain balance and/or recover from imbalances that occur during this weight shifting transition. Our results suggest that corrective behaviors are effective in indicating either an assist or a fall/near fall. With further work, a model of fall-initiation of the frail elderly will be developed to provide key biomechanical stability measures for use as a proxy for a fall in laboratory studies, as well as to provide new insights in fall intervention.

References: 1. National Council on Aging Falls Prevention Facts. (2018) Retrieved 1 March 2018 from www.ncoa.org/news/resources-for-reporters/get-the-facts/. 2. Ambrose, et al. Maturitas, 75, 51-61, 2013. 3. Kerr, et al. Neurology, 75(2), 116-24, 2010 4. Cloutier, et al. Journal of Biomechanics, 49, 1016-20, 2016. 5. Klenk, et al. Med. Eng. Phys. 33 (3), 368-73, 2011.

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Thursday, April 19 - Session 3

Real-time Monitoring of Injury Risk During Manual Material Handling Using Wearable Sensors

Oral
19-Apr
3:20

Mitja Trkov, Earl "Chip" Van Wagoner, Andrew Merryweather
University of Utah

Introduction: Low back injuries (LBI) and low back pain (LBP) are prevalent occupational musculoskeletal disorders (MSD). Repeated lifting and carrying heavy loads contribute to an increased risk for LBP and LPI. Enhanced risk factors monitoring can provide information to assess dose-response relationships between load carriage and LBP. The objective of this study is to investigate the feasibility of a lightweight, minimally invasive and low-cost Lifting Coach system that workers wear during MMH. The system would detect lifting events, estimate carried load magnitude and distance and extract features to estimate injury risk factors using the revised NIOSH lifting equation (RNLE). Additionally, it would provide instantaneous alerts and coaching cues to modify behaviors and notify workers of risk. The Lifting Coach serves as an MMH activity monitor which records cumulative lifting exposure over time (i.e. day, shift, etc). This exposure information is reported to the workers and their employers to identify risk of MMH related MSDs.

Methods: We performed a preliminary study to estimate load carriage using pressure sensitive insoles. A healthy male subject performed four load carrying trials by carrying a box with four different loads (4.75, 11.25, 17.75 and 22.15 kg). The thin pressure sensitive insoles were inserted in subjects shoes. Pressure measurements were wirelessly transmitted through Bluetooth and recorded at 30 Hz. The four individual cells per insole were separately calibrated. A least square method was applied on a small set of walking data to determine the weighting coefficients of the individual cells to estimate the ground reaction forces. Subjects body weight was subtracted and the signal was low-pass filtered to suppress the majority of dynamic effects. The load estimation results were compared to the actual carried weights.

Results: We successfully extracted information of the carried load during MMH using pressure sensitive insoles measurements. Estimated loads from the four trials carrying four different weights were 5.5±3.0 kg, 8.3±2.7 kg, 20.5±4.0 kg and 22.9±7.0 kg. The errors between the extracted and actual loads were 0.7 kg (15.3%), -2.9 kg (25.9%), 2.7 kg (15.4%), and 0.7 kg (3.4%). The average trial duration was 27.1±6.9 sec.

Conclusion: The Lifting Coach enables real-time continuous monitoring to estimate job exposure with acceptable resolution and accuracy. This represents a significant step forward in job exposure monitoring methods to help address the high incidence of MSDs during MMH. A Lifting Coach could serve as a training tool for new workers and reinforce training to improve lifting techniques. Also, a persons injury risk estimation can be improved by considering a worker's age, BMI, gender and other personal factors that have been identified through longitudinal, epidemiological studies. Benefits of more complete exposure information will improve injury model predictions. However, it is unknown how these improvements in exposure measurement will lead to our ability to prevent MSDs in the workplace. Access to more exposure data may also help improve work scheduling and assign more effective job rotation for workers exceeding recommended exposure limits. We anticipate that results from this pilot work set a foundation to perform future longitudinal studies enabling insight into enhanced understanding of exposure-injury dose-response relationship.

Acknowledgement: Research reported in this publication was supported in part by the National Institute of Occupational Safety and Health of the NIH under award number T420H008414-11.

Functional Limitations of Assistive Reachers: Pilot Results from Simulated Wheelchair Users

Oral
19-Apr
3:40

Ruoliang Tang, Sarah Cashman, Allison Fisher, Carissa Gartman, Sarah Lentner, Chelsea Prater, Jay Kapellusch

University of Wisconsin-Milwaukee

Introduction: Reaching, as a fundamental movement needed to perform various functional activities of daily living, is comprised of two components: reach and grasp, that require complex interactions of the musculoskeletal and neural systems to perform. Pathology affecting either system will limit an individual's reaching capacity and performance. Assistive reachers provide individuals with physical impairments an inexpensive means of grasping objects that is out of their reach. There has been insufficient research focusing on the functional limitations of assistive reachers regarding grip strength, the maximum weight, characteristics of the objects, and their interactions.

Methods: Twenty-five subjects served as wheelchair users in this study. These participants were healthy and free of musculoskeletal disorders or physical impairments. Subject maximum isometric grip strength at the dominant side was measured in neutral position using a Jamar hand dynamometer. Participants were asked to sit in a standard Medline wheelchair to perform reaching tasks in a kitchen-style laboratory using three commercially available reachers selected based on review popularity. Each reacher was used to reach and grasp four types of objects from five different heights. Objects were typical daily goods with various characteristics, including macaroni box, plastic peanut butter jar, cereal box, and plastic water bottle. For each object type, there were five different weights. Four different heights were also typical in daily life, including floor, counter, low cupboard, and high cupboard. One-way analyses of variance (ANOVA), with Tukey Honestly Significant Difference (HSD) post-hoc tests, were used to study average success rates with respect to the main parameters of the study: object weight, reaching height, and reacher type. A logistic regression was used to examine the influence of main parameters, the other factors (i.e., gender, grip strength, and object type), and their two-way interactions.

Results: As object weight increased, the trial success rate decreased (p ¡ 0.001). Similarly, retrieving objects from higher heights decreased success rates (p ¡ 0.010). All three reachers failed at more than one-third of the trials (p ¡ 0.015). Grip strength had a statistically significant influence on trial success rates and interacted with object weight, reaching height, and reacher type (p ¡ 0.001). Gender was associated with trial success rates, but only interacted with reacher type (p ¡ 0.05). Object type was also associated with trial success rates, but only interacted with reacher type (p ¡ 0.001).

Conclusion: Our pilot results suggest that functional limitations of assistive reachers are complex issues. In this study, object weight and reaching height seem to be two driving factors. Gender and grip strength may also be contributing factors. It should be noted that this research question could also be approached as maximum functional reaching strengths modeled as products of grip strength and upper extremity strength (i.e., wrist, elbow, and shoulder) interactions in relation to various reaching postures.

The Effect of Object Surfaces and Shapes on Hand Grip Function for Heavy Objects

Oral
19-Apr
4:00

Mario Francisco Garcia, Jazmin Cruz, James Yang, Cecilia Cruz, Patricia DeLucia
Texas Tech University

Introduction: Everyday activities require basic hand movements to complete specific tasks. These movements range from moving a light pencil in the office to moving a heavy dumbbell in the gym. To carry any type of object, one is required to grasp it and eventually release it. Due to the frequency of this set of movements throughout our lives, there have been several clinical tests to monitor hand grip function such as the Box and Block Test (BBT). The BBT has been used in the medical field to measure hand dexterity in patients with diseases such as cerebral palsy and stroke. The BBT also can be used by physical therapists to evaluate the progress of rehabilitation in patients with hand impairments. The improvement of the use of the BBT will have potential benefits for diagnosis and rehabilitation of hand impairments. In the current study, we measured performance on the BBT to determine whether there are effects of heavy object surfaces and shapes on hand grip function. If we find significant differences in BBT scores between objects with different shapes and textures, objects can be designed (e.g., with coating) to improve hand grip and thus facilitate the daily lives of those who suffer hand impairments.

Methods: Subjects consisted of 20 (10 female) young right-handed adults who were between 20 and 30 years old (Mean: 22.35 yrs.; STD: 2.30 yrs.). All individuals had no history of motor movement or visual impairment. In addition, participants had no history of previous strokes, cerebral palsy, multiple sclerosis, traumatic brain injury, neuromuscular disorder, spinal cord injury, and fibromyalgia. Subjects performed a modified version of the Box and Block Test (BBT) while seated upright with their elbows level with the table and each hand on either side of the box. The BBT time was set as 15 seconds. The order in which the block shapes and textures was presented was randomized for each participant. Each of the six unique objects were transferred twice by each subject, resulting in 12 trials. The number of blocks that were moved from one side of the box to the other was counted and defined the BBT score on a given trial.

Results: We calculated the BBT score for each condition (shape x texture) and conducted t-tests for these BBT scores to determine whether there were significant differences among conditions. No significant differences were found. We then compared differences among the three textures, and the three shapes, separately. There again were no significant differences among textures or shapes.

Conclusion: We did not obtain significant differences in BBT scores between heavy objects of different textures and shapes. This may be due to the heavier weight we used compared to prior studies of light objects. Heavy objects require a greater amount of normal force on the cube or cylinder to successfully carry it over a partition. In addition, the textures used in this experiment may not have differed sufficiently in their coefficient of friction (COF). Future studies should attempt to replicate this study using textures with a higher COF. It would also be of interest to test people who have a hand impairment as it may provide different results from our experiment and have greater generalizability to people with such impairments.

Inertial measurement units and low back posture during keg handling

Oral
19-Apr
4:20

Colleen Brents, Molly Hischke, John Rosecrance
Colorado State University

Introduction: Biomechanical risk factors such as heavy loads and awkward trunk postures have been associated with occupational low back pain. Those same risk factors are commonly experienced among workers handling beer kegs. Small breweries in the U.S surged from 1,500 to 5,000 businesses between 2006 and 2016. Many of the breweries are small and lack resources for materials handling equipment. These limitations cause much work, including keg handling, to be done manually. One risk factor associated with low back pain is occupational lifting. Indirect costs associated with occupational low back pain are estimated to exceed 100 billion U.S dollars. Measuring worker motions may help with job design to reduce risk factors associated with lifting. Kinematics (displacement, velocity, acceleration) are variables used to measure worker motion. Low back motions have been historically evaluated using observation techniques and bulky devices which are oftentimes most practical in a lab. The technological development of wireless inertial measurement units (IMUs) for human motion provides detailed information related to whole body kinematics, including low back. These small, wireless, self-contained instruments make studying worker motion more convenient and accessible in the actual environment.

Methods: The present study used a 3-dimensional motion capture system as a tool to investigate the low back biomechanics during keg handling at a brewery in northern Colorado. Specifically, six workers transferred spent kegs from a pallet to a conveyor to be filled with beer. Workers were suited with 17 IMUs. Data was collected during the portion of the shift workers handled kegs. Low back angular displacements were assessed during keg handling at two heights. Kegs originated from a high or low position and were defined as high or low lifts. Kinematic data from the study was used to estimate compressive and shear forces at the lumbosacral joint. Repeated measures analyses were performed with each low back angular displacement variable as a function of lift condition.

Results: Differences in low back biomechanics between lift conditions were identified. During low lifts, torso flexion was significantly greater than high lifts. The magnitudes of flexion achieved during low lifts significantly exceeded those of high lifts. A broader range of angular displacements was observed in high lifts. In both conditions, estimated kinetics exceeded recommended action limits, potentially putting workers at an increased risk for developing LBP.

Conclusion: Data collection was feasible during operational hours due to the portability and small design of IMUs. Data collected from experienced workers provided researchers with information directly applicable to keg handling in small breweries. Low back kinematic data established a baseline assessment and can be used to assess workplace design intervention effectiveness. Results from the study can help improve workplace design in a craft brewery, reduce risk, and create safer work.

Comparison of dynamic coefficient of friction between normal and slip-resistant footwear using an ankle/foot simulator robot

Oral
19-Apr
4:40

Charlotte Robison-Hanchett, Leon Pahler, Rodney Handy, Andrew Merryweather
University of Utah

Introduction: Slips, trips, and falls are the second highest cause of workplace injuries in the United States. Slips and trips have the potential to cause injuries even without a fall. While prior research has indicated that there are multiple factors that may affect if slips, trips, or falls will occur, the a potential remedy for improving safety in the workplace is for employees to wear slip-resistant shoes. This study examines commercially available shoes for hospital, restaurant, and construction industries.

Methods: A control shoe was selected to determine what difference, if any, the slip-resistant shoe had on dynamic coefficient of friction (dCOF). Each pair of shoes was evaluated on a flooring surface similar to what is found in each industry. An ankle/foot simulator (AFS) robot was used to recreate trajectories recorded from human gait to determine what difference, if any, existed between control and slip-resistant shoes. Trials at normal, fast, and rushed walking speeds were tested in dry, water, and glycerol-water mixture conditions.

Results: The results indicated that, with the exception of the construction trials, slip-resistant shoes maintained a higher dCOF than the control shoes, even at faster walking speeds and slippery floor conditions.

Conclusion: Future research should look at the available friction of the different floors under a variety of conditions to evaluate how floor type effects slip-prevention in conjunction with slip-resistant shoes. Additional gait trajectories from a wider range of people (e.g. young, old, male, female) should be tested to broaden generalizability.

Friday, April 20 - Annual Dr. Paul S. Richards Endowed Distinguished Visiting Lectureship in Occupational Medicine

How Results from a 30-year U.S. Study of Workers Exposed to Vermiculite Drove U.S. Public Health Policy

Keynote
20-Apr
8:30

James E. Lockey, MD
University of Cincinnati

James Lockey, MD, is currently a Professor-Emeritus at the University of Cincinnati College of Medicine. He received his BA in biology from Kenyon College and his MD from Temple University, then served his residency and a pulmonary fellowship at the University of Minnesota. He later earned a Masters in environmental health from UC, where he had previously served an occupational and environmental fellowship. During his career at UC, he was also a faculty member in the Pulmonary Division, Department of Internal Medicine. Dr. Lockeys research in occupational and environmental lung disease includes an ongoing study of the health impact from exposure to asbestiform mineral fibers found in Libby vermiculite ore; studies investigating the relationship of diesel exhaust exposure and asthma risk in a birth cohort study; a twenty-five year longitudinal study of workers exposed to refractory ceramic fibers; exposure characterization study of firefighters in collaboration with Underwriters Laboratories and cancer risk among firefighters; a study on diacetyl exposure and obstructive lung disease; and the development of an environmental sensor for real-time personal exposure assessment of ultrafine particulates in collaboration with Mechanical, Industrial and Nuclear Engineering at the University of Cincinnati. He received United States Executive Branch appointments to the National Advisory Board on Radiation and Worker Health and the Department of Defense, Defense Health Board.

Friday, April 20 - Session 4

Prevalence of Opioid and Benzodiazepine Use Among Truck Drivers

Oral
20-Apr
10:00

Robert Chestnut, Matthew Thiese, Kurt Hegmann
Rocky Mountain Center for Occupational and Environmental Health (RMCOEH)

Introduction: The purpose of this study was to quantify the prevalence of opioid and benzodiazepine use in truck drivers.

Methods: Data were analyzed from 78,741 commercial driver medical examinations performed on employed and independent drivers throughout the United States between January 1, 2005 and October 31, 2012. Opioid and benzodiazepine use were self-reported by the drivers at the time of examination. Prevalence and odds ratios with 95% confidence intervals were calculated for gender, body mass index (BMI), and age categories.

Results: There were 75,273 (95.6%) male and 3,468 (4.4%) female drivers. The prevalence of opioid and benzodiazepine use was 1.0% and 0.3%, respectively. Odds ratios for both were higher for females with OR 1.50 (95% CI 1.14-1.99) for opioid use and OR 2.44 (95% CI 1.60-3.70) for benzodiazepine use. The OR for opioid use in BMI 35 or greater was 1.24 (95% CI 1.00-1.55). Benzodiazepine use when compared to all drivers 29 years-old or younger showed: OR 1.05 (95% CI 0.72-1.54) for ages 30-39, OR 7.65 (95% CI 1.89-30.98) for ages 40-49, OR 6.27 (95% CI 1.54-25.56) for ages 50-59, and OR 7.47 (95% CI 1.79-31.08) for ages 60 and older. Opioid use also rose with age, but was not statistically significant.

Conclusion: Prevalence of opioid and benzodiazepine use was higher for female drivers. Benzodiazepine use was higher in age categories 40-49, 50-59, and 60 years-old and older. Opioid use trended higher with increasing age and BMI 35 or greater, but was not statistically significant.

The Effect of 5 Mechanical Gaming Keyboard Key Switch Profiles on Typing and Gaming Muscle Activity, Performance and Preferences

Oral
20-Apr
10:20

Charles Miller, Alan Barr, Raziel Riemer, Carisa Harris-Adamson
University of California, Berkeley, School of Public Health

Introduction: Despite the increased use of virtual keyboards and touchscreens, conventional keyboard use is highly common among computer users. Conventional keyboard use is increasing among certain demographics as the prevalence of PC gaming is at an all-time high and increasing yearly. Mechanical keyboards are preferred amongst personal computing (PC) gamers because they are highly durable and provide above average tactile and auditory feedback compared to other key switch designs. It is not uncommon for users to engage in both gaming and word processing tasks with mechanical keyboards; yet studies comparing combinations of force displacement characteristics of mechanical keyboards while performing both gaming and word processing tasks are lacking in the literature. Single force-displacement characteristics of mechanical key switches have been shown to affect performance, fatigue and discomfort during keyboard use. This study compared the effects of mechanical key switches with differing force-displacement characteristics on forearm muscle activity, typing performance, Fitts Study task performance, subjective fatigue and user preference.

Methods: Using a within subjects intervention study of crossover design, 64 subjects completed modified Fitts and typing tasks on five different mechanical key switches to mimic dual word processing and gaming keyboard use. Bilateral muscle activity was recorded using surface electromyography (sEMG); typing and Fitts task performance measures were tracked. A subjective usability and fatigue survey was completed after use of each key switch. A final survey assessing overall key switch preference was given at the conclusion of the study.

Results: Key switch 3 (linear force displacement curve) had higher net strokes and lower net typing speed than key switches 1& 2 (p¡0.05). Key switch 1 required slightly higher static, mean and peak muscle activity compared to 2 other key switches (p¡0.05). Key switch 2 (28%) followed by key switch 5 (27%), both with shorter tactile and operating travel and lower bottom forces, were most preferred overall. Key switch 3 was the least preferred overall for gaming (46%), typing (51%) and overall performance (48%); key switches 1 & 2 with shorter total travel and loud auditory feedback were most preferred for gaming (29%) and typing (36%) respectively.

Conclusion: This study finds that the linear force displacement curve had reduced typing performance and was the least preferred, despite slight reductions in muscle activity. Key switch 5 with shorter tactile and operating travel and a lower bottom force had comparable typing and Fitts Study task performance but with lower muscle activity; this key switch also ranked most preferred overall. More research is needed to assess which of these force displacement characteristics are most important in mechanical keyboards, and whether their effects interact.

Restaurant Inspection reports as a proxy measure for Occupational Health and safety: South Asian restaurant workers in New York City

Oral
20-Apr
10:40:00

Nabeel Ismail, Hasanat Alamgir

Department of Public Health, School of Health Sciences and Practice New York Medical College

Introduction: Restaurants can be hazardous workplaces for the nature of business, materials handled and tasks completed. Working with hot equipment and oil, sharp knives, lifting heavy objects, working in hot work areas for a long period of time and on slippery floors or floors cluttered with objects may result in muscle strains, sprains, and tears; cuts and lacerations and burns and scalds.

Methods: We have explored using restaurant inspection grade as a proxy measure for employee safety and working conditions. We have compiled inspection data on Indian, Pakistani and Bangladeshi restaurants in NYC. We have used 1. overall restaurant grade and 2) specific violations as means of assessing workplace health and safety.

Results: These overall grade findings suggest that 19% of the Indian, 26% of Bangladeshi, and 15% of Pakistani restaurants did not achieve grade A in these inspections. These suggest that workers in about 20% of these restaurants more than likely work in a relatively hazardous or unhygienic working conditions. We also present a list of possible violations and its implication on worker health and safety such as live roaches present in facility's food and/or non-food areas and evidence of mice or live mice present in facility's food and/or non-food areas.

Conclusion: We need to further validate this proposed alternative surveillance tool as this grading system has evolved over the last several years. There appears to be better understanding and appreciation of the grading system now since its implementation in 2011 and there has been a continuous effort to improve the accuracy of this system. Incorporating a few worker health and safety measures in the current grading system can be a very useful next-step. There is a great need to develop workplace health and safety surveillance systems for small businesses to systematically understand the cause, nature and severity of injuries and illness. Surveillance data would identify high risk worker groups within these restaurants, and allow looking at time trends and help in evaluating interventions.

The Impact of Heavy Load Carrying Practices on Musculoskeletal Health Among Sand Miners in Nepal

Oral
20-Apr
11:00

Aybuke Koyuncu, Michael Bates, Sandra McCoy, Ndola Prata, Carisa Harris-Adamson
University of California, Berkeley

Introduction: Musculoskeletal disorders represent the largest burden of disease globally and are the most prevalent cause of long-term pain, chronic ill health, and physical disability. The burden of musculoskeletal disorders in terms of disability-adjusted life years (DALYs) in developing countries is estimated to be 2.5 times that in developed countries.1 Although existing epidemiologic data are limited, heavy load carrying in low- and middle-income countries (LMIC) has been implicated as a potential cause of musculoskeletal problems, such as low back pain and neck pain. Unfortunately, there has been little research on the extent of the problem, risk factors or interventions.

Methods: To address this knowledge gap, we conducted an exploratory cross-sectional study investigating the health impacts of heavy load carrying practices among sand miners whose primary occupation is the excavation and transport of sand and stones from riverbeds in the Kaski district of Nepal. Using various measurement tools, including interviews, wearable devices, and scales, we quantified the biomechanical and physiological demands of heavy load-carrying tasks among sand miners, as well as symptoms of adverse musculoskeletal health. We defined severe musculoskeletal pain as having more than3 days of pain rated as moderate or higher (4) on a 0 10 pain-rating scale in the head/neck, back, or knees/feet/ankle regions in the last 12 months. The relationship between load-carrying exposure (weighed load and self-reported frequency and duration) and body-region-specific musculoskeletal pain was evaluated using logistic regression and adjusted for age, BMI, education, marital status, and years worked as a sand miner. Self-reported years worked as a sand miner was also independently evaluated and adjusted for age, BMI, education, and marital status.

Results: Among 50 study participants (27 male and 23 female), the average age was 38.4 years (SD=1.5) and the average weight of the load carried was 77.23 kilograms (SD=17.38). Participants reported an average frequency of 38.8 load-carrying trips per day (SD= 25.0), with an average duration of 10.5 minutes per trip (SD=6.1). Severe musculoskeletal pain in at least one body region was reported by 72

Conclusion: To our knowledge, this study is the first to evaluate the health impacts of heavy load carrying practices among sand miners in Nepal. The results of this study identify the extraordinary loads carried by sand miners and the high prevalence of severe musculoskeletal pain. The protective direction of effect estimates associated with increasing years of exposure may be due to healthy worker survivor bias. The substantial burden of musculoskeletal pain among sand miners warrants further studies to determine effective interventions that reduce morbidity associated with heavy load-carrying practices in this occupational group.

Evaluation of an Adjustable Support Shoulder Exoskeleton

Oral
20-Apr
11:20

Logan Thomas Van Engelhoven, Nathan Poon, Homayoon Kazerooni, Alan Barr, Carisa Harris-Adamson
University of California Berkeley

Introduction: Overhead work has been identified as a category of tasks with especially high risk of WMSDs [NIOSH, 1997]. Exoskeleton technology has the potential to reduce exposure to heavy exertion forces thereby reducing risk of WMSDs. Few studies have looked at the effect of an exoskeleton on shoulder muscle activation. The purpose of this study is to evaluate the impact of various assistive support (torque) settings of the exoskeleton on muscle activation for both static and dynamic tasks with light and medium weight tools.

Methods: Eight male subjects with past experience in construction or manufacturing industries were recruited for participation in this within subjects intervention study of cross over design. A static task consisted of tracing a series of lines with a tool, and a dynamic task consisted of inserting and removing a series of screws with a tool. For each task type, subjects used both a light weight (1 lb.) tool and a medium weight (5 lb.) tool. Subjects completed two trials for each combination of task type and tool weight under conditions of no support, low support (75 lb-in peak torque), medium support (115 lb-in peak torque) and high support (177 lb-in peak torque) provided by the arm supporting exoskeleton. Subjects were instrumented with Noraxon electrodes to record muscle activation of the upper trapezius (UT), anterior deltoid (AD), and infraspinatus (IF). ADPF50 and ADPF90 force data was calculated to summarize the mean and peak forces each muscle was at or below 50% and 90% of the time. Summary measurements were compared between conditions by using repeated measures analysis of variance (Stata, College Station, TX) and the Tukey post-hoc test.

Results: Mean and peak muscle activity of the UT, AD and INF decreased as level of exoskeleton support increased during static (Tables 1a & b) and dynamic (Tables 2a & b) work.

Static task-Light tool	off	low	medium	high	p
R upper trap: ADPF50	16.95(8.43)^{a,b}	13.4(7.09)	10.9(6.04)^{a}	10.63(5.66)^{b}	0.01
R uppder trap: ADPF90	22.64(11.76)^{a,b}	17.81(9.36)	14.59(8.00)^{a}	14.37(7.96)^{b}	0.00
R anterior deltoid: ADPF50	14.65(5.16)^{a,b,c}	9.85(3.61)^{a,d,e}	6.03(1.61)^{b,d}	3.12(1.40)^{c,e}	0.00
R atnerior deltoid: ADPF90	20.09(7.44)^{a,b,c}	14.83(5.95)^{a,d,e}	9.35(1.97)^{b,d}	6.07(2.01)^{c,e}	0.00
R infraspinatus: ADPF50	10.78(5.78)^{a,b,c}	9.06(4.50)^{a}	8.01(4.39)^{b}	8.15(4.23)^{c}	0.00
R infraspinatus: ADPF90	14.86(9.22)^{a,b,c}	12.33(6.94)^{a}	11.01(6.60)^{b}	11.38(6.72)^{c}	0.01

Table 1a. Muscle activity-static work/light tool.

Static task-Heavy tool	off	low	medium	high	p
R upper trap: ADPF50	21.4(9.08)^{a,b}	18.44(7.83)^{c}	16.48(9.20)^{a}	13.33(6.72)^{b,c}	0.00
R uppder trap: ADPF90	28.62(12.75)^{a,b}	25.16(11.03)^{c}	22.77(13.67)^{a}	18.49(9.12)^{b,c}	0.00
R anterior deltoid: ADPF50	18.06(6.27)^{a,b,c}	13.73(4.39)^{a,d,e}	9.87(2.98)^{b,d}	7.21(2.83)^{c,e}	0.00
R atnerior deltoid: ADPF90	25.5(9.55)^{a,b,c}	20.08(7.40)^{a,d,e}	15.50(6.05)^{b,d}	11.66(3.91)^{c,e}	0.00
R infraspinatus: ADPF50	16.63(8.39)^{a,b}	14.73(6.28)	13.19(6.73)^{a}	12.24(5.06)^{b}	0.01
R infraspinatus: ADPF90	22.37(12.34)^{a}	20.82(10.17)	18.45(10.74)	17.26(6.98)^{a}	0.05

Table 1b. Muscle activity-static work/heavy tool.

Dynamic task- Light tool	off	low	medium	high	p
R upper trap: ADPF50	15.46(5.98)^{a,b}	14.07(5.96)^{c,d}	11.44(6.56)^{a,c}	9.34(6.08)^{b,d}	0.00
R uppder trap: ADPF90	23.33(10.70)^{a}	20.28(8.63)^{c,d}	16.29(9.53)^{a,c}	13.88(8.52)^{b,d}	0.00
R anterior deltoid: ADPF50	14.08(4.31)^{a,b,c}	9.90(3.43)^{a,d}	7.55(3.21)^{b,e}	2.89(1.65)^{c,d,e}	0.00
R atnerior deltoid: ADPF90	25.61(9.62)^{a,b,c}	18.72(6.09)^{a,d}	13.36(4.76)^{b,e}	6.91(3.21)^{c,d,e}	0.00
R infraspinatus: ADPF50	9.29(5.60)	7.79(3.90)	6.86(3.00)	7.28(3.16)	0.24
R infraspinatus: ADPF90	14.36(8.28)	11.58(6.04)	10.32(4.82)	11.09(4.74)	0.11

Table 2a. Muscle activity- dynamic work/light tool.

Dynamic task- Heavy tool	off	low	medium	high	p
R upper trap: ADPF50	20.73(9.82)^{a,b,c}	16.51 (6.66)^{a}	16.11 (6.60)^{b}	13.68(7.16)^{c}	0.00
R uppder trap: ADPF90	30.63(13.67)^{a,b,c}	23.92(9.67)^{a}	22.63(9.03)^{b}	19.68(9.01)^{c}	0.00
R anterior deltoid: ADPF50	17.92(5.85)^{a,b,c}	12.79(3.16)^{a,d}	9.97(3.56)^{b}	6.73(3.26)^{c,d}	0.00
R atnerior deltoid: ADPF90	29.95(11.52)^{a,b}	23.22(6.23)^{c}	17.14(4.64)^{a}	12.90(5.54)^{b,c}	0.00
R infraspinatus: ADPF50	15.47(7.13)^{a,b}	13.19(5.49)	12.12(4.17)^{a}	11.78(4.61)^{b}	0.02
R infraspinatus: ADPF90	23.18(11.03)^{a,b}	19.93(8.77)	17.65(6.92)^{a}	17.39(6.95)^{b}	0.02

Table 2b. Muscle activity-dynamic work/heavy tool.

Conclusion: In this pilot study, muscle activity of the UT, AD and INF decreased as arm support from the exoskeleton increased. The largest reductions were seen in the anterior deltoid where peak muscle activity was reduced from 25.5%MVC during static tasks with a medium weight tool to 11.7%MVC. Reductions during dynamic tasks were even greater with the anterior deltoid muscle activity reducing from 30%MVC to 12.9%MVC when using the 5lb tool. Further study is underway to determine the activity of antagonist muscles, subjective setting preference, comfort and usability.

Notice of conflict of interest: Researchers Logan Van Engelhoven & Homayoon Kazerooni are inventors of the Arm Supporting Exoskeleton device and have applied for a patent covering the technology through the Universiy of California Berkeley. Researchers Logan Van Engelhoven, Nathan Poon, and Homayoon Kazerooni currently own equity in and work for U.S. Bionics, a company working to commercialize similar technology through a partnership with the University of California Berkeley