Welcome address

We are delighted by your attendance this year at our Annual NORA Young and New Investigators Symposium. This year commemorates our 20th 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/OH008414-16.

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Keynote address

Future Work in the Transportation Sector

William K Sieber, PhD, MScHyg

Karl Sieber is a Research Health Scientist in the Division of Field Studies and Engineering (DFSE) at the National Institute for Occupational Safety and Health (NIOSH) in Cincinnati, Ohio. He received a Ph.D. and M.S. Hyg in Biostatistics from the University of Pittsburgh Graduate School of Public Health and has been with NIOSH since 1982. His fields of expertise include Statistics, Epidemiology, and Industrial Hygiene.

Dr. Sieber's current research involves the study of health and injury among transportation workers. He is the Coordinator for NIOSH's Transportation, Warehousing, and Utilities (TWU) program, and was the Project Officer for the project, 'National Survey of Long-haul Truck Driver Health and Injury.' Dr. Sieber has taken part in several other NIOSH surveys and studies, including the National Occupational Exposure Survey (NOES) and studies of worker exposure to metal-working fluids.

Ergonomic Evaluation of Novel Aerosol Containment Hood

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Introduction: The COVID-19 pandemic has been a dynamic situation resulting in rushed innovation and varying emergency measures being implemented in hospital environments. One such measure is the use of aerosol containment hoods to protect healthcare providers against COVID-19 exposure. Many of these devices were constructed with little to no research on their ergonomics. A poorly designed device can interfere with physician/clinician performance, potentially putting the patient at risk. To maximize patient and provider safety, our aim was to perform a formal ergonomic assessment of the U-COVER, an aerosol containment hood designed at the University of Utah. Additionally, a usability survey was conducted. We report the results from a 3D motion analysis study during simulated intubation using the U-COVER first-generation prototype and propose a modified design.

Methods: Full-body optical motion capture was performed on seven healthcare providers while performing simulated intubation with and without the U-COVER first-generation prototype. Participant motion was recorded at 100Hz using a Conventional Upper Body marker set. A usability survey was conducted with each participant. Upper body joint angles were calculated in Visual3D, a biomechanics software, and the values were scored via the Rapid Upper Limb Assessment (RULA) ergonomic assessment on a per-frame basis, and temporal-spatial analyses were performed.

Results: For the RULA assessments, the differences between trials with and without the U-COVER prototype illustrated a 4% and 1% increase for the left and right sides, respectively. Overall RULA scores for hooded to non-hooded intra-participant comparisons demonstrated a mean score of 6.3 (SD = 0.9) for the left side. The right-sided evaluation behaved similarly, with a mean score of 6.6 (SD = 0.8).

Participant survey results indicate that the largest concerns were visibility through the U-COVER, and limited space was noted by 5 out of 7 individuals. Concerns about reflections from the vinyl cover, ease of removing the endotracheal tube stylet, and AMBU bag insertion/manipulation were similarly common concerns, with 4 out of the 7 expressing some level of concern. Other features of potential concern were the use of access ports, interference of the frame with the procedure, and deformation of the vinyl cover. Concerns were also raised about the potential for condensation due to patient breathing/ventilation and the device's durability.

The body and instrument position data from the ergonomic study were used to create density plots describing the motion of the healthcare provider and equipment during the procedure. 95th percentile ellipses were drawn from these density plots to demonstrate the space necessary to accommodate 95% of the marker positions. Of the instruments assessed, the endotracheal tube (ETT) demonstrated the greatest range in position and was most impacted by hood use. In the hooded trials on the y-axis (parallel to the lengthwise direction of the bed), 95% of the data fell into a range that was 43% larger; while on the z-axis (vertical), the range was 15% smaller than the procedure performed without the hood. Moreover, the 95% ranges of the left and right wrist along the x-axis (perpendicular to the lengthwise direction of the bed) were limited by 45% and 55%, respectively, while using the hood.

Conclusions: Overall RULA scores for hooded to non-hooded intra-participant comparisons did not suggest any consistent positive or negative trends. While this RULA score is considered to be high risk, the consistency between trial conditions suggests that the U-COVER does not significantly interfere with the original procedure. The density plots indicate that the healthcare provider is limited in their vertical motility and consequently must compensate by using more of the horizontal space to complete the procedure. Moreover, they indicate that the U-COVER height was sufficient to perform the procedure; however, the curved shape significantly reduced the internal space. A new hood shape with a nearly square frame and an angled corner was designed to accommodate the procedure as recorded in the non-hooded trials.

The Impact of Computer Mice Weight on Muscle Activity, Performance, and User Preferences While Gaming

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Introduction: The increasing usage of computers may contribute to health problems including pain conditions, carpal tunnel syndrome (CTS) and musculoskeletal disorders (MSDs) (Ullman et al., 2003). The design of a mouse could lead to deviated wrist postures and sustained extensor muscle loading for long durations of time. Thus, it is essential to understand the impact of mouse design, such as mouse weight, on users' physical health and performance. A prior study assessed the impact of mouse weight (70 to 190 grams) on muscle activity when performing "point and click" tasks (Chen et al., 2012). However, the impact of computer mouse weight on muscular effort while gaming, a very mouse intensive task, has not been explored. Thus, this study assessed the impact of mouse weight (40 to 140 grams) on muscle activity, performance, and user preference.

Methods: Twelve participants (10 males and 2 females) participated in this laboratory within-subjects study. Participants used six identical computer mice ranging between 40 to 140 grams to perform a Fitts' test and gaming task. Wireless surface electromyography (sEMG) was used to record muscle activity from 7 muscles of the neck and upper extremity. The normalized muscle activity was expressed as an amplitude probability distribution (APDF) to describe static (10%), median (50%) and peak (90%) muscle activity. The Fitts tests quantified mouse performance by measuring the efficiency of moving a pointer to a circular target area. All six mice were ranked and compared by participants for discomfort and overall preference.

Results: The results showed that four muscles exhibited slight reductions in static muscle activity when using the heaviest mouse (140g), although the difference was not statistically significant. Similar trends were observed in median and peak muscle activities. During the Fitts' task, participants had a higher error rate (11.32%) and number of target re-entries (0.20) when using the lightest mouse (40g). Although the lightest mouse was ranked as having the least discomfort, it was ranked 4th while the 60g mouse received the highest score in overall preference ranking.

Conclusions: Overall, this study indicates that mouse weights between 40g and 140g had little impact on muscle activities. The lightest mouse had lower performance with higher error rate and target re-entries, but was rated as having the lowest discomfort. Overall, the 60g mouse had the highest overall preference score likely because it optimized performance while minimizing discomfort.

Acknowledgement: We wish to thank Logitech for their support in this study.

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Investigating the Influence of Chair Design Features on Trunk Sway Parameters During Computer-Based Tasks Over a Prolonged Bout of Sitting

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Introduction: Advancements in technology contribute to increases in sedentary behavior [1] which has been shown to be associated with musculoskeletal symptoms such as low back pain (LBP) [2]. During prolonged bouts of sitting, increasing macromovements (changes of posture such as standing or walking) and micromovements (small movements while sitting) has been associated with decreased levels of discomfort [3]. Prior research has shown that providing adequate forearm support and seat recline can reduce low back disc compression [4,5] and discomfort [6,7]. However, the impact of the design of forearm support and chair tilt mechanism on micromovements has not been investigated. Thus, the purpose of this study was to investigate how forearm support and chair tilt impact micromovement and pressure parameters while sitting.
Methods: This within subjects study (n = 15) was conducted with participants aged 18 to 35 who performed 80 minutes of a computer gaming task. Armrest support and tilt mechanism were randomized and varied over the course of four twenty-minute sitting bouts to evaluate their influence on trunk sway and pressure parameters, including mean pressure (MP), peak pressure (PP), center of pressure (COP) displacement, and in-chair movements (ICMs). Armrest position was categorized as either ideal (per ANSI-HFES 100-2007) or non-ideal (armrests positioned at opposite extremes). Tilt mechanism was categorized as either free tilt (freely moving synchronous recline of the seat pan and back) or fixed tilt (seat pan and back locked in upright position). Statistical analysis was performed using paired t-tests ($\alpha = 0.05$).
Results: Statistically significant increases in COP displacement ($p = 0.038$) and ICM frequency ($p = 0.029$) were observed in ideal armrest support as opposed to non-ideal. COP displacement magnitude increased from 1.64 ± 0.70 to 1.85 ± 0.73 mm, and ICM frequency increased from 62.04 ± 36.15 to 75.33 ± 40.59 per hour. The relationships regarding armrest position, MP, and PP were statistically insignificant. There was no significant difference between fixed and free tilt mechanism on any of the trunk sway or pressure parameters.
Conclusions: These preliminary findings suggest that proper adjustment of a chair's armrests to optimize arm support may increase the frequency and magnitude of micromovements while sitting, which could help reduce or prevent LBP while sitting. Fixed versus free tilt mechanisms did not have an impact on trunk sway or pressure parameters, likely because the gaming task required precision and therefore forward leaning.
Acknowledgements: We would like to thank Secretlab, Ltd. for supporting chair-related research at UC Ergonomics. This study was supported by the Training Grant, T42OH008429, funded by the National Institute for Occupational Safety and Health (NIOSH) /Centers for Disease Control and Prevention (CDC).
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Ergonomic Assessments for Waste-Processing Workers

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Introduction: Musculoskeletal disorders are common among workers performing manual material handling tasks. In a study conducted among 14 municipal waste workers in Italy, high risk of injury to the lower back and limbs was captured via a series of ergonomic assessments (Battini, Botti, Sgbarbossa, 2018). In another study, sewing machine operators required to perform work on seats with unsupportive cushions had a significant association with lower back pain (2021). In 2000, a study found evidence that frequency of movement in manual material handling tasks was a larger determinant of injury risk than the magnitude of load (Kothiyal, Kayis, 2000). A waste management facility at a local university had concerns about ergonomic-related risks related to the material handling tasks of their waste technicians. The waste technicians collect and sort chemical, biological, and radiological waste produced by the research labs and hospitals in the surrounding area. This facility is housed in an older purpose-built structure. However, the organization may not have undergone the necessary expansion and updates to meet the waste needs of the customers they are currently serving. Currently, this facility has four waste technicians and turnover is high in this position as the organization promotes from within. Training required for the waste technician position is the standard university trainings and the OSHA 500 trainings, as well as driving training. Currently, there is no ergonomics training.

Methods: The research team conducted multiple site visits to the waste facility to gain sufficient knowledge of the facility and the work processes and subsequently, collect physical measurements, record video, and obtain qualitative accounts of the job tasks. A job hazard analysis (JHA) identified potential job hazards for specific tasks of waste technicians at the waste facility. Based on the verbal accounts of the waste technicians and observations, four job tasks were identified for further analysis. The tasks include flammable liquid bulking, lab packing, lab sorting, and biohazard bin pick-up and drop-off. The Rapid Upper Limb Assessment (RULA) will be used to assess wrist, arm, and torso angles, and force for the seated sorting task. The Revised NIOSH Lifting Equation (RLE) will be used to evaluate lifts and lowers that occur during the biohazard pick-up and drop-off task. Rapid Entire Body Assessment (REBA) will be used to assess the posture, exertion, type of movement, and repetition for the flammable liquid bulking and lab packing tasks.

Results: The following four job tasks were identified based on discussions and JHA results: 1) difficult repetitive lifting, twisting, and lowering during flammable liquid bulking task, 2) overreaching and repetitive handing while performing lab packing task, 3) awkward posture, lifting, and handling of heavy load during biohazard bin pick-up and drop-off, 4) awkward posture and recurring handling of materials during lab sorting. We expect to see low to moderate risk after completing further analyses including the RULA, REBA, and NIOSH RLE. These results will be completed by the conference date.

Conclusions: Technicians working at the facility are exposed to chemical, biohazards, and ergonomic hazards. This study focused on the ergonomic hazards, of which there were four tasks identified by the authors that were felt to warrant further evaluation via various job hazard analyses. We expect to find moderate to high exposure to ergonomic hazards that will highlight the need to reduce the risk of musculoskeletal injuries among technicians. After the initial assessment, the following potential abatements were identified: 1) Implement ergonomics training, 2) Hire more technicians, 3)Provide electric adjustable tables and chairs for technicians performing seated lab sorting tasks, 4) Provide a pump to eliminate the need for lifting of heavy chemicals when bulking 5) Providing electric pallet jacks to reduce the force of pushing and pulling for technicians performing flammable liquid bulking, 6) Reducing the height limit of stacked loaded biohazards bin to two bins per stack, 7) Move to a larger space to eliminate the need for stacking heavy bins.

Correlation Between Ratings of Perceived Exertion and Strength Declines for Fatiguing Order Picking Tasks

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Introduction: Shoulder musculoskeletal disorders (MSDs) are an important health concern in the workplace due to the high prevalence and prolonged recovery period. Material movers and hand laborers, including order picking, are workers at higher risk of developing shoulder MSDs. With the increase in e-commerce, the number of workers doing order picking is expected to increase. In many cases, the work involves working above shoulder level to pick products and package them. Working above shoulder level imposes a high load on the shoulder, which can lead to muscular fatigue and increase injury risk. Thus, understanding fatigue development is important for intervention design and implementation. However, it may be difficult to capture muscle fatigue through the gold standard of strength loss when measuring in the field. This goal of this study was to evaluate the relationship between ratings of perceived exertion (RPE) and fatigue-induced strength decline and to determine whether the relationship would be consistent across object weights and task pace.

Methods: Fifteen young subjects (8 females, 7 males) were invited to this study. The study consisted of four sessions completed on four different days separated by at least four days. Subjects were asked to pick weighted bottles using their right hand from approximately shoulder height and place them into a carton at waist height. A filled box with 5 bottles then placed onto a conveyor at knee level. The study included four conditions (one per session): 2.5 kg bottles at frequencies of 5, 10, and 15 bottles per min (bpm) and 1.5 kg at 15 bpm. The duration of each condition was 45 min. Subjects were asked to report their RPE on a 0-10 scale every 5 min. To measure the effect of the task on participants' muscular strength, strength tests was taken every 9 min. A cubic polynomial was fit to the RPE data to interpolate RPE values at each strength test point. Changes in strength were defined as a ratio of each strength test to the baseline. Pearson product moment correlation was used to evaluate the relationship between RPE and strength decline for each subject. Analysis of variance (ANOVA) was used to investigate the effects of bottle subjects, weight, and frequency on the average correlations across subjects.

Results: The correlation showed a negative relation between RPE and changes in muscular strength. The 1.5kg-15bpm condition showed the most negative correlation (-0.7 ± 0.34). The correlations for the 2.5kg-15bpm, 2.5kg-10bpm, and 2.5kg-5bpm conditions were similar (-0.59 ± 0.45, -0.58 ± 0.31, and -0.59 ± 0.31, respectively). The ANOVA comparison showed no significant differences in the effects of bottle weight and frequency on correlations across the subjects ($p = 0.79$), weights ($p = 0.48$), and frequencies ($p = 0.99$). In comparing the effect of weight at the 15bpm frequency and the effect of frequency for the 2.5kg weight, the correlations were equivalent ($p = 0.61$ and 0.99, respectively).

Conclusions: This warehouse workstation simulation study was designed to identify the relationships between RPE and strength change across different conditions over the course of the 45 min. According to the results, the correlation was similar across task frequencies when tested for the 2.5kg load, and between weights at the 15bpm pace. These results indicate that individuals' subjective response to the task was consistently mapped to their strength decline, regardless of the task condition.

Influence of Uniform Base Layer on Perceptions of Stress, Recovery, and Sleep in Career Firefighters

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Introduction: For the 1.1 million firefighters in the United States, the successful execution of job duties requires the ability to manage stress and recover from job demands, as well as to attain adequate sleep quality. Also important to consider in the execution of job duties is the clothing underneath the structural firefighting ensemble, which is worn for a full shift and can be an additional layer of thermal protection when called for an emergency. Given that researchers have previously explored firefighter satisfaction with various base layer fiber types, and that clothing fiber type has been found to influence perceptions of exercise function, physical effort, and sleep quality in general and athlete populations, it makes sense to expand this line of research to explore the influence of base layer fiber type on factors related to firefighter health and performance. The purpose of the current study, therefore, was to examine the influence of base layer shirt on recovery, stress, and sleep quality among career firefighters.

Methods: 14 (13 male, 1 female) career firefighters (36.07 ± 7.97 yrs; 179.98 ± 6.04; 93.88 ± 15.91 kg) from a Midwestern metropolitan fire department volunteered to participate. Over six months, firefighters completed a battery of assessments at the start of and/or following each 24-hour shift while wearing either the cotton (SHIRT A, $N = 76$) or the Nomex® knit blend (SHIRT B, $N = 66$) shirt. The Short Recovery and Stress Scale (SRSS) used to assess perceptions of stress and recovery was administered to participants both pre- and post-shift. A sleep questionnaire used to assess on-duty sleep quality (1 = strongly disagree; 5 = strongly agree) and a shirt evaluation used to assess on-duty shirt sensations (1 = very heavy/uncomfortable/hot; 10 = not heavy/very comfortable/cool) was administered only post-shift. Self-reported call volume (8.9 ± 4.68 calls) over the 24-hour shift was also collected post-shift. Pre-post shift percent change scores were calculated on SRSS items to describe changes in stress and recovery during the shift. One-way analyses of covariance (ANCOVAs) were used to examine for differences in perceptions of stress, recovery, and sleep quality between SHIRT A and SHIRT B, after controlling for the potential influence of call volume. Mixed model one-way analyses of variance (ANOVAs) were used to examine for differences in shirt sensations between SHIRT A and SHIRT B. An alpha $p < 0.05$ determined statistical significance.

Results: No significant differences in perceptions of overall stress, overall recovery, or sleep quality emerged between SHIRT A and SHIRT B ($p > 0.05$). On the shirt evaluation, significant differences in sensations between SHIRT A and SHIRT B did emerge, however. Specifically, there was a significant difference in perceptions of *Sweat Sensation* ($F_{(1, 13)} = 25.639$, $p < 0.001$), *Comfort Sensation* ($F_{(1, 13)} = 20.570$, $p < 0.001$), *Coolness/Hotness* ($F_{(1, 13)} = 21.085$, $p < 0.001$), and also *Comfort Sensation while Sleeping* ($F_{(1,13)} = 7.875$, $p = 0.014$), and *Temperature Sensation while Sleeping* ($F_{(1,13)} = 14.758$, $p = 0.002$), with SHIRT B rated significantly more comfortable and cooler than SHIRT A.

Conclusions: Firefighter perceptions of on-duty recovery and stress, as well as ability to fall asleep and have satisfying sleep did not differ according to shirt type, yet firefighter perceptions of comfort and temperature when working and sleeping did differ according to shirt type. To understand why perceptions of shirt comfort and temperature were different between shirt type, yet perceptions of stress and recovery were not different between shirt type, researchers should examine physiological and/or psychological factors that may be mediated by shirt type. Additionally, given previous evidence to suggest that ability to stay cool and comfortable during work and sleep is related to job performance, researchers should examine the influence of shirt type on job performance among career firefighters.

Metabolic Energy Analysis for Different External Loading Arrangements During Countermovement Jump

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Introduction: The ability to estimate Metabolic Energy Expenditure (MEE) can better inform military, athletes, and physical laborers about the efficiency of their tasks. Different methods can estimate energy expenditure, such as muscle-based and joint-space models. Muscle-based models are formulated using the laws of thermodynamics and rely on muscle information, joint kinematics, and kinetics. Specifically, this method depends on the sum of several variables defined as activation heat rate, maintenance heat rate, shortening heat rate, basal metabolic rate, and mechanical work rate. Only joint kinematics and kinetics are required when evaluating the joint-based energy expenditure model. This model operates with the sum of four variables: internal work, internal thermal energy, heat transfer across the system boundaries (defined as a negative value), and basal metabolic rate. This project will compare the energy expenditure estimations using muscle-based and joint-based models for countermovement jump data in four different loading arrangements (back-loaded, front-loaded, split-loaded, and unloaded). We hypothesize that for pooled sex data, the back-loaded and split-loaded conditions to have higher energy expenditure than the unloaded condition. For pooled loaded conditions, we hypothesize that male participants will have higher energy expenditure when compared to female participants.

Methods: Kinetics and kinematics were collected from 12 males (88.75 ± 16.36 Kg; 1.77 ± 0.07 m) and 12 females (62.67 ± 10.32 Kg; 1.65 ± 0.06 m) during four loading conditions using a motion capture system and force plates. Using OpenSim, model scaling, inverse kinematics, inverse dynamics, and static optimization were performed. The joint torque and joint velocities were utilized for the joint-based model, and MEE was executed using a MATLAB script. The metabolic OpenSim probe was also used to estimate energy consumption using a muscle-based model.

Expected Results & Conclusions: We are currently processing our data and expect the unloaded condition to result in the lowest MEE value. Our results will also rank our jumping conditions from least MEE to greatest MEE and compare energy expenditure between sexes when performing maximum effort jumps. Lastly, we will be able to reach MEE calculation between the muscle-based and joint-based methods. The evaluation of energy expenditure combined with the maximum jump height for the different loading conditions could potentially better inform the development of athletic training programs.

Non-Treadmill-Based Trip Training: A Preliminary Study with Healthy Young Adults

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Introduction: Falls are the second leading cause of non-fatal occupational injuries requiring days away from work, and trips account for a high percentage of these occupational falls. Trip training is a form of perturbation-based balance training that involves exposing individuals to trip-like treadmill perturbations to improve reactive balance and thus reduce fall risk. Numerous studies have shown beneficial effects and potency of trip training on the kinematic response to a trip. However, significant costs and space requirements associated with specialized treadmills for this training may hinder its adoption. An alternative method of trip training that does not require such a treadmill or significant space resources, but preserve ecological validity to simulate trips, may help expand the use of trip training. The goal of this preliminary study was to evaluate a non-treadmill training (NT) protocol among healthy young adults. NT was compared with the more commonly used treadmill training (TT) and a control group (CG). We hypothesized that NT and TT subjects would each exhibit improved reactive balance and fall rates after lab-induced trips compared to CG subjects.

Methods: A convenience sample of 18 healthy adults (9 M, 9 F), with a mean (SD) age = 20.5 (1.15) years, body height = 1.71 (0.06) m, and body mass = 67.3 (12.5) kg, was recruited from the university population. The study used a three-group, posttest-only design. Subjects were first randomly assigned to either NT, TT, or CG, i.e., six per group (3 M, 3 F). NT and TT subjects completed 1-hour training led by investigators, and CG subjects completed 30-minute walking on a treadmill at a comfortable walking speed. Following the completion of their assigned interventions, subjects were exposed to a laboratory-induced trip while walking on a walkway. Dependent variables were key measures of reactive balance after tripping and trip outcome (i.e., fall or recovery). Statistical analyses involved ANOVA for continuous dependent variables, Fisher's Exact test for trip outcome, and a significance level of 0.05.

Results: A total of 18 trips resulted in 14 falls and 4 recoveries. The incidence of falls or recoveries did not differ between CG vs. NT or between CG vs. TT. Recovery step time differed between groups. NT subjects showed 0.07 s faster recovery step time than CG subjects ($p = 0.01$). Similarly, TT subjects showed 0.06 s faster recovery step time than CG subjects ($p = 0.04$). However, this measure may have been confounded because more CG subjects used the lowering strategy (which generally takes longer than the elevating strategy) after the trip than NT or TT subjects. No other differences between groups were found. Change in trunk angle and trunk angular velocity over the first 350 msec after trip onset also did not differ between groups given no group x time interaction effects that would have existed with differential training effects between the three groups.

Conclusions: A novel NT regimen showed no clear differences in reactive balance after a laboratory-induced trip when compared to TT and a control intervention. Several potential reasons may explain why such results were shown. First, our subjects were healthy young adults at a moderate to high level of fitness (based anecdotally on investigator observation). Given high success rate of trip recovery among healthy young adults in prior studies, they may have been a poor choice of subject population for this preliminary study, providing less potential for improvement in reactive balance after tripping compared to lower physical-functioning middle-age or older adults. Second, we attempted to increase the difficulty of the trip by using a 15-cm-tall trip obstacle, tripping the non-dominant foot, and requiring subjects to walk quickly, anticipating our young adults to have a higher level of physical function than middle-age or older adults. We may have made the trip too challenging that only four successfully recovered from the trip, while 14 failed to recover and received meaningful harness support. Third, the three types of training appeared anecdotally to differ in cardiovascular exertion levels in that some subjects during NT and/or TT exhibited higher breathing rate and sweat volume. This could have resulted in different levels of fatigue between the three groups and therefore confounded our outcome measures. While these results did not support our hypothesis, this preliminary study provided invaluable lessons learned for future studies investigating NT for reducing the risk of trip-induced falls.

Significance of Seat Belt Buckle Release Force Post Passenger Vehicle Rollover

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Introduction: The number of motor vehicle crashes and road traffic death on the world's roads remains unacceptably high. According to data obtained from World Health Organization, *every 24 seconds*, someone dies on the road around the world. Road traffic crashes cost most countries 3% of their Gross Domestic Product (GDP). In the United States, road traffic crashes are a leading cause of death for people aged 1–54. Over 30,000 people die from motor vehicle crashes every year in the U.S despite considerable technological advancements in vehicular structures, sensors, various safety features, and high rates of seat belt use. A particularly fatal type of motor vehicle accident is a rollover crash. Rollover crashes contribute to about 3% of all motor vehicle crashes but they account for almost 30% of all fatalities and contribute to more than 30% of the injury costs in the United States every year.

When used properly, the three-point lap/shoulder seat belt is considered, almost universally, to be the most effective safety device yet devised for protecting vehicle occupants in collisions. Numerous studies over the past 8 decades have demonstrated the effectiveness of seat belts in reducing fatalities and non-fatal injuries in motor vehicle collisions. However, belted fatalities still occur. Since 2003, *more than 40% of annual fatalities were restrained.* For rollover accidents, since 2009, on average almost 30% of rollover fatalities were belted.

The Government and the Auto industry have repeatedly identified belt use as a critical safety element for occupants in rollover crashes, but neither have considered seat belt buckle release force in rollover crashes. The seat belt buckle according to the Federal Motor Vehicle Safety Standard FMVSS 209 S4.3 (d)of a Type 1 or Type 2 seat belt assembly shall release when a force of not more than 133 N is applied. A literature review revealed two vital points a) the buckle release force may be relatively high for a majority of the vehicle occupant population and b) webbing tensions are high in a rollover accident, potentially causing the release force to increase substantially.

Methods: The primary goal of this experiment is to study the strength capabilities of adults to unlatch a push-button seat belt buckle in a rolled over orientation. Sixty (60) subjects (30 males and 30 females) aged 18 and up will be recruited from Auburn University. They will be divided into three groups based on their BMI (<18.5, 18.5-29.9, ≥30). A custom test apparatus was built to simulate a passenger vehicle front seat rollover. The experiment is planned to be conducted in 2 stages: Stage one will measure the force subjects are able to exert in different orientations (0°,90°,180°, and 270°) using their fingers and thumb for each hand. Stage two will measure the unlatching ability of the subjects in different rolled over orientations (90°,180°, and 270°).

Results: Data collection will commence in April 2022.

Conclusion: An extensive literature review has failed to uncover the basis for the relatively high buckle release force requirement of 133N. To the best of our knowledge this would be the first study to evaluate the capabilities of adults to unlatch a seat belt buckle in rolled over orientations. We believe that a potential reason for some of the belted fatalities and injuries could be high seat belt buckle release force. An occupant may find themselves restrained in stressful positions (i.e., upside down or sideways) in a seat for an extended period, struggling to unlatch the seat belt to evacuate and/or avoid possible further harm after a motor vehicle crash (i.e., smoke, fire, secondary collision with other motor vehicles).

Design and Testing of Engineering Controls for Residential Riding Lawn Mowers to Reduce the Frequency of Ride-Over Accidents

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Introduction: Riding lawn mowers have been a boon to multi-acre homeowners and others with large yards or limited mobility. Not only are grass-cutting blades motorized on these mowers, but the seated operator is propelled by a powered drivetrain. Whether such a lawn mower is powered by gasoline or electricity, the motion of the unit—and especially of the sharp blades—pose safety hazards to those in the vicinity of the mower. Both the operator and bystanders—as well as pets—could be harmed by such a mower. Although objects can be thrown by the blades and people could be injured in the event of a mower rollover event, this project is focused solely on the "ride-over" event. This is an event where the mower, with its blades spinning, drives either forward or backs-up over an adult, child, or pet.

Methods: Two design approaches were used in this project. First, established technologies (within the power-equipment industry) were used to create an interlocked push bar to signal physical contact with an obstacle. Second, technologies not widely used on residential power-equipment were incorporated to fit a back-up camera and ultrasonic sensors to warn the operator of the presence of obstacles in both the forward and the rearward paths of the mower. A video display is attached to this system and could be interfaced with the vehicle drive and blade-drive control systems to halt either or both. At the present stage, the control signals from the added devices are not interfaced with the vehicle control system in order to avoid interfering with vehicle function.

Laboratory and field tests were performed on both types of systems to assess the viabilities of such engineering controls—or safeguards—on riding lawn mowers.

Results: The results of this initial round of testing were promising. They showed the significant potential for such devices to lower the frequency of ride-over accidents with riding mowers through providing visual signals to operators. These results, through the product design-and-development program, also showed that such system types are both technologically feasible and economical (given mass production) for residential riding mowers. Due to the scope of the design project, these systems remain at the prototype stage. Additional design, development, and testing would improve the performance, durability, and reliability of such systems and should be undertaken prior to any implementation in vehicle for public use.

Conclusions: These relatively simple systems and their preliminary results show that such devices have the potential to reduce the frequency of real-world ride-over accidents which can seriously injure operators, bystanders, and pets. Given the proper implementation within the overall vehicle-control systems, they could also reduce the severity of the ride-over accidents which still may occur. Although the equipment focus was on residential riding lawn mowers, such vehicles are also often used in industrial and occupational settings involving light-to-medium scale landscaping and lawn maintenance.

Burnout and Engagement's Relationship to Drug Abuse in Lawyers and Law Professionals

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Background: Lawyers and other law professionals play a vital role in the function of our society. These law professionals are leaders in business, government, and community who often guide decision-making and shape policy at many levels. Despite the level of influence that lawyers and other law professionals have, they reportedly have a range of psychological stressors and remain an understudied population in today's biomedical literature. Legal professionals have stated that they face many mental stressors such as long work hours, high workloads, and challenging cases. Those mental stressors may be associated with poor mental outcomes like anxiety or depression, burnout, or drug abuse. The current study investigates the relationship between psychosocial factors of burnout, work engagement, and drug abuse in lawyers and law professionals.

Methods: Three recruitment methods were used for this study to maximize participation and minimize selection bias. The first recruitment method was to randomly select lawyers from the current membership profiles of active attorneys in the participating state Bar. The random selection was stratified by urban versus rural. The second recruitment method was a convenience sample collected using advertisements in the bimonthly Bar Journal and at the spring and summer Bar conventions. Advertisements included having a small ad in the journal for two months. The third recruitment method included the invitation sent to entire firms' employees, inviting all employees to participate. Specific firms were not individually selected to be invited to participate; any firm could do so. After consent, participants completed the questionnaire. The questionnaire consisted of 59 questions assessing demographics, work environment, depression, anxiety, work engagement, burnout, and satisfaction with life, drug abuse, problem drinking, chronic pain, prior medical diagnoses, physical activity, and behaviors.

Results: A Spearman correlation analysis between engagement and burnout showed a significant inverse correlation (r_s = -0. 38, $p < 0.01$, n = 681). In the engagement final model looking at all law professionals, confounding variables of PHQ9, marital status, showed statistically significant odds ratios, as well as the type of law practice showing a protective odds ratios ($p < 0.05$). In the burnout final model looking at all law professionals, confounding variables of PHQ9, and marital status, showed statistically significant odds ratios, and type of law practice also showing a protective odds ratios ($p < 0.05$).

Conclusion: Study findings showed that there is potentially a way to affect the prevalence of drug abuse in law professionals by affecting the engagement and burnout dichotomy. The current study serves two significant purposes: a preliminary study of the relationship between burnout and engagement and drug abuse in law professionals. First, it provides a significant warning to show lawyers and law professionals themselves concerning drug abuse in this integral occupation and how it can be potentially changed by affecting the engagement and burnout dichotomy. Second, it provides researchers with a needed starting point and a place to focus on to start a process of improving the well-being of lawyers and other law professionals.

The Relationship Between Safety Climate and Mental Health During the COVID-19 Pandemic in the Grocery Industry Using an Item Response Theory Modeling Approach

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Introduction: At the beginning of the pandemic, initial prevention measures were primarily focused on health care workers but lagged weeks behind for the essential workers in the grocery industry. In collaboration with researchers from UC Berkeley, UC San Francisco, the Labor Occupational Health Program (LOHP), and the United Food and Commercial Workers (UFCW) union, a survey was sent to grocery workers in California during the summer of 2020 to gather information about workers' experiences in the workplace during the pandemic. Items from the survey were grouped by themes relating to prevention measures, employer practice & organizational climate, work demands & psychosocial stressors, and mental health. Thus, this study aims to specifically explore the relationship between safety climate, a branch of organizational climate, and mental health. Specifically, we evaluated the validity of safety climate and mental health items from the grocery worker survey using an item response theory (IRT) modeling approach. IRT consists of a set of generalized linear models and associated statistical procedures that connect the observed survey responses to a subject's position on an unmeasured trait, also known as the latent trait (Hays et al., 2000; Mellenbergh, 1994). In other words, IRT models can specify a relationship between a respondent's ability (theta), the items' difficulty, and the probability of a correct response to the items (Wilson, 2004). For this analysis the respondents' abilities were their perceived safety climate and mental health during the early months of the pandemic.

Methods: The respondents' ability levels within the constructs of safety climate and mental health were developed in the form of a Construct Map that is typically used to describe an idea or concept that consists of qualitatively distinguishable categories along a continuum of ability. To address the validity of the survey, the respondents' ability levels and item difficulties were examined graphically by visualizing them together through a Wright Map. Specifically, the constructs of safety climate and mental health were defined with their respective items and their corresponding responses were scored according to the theoretical thresholds from their construct maps that were then calibrated to develop a Wright Map. As a secondary analysis, the relationship between safety climate and mental health was statistically investigated through a Pearson's correlation test using respondents' estimated ability levels (theta) for answering items within those two constructs.

Results: From the IRT analysis, the number of items related to mental health were limited. This affected the validity of the instrument for this specific construct and limited the analysis. Alternatively, there was an adequate number of items related to the safety climate. The safety climate items required greater discrimination to determine the respondent's true perception of safety climate. In other words, the ability to differentiate among respondents who had a higher or lower perception of safety climate needs to be improved by redesigning the items within the construct, such as changing the items from Likert-style to an open response that would allow respondents to elaborate on their responses. Additionally, a few safety climate items were either too easy or difficult for respondents to complete, suggesting that those items would also need to be redesigned. The correlation between the safety climate and mental health constructs was 0.15 ($p > 0.05$).

Conclusions: This research assessed the relationship between safety climate and mental health among grocery workers during the COVID-19 pandemic. The IRT approach was useful in evaluating the validity of the safety climate and mental health constructs identified in the grocery worker survey. In the secondary analysis, the correlation between safety climate at work and mental health was weak. It is possible that other factors about the pandemic impacted mental health more than the safety climate at work, such as customer interactions, proper recognition from management, or one's perceived stress in the workplace. Understanding factors associated with mental health among workers, particularly during a pandemic, is important to understand so adequate resources can be developed to support essential workers during this public health crisis.

Working Alone and Remote: Preventing the Risk of Fatality From Cardiovascular Events in Oil and Gas Extraction Workers

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Introduction: Oil and gas extraction workers experience unique risks for fatality when performing gauging and sampling duties at wellsites. These workers often perform these duties in remote locations frequently without supervision or other workers nearby. These factors may contribute to the risk of fatality not only due to workplace hazards from the duties being completed, but also from health-related incidents including cardiovascular events. Information regarding these workplace fatalities in the oil and gas industry is collected by NIOSH and compiled in the Fatalities in Oil and Gas (FOG) database. To date, the risk of working alone or in a remote environment has not been addressed in research involving oil and gas workers and the information collected in the database offers the opportunity to evaluate such factors. This paper looked specifically at the fatalities of workers in the oil and gas extraction (OGE) sector as a result of a cardiovascular incident in order to determine how often the worker was alone or experienced a delay in reaching definitive medical care.

Methods: Data from the NIOSH FOG database was reviewed to identify 46 fatal cardiovascular events among oil and gas extraction workers during 2014-2018. NIOSH received reports of cases through formal investigations by various government agencies such as the Occupational Safety and Health Administration and the Bureau of Safety and Environmental Enforcement, or informally through media reports and press releases. The information regarding these cases was then compiled from available sources including investigation reports, autopsies, obituaries, and media reports. The cases were categorized with the NIOSH staff using the variables of interest. During this process a "lone worker" was defined as an individual working at a wellsite without any other people present. An "unobserved" event was an individual who was with another worker at the wellsite but that person was unable to see or hear that the individual was in need and therefore was unable to respond to the cardiovascular event immediately. Lastly, a "delay in care" was a cardiovascular event that was observed by other workers, but the individual continued to remain at work after onset of symptoms or there was a clearly stated delay in the medical response. After reviewing the database, an examination was performed on five cases that represent the complex dynamics not yet documented in oil and gas research which resulted in a fatality following a cardiovascular event. After summarizing the key findings, recommendations to address these risks were presented.

Results: Between the years of 2014-2018 there were 46 cardiovascular fatality cases which were reviewed and summarized in Table 1. The population consisted of 28 men and 1 woman (17 unknown). The mean age was 51.9±13.1 years (17 unknown) ranging between 20-68 years. Of the 46 fatalities from a cardiovascular event 35 of these cases (76.1%) contained enough information within the file to determine if the event was unobserved, observed, or during lone work. From those 35 files, 18 (51.4%) were during lone work, 7 (20.0%) were an unobserved cardiovascular event, and 10 (28.6%) were observed cardiovascular events. Out of the 10 observed cases, 4 (40.0%) had a notable delay in receiving definitive medical care. There were 45 cases that had documentation regarding chemical exposure, 33 of these (71.7%) were without evidence of a chemical exposure, 12 (26.1%) had evidence of a possible workplace exposure, and 1 was unknown due to limited information. From the 11 files that had limited information 72.7% of the incomplete case files occurred during 2018 with many variables missing from the data.

Conclusions: The NIOSH FOG database provides valuable information necessary to evaluate the unique health and safety concerns of the population of OGE workers who perform duties at remote oilfield sites. This includes the risk of fatality from a cardiovascular event while working alone or experiencing a delay in receiving medical care while in a remote environment. Although many of the case files in the database were thorough there were inconsistencies noted in the reporting and gathering of information which was a recognized limitation to evaluating the full extent of the threat from working alone or at a remote wellsite. This paper offered insight into these unique risk factors encountered by OGE workers and presented recommendations for implementing novel approaches with the goal of preventing future fatalities from cardiovascular events.

Leveraging Current Research on SARS-CoV-2 Pandemic Response to Protect Workers From Future Respiratory Threats Through the Total Worker Health Core Competencies Framework

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Introduction: The SARS-CoV-2 pandemic disrupted productivity across all industries, but workplaces deemed essential experienced particular threats to worker well-being, including high infection rates, disruption of routines, and resulting adverse effects on worker mental health. There is a critical need to analyze past responses to better prepare for future pandemics and other emerging threats to worker health. The Total Worker Health® approach, which seeks to jointly promote and protect health, contains key core competencies useful to understanding past responses and imagining future protective practices.

Methods: Using a case-study approach, we identified how use of Total Worker Health (TWH) core competencies offer an agile and responsive framework to resolve disruptions to productivity and wellness posed by SARS-CoV-2.

Results: A pet food manufacturing company that was deemed an essential employer was able to continue normal operations in spite of COVID-related lockdown orders in March 2020. Initial protective interventions included implementing physical controls to minimize disease spread, creating worker cohorts that minimized exposure to others, and adding a surveillance system for early detection and quarantine. Later the program expanded to include SARS-CoV-2 testing and on-site vaccine clinics for workers and their families. Upon analysis, it was found that core TWH competencies of (1) communication and dissemination, (2) subject matter expertise, and (3) partnership building and coordination were critical to a response that protected worker health outcomes and maintained productivity.

Conclusions: Use of TWH Core Competencies can be applied to successfully and swiftly mitigate workplace threats, and may improve rapid response to emerging threats.

Negotiating the Challenges, Risks, and Responsibilities of Conducting Community Based Participatory Research (cbpr) With Business Owners

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Introduction: Occupational health research often must bridge between the profit-oriented structure of business and the norms established in the 1979 Belmont report for the responsible conduct of research. Conflicts may especially arise when conducting community-based participatory research (CBPR), which involves "collaborative, equitable stakeholder involvement in all phases of the research" (Israel et al., 2001). In occupational health, this partnership translates to collaboration between researchers, employers, and individual workers, which creates the potential for disproportionate power differentials and greater complexity within the study.

Methods: This study sought to identify conflicting motives that threaten ethical integrity in CBPR conducted with for-profit businesses. A literature search in Google Scholar was conducted using the following keywords: "community-engaged research," "ethical considerations," and "business." As CBPR was most formally defined in 2001 by Israel et al., only publication in 2001 and later were reviewed.

Results: Initial searches found Israel et al.'s 2001 work had been referenced 843 times, and 102 of those articles referred to "business." Following a review of abstracts for 102 papers, only two were determined to be somewhat relevant to the discussion. However, none could offer guidance on using CBPR principles when working with businesses. There is considerable need to explore and study potential conflicts and remedies for CBPR conducted in collaboration with businesses.

Conclusions: If successful CBPR is to be conducted in collaboration with businesses, researchers must consider both the continued functioning of an enterprise as well as the health of its workers. The available literature does not currently provide guidance for researchers. An example of preliminary work from a study that incorporates CBPR with a for-profit business is provided, and areas of tension for research are noted for future exploration.

Analysing 3D Anthropometrics of Diverse Populations for Respirator Sizing Outcomes

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Introduction: Previous research has emphasized the importance of facial anthropometrics (shape and size) when considering ideal respirator fit (Brazile et al., 1998; Zhaung et al., 2010). It is also possible that facial anthropometrics vary by age, sex, and ethnicity; all of which need to be considered in the context of respirator fit. The purpose of our research is to quantify the differences in facial anthropometrics between Caucasian, African American, LatinX/Hispanic and Asian American workers, as well as across and within the demographics of age and gender. The respirator-wearing workforce continues to diversify in the context of demographics, and this research seeks to understand if current respirators are adequately sized to protect diverse working populations. This research utilizes 3D facial image scans for data collection and analysis.

Methods: The 3D facial images for this research were recently obtained by Human Solutions North America using the Artec Eva handheld 3D body scanner on n=2022 United States participant volunteers. The researchers are digitizing the facial scans to gather key facial dimensions for respirator and mask fit. These key dimensions include traditional linear measurements which can be gathered manually, as well as contour measurements which are best gathered in 3D. Inter- and intra-rater reliability tests are being conducted among the four research personnel that are manually digitizing the facial points associated with the key facial dimension. Demographics of the workers were also collected and included gender, ethnicity, age, occupation status, income, and various health and lifestyle factors. The data will be analysed using a variety of statistical tests that will help the researchers understand if face anthropometric differ across and within the demographic groups of age (bracketed), gender, race, and ethnicity. Furthermore, specific statistical procedures for developing size systems will be conducted to understand if the current respirator sizing system (frequently one-size or small, medium, large) is sufficient to protect the diverse workforce.

Results: An analysis of the demographic data for the 3D facial scan participants indicated that the mean participant age is 34.6 years (SD=11.5), primary ethnicity was Caucasian (61.2%), and females represented 53% of the total sample. Digitizing of the n=2022 facial images is currently taking place, and inter- and intra-rater reliabilities are being tested continuously. Though this work is not yet complete, it is expected that there will be differences in key facial anthropometric dimensions for respirator fit both across and within demographic groups. Furthermore, it is expected that inter- and intra-rater reliability will score high enough to warrant 3D scan data be used as a viable tool for future anthropometric studies.

Conclusions: Utilization of 3D facial data and digital extraction of anthropometrics is expected to provide a greater amount of measurement and fit information when compared to manual measurement techniques used in many previous research endeavours. This research marks the first large-scale use of 3D anthropometric data to analyse demographically diverse facial dimensions for respirator fit outcomes. The significance of this research is the quantification of facial anthropometric differences across diverse demographic backgrounds as well as the utilization and analysis of 3D scan data. It is expected that this research will contribute to improved respirator fit and better face mask sizing to protect workers and the general population that may be exposed to respiratory hazards such as wildfire smoke, agricultural dusts, and aerosolized viruses. Further, this research answers several calls for incorporation of 3D technology into anthropometric research, thus it is expected that the findings will be of use to government, academic, and industry who wish to utilize similar technologies in anthropometric research.

Parental Individual- and Neighborhood-Levels Socioeconomic Status as Predictors of Childhood Mortality

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Introduction: Early life socioeconomic status (SES) may affect the risk of childhood mortality. However, due to the lack of available parental individual-level SES measurements in birth certificates, neighbourhood-level SES measurements, such as median household income, are commonly used as proxies in population-based studies. Recently, the practice of using neighbourhood-level and individual-level SES measurements interchangeably has been questioned in studies of health inequalities. This study aims to assess whether neighbourhood-level SES measures are suitable proxies for individual-level measures through comparison of parental occupation and family income.

Methods: Using data from Utah Birth Certificates 1978-2008, we first assessed the association between parental occupation standing and family income at the time of the births using Kappa statistics. Parental occupation standing is determined as the either father's or mother's Nam-Power-Boyd Occupation Status Scale (NPBOSS) in quartiles calculated from parental occupation data based on Census 2010 Industry & Occupation Classification System. Family income is determined as median household income in quartiles corresponding to the census tract of mother's residential address mapped to Census 2010 tracts. Demographic characteristics (i.e., sex, birth year, race, ethnicity, birth county, birth order, and parental education) were compared by quartiles of parental occupation standing and family income. Cox proportional hazard regression models were used to estimate the effect of parental individual-level and neighbourhood-level measures on childhood mortality.

Results: Agreement between parental occupation standing and family income was low, as indicated by the low Kappa statistics for same measures (same quartiles) (K = 0.09). Socioeconomic disparities in childhood mortality were greater for parental SES (occupation standing) than neighbourhood-level SES (family income). For parental occupation standing, childhood mortality rate was 1.8 times higher in the lowest quartile compared to the highest quartile (5.2 deaths per 10,000 versus 2.9 deaths per 10,000). For family income, childhood mortality rate was 1.4 times higher in the lowest quartile compared to the highest quartile (4.6 deaths per 10,000 versus 3.3 deaths per 10,000). When stratified by family income, childhood mortality rate decreases as parental occupation standing increases. However, when stratified by parental occupation, this gradient was not seen as clearly across family income quartiles. Both parental occupation standing and family income were both significantly associated with childhood mortality after adjusting for demographic characteristics.

Conclusions: The low agreement between parental occupation standing and family income indicates that the two SES measurements capture different SES domains. These measurements provide unique information about an individual that are largely independent of each other. Although median household income is an insufficient proxy for missing parental occupation data, it is still of value for understanding the SES experience of the population.

The Relationship Between Psychosocial Stress, Biomechanical Stress and Musculoskeletal Disorders in Hotel Room Cleaners

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Background: The rate of injuries and musculoskeletal disorders (MSDs) among hotel room cleaners (HRCs) is 40% more than any other type of hotel work. According to the bureau of labor statistics, 1.9 million workers in the hotel industry, and approximately 900,000 of those are HRCs. These MSDs are a problem that affects the US's immigrant population because approximately half of them work in the blue-collar or service industry. HRCs make up the largest occupational group in this industry (24%), primarily composed of female immigrants with high school educations or less. HRCs work long hours and irregular hours due to the demand in the hospitality industry. HRCs also perform physically demanding tasks like having to stand for long hours and perform a task with less than optimal posture exposing them to higher injury rates. Studies also identified that the risk of injury to HRCs had increased from 47% to 71% over six years (1999 - 2005). The turnstile nature of the hospitality industry, along with irregular shifts and labor-intensive work, leads to above-average levels of stress mentally and physically to its employees. This study will investigate the relationship between physical and psychosocial stressors and the prevalence of low back pain (LBP) and shoulder pain in the HRCs.

Methods: Hotels were selected from the city center on a radial proximity basis. Once hotels at each radial level were exhausted, the research team moved to the next radius level (5-miles). Inclusion criteria were that each hotel had to be a commercial brand hotel (e.g., Hilton, Marriott) vs. not (e.g., bed and breakfast, extended stay, or motel). Participants filled out a questionnaire offered in English and Spanish that took approximately 45 minutes to complete. The survey attempted to measure the prevalence of LBP, shoulder pain, and biomechanical and psychosocial stressors.

Results: This study reveals a trend toward significance, which led to a post hoc analysis of the data to explore where the trends were. The data showed two trends toward significance. 1) The association between should pain over the past year and biomechanical stressor of the number of rooms cleaned during an 8-hour shift ($p = 0.20$). 2) The association between the prevalence of LBP at the week level and the biomechanical stressor of room cleans during an 8-hour shift ($p = 0.07$). Analysis showed that the odds that a HRC had experienced shoulder pain that year were 11.6 times higher if the HRC cleared less than the six beds on their 8-hour shift. Those odds rose to 16.9 times higher adjust forget and gender ($p = 0.01$, $p = 0.01$ respectively). The odds that an HRC had experienced LBP that week was 30 times higher if the HRC cleaned more than 18 and less than 31 beds and bathrooms when compared to those who only cleaned more than six and Less than 17 ($p = 0.02$).

Conclusion: In conclusion, despite this study being underpowered, the data shows a meaningful relationship between biomechanical stressors, psychosocial stressors, and MSDs of LBP and Shoulder pain. These results show that the HRCs can perform a range of tasks before they risk injury increases. Future research should investigate precisely where this threshold is.

Incidence of COVID-19 Infection in Utah Children During Delta and Omicron Circulation

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Introduction: Children remain an under-studied population with regard to SARS-CoV-2 and COVID-19 trends, exposures, and vaccine effectiveness. Our objective is to describe a prospective cohort ages 6 months to 17 years, and detail COVID-19 trends within that population.

Methods: *Pediatric Research Observing Trends and Exposures in COVID-19 Timelines* (PROTECT) is a multi-site prospective cohort study monitoring symptomatic and asymptomatic SARS-CoV-2 infections among participants aged 6 months–17 years. The Utah cohort of 275 children reside in Salt Lake County and surrounding, largely urban counties. Upon enrollment, parents or legal guardians provided the participants' demographic, health, vaccination history, and prior SARS-CoV-2 infection information; the number of hours and percentage of time participants wore masks in school and in the community were reported monthly. Vaccination was verified by vaccine cards, electronic medical records, and state immunization registries. Active surveillance for SARS-CoV-2 infection and any COVID-19–associated symptoms within the preceding 7 days occurred through weekly submission of a survey and nasal swab for reverse transcription–polymerase chain reaction (RT-PCR) testing and viral whole genome sequencing. Specific symptoms and duration, hours of school missed because of illness, and receipt of medical care were documented through the electronic surveys. The study date is from October 1, 2021 to February 28, 2022.

Results: From October 1, 2021 to Feb 28, 2022, vaccination rates were 1% fully vaccinated with a booster dose, 47% fully vaccinated with 2 doses, 11% partially vaccinated with 1 dose, 39% unvaccinated, and 2% unknown/unconfirmed. Majority of the Utah cohort were younger than 12 years, with 43.4% between 6 months–7 years, 41.6% between 7—12 years, and 15.0% between 12—18 years. Most (78.5%) attend in-person school or daycare. A breakdown of vaccine status according to demographic measures is shown in the Table 1. Prior to the first case of Omicron variant in Utah, daily SARS-CoV-2 positive tests did not exceed 1.36% of our cohort. When Omicron circulation was predominant, infections were as high as 5.75% on January 18th, 2022. To date, there are no hospitalizations or deaths in the Utah cohort.

Conclusions: In the Utah cohort, the percentage of fully vaccinated children are below 50% at the time of analysis while infection rates rose during the Omicron period. Understanding COVID COVID-19 trends in children is important for a complete understanding of the pandemic.

Community-Engaged Approaches to Minimize Worker Exposure to COVID-19 in the Workplace

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Introduction: In response to the COVID-19 pandemic, the Occupational Safety and Health Administration (OSHA) established an emergency temporary standard (ETS) that mandated COVID-19 testing and vaccination policies. While this ETS has concluded among all industries but healthcare, employers continue to have obligations under the General Duty Clause to provide a work environment that is "free from recognized hazards that are causing or are likely to cause death or serious physical harm" (CDC, 2020). Approaches from *Total Worker Health®* and community-based participatory research (CBPR) principles can inform discussions between workers and managers to create working environments that comply with the General Duty Clause.

Methods: Through existing worksite-university relationships, we have developed questions to guide workers and managers to form a collaborative, worker-engaged process that utilizes principles of Total Worker Health (TWH) and CBPR in complying with the General Duty clause as well as any future OSHA regulations. Mountain Country Foods, deemed essential workers during the COVID-19 pandemic, serves as a case study for how workers and managers can collaborate to promote worker safety.

Results and Discussion: Qualitative data from early conversations with stakeholders will be presented, along with proposed solutions to reduce risks related to respiratory pathogens. The case scenario findings will highlight which TWH and CBPR principles helped to structure the conversation and proposed implementation for worker-engaged solutions to protect workers from COVID-19. With time, these findings will be developed into guidelines available through the Utah Center for Promotion of Work Equity Research (U-POWER) as a way to share successful practices with other worksites.

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Mask-Use Trends and Prevalence of SARS-CoV-2 Infection During the Omicron Surge in a Utah Population of Healthcare Workers, First Responders, and Other Frontline Workers

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Introduction: With the recent emergence of the SARS-CoV-2 variant: B.1.1.529 (Omicron) in Utah, there has been a surge in Covid-19 throughout the state and more research is needed to understand the role of mask usage and its effects in essential workers. Mask usage has been shown to reduce the rates of SARS-CoV-2 infection. Mask usage varies between different occupational categories and these variations may influence rates of infection in these occupations. A study from the HEROES-RECOVER network reports an association between below average facemask use and a higher risk of SARS-CoV-2 infection in unvaccinated essential workers. Our objective is to describe self-reported mask use trends and assess how these trends impact the prevalence of SARS-CoV-2 infections in a large population of Primary Healthcare Workers (i.e. physician assistants, physicians, and doctorates of nursing practice), Other Allied Healthcare Workers (i.e. nurses, technicians, front desk.), First Responders (i.e. firefighters, police officers), and other Frontline Workers (i.e. teachers, grocery store clerks, construction workers) over the course of the Omicron variant surge.

Methods: We analyzed data from 767 workers from the Utah site of the Research on the Epidemiology of SARS-CoV-2 in Essential Response Personnel (RECOVER) Study: a multisite prospective cohort study of Primary & Other Allied Healthcare Workers (HCW), First Responders (FR), and Frontline Workers (FW). Participants self-collect weekly nasal swabs (with or without symptoms), complete weekly and quarterly surveys, and participate in quarterly blood draws. Our analysis takes a cross-sectional approach focusing on the Covid-19 prevalence during the Omicron surge period in Utah from December 26, 2021 (date of ≥50% predominance of Omicron variant in Utah) to February 28, 2022. Data for the prevalence calculations were from reverse transcription-polymerase chain reaction (RT-PCR) confirmed positive weekly nasal swab test results from December 26, 2021, to February 28, 2022. Participant demographic data was from electronic surveys upon enrollment and mask use data was collected from self-reported quarterly surveys completed from October 5th, 2020 to February 28th, 2022. We calculated the mean for participant community mask use and workplace mask use. Participants were grouped based on the percentage of mask usage: low mask usage (0-33%), medium mask usage (34-66%), and high mask usage (67-100%). Prevalence of SARS-CoV-2 infection was calculated for each of the occupational categories (Primary HCW, Other Allied HCW, FR, and FW) and for the three mask-usage categories.

Results: From December 26, 2021 to February 28, 2022, majority of the participants were female 473 (62%) and identified as Caucasian 664 (87%). The largest occupational group consisted of healthcare workers, with 85 (11%) being Primary HCW, and 326 (43%) being Other Allied HCW. In terms of vaccination status, 133 (17%) participants were unvaccinated, 292 (38%) fully vaccinated with 2-doses, and 342 (45%) boosted with 3-doses. There were 77 (10%) participants that had a SARS-CoV-2 infection prior to December 26th, 2021. During the study analysis period, other Frontline Workers had the highest prevalence of SARS-CoV-2 infection (23%). Of the participants who reported using masks outside of work in the community, the low usage category had the highest prevalence (33%), and the high usage category had the lowest prevalence (20%). Of the participants that reported using masks in the workplace as part of their personal protective equipment (PPE), the medium usage category had the highest prevalence (34%), and the high usage category had the lowest prevalence (21%). For the overall mask usage, including both at work and in the community, the low usage category showed the highest prevalence (34%), and the high usage category was the lowest prevalence (20%).

Conclusions: In the Utah cohort of essential workers, there was a lower prevalence of SARS-CoV-2 infection in those with medium and higher mask usage at work than those with low or no mask usage during the Omicron period.

Design of a Portable Chin-Rest System for Patient Eye Examinations in Remote Locations

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Introduction: Global health and medicine outreach efforts often find clinicians needing to both diagnose and treat isolated patients in underserved or underdeveloped regions and nations. In the case of ophthalmologists and their teams treating cataracts and other eye problems, the need to quickly examine patients to determine the type of disease, as well as its degree of progress, is vital for medical-mission success.

As part of an earlier Capstone Design project, students had constructed a quick and simple chin-rest system. Since that Capstone effort involved many other more-significant components, that chin-rest system was fragile and hard to adjust. A demand for such a device or system was acknowledged by the project sponsor once the chin-rest was shown to other ophthalmological organizations. It was decided that a more-robust version was needed.

A complete re-design of the system which focused only on the head and chin rest was undertaken. The resulting design, named "HALO," is a durable, light, and adjustable system for rapid set-up, break-down, and transportation by medical teams. System affordability was also considered during design with a cost of $150 the goal.

Methods: A critical review of the prior design was conducted by the design team. Consultations with the ophthalmological organization sponsoring the design project were conducted early in the design phase and continued through design development and refinement phases. In addition, clinical use was observed by the design team both in a hospital setting as well as in a remote site to an underserved rural population. Any concerns from either a patient or a clinician were considered by the team.

To compare and contrast the ergonomics of the portable chin-rest system to a non-portable in-clinic system, a RULA (Rapid Upper-Extremity Assessment) was conducted.

Results: The results of in-clinic testing and ergonomic analysis show that comparable ergonomics are achieved between the portable and non-portable systems for both the patient and the clinician. The functionality of the chin-rest system was considered acceptable to clinicians, patients, and medical-support staff responsible for set-up, break-down, and transportation. The current cost of the resulting basic chin-rest system is approximately $250.

Conclusions: The engineering team was able to design, fabricate, and deliver a transportable and rugged head and chin-rest system that disassembles for easy packing and carrying by medical teams visiting remote areas. The ergonomics to all involved in the eye-examination process was suitable for its purpose. The target cost was not achieved, but the resulting cost is not considered expensive enough to preclude chin-rest system adoption and could be reduced further through design development.

Due to the interest in the original system, it is envisioned that this system will be made available and used by other medical teams and ophthalmological efforts involved in reaching underserved and underdeveloped regions with eye care.

Noise Hazard Characterization in Academic Support Facilities

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Introduction: Noise induced hearing loss (NIHL) is a significant concern across many industries. Noise is characterized as unwanted sound or vibration that propagates as a wave through elastic media, such as gases, liquids, or solids. Hearing is a complex process involving a combination of biological, mechanical, and neurological processes. Given the intricate relationships and potential damage to these processes, high sound levels for extended or even short periods can be an occupational hazard and cause hearing loss. Several strategies exist to encourage compliance and mitigate noise levels in facilities. The goals of this research project were to both characterize noise exposure in a regional academic institution's heat and cooling facilities and recommend controls following a health promotion centered 'total exposure health' continuum.

Methods: Initial site visits were conducted to interview employees and gather area sound level surveys for two high-temperature water facilities at a regional university during February 2022. General sound level surveys measured on a A-weighted decibel (dB scale) as well as octave band analysis for identified point sources measuring frequencies from 0-20,000 Hz were taken throughout the facilities. A data-logging area sound level meter equipped with octave band analysis systematically collected sound level surveys and octave band analysis (Larsen Davis, Provo UT). The data collection procedure followed ACGIH Threshold Limit Value methodology. Microsoft Excel® (Microsoft Office Professional Plus 2019) was used to process data and used Python (Anaconda Distribution, version 3.7, 2018) for the data analysis and graphical representation. Due to the sampling being sparse relative to the space of the facility resulting from inaccessibility due to running machinery, interpolation was used to assign noise values to regions that weren't sampled. Recommendations were formulated within the framework of total exposure health and addressed the following areas: 1) physical exposures within the workplace and 2) organizational involvement in promoting healthy worker habits which extend beyond hazard characterization.

Results: Noise measurements from the facilities were represented as an isopleth. Visualizing the noise distribution as an isopleth showed peak noise levels near 90 dBA around point sources. Octave band analysis at the point source of noise propagating equipment showed the frequencies were approximately normally distributed with a mean frequency in the range of 500-1,000 Hz. After graphically exploring different interpolation methods, linear interpolation was selected to create the final isopleth.

Conclusions: In the two facilities, there are isolated areas where noise exposure exceeds action levels of 80 dBA, the 8-hour time-weighted average action level set by the ACGIH. During routine operations, these areas do not contain staff. However, it is essential to indicate a potential noise hazard in these areas to employees. While it is unlikely that employees spend their shifts in these areas long enough to pose a health hazard or result in a compliance issue, employers have an opportunity to impact health beyond occupational exposure. Worker health extends outside of regular work hours, and well-being at home directly impacts their success and safety in the workplace. In the instance of noise monitoring, sharing results of area noise surveys with employees provides both a situational (e.g., time and place) and conceptual opportunity to improve employee education on the cumulative load of noise exposure experienced within and outside of the workplace. Promoting healthy lifestyles to workers is done by ensuring employees can recognize noise hazards in an all-aspect-of-life approach, not just an occupational one. To this end, positive changes in worker's everyday lives can be accomplished by improving and preserving their overall health. In order to do so, organizations have a unique position that allows them to provide their employees with an awareness of occupational noise sources as well as education of other common noise sources they may encounter outside of work, where an impact to hearing may still occur.

Respirable Dust Sampling at a Composites Manufacturing Site

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Introduction: Engineered composites are created by impregnating woven materials (such as carbon fibers, Kevlar®, or other materials) with an epoxy or resin compound. These components are combined and then layered in a mold. The molds are subjected to specific heat and pressure to cure the resin and create a molded product. Once the materials are set, significant post-processing occurs before the parts are ready for assembly. The heating and pressing process leaves a 'flash' of hardened resin around the molding edges. The flash is removed, and additional fitments are drilled or cut out before the next assembly phase. The composite parts' grinding, cutting, and drilling can create significant airborne particulate exposure to which workers are exposed. The primary health concerns regarding occupational exposure to particulate-laden aerosols include pneumoconiosis, hypersensitivity pneumonitis, and occupational asthma. This study intends to determine if this process at composites manufacturing company in Salt Lake City, Utah generates particulate aerosols that exceed regulated and voluntary exposure limits. The resulting information can inform appropriate controls needed for remediation or mitigation.

Methods: The method used to sample respirable dust was NIOSH method 0600, "Particulates Not Otherwise Regulated, Respirable." Using two personal cyclone aerosol samplers, samples of respirable particulate matter were collected during the grinding, cutting, and drilling of carbon fiber composite parts of a product used in the military aerospace industry. Worker 1 was primarily drilling holes and grinding in the edges of the molds. Worker 2 was responsible for cutting strategic holes in the molds. Five filters were pre-weighed before sampling began—four for sampling, one as a blank—and the sampling pumps were pre-calibrated. Two different cyclone samplers were each coupled with a three-piece cassette containing a 37-micrometer polyvinyl chloride filter attached to the top of the cyclone and placed on the workers. The pumps were set at a flow rate of 2 L/min for the duration of two workers' 8-hour shifts. Sampler cassette and filters were exchanged mid-shift to mitigate the risk of over saturating and perforating the filters. The four filters (A, B, C, D) were post weighed, and the pumps were post calibrated. Using gravimetric analysis, the pre and post weight of the filter was subtracted to obtain the weight of the dust collected.

Results: The total dust collected for worker 1 on cassette A was 2.84 mg for 300 minutes. The total dust for cassette C was deemed invalid because the cyclone had been tipped, and the excess dust in the grit pot fell onto the filter. The average of the pre and post-pump calibration was 2.00415 L/min. The total concentration was calculated using the time-weighted average (TWA) 8-hour equation and was found to be 4.24 mg/m^3. The total dust collected for worker 2 on cassette B was 2.48 mg for 243 minutes. The total dust for cassette D was 2.74 mg for 185 minutes. The average of the pre and post-pump calibration was 1.99847 L/min. The total concentration was calculated using the TWA 8-hour equation and was found to be 5.46 mg/m^3.

Conclusions: The OSHA permissible exposure limit (PEL) for respirable dust is 5.0 mg/m^3. The ACGIH threshold limit value (TLV)for respirable dust is 3.0 mg/m^3. The respirable dust over an 8-hourtime-weighted average (TWA) for worker 1 was 4.24 mg/m^3, a value that does not exceed the PEL but exceeds the TLV. The respirable dust 8-hour TWA for worker 2 was 5.46 mg/m^3, a value exceeding both the PEL and TLV. It is recommended that further evaluation of current personal protective equipment (PPE) be assessed for the appropriate protection level of the workers. Engineering controls to improve ventilation techniques, such as placing a hood directly above the grinding area, may be adequate to reduce the total respirable dust. If moisture does not damage the product, wetting techniques may also lower dust levels in the air. Administrative controls, such as limiting time in the grinding booth, may also be suitable. Finally, PPE beyond a passive half-facemask, such as a powered air-purifying respirator (PAPR), may reduce workers' exposure to the respirable dust generated from cutting, drilling, and grinding composite products.

Combustible Dust Analysis at a Utah-Based Company

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Introduction: A consumer product manufacturing company based in Salt Lake City, Utah, requested a survey for combustible dust within their warehouse and mixing areas. Combustible dust is a fine particle that presents an explosion hazard when suspended. Failure to recognize the presence of combustible dust in the industry can have catastrophic results, and there have been significant accidents in recent history with combustible dust as the causal factor. OSHA's "Hazard Communication Guidance for Combustible Dusts" helps manufacturers recognize the potential for dust explosions. No OSHA single standard exists to regulate the hazards presented by combustible dust in the workplace. The NFPA 652 provides the basic principles and non-legally binding standards for identifying and managing combustible dust's fire and explosion hazards. Our background investigation indicates this facility has been operating with similar raw materials and work methods for several years with no incidence of fire or explosion. To their credit, the company is embracing a focus on the environment, health, and safety and, as a result, sought independent, expert consultation with regards to the dust emanating from their processes. Our primary objective is to determine if combustible dust is indeed present and, if so, provide recommendations for controls and a summary of applicable regulations.

Methods: There are two methods to determine dust combustibility. One method uses previously established industry-published values for the chemical components of the dust listed on Safety Data Sheets (SDS). Dust deflagration index greater than zero in one or more chemical components is considered combustible. The SDS analysis is limited because it does not show precisely what constituent of the dust is combustible, and combustion data for each component may not be available. However, it can serve as an inexpensive and expeditious way to know whether further investigation is required. The other more preferred method is the laboratory method, which is more objective. The laboratory method includes a go/no-go test for explosion pressure, and in the case of a "go" result would require further testing. Due to prohibitive costs, the SDS method was found to be preferable over laboratory analysis at this time.

Results: Analysis of the SDS provided lab-tested combustible dust information in varying degrees for several of the materials used at this facility, but not for all. The SDS combustible dust information was taken into consideration with the quantities and frequencies of use in order to identify the materials that would present a likely combustible dust hazard and for which follow-up lab analysis would be recommended. Four materials were identified as Hazard Class 1 (ST1) dusts on their SDS, one is used in high quantities (60-70kg) and the others are used in low quantities (~1kg) per use, several times each month. No laboratory test data was provided on the SDS for the remaining materials. One common attribute of many combustible dusts is that they are fine, organic powders, five of which were identified by the SDS review. Standard Operating Procedures (SOPs) and cleaning checklists were reviewed to identify potential dust generation. Increased risk of dust generation was identified for acts such as wiping down surfaces, vacuuming, adding materials to a hopper, weighing, and reverse weighing. While the pre-weighing area and hoppers are provided with local exhaust ventilation (LEV), SOPs did not include information on LEV operation.

Conclusion: Due to the presence of several identified ST1 dusts, as well as the use of large quantities of other fine, organic powders, combustible dust testing is recommended at this site. Areas where dust-generating procedures such as mixing and weighing occur, and areas with visible, layered dust accumulation due to historical operations should be prioritized. Additional recommendations include improved housekeeping procedures and clear guidance on LEV operations.

Quantifying Upper Body Postures with a Motion Sensing Garment

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Introduction: Upper extremity musculoskeletal disorders occur at high rates within the workplace [1]. There is a need for a non-optical, wearable option for evaluating and monitoring ergonomic posture in the workplace. A motion sensing garment (MSG, Analog Devices, Inc, Wilmington, MA) is a lightweight garment that is instrumented with seven inertial measurement units (IMUs). The MSG enables the quantification of torso, shoulder, and elbow angles, which can be used to inform an ergonomic assessment model such as the Rapid Upper Limb Assessment (RULA). Analyses are focused on a comparison of joint angles between systems with an overarching objective to quantify the reliability and accuracy of the MSG as an option for noninvasively quantifying hazardous postures in the workplace.

Methods: A subset of 6 participants was analyzed (5 male (1.84 m, 83.8 kg), 1 female (1.70 m, 61.2 kg)). The movement data were recorded simultaneously by the VICON motion capture system (VICON Nexus v2.41, Centennial, CO) and the IMUs in the MSG. Retroreflective markers were placed based on a modified Helen Hayes full body marker set. The VICON data were post-processed in Visual3D (C-Motion, Inc, Germantown, MD). The IMU data were processed using custom algorithms written in Python. The following movements were analyzed: elbow sagittal flexion, elbow transverse flexion, and shoulder external rotation. Analyses were conducted in Python using 1D Statistical Parametric Mapping (SPM). SPM evaluates waveform data over time by conducting a series of t-tests.

Results: The MSG shows significant differences in some primary planes of movement. However, the general shapes of the waveforms from the VICON data and the MSG match. Non-primary planes of movements can show inconsistent tracking between the two systems. Further investigation of the IMU data is needed to fully determine the capabilities of the MSG. Sources of error could be originating from the sensors themselves, time alignment of the data, calibration poses, or improper fit of the shirt. In processing IMU data, calibration poses were uniquely defined for each movement trial, whereas in the processing of the VICON data, a single calibration pose was used for all trials. Any variance in the calibration poses could contribute to error.

Conclusions: Non-optical, wearable technology like the MSG has the potential to accurately measure kinematics and identify hazardous ergonomic postures in the workplace. A wearable system like the MSG can help provide new knowledge about how posture, frequency, and duration of movements contribute to workplace musculoskeletal disorders. This technology would offer a non-optical and noninvasive solution for ergonomic monitoring in the workplace. Outside of occupational biomechanics, this wearable garment could also have an impact in rehabilitation, at-home physical therapy, and athletic training.

[1] US Bureau of Labor Statistics. (2019). *Occupational injuries and illnesses resulting in musculoskeletal disorders (MSDs)*.

Why Am I So Exhausted?: Exploring Meeting-To-Work Transition Time and Recovery From Virtual Meeting Fatigue

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Introduction: Meetings have increasingly become a key organizational tool for employees to exchange information, monitor progress, and strengthen social relationships. Ineffective meetings have been well-documented as presenting considerable direct (e.g., salary, benefits) and indirect costs (e.g., stress, employee burnout, opportunity losses). We explore the idea that people need meeting recovery, or time to transition from meetings to their next task. We also explore how relevance of a given meeting can impact the relationship between meeting outcomes and meeting recovery. Doing so may help reduce employee burnout.

Methods: We recruited participants using Amazon's Mechanical Turk (MTurk), an electronic survey platform, from April 15, 2020, to April 30, 2020. Participants were at least 18 years old, full-time employees within the United States, and attended more than one work meeting each week. A total of 496 participants responded. Participants whose last meeting was not virtual, who did not attend work-related meetings, or were not full-time employees were excluded (n = 300). The final sample was 195 participants. The survey responses of these individuals were used to determine the relationship between meeting outcomes (satisfaction and effectiveness) and meeting recovery.

Results: We found that meeting recovery and transition time were significantly related ($r = 0.38$, $p < 0.05$)

We found that meeting satisfaction was related to meeting recovery ($r = -0.38$, $p < 0.05$) but was not related to transition time ($r = -0.08$, $p > 0.05$). Meeting effectiveness was also related to meeting recovery ($r = -0.22$, $p < 0.05$) but not to transition time ($r = -0.05$, $p > 0.05$). In order to measure how meeting relevance impacted these relationships we performed a regression analysis to confirm the direct negative relationship ($\beta = -0.41$, $p < 0.05$) and then explored the interaction between meeting satisfaction and relevance. We found a significant interaction effect ($\beta = -0.17$, $p < 0.05$). The same process was done for meeting effectiveness and similar results were found in the regression analysis ($\beta = -0.39$, $p < 0.05$) and the interaction effect ($\beta = -0.22$, $p < 0.05$).

Conclusions: This study explores virtual meeting fatigue with a focus on meeting quality, and explores the need for recovery after workplace meetings. The findings confirm that virtual meetings may create fatigue that requires recovery. Creating recovery time may be an important practical process to incorporate when scheduling meetings. Future research should further explore the relationship between meeting recovery and other meeting outcomes.

Introduction to Total Worker Health® and U-POWER

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Introduction: Injuries, illnesses, and fatalities tabulated by the Bureau of Labor Statistics affirm that workplaces can have direct and often acute, adverse impacts on health. The vast majority of occupational health and safety efforts have approached work as a physical determinant of health, and sought to avoid or minimize exposure to hazards that physically determine health. Occupational health and safety professionals have, among many other efforts, assessed and controlled physical worksites and worker behaviors, diagnosed and treated injuries related to work, or researched patterns among injured, ill, and dead workers. This approach has led to tremendous reductions in pain and suffering among workers and their families over the decades, but it has failed to capture and prevent the true toll of work on health.

Work conditions that lead to adverse health outcomes are defined by social and political structures and ideologies and serve as a pathway through which these social structures determine health. That is, work is a social determinant of health. Working conditions are not limited to the conditions and characteristics of a worksite. The labor market, for example, defines work conditions related to employment relationships, work arrangements, norms for compensation and benefits, and also manifests social determinants of health that can lead to material deprivation, ill health and limited access to healthcare.

Methods: Total Worker Health® is a National Institute for Occupational Safety and Health (NIOSH) initiative to address the totality of factors that contribute to the safety, health, and well-being of workers, reflecting the role of work in the social determinants of health. Total Worker Health (TWH) is defined by NIOSH as policies, programs, and practices that integrate protection from work-related safety and health hazards with promotion of injury and illness prevention efforts to advance worker well-being. TWH prioritizes organizational approaches over individual behavior change and identifies issues relevant to advancing worker well-being across multiple domains: the physical and psychosocial characteristics of the workplace; employment terms, patterns, and organization; public policies regarding work, communities, and the social safety net; and workforce demographics.

Results: The Utah Center for Promotion of Work Equity Research (U-POWER), a NIOSH-funded Center of Excellence in TWH, seeks to advance TWH through innovative research and practice across the translational research spectrum and propel the TWH framework forward to interrogate the role of power in defining work conditions that must be modified to advance TWH and work equity. U-POWER considers that the inequity and persistence of work-related injuries, illnesses, and fatalities–the true burden of which remain unknown–motivates the need for transformational thinking about the root causes of work conditions that detract from or promote equity, health, and well-being.

Conclusions: Power is a theme that 1) examines the underlying structures and causes of unsafe and unhealthy work, and 2) studies, designs, and develops means to overcome the multifaceted barriers to safe and healthy work. Inequitable distributions of power manifest in work as myriad issues relevant to advancing TWH: exposure to hazards, heightened risks among groups of workers and industries, difficulties in creating cultures of safety and health, poor communication between workers and employees, unstable employment, and lack of adaptation of work to the needs and characteristics of workers. We posit that exploring the role of power in defining and sustaining conditions of work that influence health and well-being offers a transformative path towards identifying and modifying social and determinants of work and health.

Examining the Best Meeting Practices Across Modalities

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Introduction: Meetings are tools utilized by every industry to cultivate space for shared decision-making, problem-solving, and conflict resolution. Meeting satisfaction has been linked to work attitudes and overall job satisfaction. Meeting effectiveness and satisfaction are generally the largest contributors to a successful meeting. Challenges due to the novel coronavirus (COVID-19) pandemic brought modality to the forefront of study as most organizations had employees begin remote work. As the nature of the pandemic changed there was more shifting of where employees were working. With this shift came the expectation of employees to successfully conduct group meetings via different meeting modalities. The best practices for effective group meetings were summarized in a publication by Mroz and colleagues (2018). Most best meeting practices were studied pre-pandemic where the majority of meetings studied were face-to-face. Recent research suggests that as many as 90% of the best practices in meeting science captured from these face-to-face meetings still apply in the virtual environment. Although implementing all the best practices is proven to help improve meetings, many organizations are still looking for a quick fix. What is the best, most important meeting practice that can be implemented across modalities to improve meeting effectiveness and meeting satisfaction? Does the best meeting practice differ by modality? This study seeks to answer these questions by identifying differences across modalities and determining the meeting practices associated with higher meeting effectiveness and meeting satisfaction scores.

Methods: A quantitative survey was used to capture meeting perceptions of working adults via Amazon's Mechanical Turk (MTurk), an electronic survey platform, from May 26, 2021 to June 18, 2021. Participants were required to be 18 years of age, full-time employees within the United States, and have attended more than one work meeting each week. A total of 769 participants responded to the survey. Participants whose last meeting was over 30 days ago, had less than two individuals present or lasted less than five minutes were excluded (n=449). This sample was further grouped via meeting modality. The final sample included face-to-face (n=163), virtual (n=172), hybrid (n=32), and teleconference (n=40) for a total of 407 participants. Survey responses were used to determine if there were differences between group meeting processes and outcomes by modality. Descriptive statistics were calculated and a one-way ANOVA was used to compare the means of group meeting processes and outcomes including meeting satisfaction, meeting effectiveness, meeting voice, meeting relevance, meeting recovery, meeting participation, surface acting, counterproductive meeting behaviors, individual participation, entitativity, and pre-meeting talk. Further analyses will include assessing specific meeting characteristics, such as the use of an agenda or properly working technology, and comparing them to specific group meeting outcomes. These will be complete by the conference date. All analyses were performed using SAS 9.4.

Results: Initial analyses to assess differences in meeting processes and outcomes across modalities yielded statistically significant differences using the alpha value 0.05 in meeting recovery (f-value=7.46, $p<0.0001$), meeting participation (f-value=3.01, $p=0.03$), surface acting (f-value=5.76, $p=0.001$), and counterproductive meeting behaviors (f-value=4.8, $p=0.003$). This sample has uneven groups of participants which may warrant a larger alpha value. Other ANOVA results to note that are not below the alpha threshold of 0.05 but should be included in further analyses are meeting satisfaction (f-value=2.37, $p=0.07$), entitativity (f-value=2.17, $p=0.091$), and pre-meeting talk (f-value=2.61, $p=0.051$).

Conclusions: This study seeks to unearth which meeting practice contributes most to positive meeting outcomes that determine meeting success, satisfaction, and effectiveness. Initial analyses indicate that there are differences in outcomes and processes across meeting modalities. Statistically significant differences were found across meeting modalities in meeting recovery, meeting participation, surface acting, and counterproductive meeting behaviors. Deeper analyses will be performed by the conference date to determine which meeting practice is most beneficial for positive meeting outcomes.

Structured Creativity Techniques for Occupational Safety and Health

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Introduction: Innovation and creativity techniques have increasingly been deployed in non-entrepreneurial domains. However, concepts such as entrepreneurial mindset and structured thinking have great promise for generating occupational safety and health (OSH) solutions. Disruptive innovation typically comes from outside of a domain. In this case, the "disruption" may be the process itself. Creativity is a function of both education and experience. The greater the diversity of experiences and knowledge in a variety of domains, the greater the chance for breakthrough, novel solutions. OSH lends itself well to such innovation processes since it is interdisciplinary by nature and involves teamwork from diverse stakeholders such as ergonomists, occupational health nurses, industrial hygienists, safety engineers, occupational medicine physicians, and the workers themselves. Rarely does all of the necessary expertise and information reside in a single individual. In fact, multi-disciplinary OSH teams often represent an ideal collection of education, training, skills, and expertise to creatively generate and implement solutions. However, an OSH team's full capability is not always realized.

Methods: The authors have pooled their collective experience and education to explore creativity methodologies or "engineered creativity." This involves the application of structured engineering and innovation strategies to solving problems. The focus here is on OSH-related concerns. The authors have hosted workshops on innovation (e.g., "Innovation in Occupational Safety and Health" presented at Annual Utah Conference on Safety and Industrial Hygiene), created and taught a class focused on creativity (INSY 4970: "Engineered Creativity: Generating Innovative Solutions"), and have conducted an OSH-themed hackathon ("Build Plate Ergonomic Challenge").

Creative solutions require both domain expertise and unique perspectives. These perspectives come from one's collective experiences such as frequently practiced activities (e.g., weekly golfing) as well as from novel experiences, even if limited in scope and duration (e.g., taking a single cooking class, learning to juggle, trying a new sport, etc.).

An assortment of structured creativity techniques has been explored. Many of these approaches are intended to change the participants' perspectives and to explore the application and relaxation of constraints. Many of the traditional barriers to solving OSH problems can be mitigated using these techniques.

Results: The authors have hosted numerous OSH-themed workshops and creativity sessions in both academia and industry. Successes include: improving OSH continuing education course offerings and deployment, fabricating data collection devices by modifying unrelated equipment, inspiring collaborative research projects with other departments (i.e., Audiology, Communications, and Veterinary Medicine), generation of dissertation topics, and submission of safety themed invention disclosures.

The Engineered Creativity class has generated several OSH-related ideas that have been or will be submitted to Auburn University's Office of Innovation Advancement and Commercialization. These include, a device to improve the manual scanning of books and other media; an improved buckle for securing tie-down straps; and pallet designs that facilitate improved ergonomics.

An OSH-hackathon was organized for and sponsored by a local aerospace manufacturing firm. The company is currently prototyping several of the hackathon submissions to evaluate them for feasibility.

Conclusions: Approaches that have been demonstrated to be effective for generating and capturing novel business ideas can also be successfully applied in the safety domain. However, special consideration must be given to avoid unintended, negative consequences. For example, safety analyses, such as load testing/certifying lifting devices, must take place before a final solution is adopted. The ideas generated using creativity techniques can produce a greater number of potentially effective solutions, accelerate solution generation and adoption, and can, therefore, save valuable time and resources.

Certified Hand Therapists' Interactions with Occupational Safety and Health Professionals, and Their Roles in the Treatment and Prevention of Occupational Hand Injuries

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Introduction: Certified Hand Therapy is a subset of Occupational/ Physical therapy. Certified Hand Therapists (CHT) help those with hand injuries, including occupational injuries, rehabilitate to a point where they are independent, can perform daily life activities and/or return to work. The role of the CHT in workplace settings is not well understood. And, the role of the CHT in the prevention and treatment of work-related hand injuries is not well understood. This study aimed to discern the roles of the Certified Hand Therapists in rehabilitating individuals with upper extremity injuries, to assess their participation in work-related injury prevention, to examine with whom a CHT interacts with during the rehabilitation process, and to gain insight into how the relationships between CHT and occupational safety and health professionals can be improved.

Methods: Structured interviews were conducted with eight Certified Hand Therapists or occupational therapists who are in the process of being certified. Interviews were recorded, transcribed, and analyzed to delineate themes related to the study objectives.

Results: Content analyses demonstrated analogous answers among the participants related to trends in job roles, interactions with occupational safety and health professionals, the importance of patient education in the prevention and rehabilitation of injuries, and barriers to effective treatment of work-related hand injuries.

Conclusions: CHTs have similar thoughts about their profession. Responses revealed common themes across the eight interviews. Specifically, many CHT believe education is a vital part of the profession in terms of improving the profession itself and in the rehabilitation process. In addition, patient compliance and the current workers' compensation system were seen as challenges when rehabilitating patients.

Annual Dr. Paul S. Richards Endowed Distinguished Visiting Lectureship in Occupational Medicine

Product Safety: the Nuts, Bolts, and Screw-Ups

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Don Mays is Founder of Product Safety Insights LLC, a consulting enterprise that advises companies on product safety assurance. He has a rich background of experiences that included serving as Chief Safety and Quality Officer at Samsung North America, and Managing Director, Product Safety and Quality for Deloitte. For nearly 20 years, Don worked for Consumer Reports, most recently as its Senior Director, Product Safety and Technical Policy. He was also Vice President of Retail and Consumer Product Services at Intertek, as well as the Technical Director for the Good Housekeeping Institute. Don is currently Vice President of the Society of Product Safety Professionals, Chairman of ASTM Committee on Consumer Products, and a board member for Kids In Danger.

Classifying Hazardous Movements and Loads During Manual Materials Handling Using Accelerometers and Instrumented Insoles

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Introduction: The most common class of non-fatal work-related injuries regardless of industry is from overexertion. Many of these injuries are the result of manual materials handling (MMH). In recent years, work related musculoskeletal disorders (WMSDs) have accounted for 40-50% of all days away from work (DAFW) cases in professions involving frequent physical handling. To decrease WMSD and injury risk, several ergonomic assessment tools and methods such as the Revised NIOSH Lifting Equation (RNLE) have been developed to characterize exposures using posture, frequency, load level, duration, and other factors. These factors are collected using observational methods or direct measurements such as motion capture, inertial measurement units (IMUs) or instrumented insoles. IMUs and motion capture methods can determine posture and frequency factors, but are unable to provide load level information. Pressure-sensitive insoles are able to directly provide load level information, but are unable to easily categorize postures. The goal of this study was to develop a machine learning classifier to detect MMH activities based on measurements from instrumented insoles and a single chest-mounted accelerometer. The algorithm would be able to determine important exposure parameters used to generate a real-time risk score with the RNLE.

Methods: Six young adult males with no history of musculoskeletal disorders or back pain participated in the research. Participants were instructed to perform lifting and lowering activities in 6 different postures with varying risk (stoop, squat, extended, jerky, side asymmetrical, and side shoulder) and 2 different weights in addition to pushing, pulling, and carrying. Approximate risk values were computed using the RNLE for the different postures to determine optimal load levels for testing. Loads were chosen so that for all lifting activities the lighter (5.7kg) had a safe risk value and the heavier (12.5kg) had an unsafe risk value. Test data was collected at 50 Hz using an IMU on the chest (Delsys Trigno wireless accelerometer, Delsys Inc., Natick, MA), and a pair of instrumented insoles with pressure sensors and a tri-axial accelerometer (Science Pro+, zFLO Motion, Westbrook, ME; produced by Moticon GmbH, Germany). This gave a total of 16 dependent variables: 9 accelerations, 3 forces (left, right, combined), and 4 center of pressure (COP) displacements. 6 features (average, standard deviation, maximum, minimum, range, and kurtosis) were extracted from the data for machine learning using a sliding window of 2 seconds with 95% overlap. 10% of this data was put aside as an independent test set.

Results: Five initial multi-class classifiers were chosen for initial analysis: k nearest neighbours (KNN), support vector machine (SVM), bagged decision trees (BT), Naive-Bayes (NB), and single decision tree (ST). SVM performed best with 85.3% accuracy on test set when using all variables from shoe and chest sensors, with a ~4% drop in accuracy without chest sensors. Accelerations were found to be best at predicting differences in activities, while ground reaction forces (GRF) were found to be best at predicting differences in load level. COP performed the worst out of all signals. Activity frequency was determined using a secondary calculation. After making predictions on time series test data, a sliding window of 1 minute was used to count the per-minute occurrences of each activity. Squatting (5.7, 12.5 kg) and stooping (12.5kg) lifts reached the appropriate peak value, while stooping (5.7kg), extended (5.7, 12.5kg), and jerky (5.7kg) lifts reached 95%, 64%, 75%, and 88% of their true values, respectively. RNLE load index was computed over time using these frequency values with constants based on the detected activity.

Conclusions: We tested a method for ergonomic risk estimation using instrumented insoles and a chest mounted accelerometer. Best performing classifier was SVM with 85.3% accuracy. A negligible (<2%) rise in classification accuracy was found when loads were not distinguished, and a slightly larger drop (~4%) was observed when not using a chest sensor. Predictor combinations including accelerations and GRF performed better on activity and load distinction respectively. Activity frequencies were continuously computed to calculate the RNLE Load Index, a single variable of risk quantification. The proposed system enables direct measurements for real-time risk estimation. This research enables collection of detailed information about the workers' actual exposure to advance our understanding of WMSDs, and will help develop preventative strategies.

Assessment of Manhole Removal and Placement Using Inertial Motion Capture

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Introduction: Utility hole maintenance is essential to ensure that underground pipelines and other systems are in good condition. The utility hole is covered with a manhole cover to prevent people, animals, and objects from entering or falling into the workspace. There are approximately 270,000 manhole covers in New York City. Workers in charge of manhole inspection open and reclose anywhere from dozens to over a hundred manholes a day, lifting manhole covers that weigh on average 85 kg (188 lbs). These jobs are intended to be carried out by teams of two workers; due to time constraints and other external factors, workers sometimes perform the lifting task alone. A substantial lifting force is required to remove/replace manhole covers from their closed position, which can be made even more difficult depending on the weight of vehicles that pass over them and the existence of particulates such as dirt, debris, dust, and paving material of the road. Because mechanical loading of the spine has been identified as an important risk factor for low-back pain, our goal is to understand the forces and moments involved. This study aimed to estimate 3D L5/S1 moments and compressive forces at L5 disc level, occurring when workers removed and replaced manhole utility covers on the streets of New York City. The kinematic data necessary for the kinetic estimates were obtained using a wearable inertial motion capture (IMC) system.

Methods: Data collection was completed during two field visits to New York City locations, one in The Bronx and one in Queens. Two types of manhole covers were evaluated, circular and squared. A total of three male workers volunteered as participants for the data collection (mean height = 185.67 cm ± 10.26 SD; mean body mass = 101.67 kg ± 20.53 kg SD). The equipment used for the motion capture was the MVN Awinda System, from Xsens technologies©, which consists of a number of sensors fitted to the subject. Each Inertial Measurement Unit (IMU) sensor is a small wireless, battery-powered unit that measures and stores acceleration, angular velocity, and magnetic field information. Cameras were also used to record video of the tasks performed. Subjects were fitted with 17 IMU sensors, which were secured using elastic neoprene straps and hypoallergenic athletic tape. The workers removed and replaced the maintenance hole covers using the tools they usually use (hooks) and their preferred technique (which varied between workers). Depending on the staffing availability at the sites visited, one or two workers performed the task. Biomechanical models using a Top-Down approach were used to obtain the kinetic estimates.

Results: The initial exertions for both removing and replacing the manhole covers represented both the peak moments and forces for all of the workers, whether it was a single worker or two workers performing the task. These initial exertions involved significant torso flexion for all workers in all cases. Results are shown in Table 1.

Table 1. Manhole cover operation forces and moments.

	Removing the cover			Putting the cover back		
	Peak Compressive Force (N):	Peak Shear Force (N):	Peak moment (Nm)	Peak Compressive (N):	Peak Shear Force (N):	Peak moment (Nm)
S02 Solo	2,398	679	358.96	2,479	821	195.36
S02 Team	1,229	374.2	392.15	1,546	504.3	199.11
S03 Solo	3,050	951.7	207.88	3,287	722.4	203.77
S04 Solo	2154	774.6	315.41	2,545	835.3	346.4

Conclusions: IMU sensor technology can work well to capture data in the field for the evaluation of these types of jobs Substantial forces were observed at L5/S1 level; if we consider the NIOSH limits for compressive (3,400 N) and shear (1,000 N) loading, these tasks could put workers at risk. In addition, peak moments beyond 300 Nm were observed in some cases. Considering that utility workers often perform these tasks many times per day, the risk of developing musculoskeletal disorders could be significant and needs to be further investigated with a larger sample size and all types of covers.

Prediction of Fit and Support Settings for ShoulderX Passive Exoskeleton

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Introduction: Occupational, passive exoskeletons can augment the physical capacity of workers and may reduce the risk of work-related musculoskeletal disorders, but proper fit and support levels are important for usability. A recent survey of construction workers identified fitting an exoskeleton as a potential barrier to use. The purpose of this study was to predict the fit settings and support level settings for a passive arm-support exoskeleton (ASE) based solely on a user's' height, weight, and sex.

Methods: This study compared predicted to correct exoskeleton settings for both fit and support level. Eligible subjects were 18 years of age or older and chosen based on a sample of convenience. The height, weight, and sex of each subject were inputs to a set of equations predicting fit settings and support level settings. The ANSUR II database, which includes measured body dimensions of over 6,000 males and females, was used to derive sex specific coefficients to predict four body segments (bideltoid breadth, shoulder to elbow length, cervicale height, and iliocristale height) as a percentage of stature. Next, a function was derived that mapped the four predicted sex specific body segments to exoskeleton specific settings. Additionally, an equation was derived to calculate 100% support level defined as the amount of force required to completely support the arms while the elbows and shoulders are in 90º of flexion. This process was repeated for three different ASEs including the Paexo Shoulder (Ottobock, Duderstadt, Germany), EVO (Ekso Bionics, Richmond, CA, USA) and Shoulder X Version 3, SuitX, Emeryville, CA, USA; the results of one ASE is presented below.

ShoulderX Exoskeleton Settings:

- $Shoulder\ Breadth\ Setting = function\ ((m/f)Bideltoid\ breadth\ coefficient * Stature)$
- $Arm\ Length\ Setting = function(0.7 * (m/f)ShouldertoElbow\ coefficient * Stature)$
- $Torso\ Ht.Setting = function(\ ((m/f)CervicaleHeight\ coefficient - (m/f)IliocristaleHeight\ coefficient) * Stature + 2)$

Where 'function' is an equation that maps the body segment dimension of an individual predicted by their height and sex (m/f)) to an exoskeleton setting

"Correct" fit settings meant that fit guidelines were met without any further adjustments having to be made. "Correct" load settings meant that the arm was fully supported and "floated" with elbows and shoulders in 90º of flexion; if the arm dropped or elevated overhead, the load setting was classified as incorrect. Overall, three fit settings and one support level were predicted per participant.

Results: Nine subjects participated; three females and six males. For females, the average weight (SD) was 65.7kg (10.4) and the average height was 164.5cm (5.4). For males, the average weight was 83.2kg (16.18) and the average height was 179.9 cm (13.77). For each participant, 3 fit settings and 1 support level setting were predicted. Of the 27 predicted fit settings (3 fit settings x 9 participants), 9 were incorrect including seven arm length predictions. Of the 9 support levels predicted, only one prediction required modification. Across all exoskeletons in the study, the success of predictions was 83% for force predictions and 85% for fit predictions.

Conclusions: The goal of this study was to evaluate an anthropometry-based model to predict fit and support settings of an arm support exoskeleton to facilitate proper fit, thereby improving usability. The preliminary data demonstrate that the model can predict force level and fit settings well, but also show that some model refinements are required. If successful, this approach can be used in guidelines designed to improve proper fit and support for an individual based on their height, weight, and sex without an exoskeleton expert present.

Manual Material Handling in Confined Spaces Using a Wearable Lift-Assist Device

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Introduction: Low back pain (LBP) is a prevalent injury, costing companies more than $100 billion annually [1]. A population vulnerable to these injuries are airport baggage handlers due to the nature of frequent heavy lifting, especially in awkward postures in the cargo bin. One study reported that up to 70% of airport baggage handlers experience LBP [2]. A survey reported that 70% of baggage handlers feel that the cargo bin is the most likely place they would get injured [3]. With the prevalence of LBP, this study aims to assess the potential for an anterior-mounted passive back-exoskeleton (SpringZBack) and an elastic squat belt used primarily for athletics (Suresquat) to be used by baggage handlers in the cargo bin.

Methods: 2 participants were recruited among the campus community. Participants were required to be between the ages of 18 and 45, no history of LBP, and are male. These two participants were categorized as "moderate" and "high" fitness levels according to the IPAQ-7. Motion capture (Motive) and surface electromyography (sEMG) (Delsys) systems were used to collect data for trunk kinematics and muscle activity in the erector spinae and external obliques respectively. Participants were given the opportunity to become familiar with the lifting devices prior to the lifting trials. The exoskeleton and belt were fitted to the participant by the same researcher for consistency of device support between groups. Maximum voluntary contractions were taken before the trials for normalization of sEMG data. Participants performed a total of 18 lifts: 2 consecutive lifts of a 20lb. and 40lb. luggage in three postures (crouched, crawling, and kneeling) with three conditions (exoskeleton, belt, control). After completing a series of lifts for a condition, the System Usability Scale (SUS) was administered to assess user perception of usability and comfort. This survey utilized a Likert scale from 1 to 5 and gives a rated score on a scale of 0 to 100. Participants were free to make any other comments about the lifting devices and the task. Data were processed in MATLAB for sEMG and Motive for motion capture.

Results: EMG data reveals reduced back muscle activity with the exoskeleton compared to the belt and control groups across most postures. There were also slight reductions in trunk muscle activity across most trials while wearing the exoskeleton, but the crouching posture shows slight increases in trunk muscle activity for both participants. The belt did not show significant changes in back nor trunk muscle activity compared to the control group. The devices seemed to have a slightly larger impact on the subject classified at a "moderate" fitness level compared to the subject classified at a "high" fitness level. Motion capture data shows a more upright torso is needed to complete tasks while wearing the exoskeleton compared to other groups, especially in the crouched posture. The SUS scores are rated on a scale of 0 to100. The mean and standard deviation for the exoskeleton is 45 ± 14.122, control 78.75 ± 15.91, and belt 80 ± 14.142. Both participants noted the belt's straps around the knees caused slight discomfort. One noted the exoskeleton felt restrictive in general, whereas the other noted it only felt restrictive in the crouched posture.

Conclusions: The survey results show that the participants do not like the exoskeleton for this task compared to the other two conditions, even though the exoskeleton helps reduce back muscle activity. Even if it is effective, the discomfort makes this exoskeleton incompatible for this task according to the data reported thus far. The belt did not make meaningful differences to muscle activity nor kinematics; therefore, this device will likely not be useful in a baggage handling setting in the cargo bin. Overall, the exoskeleton was mostly effective in reducing back muscle activity, but it had the most impact on kinematics of the trunk. Data collection is ongoing as more participants are being recruited at this time. Formal statistical analyses and data for 5 participants are expected by the time this conference takes place.

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Quantifying Workload in Active-Duty Firefighters

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Introduction: Firefighting is a strenuous occupation with a high risk for injuries. Firefighters (FF) are at the greatest risk for injury on the fireground where tasks elicit maximal physiological responses. Among sport-athlete populations, task workload has been linked to injury risks, however, defining workload within the fire service is relatively elusive due to the unpredictable nature of emergency calls and shifts. The current commonly used metric to quantify FF workload is total call volume within a 24-hour shift. However, FFs respond to different call types (i.e., medical, fire rescue) that are known to elicit different physiological demands and this call-to-call variation in workload is not reflected in total call volume alone. To better understand on-duty injury risks and quantify the workload of specific tasks, a heart rate derived measure of load termed Edward's training impulse (eTRIMP) has recently been used to quantify the workload of simulated job-demands in FFs. Specifically, eTRIMP is quantified by summing the duration of time in five heart-rate intensity zones and multiplying the time by a zone-specific weighting factor to determine task workload. One current test utilized by the fire service to identify readiness to meet maximal physiological demands on the fireground is a maximal graded treadmill test. However, it remains unknown if the workload of a lab-based maximal treadmill test is indicative of the expected field-based fire suppression workload. Therefore, the purpose of this study was to compare the workload of a maximal lab-based test and a field-based controlled fire task.

Methods: 15 (13 male, 2 female) career FFs (34.40 ± 7.38 yrs, 179.49 ± 6.20 cm, 91.76 ± 17.24 kg) from a midwestern metropolitan fire department volunteered for this study. At the first session, the FFs completed a maximal graded treadmill test (TREAD). At the second session, the FFs completed a fire suppression activity (BURN) while donning personal protective ensembles and breathing from a self-contained breathing apparatus. In crews of three, the BURN required participants to breach a ground-level door to a burn tower, advance hose to a fire set on the 3rd floor of the tower, suppress the fire, complete a victim search of the area, and retreat from the tower. During TREAD and BURN, participants donned a physiological strap that continuously recorded heart rate (HR). Post-hoc, the percent of the total task time (%ZONE) spent in 50-59% ($\%ZONE_{50}$) maximal HR (HR_{MAX}), 60-69%HRmax ($\%ZONE_{60}$), 70-79%HRmax ($\%ZONE_{70}$), 80-89%HRmax ($\%ZONE_{80}$), and ≥90%HRmax ($\%ZONE_{90+}$) zones were quantified and internal load was calculated as eTRIMP (AU) for TREAD ($eTRIMP_{TREAD}$) and BURN ($eTRIMP_{BURN}$). A paired *t*-test examined for differences between $eTRIMP_{TREAD}$ and $eTRIMP_{BURN}$ and a bivariate Pearson correlation examined for relationships between both measures. A 2 x 5 (TEST x %ZONE) within-subjects repeated-measures analysis of variance (RM ANOVA) with Bonferroni adjustments examined for differences in the %ZONEs for both tests. An alpha of $p < 0.05$ determined statistical significance.

Results: $eTRIMP_{TREAD}$ (35.87 ± 6.17 AU) was significantly ($t = -4.885$, $p < 0.001$) less than $eTRIMP_{BURN}$ (49.13 ± 9.64 AU) and the measures were non-significantly related ($r = 0.172$, $p = 0.540$). A Greenhouse-Geisser correction was applied to the 2 x 5 (TEST x %ZONE) RM ANOVA and demonstrated a significant interaction ($F_{4,1.711} = 12.189$, $p < 0.001$). Follow-up simple effects for TEST indicated significant ($p < 0.001$) differences for $\%ZONE_{50}$ (TREAD [17.19 ± 11.0%] > BURN [00.00 ± 0.0%]), $\%ZONE_{60}$ (TREAD [15.75 ± 8.53%] > BURN [2.02 ± 6.21%]), and $\%ZONE_{90+}$ (TREAD [28.28 ± 8.63%] < BURN [61.90 ± 33.44%]). For TREAD, $\%ZONE_{60}$ ($p = 0.003$) and $\%ZONE_{70}$ ($p = 0.012$) were significantly less than $\%ZONE_{90+}$. For BURN, $\%ZONE_{50}$ was significantly less than $\%ZONE_{80}$ ($p = 0.003$) and $\%ZONE_{90+}$ ($p < 0.001$), $\%ZONE_{60}$ was significantly less than $\%ZONE_{80}$ ($p = 0.012$) and $\%ZONE_{90+}$ ($p < 0.001$), and $\%ZONE_{70}$ was significantly less than $\%ZONE_{90+}$ ($p = 0.011$).

Conclusions: The workload of a maximal treadmill test is less than, and unrelated to, simulated fire suppression task workload. Further, FFs spend a significantly more time ≥90%HRmax than ≤79%HRmax for a fire suppression task. Additionally, in comparison to a lab-based maximal treadmill test, a fire suppression task elicits significantly less time ≤69%HRmax and greater time ≥90%HRmax. As such, it is possible that a lab-based treadmill test may indicate firefighter fitness, but does not elicit a workload similar to a field-based burn task nor indicate the expected load of a controlled burn. Therefore, a maximal lab-based treadmill test may not be representative of readiness for duty or identify individuals at risk for job-related injuries.