23rd Annual

UTAH NORA SYMPOSIUM

April 17-18, 2025

UTAH
NORA SYMPOSIUM
2025

ROCKY MOUNTAIN CENTER
for OCCUPATIONAL AND ENVIRONMENTAL HEALTH

Welcome Address

We are delighted by your attendance this year at our Annual NORA Young and New Investigators Symposium. This year commemorates our 23rd 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.

Contents

Day 1: Thursday, April 17 – Morning Session

Poster Session

Thursday, April 17 – Afternoon Session

Social Event – Come and go as you please – Food, drinks and good company
   18:00 to 20:00, Level 2 Deck (or garden level if inclement weather)

Day 2: Friday, April 18

8:00 – 8:30: Continental Breakfast

12:30 – 13:30: Lunch and Conclusion

Lunch, conference discussion, wrap up, and presentation of the BLOHSWEIC Prize awards.

Keynote Speaker

Eric Lutz, PhD

Eric Lutz, PhD, CMSP, BSC, IHS is an Airman, entrepreneur, and Professor of Practice at the School of Mining and Mineral Resources at the University of Arizona. Dr. Lutz is a co-founder and serves as the national lead of occupational health and safety for the consultancy Custos Fratris, L3C. He is also a Major in the US Air Force, Arizona Air National Guard as a Public Health Officer, International Health Specialist and innovation educator with ARCWERX.

In these roles, Eric leads world-class service, research, and training across the military, public health, and mining community in innovation, occupational health, safety, regulatory compliance, and mine emergency prevention, response, and recovery. Dr. Lutz has over 30 years of industry experience mitigating infectious disease risk, occupational exposures, and emergencies as an industrial hygienist, safety and health professional, global and community health expert, emergency responder, and leadership trainer.

He conducts occupational and population health and safety research, and partners with mines to solve complex health and safety challenges across all commodity sectors throughout the world. Dr. Lutz is the former NIOSH Mining Spokane Division Director and also served as the Associate Director of the University of Arizona School of Mining and Mineral Resources.

Impact of Assistive Hip Exoskeleton on Muscle Effort in Squat Lifting Task

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Introduction: Musculoskeletal disorders resulting from overexertion during lifting tasks made up almost a third of occupational injury and illness cases in 2015, leading to a median of eight workdays missed per case [1]. Both active and passive wearable back support exoskeletons have been shown to reduce exertion of the back muscles in common lifting tasks [2]. Several exoskeletons for assistance in occupation-related lifting tasks are on the market. These devices aim to reduce strain on the lower back during lifting tasks and reduce workplace injuries [3]. Passive exoskeletons are limited in that the assistive torque provided is solely a function of the deformation of their springs, which offers less flexibility and control compared to active exoskeletons. Active exoskeletons can employ dynamic control schemes, allowing for varying levels of support depending on the situation. This study investigates the efficacy of an active exoskeleton with a control scheme intended to mimic that of a passive device.

Fig. 1 An Image of a user wearing the exoskeleton device while lifting a box

Methods: A SuitX Paexo passive back support exoskeleton was retrofitted wit h active hip exoskeleton actuators [5] which were controlled using a simple virtual spring to mimic the torque response of a passive exoskeleton. The subject was asked to lift a 10kg. box from the ground until the subject reached an upright position. The maximum assistive torque offered by the exoskeleton was set to be 15% of the expected peak torque exerted during the lift, which was 75 Nm [4]. Delsys EMG sensors were placed on the subject's vastus lateralis and multifidus lumborum. After collection, the data was segmented into the lifting and lowering phases of each rep, the EMG signal was bandpass filtered, an envelope was fit to the signal, and the peak EMG reading was used as a measure of maximum muscular effort.

Results: This study showed that the exoskeleton's assistance reduced peak multifidus activation by 19% in the lowering phase and 13% in the lifting phase. While a 7% reduction in peak Vastus Lateralis activation was seen with exoskeleton assistance in the lowering phase, there was also a 7% increase in peak activation during the lifting phase.

Fig. 2 A bar plot showing change in average peak muscle activation of the vastus lateralis (blue) and multifidus lumborum (orange) during the lifting (left) and lowering (right) phases of a squat lift.

Conclusion: This case study evaluated the influence of a passive-like active exoskeleton on muscular effort exerted by the user during squat lifting. Results showed a reduction across the entire lift in peak multifidus activation, but the effect on vastus lateralis activation was unclear. While peak vastus lateralis activation potentially reduces during the lowering phase, it may increase during the lifting phase, highlighting the need for a more nuanced control scheme to ensure the exoskeleton never works against the user. Future studies should increase the sample size to improve statistical significance and ensure generalizability. Future work should also leverage the active nature of the exoskeleton by investigating the effect of varying levels of support between the lifting and lowering phases of the movement.

References: [1] Bureau of Labor Statistics, U.S. Department of Labor, Nonfatal Occupational Injuries and Illnesses Requiring Days Away From Work, 2015; [2] Walter T et al. (2023) Front. Bioeng. Biotechnol. 11:1143926; [3] Reimeir B et al. Wearable Technol. 2023 Apr 19;4:e12; [4] Hwang S et al. BMC Musculoskelet Disord. 2009 Feb 2;10:15; [5] Ishmael, M.K et al. IEEE/ASME Transactions on Mechatronics, vol. 27, no. 6, pp. 4561-4572, Dec. 2022

An Exploration on Heterologous/Homologous Boosters and COVID-19 Using the BEEHIVE Study Population

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Introduction: Multiple, diverse vaccine platforms were developed against the SARS-CoV-2 virus, allowing researchers to analyze the effectiveness and drawbacks of various vaccine types. One topic we have especially been interested in is heterologous and homologous boosting. Recent studies using mRNA and adenovirus vector vaccines have shown that a heterologous booster may offer an immunological advantage over a homologous one by increasing serum levels of IgG and CD8+ T cells, leading to a more robust immune response against COVID-19 (Atmar et al., 2022; Orlandi et al., 2023). As such, there is a need to research the potential protective benefits of various primer and booster vaccine combinations. Our primary objective is to compare the COVID-19 frequency of a protein subunit heterologous booster (Novavax's 2023-2024 updated COVID-19 vaccine) to a homologous mRNA booster (Pfizer's 2023-2024 updated COVID-19 vaccine) using the BEEHIVE study population.

Methods: A total of 1176 participants enrolled in the BEEHIVE study and the surveillance period ran from August 2023 to November 2024. In this double-blinded study, 898 participants chose to be vaccinated, and were randomized to receive either the Novavax or Pfizer booster (n = 444 and n = 454 respectively). The remaining 278 participants opted for no booster shot and served as the study's non-randomized control group. Participants self-administered weekly OSANG Healthcare COVID-19 Rapid Antigen Self-Tests (RAT) for 24 weeks regardless of symptoms. If the result was positive, or the participant had COVID-like symptoms, additional tests were administered for confirmation. Each participant's COVID vaccination history was then extracted along with additional exclusion criteria. After further filtering, a total of 975 participants were kept (375 for Novavax, 369 for Pfizer, and 231 for the control). COVID RAT results were then categorized by the participant's booster type: heterologous (mRNA primer + Novavax booster), homologous (mRNA primer + mRNA booster) or unvaccinated. Additional subgroup analysis was based on the number of vaccinations a participant received prior to study enrollment (2, 3, 4, or ≥5 doses). Statistical analyses included chi-squared tests and odds ratios; all confidence intervals were set to 95%.

Results: When comparing the pooled boosted vs un-boosted groups, the odds ratio of a positive RAT was 0.549 (95% CI, [0.363, 0.838]). After categorizing by booster type, the odds ratio of a positive RAT for the heterologous booster vs un-boosted group was 0.624 (95% CI, [0.389, 1.002]) and for the homologous booster vs un-boosted group was 0.474 (95% CI, [0.287, 0.781]). After stratifying the boosted group by the number of vaccinations received before BEEHIVE, odds ratios for heterologous vs homologous boosters showed a statistically significant difference for RAT positivity in the three-dose group only: 2.985 (95% CI, [1.190, 8.215]).

Discussion: Receiving a vaccination in general was associated with lower odds of testing positive for COVID-19. However, the analysis comparing heterologous vs homologous booster vaccine schedules found no significant difference in RAT COVID-19 positivity except in the group receiving 3 mRNA doses prior to enrollment. Thus, the results of our analysis remain largely inconclusive as we were unable to reject the null hypothesis for the rest of the dosage groups. It is possible our study was underpowered to detect a significant difference in this subgroup analysis, though our overall findings are consistent with a recent study that showed booster type had little to no difference on COVID-19 prevalence at a population level (Asante et al., 2024). Additionally, hybrid immunity could be a potential confounder, as it was statistically associated with RAT COVID-19 positivity (chi-squared test p-value: 0.044), and further research investigating this relationship is needed. Future studies could also look at the impact of booster type on special patient populations, adverse events or hospitalization rates.

A Comparison of Sampling Strategies to Accurately Quantify the Duration and Frequency of Hand Exertions

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Introduction: Approximately 2 million U.S. food and beverage processing plant workers face increased risks of musculoskeletal disorders (MSDs) from repetitive hand movements. Accurate measurements of the duration of hand exertions (duty cycle) and the frequency of hand exertions (repetition rate) are essential for estimating MSD risk. This research explored the minimal necessary sample of video to accurately quantify duty cycle and frequency.

Methods: Twenty-five videos, each video corresponding to an individual worker, ranging from 10-15 minutes were collected at 30 frames per second. Five minutes of each video were analyzed using Multimedia Video Task Analysis (MVTA), a software that allows the categorization of each frame to determine an accurate repetition rate and duty cycle. The five workers performing five distinct jobs fell into four different pace-related categories: line position (n=5) (pace dependent on worker position on line), line pace (n=10) (pace dependent on assembly line speed), partially routinized pace (n=5) (pace partially dependent on assembly line speed), and quality-driven pace (n=5) (pace dependent on worker). The repetition rate and duty cycle were calculated for each minute of the five minutes of video and for, 3-, and 5-minute samples of the video. The intrasubject coefficient of variation (CV) was calculated between each minute for every individual subject. The intersubject CV was calculated for all the aforementioned time intervals to understand how the repetition rate and duty cycle varied across workers doing the same job. A CV <0.2 indicated low dispersion, while CV >0.5 indicated high dispersion.

Results: The line paced jobs had CVs <0.2 for both intrasubject CVs and intersubject CVs, indicating that 1-minute intervals and five subjects were an adequate sample. The partially routinized and quality driven paced jobs had intrasubject CVs <0.2, suggesting one minute of analysis was likely sufficient, but intersubject CVs were >0.2 but <0.5, indicating that more than five subjects may be needed. The line position paced job had intrasubject and intersubject CVs >0.2 but <0.5, suggesting that longer intervals *and* more subjects may be needed in the sample.

Conclusions: Job pace characteristics affected measurement dispersion. One minute of analysis from at least 5 workers was generally adequate for most jobs indicated by no CV higher than 0.5. Line-paced jobs generally had lower CVs, indicating more uniform task execution. However, jobs with moderate intersubject CVs may need more workers to increase the accuracy of measurements.

A Comparison of Ankle Joint Kinematics via Optical Motion Capture and Biplane Fluoroscopy

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Introduction: For optical motion capture-based studies, the gold standard of marker placement is directly over anatomical landmarks on the skin. However, tracking the motion of the foot for the evaluation of footwear and their potential impacts on performance poses challenges when using this approach. Unless a worker is performing their duties barefooted, optical markers must be placed on shoes with the assumption that foot motion inside the shoe is effectively captured by the motion of the shoe itself. However, recent advancements in X-ray video imaging (e.g., biplane fluoroscopy) now enable a more comprehensive collection of foot biomechanics. Thus, to contrast traditional motion capture with more advanced imaging, this study compared foot kinematics from metallic beads situated upon anatomical landmarks and optical motion capture markers placed on shoes. We hypothesize that differences in ankle joint angles will be observed between marker- and bead-based results due to increased fidelity in capturing foot motion.

Methods: Three healthy adults completed three walking trials along a raised walkway with and without standardized shoes (New Balance 880). Metallic beads were placed on the skin surface of foot and shank anatomical landmarks. In barefooted trials, corresponding optical motion capture markers were placed atop the beads. Marker placement was based on the Milwaukee Foot Model. During shod trials, optical motion capture markers were placed on the shoe surface over landmarks that were palpated through the shoes. Simultaneous biplane fluoroscopy data were collected during the stance phase of the dominant foot.

Three-dimensional bead and optical motion capture marker data were processed via DSX and Vicon Nexus 2, respectively. Data were filtered with a 6Hz Butterworth filter and synched using custom MATLAB scripts. Ankle joint angles were defined as the angle of the calcaneus relative to the shank, and two separate models were created with a marker-defined shank and marker-based or bead-based foot. Due to limitations in capture volume size, bead location time-series were cropped such that a consistent range of stance (heel strike to end of single-limb support) could be reconstructed and compared. Statistical parametric mapping was used to compare time-series angle data from the two models using independent t-tests ($\alpha = 0.05$).

Results: No statistically significant differences were observed between optical marker- and metallic bead-derived ankle joint angles about any of the three axes in shod (Figure 1) or barefoot conditions.

Conclusions: A lack of statistically significant differences between ankle joint definition methods may suggest that on-shoe optical motion capture markers can reasonably approximate in-shoe calcaneus-shank kinematics. However, a greater sample size and the incorporation of multi-segment foot models will better conceptualize the capacity of optical motion capture marker placement to approximate in-shoe kinematics. Moreover, future work will include additional footwear types representative of different occupational populations (e.g., combat boots or composite-toe work shoes).
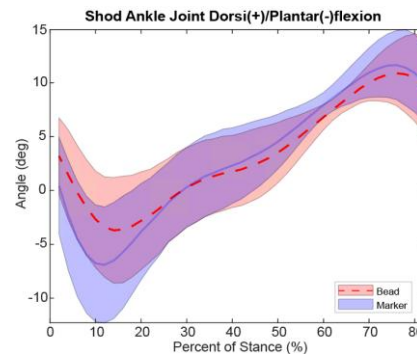
Figure 1. Shod ankle joint kinematics over percent of stance phase from bead and optical marker data.

The Relationship of Demographics to Adverse Events Following Immunization within the Utah BEEHIVE Study Population

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Introduction: Misinformation surrounding COVID-19 vaccines has contributed to public skepticism, particularly regarding vaccine safety and potential adverse effects.[2] Anti-vaccine narratives have lowered vaccination intent among those susceptible to such messaging.[2] Concerns about Adverse Events Following Immunization (AEFI) may be a key factor in this hesitancy. Understanding how AEFI relates to demographic factors such as sex, race, and ethnicity is essential for addressing public concerns, improving vaccine confidence, and informing public health strategies. To increase knowledge related to AEFI of COVID-19 vaccines, we aimed to determine whether there is a relationship between AEFI, and the demographic factors using data collected in the BEEHIVE study.

Methods: Data used was collected in the BEEHIVE study: A randomized, double-blind vaccine efficacy study. Participants were recruited from the Greater Salt Lake City area from Nov 2023 to Mar 2024. Vaccinated participants were randomized 1:1 into either the Novavax (protein subunit) or the Pfizer (mRNA) booster groups Participants completed an online enrolment survey, and an in-person vaccination visit. Booster recipients were monitored for adverse events, completing post-vaccination surveys (PVS) on Days 1, 2, and 7. For our analysis, boosted participants who finished 2 PVS (n=868) and were not withdrawn were considered. PVS answers were categorized to symptom/no-symptom groups and answers were sorted into demographic and vaccination type categories. Each group's percentage answer to each symptom was determined by normalizing the number of each response by the group size. Additional analysis was performed on symptoms shown to have a p-value less than 0.05 determined by a hypothesis z-test between group and non-group responses. Odds ratios and confidence intervals were determined for these cases by comparing the answers of respondents categorized into that group against the respondents categorized in all other groups.

Results: In the vaccine comparison, the difference between the Novavax (n = 432) and Pfizer (n = 435) vaccines was significant for all symptoms except for nausea. In the race and ethnicity categories, white respondents (n = 783) showed significant difference from non-white groups for injection site swelling (p = 0.002) and muscle pain (p = 0.044). Hispanic respondents (n = 98) showed significant difference from non-Hispanic groups for muscle pain (p =0.01). In the sex assigned at birth comparison, the difference in symptoms between male (n = 390) and female (n = 477) was significant for injection site swelling (p = 0.00008), fatigue (p = 0.04), and nausea (p = 0.003). See figures A – B and G – J. Odds ratios and confidence intervals for significant symptoms determined the following: each symptom recorded except for nausea was more likely to occur in participants who received the Pfizer vaccine, Female respondents were more likely to experience injection site pain, injection site swelling, fatigue, and nausea, Hispanic respondents were more likely to experience muscle pain than non-Hispanic participants and white respondents were less likely to experience muscle pain and injection site swelling than other groups. See figures C – F.

Conclusions: Within the BEEHIVE study population, AEFI was shown to be affected by race, ethnicity, sex assigned at birth, and vaccine type. The sweeping differences in AEFI likelihood shown between the Novavax (protein subunit) and Pfizer (mRNA) vaccines suggest that AEFI is less commonly experienced by individuals who receive the Novavax vaccine compared with the Pfizer vaccine. Similar conclusions can also be drawn between female and male participants, suggesting that participants assigned female at birth are more likely to experience AEFI. Race and ethnicity are also suggested to influence AEFI, and further testing with larger datasets is needed for future studies.

Effects of Complex Visual Cues on Temporal Stepping Response

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Introduction: Falls are the primary cause of both injuries and fatalities in the workplace, accounting for nearly 20% of work-related hospitalizations[1]. Older workers, who are especially vulnerable, face a heightened risk of falling. As the workforce continues to age, the incidence of fall-related injuries is expected to rise, further straining the healthcare system[2]. The risk of falls in our aging workforce can be reduced through exercise-based interventions that incorporate step training[3]. However, the effectiveness of step training varies across individuals, likely due to differences in step training design parameters and age-related abilities[4]. Regardless of these factors, step training requires motor processes that challenge balance, but there is a lack of knowledge on how design parameters influence the balance demands. To design more effective step training interventions, we are investigating the effect of design parameters on stepping performance. Specifically, this study examines the effect of visual cue complexity on challenging the biomechanical stepping response. We hypothesize that greater visual cue complexity will result in longer response times, indicating a greater challenge to balance and motor control.

Methods: This preliminary study is intended to inform our approach to designing more effective fall prevention strategies. We plan to recruit 40 participants to address the broader objective of designing more effective fall prevention strategies. To date, two healthy younger adults were recruited to pilot our stepping training paradigm. Participants were asked to complete a total of six stepping trials, consisting of three simple and three complex stepping trials in a randomized order. Simple stepping trials comprised cues to step in one of six locations. Complex stepping trials comprised cues to step and inhibitory cues to not step in one of six locations. Center of Pressure (CoP) data were collected from four force plates at 1200 Hz, while stepping cues were controlled using E-Prime software. Participants were instructed to follow the on-screen prompts, stepping or withholding steps when cues were presented. Temporal biomechanical metrics of stepping were analyzed. Specifically, we assessed total response time (time from cue onset to step response contact) for all accurate stepping responses. Human research ethics approval (IRB_00183429) and informed consent were obtained.

Results: Preliminary analyses of the pilot data suggest that increased cue complexity is associated with longer total response time (Fig.1). Complex cues increased total response time by 165.4 ms (SD = 5.05 ms). These initial findings highlight a potential relationship between cue complexity and decision-making efficiency, suggesting that more complex visual cues may challenge participants' ability to respond quickly and accurately.

Conclusions: These preliminary results underscore the potential impact of cue complexity on balance and stepping performance. These pilot findings will allow us to verify that our methods challenge balance before proceeding to the target older adult population. A greater understanding of how design parameters affect step training will lead to improved administration of these interventions for age-friendly care and fall prevention.
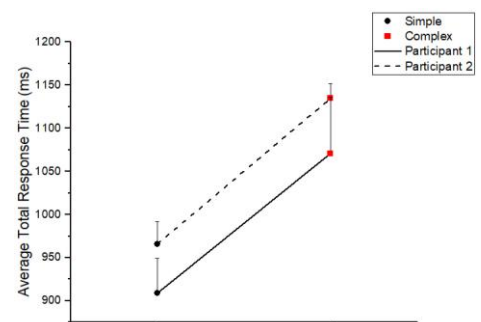
Figure 1: Average total response time during simple and complex trials across participants

Integrating Spiritual Care in the Job Demands-Resources Framework: Expanding the Understanding of Palliative Nursing Practices

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Introduction: Spiritual care remains an under-addressed yet crucial component of holistic end-of-life (EOL) care. Patients experiencing terminal illness often face not only physical pain but also deep emotional and spiritual distress, making the integration of spiritual care essential for enhancing their quality of life. Nurses are on the frontlines in providing this care, yet they frequently encounter substantial challenges, ranging from limited time and heavy workloads to insufficient training in addressing spiritual needs. This study was undertaken to examine how EOL nurses perceive and provide spiritual care framed in terms of the balance between job demands and available resources.

Methods: A qualitative study design was employed, involving twenty-one semi-structured interviews with community and hospice nurses in southeast England. All participants were selected based on their extensive experience in EOL care and their direct exposure to patients experiencing spiritual distress. The interview protocol was designed to elicit detailed narratives regarding nurses' personal experiences with providing spiritual care in patients, the range of resources available to them, and the demands they experience. Interviews were audio-recorded, transcribed verbatim, and then subjected to content analysis. Themes were derived using Q-sort methodology, which allowed for the systematic categorization of recurring patterns in the data.

Results: Thematic analysis revealed several key demands including nursing challenges, time constraints, specific EOL challenges, and the experience of multi-dimensional pain. In response, nurses relied on diverse resources such as personal experience, expert consultation, prior EOL experience, and ongoing training and education. As one EOL nurse explained:
"We ask about faith, but spiritual care goes beyond that. It's about helping patients feel at peace, whether that means reconnecting with family, finishing something important to them, or just being present."
– EOL Nurse, Female, 55

Conclusions: This study reveals the dual burden of high job demands and limited support resources that EOL nurses face when addressing spiritual distress. The reliance on ad hoc strategies and personal experience underscores a critical importance of nurses' heavy reliance on intuition and a lack of formalized care processes. To improve the integration of spiritual care, targeted interventions are necessary—such as the implementation of formal training programs, the establishment of clear interdisciplinary protocols, and the allocation of additional staffing resources to alleviate time pressures. Such measures could lead to improved patient outcomes and increased job satisfaction among nurses.

When Leaders Listen: Firefighter Perceptions of Safety Leadership Walkarounds

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Introduction: Safety climate refers to employees' shared perceptions of how safety is prioritized through organizational policies, procedures, and practices, including how safe behaviors are supported and rewarded (Zohar, 1980). A strong safety climate predicts increased compliance, initiative, and safety citizenship, and is associated with reductions in injuries, burnout, and turnover (Christian et al., 2009; Huang et al., 2016; Nahrgang et al., 2011). In the fire service, improving safety climate is particularly critical, as enhanced engagement and retention strengthen both responder effectiveness and community service (Taylor et al., 2019). The Fire Service Organizational Culture of Safety (FOCUS) survey assesses safety climate across two levels: Management Commitment to Safety and Supervisor Support for Safety (Taylor et al., 2019). While both are linked to key safety outcomes, Management Commitment scores are consistently lower, suggesting a need for leadership-focused interventions. Safety Leadership Walk Arounds (SLWAs), adapted from Executive Walkarounds (EWAs) in healthcare, are one such intervention. SLWAs involve senior leaders engaging frontline staff in informal, on-site discussions to identify safety concerns and build trust. Evidence from healthcare shows that this intervention improves safety climate when leaders engage meaningfully and follow through on concerns (Schwendimann et al., 2013; Sexton et al., 2018). Despite their promise, little is known about the processes that drive SLWA effectiveness. Drawing from meeting science, this study examines micro-level behaviors exhibited during the Elicitation Phase (first phase) of the SLWA to assess, the fidelity of the intervention protocol aimed at improving Management Commitment and advancing safety culture in the fire service.

Methods: This study employed a mixed-methods, observational design to analyze leadership behaviors during the first phase of the SLWA, the elicitation phase, and their relationship to meeting outcomes in U.S. fire departments. Participating departments were purposively selected based on prior engagement with the Fire Service Organizational Culture of Safety (FOCUS) survey. Recruitment was facilitated through partnerships with the Center for Firefighter Injury Research and Safety Trends (FIRST), with leadership contacted first to ensure organizational support. Departments were located in the southwestern U.S. and varied in size from 2 – 4 stations. Leadership teams (1-3 individuals) from each department were invited to participate and underwent a preparatory training session prior to data collection. During the Elicitation Phase, leadership teams conducted meetings with fire crews at each station across all 3 shifts. These meetings occurred in person and were both video- and audio-recorded to capture verbal and non-verbal interactions. Recordings were subsequently transcribed, segmented, and behaviorally coded using Mangold INTERACT software following the Act4Teams coding schema. Immediately after each SLWA, non-leadership personnel who participated in the meetings were invited to complete a survey. The survey captured perceptions of the meeting, including measures of meeting quality and participant experience, as well as demographic, organizational, and mental health variables. Analyses will include Regression analyses and multilevel modeling to examine associations between observed meeting behaviors and self-reported meeting outcomes. All quantitative data analyses were conducted using SAS 9.4.

Results: Data collection is ongoing but is scheduled to be completed prior to the conference date. Preliminary findings will be presented including frequencies of meeting behaviors descriptive stats on participant make up and general trends in meeting experience observed from fire service membership.

Conclusions: Although data collection is ongoing, this study represents an important step toward understanding how leadership behaviors during SLWAs influence meeting outcomes in the U.S. fire service. By integrating principles from meeting science with established safety climate research, this project addresses a critical gap in how a safety-focused leadership intervention is enacted and experienced on the ground. Given the fire service's unique operational risks and team-based structure, identifying behavioral strategies that improve communication, trust, and psychological safety during routine interactions like SLWAs has the potential to drive meaningful improvements in engagement, injury prevention, and overall safety culture.

The Meeting Checklist: A Blueprint for Better Meetings

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2 University of Utah, Salt Lake City, Utah

Introduction: As organizations adopt more dynamic, team-oriented structures, meetings play a crucial role in information sharing, collective problem solving, and strategic alignment (Mroz et al., 2018). When effective, meetings facilitate shared mental models, goal alignment, and individual role clarity. Conversely, poorly run meetings can decrease productivity, lower employee engagement and increase emotional exhaustion (Kauffeld et al., 2011; Lehmann-Willenbrock at., 2016). Traditional quantitative methods, such as surveys, often interrupt the dynamics they seek to measure (Hill et al., 2013), leading researchers to seek unobtrusive alternatives. Behavioral coding allows for real-time or post-hoc analysis but is time-intensive and requires intensive training. Many existing tools focus on isolated constructs rather than offering a comprehensive evaluation of meeting effectiveness (Salas et al., 2015). To address this challenge, we propose the Meeting Inventory Checklist, a tool that compiles all observable behaviors linked to meeting success or failure (Allen & Lehmann-Willenbrock, 2023). This project aims to validate the checklist's effectiveness in assessing meeting quality across various modalities, including hybrid and virtual settings (Shockley et al., 2021; Reed & All, 2021).

Methods: To test and validate the checklist, publicly available meeting recordings were compiled from YouTube, primarily standing or working meetings at a major tech company. Two researchers independently coded a subset of recordings, refining checklist criteria and resolving discrepancies until they reached at least 75% rater agreement on three separate attempts. Once reliability was established, the researchers coded the remaining 27 team meeting recordings. The coding process involved systematically analyzing meeting recordings and identifying observable behaviors corresponding to the checklist. Only meeting characteristics and behaviors that could be observed or reasonably inferred were coded, unobservable characteristics were coded as "NA." Observed behaviors would be coded as "Yes", "Somewhat", or "No".

Results: Our team is currently in the process of validating the Meeting Inventory Checklist by comparing behavioral results with independent evaluations of meeting satisfaction, effectiveness, and participation. These evaluations will be provided by subject matter experts (SMEs) with expertise in the science of team meetings. Additionally, SMEs in Information Technology and team leads at the major tech company from which the videos were soured will evaluate using the same measures.

Conclusions: Meetings are critical to organizational success, yet effective assessment tools remain limited. The Meeting Inventory Checklist was developed to address this gap, offering a comprehensive, behavior-based approach to evaluating meeting effectiveness. By systematically coding observable behaviors, the checklist provides a practical framework for identifying best practices and common pitfalls. It is our team's goal to continue to refine and validate this tool so that it may be effectively applied to various meeting settings by researchers and practitioners alike.

Effects of Physical Activity on Meeting Outcomes

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Introduction: Workplace meetings are critical in modern workplace settings, yet their necessity and effectiveness are often questioned by employees. One under-studied factor that could potentially improve employees' experience of meetings is physical activity. The purpose of this study is to explore the extent to which the positive effects of physical activity extend into workplace meetings. Specifically, we explore the question, "Does self-reported physical activity increase meeting satisfaction and effectiveness while lowering meeting recovery needs?" We explore these potential relationships using the job demands-resources model through identifying physical activity as a resource that provides workers with more energy, which is beneficial for effective and satisfying meetings (Bakker & Demerouti, 2007)

Methods: A sample of 961 full-time employed individuals were surveyed about their physical activity and meeting outcomes of their most recent workplace meeting to quantify the relationship between physical activity, mental health and meeting outcomes. Crude and adjusted linear regression were used to assess these relationships. Moderated generalized linear model analysis looking at physical activity and meeting outcomes, with a computed interaction term between physical activity and well-being variables (burnout, depression, and anxiety) was analyzed using the estimates created.

Results: Physical activity was positively associated with meeting satisfaction and recovery. Specifically, total days active and vigorous MET hours were significantly associated with improved meeting satisfaction ($\beta = 0.695$, $p < 0.001$) and longer recovery time ($\beta = 1.687$, $p < 0.001$). No significant associations were found between physical activity and meeting effectiveness. Depression, anxiety, and burnout moderated the relationship between physical activity and meeting outcomes. For example, the positive association between total days active and meeting satisfaction was stronger in individuals with lower depression and anxiety scores ($\beta = 0.025$, $p = 0.0003$ for depression; $\beta = 0.027$, $p = 0.002$ for anxiety).

Conclusions: Effects of physical activity on workplace meetings are influenced by workers' mental health symptoms. The job-demands resources model appears to be an appropriate way to think about and investigate how meetings impact employee well-being. Physical activity is a resource that appears to potentially enhance meetings. That effect is dependent on the current well-being situation of the worker. Meeting science researchers should look to other potential resources that may be used to improve meeting experiences and meeting outcomes for employees. In future research, changes to the study design should be made to gather more powerful data.

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Aspects of Frontline Worker Occupational and Demographic Factors on COVID-19 Frequency

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Introduction: Frontline workers have been identified as having potentially the highest risk of exposure to COVID-19 (2). Additionally, this occupational group has been reported to have higher mortality rates from COVID-19 than other workers (1). This study aims to determine the difference in occupational and/or demographic factors with the frequency of COVID-19 within the boosted and non-boosted frontline workers.

Methods: We analyzed frontline worker data from the BEEHIVE study, which was gathered from November 2023 to August 2024. Participants performed weekly COVID-19 rapid antigen test (RAT) regardless of symptoms for 24 weeks. Participants were excluded for analysis if they did not meet eligibility criteria or failed to comply with study activities or had inconclusive/missing test results (N=124). A COVID-19 case was defined as one positive RAT accompanied by COVID-like illness (CLI) symptom or two or more positive RATs with or without CLI (N=140). We classified healthcare workers, first responders, and other essential workers as frontline workers (N=608), and other occupation types/ unemployed as non-frontline workers (N=455). Within the frontline worker population, we compared the boosted and un-boosted populations. We conducted Chi-square tests to determine the difference in occupational and/or demographic factors with the frequency of COVID-19.

Results: Chi-square tests were conducted to analyze if there were demographic relationships with COVID-19 prevalence within the boosted as well as for non-boosted populations. There was not a significant difference of COVID-19 incidences between frontline workers and non-frontline workers, $p=0.704$, nor between boosted and non-boosted frontline workers, $p=0.075$. There was a difference in COVID-19 cases for the following factors: ages 18-49, $p=0.015$, making less than $24,000, $p<0.001$, making $50,000-74,999, $p=0.037$, or working in intensive care, $p=0.011$. We did not observe other occupational factors to have a significant difference on COVID-19 cases in the boosted or non-boosted frontline workers.

Conclusions: In contrast with prior research, we did not see a significant difference in COVID-19 frequency in frontline workers compared to non-frontline workers in our study population. Non-boosted frontline workers had a higher COVID-19 frequency if they reported that they were between the ages 18-49, made less than $24,000 or made between $50,000-75,000, or that they work in intensive care. This may suggest that the vaccine had a protective effect in these populations of potentially higher virus circulation. Limitations to our study include demographic and occupational factors were self-reported leading to possible risk of response bias and we had limited statistical power in some of our subgroup analyses. Future research should consider the role of vaccination in specific occupational environments.

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Evaluating Fatigue Among Airline Employees at a Major Metropolitan International Airport

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Introduction: The airline of interest employs over 5,000 individuals at a major international airport. These employees can be divided into above- and below-wing jobs. Examples of above-wing employees include gate agents and check-in staff, among other job tasks. Below-wing staff may consist of baggage handlers, ramp workers, maintenance staff, and anyone else whose job occurs on the tarmac. The airport operates 365 days a year, 24 hours a day. This is a demanding schedule with no downtime. Additionally, the airline may have over 200 flights depart from the airport on any day. Given these operational demands, the airline requires people to work throughout the night, long hours, or any other non-traditional combination. Given the high work demands and work schedule, the airline strives to be a workplace health and safety leader. The airline has a robust health and safety program with various employee resources. However, fatigue is a driving factor for the risk of injury while at work. The airline tasked our group with developing a survey that they could administer to their employee populations to assess fatigue among above- and below-wing employees.

Methods: The purpose of developing a survey for airline employee fatigue was to define a feeling of tiredness, whether physical or mental, that may impact an individual at work. Based on the literature on this topic, survey questions were broken into five main domains: Demographics, Sleep, Family Life, Shift type, and self-reported fatigue levels. Demographics, Sleep, Family Life, and Shift type are all well-understood contributing factors for fatigue. The survey was 39 questions long and was hosted on the platform Qaltrics.

Results: The bulk of the literature around surveys for fatigue is built around long, over 100-question validated surveys. While these surveys hold value to the scientific community, they did not serve the airline's needs. Therefore, a significant amount of time was spent selecting the 39 questions that did end up in the survey. We feel that these questions capture the most actionable items that this airline can use to help reduce fatigue at work. The airline wanted a study that could be done quickly on one's mobile device. A mixed modality of questions was implemented to keep the employees engaged while completing the surveys. Multiple choice, slider, and some short answers text boxes were used throughout the study.

Conclusions: The airline has been given the survey with a link that they can use to distribute the survey. However, while the survey was distributed to airline employees, it currently had zero responses. There may be many reasons why the survey hasn't been distributed, but we hope to analyze any results when responses come in.

Postural Adjustments as a Metric of Perception to Falling Hazards

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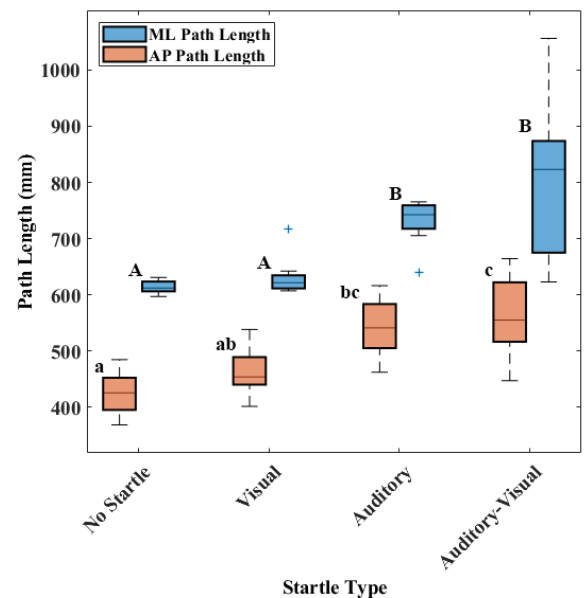1 Department of Mechanical Engineering, University of Utah, Salt Lake City, UT, USA

Introduction: Contact with objects and equipment remains one of the leading causes of work-related fatalities [1]. While effective hazard perception plays a key role in injury prevention [2], there is limited understanding of how individuals biomechanically perceive and respond to falling hazards. Understanding human perception and its limitations is critical for improving safety interventions. Biomechanical metrics could offer a more objective approach to assessing hazard perception. The presence of a hazard can trigger a startle response, often resulting in postural changes [3], which can be analyzed using center of pressure (CoP) metrics like path length [4]. Consequently, biomechanical data should be investigated as a potential indicator of worker hazard perception. The objective of this analysis is to explore biomechanical metrics of postural adjustments to a startle event initiated from a falling hazard. We hypothesize that exposure to a falling hazard will result in greater CoP displacement and therefore a longer path length compared to a no-hazard condition.

Methods: This case study examined the biomechanical responses of a healthy younger adult participant to falling hazards. Institutional Review Board (IRB) approval and informed consent were obtained prior to the study. The participant completed 32 randomized trials while standing. Each trial exposed the participant to one of four startle conditions: auditory, visual, auditory-visual, or a no-startle control. The stimuli consisted of a falling object, with release time and location (left or right of the participant) varied across trials. CoP data were collected from two force plates at 1200 Hz. Movement metrics such as total path length, and path length in the medial-lateral (ML) and anterior-posterior (AP) directions were calculated over a two second timeframe after hazard release. The resultant CoP distance (RD) was calculated as the vector distance between the mean CoP and the CoP location at each time point. One-way ANOVAs were conducted on biomechanical metrics with startle type as the independent variable, followed by Tukey's HSD post-hoc test if significant differences were found.

Figure 1: Box plot of AP and ML path length among different startle types. Non-matching letters indicate conditions that are significantly different than one another.

Results: This exploratory analysis found total path length varied across startle type ($F_{3,28} = 14.5$, $p < 0.001$) in the ML ($F_{3,28} = 12.4$, $p < 0.001$) and AP ($F_{3,28} = 10.7$, $p < 0.001$) directions. Total path length was greater in the auditory ($p = 0.002$) and auditory-visual ($p < 0.001$) conditions compared to the no-hazard condition and differed between visual and both auditory ($p = 0.020$) and auditory-visual ($p < 0.001$) conditions. In the ML direction, path length was greater in both the auditory ($p < 0.001$) and auditory-visual ($p < 0.001$) conditions compared to the no-hazard condition. ML path length also differed between visual and both auditory ($p = 0.025$) and auditory-visual ($p = 0.003$) conditions. In the AP direction, path length was greater in both the auditory ($p = 0.024$) and auditory-visual ($p < 0.001$) conditions compared to the no-hazard condition, with only differences between visual and auditory-visual conditions ($p < 0.001$).

Conclusions: These initial findings suggest that CoP displacement, measured by path length, may better reflect startle-induced postural adjustments in response to auditory and auditory-visual startles. The stronger postural responses to these hazards indicate they may cause a greater reaction than visual stimuli alone. Further research into the role of auditory stimuli in hazard perception across a wider range of participants is needed.

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Factors Associated with Burnout in Hispanic Lawyers

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Introduction: Current research evidences the poor mental health that American Lawyers have, with burnout accounting for 14% of it. Hispanics in the demographics compose around 3% of the sample population. Therefore, little is known about the well-being of minorities exercising the legal profession. This post hoc analysis aims to identify the factors that prevent or contribute to burnout in Hispanic Lawyers.

Methods: In this cross-sectional study, lawyers who attended Hispanic National Bar Association (HNBA) events and/or were part of HNBA used the RedCap platform to answer a 56-66-item questionnaire. The questionnaire contained demographic variables, work-related variables, validated instruments, and items specifically tailored to meet the expressed needs of the targeted population (discrimination aspects, first-generation attorneys, and the role of family in conflict resolution). Recruitment was from April to July 2024. The outcome variable of Burnout was measured with the single-item Maslach Burnout Inventory (MBI-EE). Descriptive statistics and logistic regression were used to assess statistical relationships and calculate Odds Ratios (OR) and associated 95% Confidence Intervals (95% CI).

Results: Of 314 participants, 87% were Hispanics, 73% females, and 43 years old was the mean age; the period of prevalence of experiencing burnout at least once a week was 37%. We identified 38 possible factors associated with burnout; 14 had no statistically significant association, 22 contributed to burnout, and 5 demonstrated a statistically significant protective factor. We classified them into Demographic (2), Occupational Factors (21), and non-occupational (15) factors. Pertaining to the 61-65 age group (demographic factor) decreases 8 times the likelihood of being burnt out (OR 0.21 [0.05- 0.83]. Of the 15 non-occupational factors, 9 had no statistically significant association. Some of the six that were positively associated with burnout were: having 1 or 2 close friends (OR 2.91 [1.34-6.34], meeting major depressive disorder criteria (OR 5.47 [3.21-9.31] and anxiety (OR 6.20 [3.69-10.40]. Most of the occupational community (6 out of the 21) contributed to burnout by > 100 when Hispanic lawyers were almost never enthusiastic about being a lawyer (OR 167.80 [16.2-.999.99], by almost 8 times if they had the intention to leave the profession (OR 7.74 [4.47-13.38], nearly 15 times if they did not feel comfortable taking time off to address family needs, physical health of mental health (OR 14.81 [5.48-40.01], almost 10 times if they strongly disagree with the statement of being treated with respect (OR 9.,39 [1.87-47.06] and between 2 to 5 times if they very often felt discriminated in the workplace, courtroom or the legal community (OR 5.66 [1.70-18.82], OR 4.04 [1.03-15.78], OR 3.54 [1.13-11.04]), respectively.

Conclusion: Our study showed that more than 1 in every 3 Hispanics exercising the legal profession face every day the endeavor of performing their daily activities while being burnt out. Even though the factors that contribute to burnout outnumber the ones that inhibit it, being able to identify them is the first step towards the creation of strategies for optimizing Hispanic Lawyer's well-being.

Oxygen Consumption and NASA-Task Load Index Subscales in Maximal and Constant Heart Rate Tests in Firefighters

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Introduction: In firefighters (FFs), measurement of oxygen consumption (VO_2) and NASA Task Load Index (TLX) have been used to differentiate physiological and psychological workload, respectively, between task intensities. The NASA TLX uses subjective rating of six distinct subscales: Mental Demand (MD), Physical Demand (PD), Temporal Demand (TD), Effort (EF), Frustration (FR), and Performance (PE) to quantify a total score of perceived psychological workload. However, it is unclear whether the contribution of the NASA TLX subscales to total score differs based on task intensity. Further, there is a growing interest to capture work efficiency in the fire service, yet it has been suggested that concurrent measurement of air consumption and heart rate (HR) may be redundant. As such, the purpose of this study was to investigate differences in the contribution of NASA TLX subscales to total score, HR, and VO_2 in a maximal and submaximal task in FFs.

Methods: Eleven male active-duty FFs (33.73 ± 8.11 yrs, 1.79 ± 0.03 m, 87.63 ± 16.54 kg) from a Midwestern metropolitan fire department completed a maximal ramp treadmill test (TM) with direct breath analysis through a calibrated metabolic cart to capture maximal aerobic capacity (VO_{2PEAK}, mL/kg/min) and the Respiratory Compensation Point (RCP). HR was collected continuously to measure peak HR (HR_{PEAK}, bpm) and the HR achieved at the RCP (HR_{RCP}, bpm). On a separate day, participants completed a constant HR treadmill run (CHR) at a target HR (THR, bpm) of $85\% \pm 2$ bpm of HR_{PEAK} for a maximum of 30 minutes. HR was monitored continuously to calculate average HR of the test (HR_{AVG}, bpm). VO_2 was measured continuously to identify the starting ($VO_{2\text{-}START}$) and ending ($VO_{2\text{-}END}$) values of the CHR test. The difference in starting and ending treadmill velocity (DV, mph) identified work rate change during the CHR test. Participants completed the NASA TLX after the TM and CHR tests to establish a total perceived workload score (AU) and percent contribution (%) of each TLX subscale to total score. A paired t-test examined differences in NASA TLX scores between the TM and CHR tests, with follow-up pairwise comparisons with a Bonferroni correction to explore differences in percent contribution of subscales between tests. Repeated measures ANOVAs identified significant differences between TM test HR_{PEAK} and HR_{RCP} and CHR test THR and HR_{AVG} as well as TM test VO_{2PEAK} and CHR test $VO_{2\text{-}START}$ and $VO_{2\text{-}END}$ with follow-up pairwise comparisons using a Bonferroni correction. An alpha of 0.05 determined statistical significance.

Results: NASA TLX score post-TM test (70.80 ± 11.03 AU) was higher ($t = 2.65$, $p = 0.025$) than the CHR (54.43 ± 12.40 AU). PD and EF were the highest contributors to total score in the TM (PD = 31.34 ± 8.73 %, EF = 32.49 ± 7.58 %) and CHR (PD = $31.11 \pm 9.58\%$, EF = $24.99 \pm 14.61\%$) tests, yet percent contribution to total score was not significantly different between tests for any subscale. HR_{PEAK} (185.6 ± 9.1 bpm) was higher than HR_{RCP} (159.3 ± 13.3 bpm, $p < 0.001$) and HR_{AVG} (159.9 ± 8.1 bpm, $p < 0.001$). HR_{AVG} was not different from HR_{RCP} ($p = 1.00$), but was higher than THR (158 ± 7.7 bpm, $p = 0.002$). THR was not different from HR_{RCP} ($p = 1.00$). VO_{2PEAK} (47.13 ± 7.68 mL/kg/min) was higher than $VO_{2\text{-}START}$ (34.68 ± 4.88 mL/kg/min, $p < 0.001$) and $VO_{2\text{-}END}$ (29.84 ± 6.45 mL/kg/min, $p < 0.001$), and $VO_{2\text{-}START}$ was higher than $VO_{2\text{-}END}$ ($p = 0.02$). The average ΔV was 1.60 ± 0.75 mph.

Conclusions: Despite significant differences in cardiorespiratory demand between the TM and CHR tests, as evidenced by VO_2 and HR, only the NASA TLX total score differed. The lack of change in PD and nonsignificant decrease in contribution of EF between tests may reflect HR remaining below the severe intensity domain in the CHR test. Thus, changes in oxygen consumption and work rate intensities were not reflected in NASA TLX subscales of perceived load despite maintaining a constant heart rate. An area for future research should be to examine the relationships between NASA TLX subscale scores and measures of air consumption in firefighting tasks. The NASA TLX can be a practical way to quantify perceived physical and mental load in submaximal tests.

Measures of Obesity as Predictors of Firefighter Recruit Academy Success

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Introduction: Over the last decade there have been growing concerns of recruitment and retention in the firefighter (FF) population in the United States. Thus, there has been growing pressure on FF academies to meet this demand with a consistent supply of recruits who are prepared for the field. Body composition is one of the most significant predictors of overall FF performance, however, there has been little investigation as to the impact of body composition on the successful graduation of recruits from the recruit academy. Further, there is continued contention regarding the appropriate usage of body mass index (BMI) or body fat percentage (BF) to represent body composition in the firefighting population. Thus, the purpose of this study was to investigate the predictive abilities of BMI and BF to determine recruit academy success.

Methods: Body composition data were collected from 14 separate FF academy recruit cohorts (2012-2019, 2021-2024) resulting in a total of 449 (400 males, 49 females) recruits (27.00 ± 7.34 yrs; 1.78 ± 0.08 m; 87.82 ± 16.67 kg). In the first week of each academy, recruits completed body composition testing including body mass index (BMI) assessment via body mass measurement (kg) and self-reported height (m), as well as estimation of body fat percentage (BF, %) via 3-site skinfold measures. Continuous BMI and BF data were categorized according to the American College of Sports Medicine age- and sex-based criteria. Academy completion data (i.e., graduated or released) were obtained after the completion of each class. Logistic regression modelling was used to predict the odds of recruit academy release using BMI and BF as predictor variables. Wald tests were used to evaluate regression coefficients, followed by likelihood ratio test to confirm reduced model fit. An alpha of 0.05 determined statistical significance.

Results: To account for cell distribution inadequacies, BMI and BF categories were condensed. For BMI, the "Underweight" and "Normal" were combined into one "Normal" category, and all three "Obesity" classes were combined into one "Obese" category. For BF, the "Very Lean" and "Excellent" were combined into one "Excellent" category, and the "Very Poor" and "Poor" were combined into one "Poor" category. Overall, 56 recruits (12.5%) were released from the recruit academy. BMI was not a significant predictor of being released from the recruit academy ($X^2 = 1.11$, $p = 0.5744$), however, BF was ($X^2 = 8.08$, $p = 0.0443$). The reduced model using BF was more parsimonious than the full model ($G^2 = 1.17$, $p = 0.5579$). The odds of being released from the recruit academy for those in the "Excellent" category were about half of those in the "Good" category (OR: 0.63 [95% CI: 0.23, 1.73]), while those in the "Fair" category had about equivalent odds (OR: 1.01 [95% CI: 0.38, 2.69]). Those in the "Poor" category, however, had over twice the odds of being released from the recruit academy compared to those in the "Good" category (OR: 2.59 [95% CI: 1.21, 5.55]). The relative risk of being released from the recruit academy for those in the "Poor" category compared to all other categories was 2.57 [95% CI: 1.58, 4.19].

Conclusions: BF may be better than BMI as a body composition screening tool to implement prior to entering the recruit academy. This also suggests that while body composition may be a crucial component to success in the recruit academy, there is a wide range of acceptable body fat levels. However, there may be a threshold level of body fat that impedes performance to a degree which the recruit academy physical training cannot overcome.

Predicting Forearm Muscle Activity in Hand-Intensive Work Tasks

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Introduction: Musculoskeletal disorders (MSDs) related to hand-intensive work remain a significant concern; upper extremity MSDs have risen from 23.2 per 10,000 workers in 2007 to 32.6 in 2015, costing the US up to $6.5 billion annually in direct expenses (Silverstein, Viikari-Juntura, and Kalat 2002; US Bureau of Labor Statistics 2024). Hand exertion force has been shown to be one of the most important exposures associated with increased risk of MSD (Harris-Adamson et al. 2014), yet is one of the more challenging exposures to measure. Surface electromyography (EMG) has been used to measure muscle activity and estimate hand exertion force, but has typically required expensive equipment and resource-intensive processing. Therefore, this cross-sectional study aimed to predict EMG-based normalized peak force (NPF) estimates from self-reported data that was easier and less costly to collect.

Methods: This cross-sectional study (n = 257) is part of a larger research study evaluating the impact of poultry processing line speed on worker health (Harris-Adamson et al. 2025). For this analysis, data were collected from 11 establishments across six US poultry processing companies, focusing on eleven hand-intensive jobs. Through interview-facilitated surveys, workers provided information on demographics, pain, prior injuries, and self-rated NPF using the Borg CR-10 scale (Borg 1990). Grip strength was collected using a digital grip dynamometer (Biometrics, Ltd., Cwmfelinfach, Wales), with participants instructed to maintain a standardized posture. Hand activity level (HAL) was quantified using Multimedia Video Task Analysis (MVTA). Surface EMG (Mindrove, Kft., Győr, Hungary) was used to measure forearm muscle activity during work tasks, with electrodes placed over the flexor and extensor muscle groups. EMG data was normalized to each participant's maximum voluntary contraction (MVC). Key predictor variables included self-rated peak hand force, grip strength, age, sex, pain, prior injury, tenure, and HAL. Statistical analyses included correlation matrices and regression models to identify predictors of EMG-based NPF.

Results: Increased EMG-based NPF was associated with higher HAL (r = 0.22), while greater grip strength was correlated with lower EMG-based NPF (r = -0.26). Additionally, tenure showed a negative correlation with grip strength (r = -0.32), and males exhibited higher grip strength (r = 0.44). Self-reported NPF, presence of pain, and prior injury dropped out of the model due to low correlation with EMG-based NPF. The final model is: EMG-based NPF = 0.639521 + (0.163018 × Age Group 30-49) + (0.630298 × Age Group 50+) + (−0.351413 × Male) + (0.939083 × HAL) + (−0.006189 × Max Grip Strength), with $R^2 = 0.17$.

Conclusions: This predictive model explains a small portion of the variance in EMG-based NPF, and more complex relationships or additional variables may need to be considered in future predictive models. EMG measurements are still necessary for accurately capturing muscle activity.

Burnout, Anxiety, and Depression Within Hispanic and Non-Hispanic Lawyers: Prevalence and Overcome Challenges

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Introduction: A growing body of literature shows high rates of poor mental health among lawyers. However, anecdotal data suggests that Hispanic lawyers may differ from their non-Hispanic peers.

Objective: This study aims to compare the prevalence of Burnout, Anxiety, and Depression among Hispanic Lawyers, non-Hispanic Lawyers, and the General Working Population, as well as the challenges faced in making these comparisons.

Methods: Data was obtained from different cross-sectional studies. Hispanic National Bar Association (HNBA) lawyers used REDCap to answer a 56-item questionnaire (recruitment from April to July 2024), for non-Hispanic we used the New Jersey State Bar Association (NJSBA) 2022 report, and for the General Working Population 2021-2023 NHANES dataset. Outcome variables were measured by the Patient Health Questionnaire (PHQ9, depression), General Anxiety Disorder (GAD-2, anxiety), and single-item Maslach Burnout Inventory (MBI-EE, burnout). The instruments for data collection were similar; however, adjustments in data analysis had to be made to promote equity and minimize disparities. Descriptive statistics and logistic regression were used to assess statistical relationships and calculate Odds Ratios (OR) and associated 95% Confidence Intervals (95% CI).

Results: HNBA (n=314), NJSBA (n=1632), NHANES (3 subgroups n=5226, 2279,992). Statistical significance for ethnicity, gender, and prevalence of Depression and Burnout ($p<0.0001$-0.0003). Regarding Depression, non-Hispanic and Hispanic had a 3-4 increase in odds compared to the general working population (OR= 3.19, 95% CI 2.47-4.10, OR=4.10, 95%CI 2.94-5.71). Hispanic Lawyers are less likely to be burned out compared to NJSBA lawyers (OR=0.63, 95%CI 0.49-0.81). Anxiety showed no statistically significant associations ($p=0.15$).

Conclusion: There are statistically significant relationships between Hispanic lawyers compared with both non-Hispanic lawyers and the general working population regarding Depression and Burnout. Depression showed the highest prevalence in the Hispanic Lawyer population. The differences evidenced in our study present an opportunity to reassess existing programs that seek to address mental health in the legal profession. This new data indicates that within the legal profession, there are differences that may extend beyond work-related factors and are impacting the well-being of professionals exercising law; further research with consistent measurement instruments would elucidate current findings.

Assessing the Risk of Upper Extremity Disorders in Janitorial Tasks using Time-Motion Analysis and the ACGIH TLV for Hand Activity

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Introduction: Janitorial work is physically demanding, involving repetitive hand movements, forceful exertions, and awkward postures that significantly contribute to musculoskeletal disorders (MSDs). Approximately 2.3 million janitors work in the U.S., with over 200,000 employed in California. Janitors ranked third among occupations for nonfatal injuries and illnesses involving lost workdays, with 21,100 cases in 2020 and injury rates 2.7 times higher than the average across all occupations (2015 data). Given these high MSD rates, it is crucial to identify tasks with the highest biomechanical demands to guide ergonomic interventions. This study quantified the upper extremity MSD risks associated with common janitorial tasks using the ACGIH TLV for Hand Activity.

Methods: This cross-sectional study examined janitorial tasks performed in different spaces across three venue types including a shopping mall, an airport, and an event/convention center. Janitors had to be at least 18 years old and have at least six months of work experience to participate and were excluded if they had any injuries preventing them from performing their typical duties. For each janitor, approximately four hours of video data was collected at 30 frames per second while they performed common cleaning tasks. Multimedia-Video Task Analysis (MVTA) software was used to categorize each frame to identify each hand exertion, the task performed (i.e., wet mopping, vacuuming, surface disinfecting, etc.), and the workspace the task was performed in (i.e., bathroom, common space, cafeteria, etc.). From the MVTA analysis, the repetition rate and duty cycle of hand exertions are used to calculate the Hand Activity Level (HAL). An observer-based consensus approach was used to estimate the Normalized Peak Force (NPF) for each task performed in each workspace. The HAL and NPF were used to calculate the PFI-TLV, the primary metric of the ACGIH TLV for Hand Activity. A PFI-TLV > 1.0 was considered high risk. Data was processed using Python scripts and Excel-based analytics to identify high-risk tasks.

Results: Eight out of 11 janitorial tasks exceeded an average PFI-TLV of 1.0, indicating high risk for MSDs. The highest mean (SD) PFI-TLV scores were washing windows (1.69 (0.09)), carpet/rug moving (1.64 (one sample)), wiping (1.51 (0.25)), wet mopping (1.48 (0.08)), and disinfecting/scrubbing (1.41 (0.06)). Additionally, when task-level PFI-TLV scores were averaged by workspace, each workspace had a PFI-TLV exceeding 1.0. Across venues, offices (1.41 (0.53)), bathrooms (1.37 (0.06)) and outdoor (1.23 (0.02)) had the highest MSD risk.

Conclusions: This study underscores the number of janitorial tasks that increase MSD risk of the upper extremities indicating that mitigation efforts are needed. Many tasks involved prolonged tool gripping, repetitive wrist movements, and high-force exertions. To mitigate upper extremity MSD risk, tasks should be redesigned to reduce force and repetition rates, thus reducing the PFI-TLV Score to less than 1.0.

Powered Knee Exoskeleton Reduces Effort During Lifting Task

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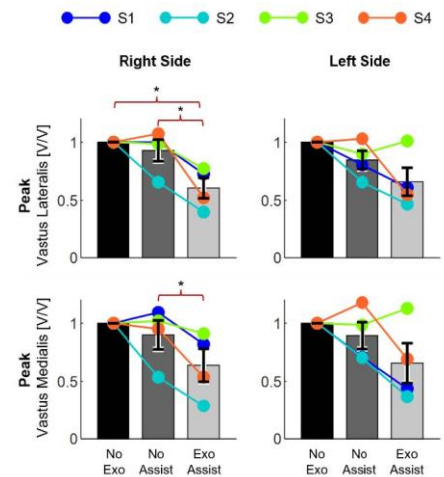2- Department of Mechanical Engineering, University of Utah, Salt Lake City, Utah
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Introduction: Over 7.1 million jobs in the United States can be categorized as Hand Laborers and Material Movers [1]. Hand laborers and material movers are required to lift and carry heavy objects, which makes the labor physically demanding and repetitive. The industry has an incidence rate of 289.8 nonfatal injuries per 10,000 full-time equivalent workers [1]. Sprains, strains, and tears make up the largest injury category for this kind of work [1]. This labor's highly repetitive and physically demanding nature cannot always be adapted to reduce injury rate. Powered exoskeletons have the potential to reduce occupational injury rates by augmenting human ability. Exoskeleton assistance allows the work to be done similarly while potentially reducing the strain on the musculoskeletal system. We hypothesize that bilateral assistance from the Utah Powered Knee Exoskeleton will reduce muscle activity in the quadriceps without negativity affecting other biomechanical outcomes.

Methods: Four subjects performed a lifting and lowering task under three conditions: without the exoskeleton (No Exo), while wearing the unpowered exoskeleton (No Assist Exo), and while assisted by the exoskeleton (Assist). The Utah Powered Knee Exoskeleton was worn bilaterally. Subjects lifted a 9 kg box from a 6-inch tall platform to waist height and then return it to the platform. In each condition, subjects lifted the box 10 times. Electromyography (EMG) was used to measure the muscle activity of each leg's vastus medialis (VM) and vastus lateralis (VL). Full-body motion capture was used to collect the biomechanics of the subject, with markers used to track each exoskeleton and the box independently.

Results: Assistance from the Utah Powered Knee Exoskeleton reduced all EMGs' average peak muscle activation (Fig 1). When comparing the No Exo condition to the Exo Assist condition, We saw an average decrease of 36% in the average peak of the right vastus medialis. For the left vastus medialis, the exoskeleton assistance decreased peak EMG activation by 34% compared to the No Exo condition. For the right vastus lateralis, the exoskeleton assistance decreased peak EMG activation by 39% compared to No Exo (p=0.041). The biological knee power significantly decreased in the Exo Assist conditions compared to the No Exo and No Assist Exo conditions. Paired t-tests compared No Exo to Exo Assist, and No Assist to Exo Assist, and corrected for multiple comparisons.

Figure 1 The average peak EMG activity decreased for all muscle groups bilaterally between the No Exo and Exo Assist Conditions. Asterisks on the bar plot above show statistical significance (p<0.05).

Conclusion: This work supports our hypothesis that a powered knee exoskeleton can reduce muscle activity and biological knee torque in the quadriceps. Furthermore, the exoskeleton had minimal effect on kinematics, suggesting no adverse compensatory movements were observed when wearing and using the powered exoskeleton. Other researchers have shown that EMG activity is reduced in major muscle groups when using powered knee exoskeletons for lifting tasks [2]. However, we found these results incomplete without analyzing the effects on the full-body biomechanics.

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The Associations of Poultry Evisceration Line Speed and Worker Speed on the ACGIH TLV for Hand Activity Score.

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Introduction: The US Department of Agriculture (USDA) regulates evisceration line speed (ELS) in poultry processing plants. The USDA has permitted some processing plants to operate up to 175 birds per minute (BPM), an increase from their previous maximum of 140 BPM. Poultry processing involves repetitive motions and sustained exertions of the hands, increasing the risk of upper extremity musculoskeletal disorders (MSDs)[1,3]. Although some jobs, such as evisceration, have been automated for efficiency, other jobs such as Live Hang and Chiller Rehang remain hand intensive[2]. The increase of ELS may expose workers to increased MSD hazard. To address this concern, we examined associations between ELS, piece rate (a surrogate measure of worker speed), and a measure of MSD hazard (ACGIH TLV for Hand Activity Score) among poultry processing workers.

Methods: A cross-sectional study of ELS, piece rate, and PFI-TLV Score was conducted among 110 workers performing Live Hang and Chiller Rehang at 11 poultry plants. These jobs were selected because they were performed immediately before and after evisceration and were expected to be influenced by ELS. ELS, as reported to the USDA, was categorized as low (operating ≤145 BPM), medium (>145 to <175 BPM), and high (175 BPM). Worker pace, defined as the number of chickens handled per minute, was ascertained with frame-by-frame analysis of video recordings and categorized as low, medium, and high BPM tertiles. The Peak Force Index Threshold Limit Value (PFI-TLV) Score (ACGIH TLV for Hand Activity) was calculated from normalized peak forces (ascertained with surface electromyography measures of forearm muscle activity), and hand activity levels (ascertained with frame-by-frame video analysis to quantify hand exertion frequency and duration).

Results: Among Live Hang workers, no differences of mean PFI-TLV scores were observed between the low (mean=1.2; SD=0.2) and medium (mean=1.3; SD=0.2) ELS groups (p≥0.99), nor between the low and high (mean=1.2; SD=0.2) ELS groups (p≥0.99). However, among Chiller Rehang workers, a statistically significant difference of mean PFI-TLV scores was observed between the low (mean=1.6; SD=0.2) and medium (mean=1.2; SD=0.2) ELS groups (p<0.04), and a nearly statistically significant difference was observed between the low and high (mean=1.2; SD=0.2) ELS groups (p<0.07). In contrast to ELS, PFI-TLV Score increased with increasing piece rate for both jobs, but the differences were statistically significant only between the low and high piece rate groups. Specifically, among Live Hang workers, no statistically significant difference of mean PFI-TLV scores was observed between low (mean=0.9; SD=0.2) and medium (mean=1.3; SD=0.2) piece rate groups (p=0.60). In contrast, a statistically significant difference of mean PFI-TLV scores was observed between low and high (mean=1.8; SD=0.2) piece rate groups (p=0.01). Chiller Rehang Workers showed a similar pattern. Specifically, no statistically significant difference of mean PFI-TLV scores was observed between low (mean=1.0; SD=0.2) and medium (mean=1.5; SD=0.2) piece rate groups (p=0.20). In contrast, a statistically significant difference of mean PFI-TLV scores was observed between low and high (mean=2.0; SD=0.2) piece rate groups (p=0.01).

Conclusions: Our findings suggest that ELS, which is regulated by the USDA, was not significantly correlated with MSD risk in two manual poultry processing jobs. However, worker speed (i.e., piece rate) was associated with increasing MSD hazard (PFI-TLV). Since piece rate is directly influenced by JLS and staffing levels, adjusting these to achieve a piece rate that keeps the PFI-TLV to less than 1.0 can be implemented. PFI-TLV scores >1.0 indicate elevated MSD risk.

Biorepository Ergonomic Evaluation for Patient Health Information Removal Tasks

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Introduction: Musculoskeletal disorders (MSDs) are a leading cause of workplace injuries, with significant implications for worker health, productivity, and healthcare costs (Reindel & Shrestha, 2024). In environments requiring repetitive, force-intensive tasks and long-duration static work posturing, employees face heightened ergonomic risks (Dzakpasu et. al., 2021). This study investigates the cumulative ergonomic hazards associated with patient information removal tasks at a biorepository, where incident reports have documented cases of elbow and shoulder MSDs, as well as laceration injuries caused by the use of scraper tools and the handling of glass shards. By identifying these risks, the study aims to inform targeted ergonomic interventions to enhance worker safety and operational efficiency.

Methods: A comprehensive ergonomic evaluation was conducted to assess patient health information (PHI) removal tasks in a biorepository. Video recordings captured technicians performing tasks in their natural environment, with ergonomic risks analyzed using the Moore-Garg Strain Index (SI) and ACGIH Hand Activity Level (HAL) Threshold Limit Value (TLV) for hand strain, while the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA) assessed postural risks. Additionally, 3DSSPP software quantified low back compression forces and localized fatigue of the upper extremities. Finally, a fault tree analysis (FTA) was employed to identify potential root causes of hand cut injuries while performing scraping tasks on glass slides and blocks. Evaluations were conducted across three phases: pre-abatement, post-abatement, and supplementary abatement to determine the effectiveness of interventions in reducing ergonomic risk.

Results: Post-abatement ergonomic assessments of slide and block scraping tasks revealed that while SI and ACGIH HAL TLV metrics were below critical thresholds for all cases, RULA scores exceeded the action limit (≥ 3), indicating ergonomic concerns should be mitigated. 3DSSPP analyses confirmed that back compression, strength percentile, and duty cycle percentages remained well below action limits. The findings did not differ significantly from the pre-abatement RULA assessment, suggesting the need for further postural corrective intervention. The FTA identified several root causes and a single point failure; the blade replacement and slide scraping tasks were among the most concerning tasks. Identification of these tasks will allow the biorepository to address the root causes over time.

Conclusion: Persistent postural risks highlight the need for further ergonomic interventions beyond initial abatement. Enhancing tool and workstation design, supplementary engineering solutions including sit-stand desks, retrofitting office chairs with compression brake castor wheels, improving surface grip while scraping and replacing blades, adjusted performance of tasks to prevent accidental cuts, and ergonomics education and individualized workstation consultation to improve postures can better mitigate MSD and injury risks, improving worker safety and efficiency in biorepositories.

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Keynote Speaker

Leslie Hammer, PhD

Dr. Leslie B. Hammer specializes in the effects of workplace conditions, including supportive supervision at work and occupational stress, on workplace mental health and well-being. She is the Associate Director of Applied Research and Professor in the Oregon Institute of Occupational Health Sciences at Oregon Health & Science University and the Director of the Oregon Healthy Workforce Center, one of 10 centers of excellence in *Total Worker Health*® funded by the National Institute of Occupational Safety and Health.

She is also Professor Emerita at Portland State University. Dr. Hammer has extensive experience in designing, implementing, and evaluating worksite supervisor training programs to improve employee mental health and well-being outcomes. She conducts applied research that focuses on workplace interventions aimed at improving supervisor leadership skills and in turn, evaluating the impact of such trainings on both supervisor and worker mental and physical health, safety, and well-being. She has been Principal Investigator of 5 large workplace intervention randomized controlled trials evaluating the effectiveness of supervisor support training funded by the NIH, CDC/NIOSH, and the DoD.

She is a Fellow of the American Psychological Association, the Society for Industrial and Organizational Psychology, and the European Academy of Occupational Health Psychology. She is also the Founding President of the Society for Occupational Health Psychology. She co-wrote a book entitled *Working Couples Caring for Children and Aging Parents* (2008), and publishes widely in such outlets as the *Journal of Applied Psychology, Journal of Occupational Health Psychology, and Journal of Environmental and Occupational Medicine*

Glucose as a Biomarker for Stress in Firefighters

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Introduction: Firefighters experience high rates of chronic health conditions like cardiovascular disease, obesity, and behavioral health issues. Throughout their careers, firefighters are exposed to intense levels of chronic occupational stress. However, the magnitude and extent of this stress has yet to be quantified and the relationship between chronic stress and disease in firefighters is not fully understood. Chronic stress can hyper-activate and dysregulate the hypothalamus-pituitary-adrenal (HPA) axis, and this dysregulation is a known contributor to the chronic health conditions that firefighters suffer. The HPA axis mediates the stress response by activating the sympathetic nervous system (SNS), resulting in increased heart rate, blood pressure, and blood glucose levels.

Methods: As a biomarker for stress and SNS activation, glucose levels in 15 firefighters were monitored over a 12-day period. Survey data was collected to assess the participant's perceived stress levels during specific events both at work and at home.

Results: Firefighters reliably showed glucose increase during emergency response as well as decrease. Stratifying for perceived stress ranking of the emergency responses affected the magnitude of the glucose change. A positive dose-response relationship was observed between glucose rise and length of the emergency response.

Conclusions: Observing glucose levels as a biomarker for stress offers new insights into the health and wellbeing of firefighters.

The Perception of Heat Strain and its Related Health Impact on Chilean Wildland Firefighters During the 2023-2024 Season

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Introduction: Wildland Firefighters (WLFFs) work is among the most hazardous globally, with annual fatalities attributed to accidents, extreme burns, and physical overexertion (Glover et al., 2024). This work is unique in the physiological, psychological, performance, and safety demands it imposes on its workers (Ruby et al., 2023). WLFFs primarily work outdoors and are often exposed to extreme temperatures while performing high workloads. This study quantified the proportion of WLFFs who reported heat strain and evaluated the associations between different WLFF tasks and the increased odds of reporting heat strain.

Methods: This was a cross-sectional study of 357 Chilean WLFFs in the 2023-2024 season. An interview-administered survey assessed heat strain perception using the Heat Strain Score Index (HSSI), a validated questionnaire consisting of 18 items, including perceived temperature, humidity, air circulation, sweating, fatigue, thirst sensation, uniform characteristics, personal protective equipment, working posture, and symptoms. The HSSI evaluated workplace heat stress using three categories: ≤13.5 "safe level," 13.6–18.0 "caution level," and >18.0 "danger level" (Dehghan et al., 2015). The intensity of the physical effort spent on nine tasks: 1) building fire lines (real wildfire), 2) building fire lines (training), 3) equipment maintenance, 4) hose operations cleaning of dormitories and camp, 5) training and drills, 6) rescue operations 7) walking with equipment (flat) and walking with equipment (slope) was evaluated using the Borg-CR-10 scale where zero indicated no effort and ten indicated maximal effort (Borg, 1982). We assessed the presence of musculoskeletal pain and considered> 5 as the presence of severe pain in the Numeric Pain Rating Scale (NPRS). We analyzed the associations between effort/pain and effort/HSSI.

Results: The WLFFs had an average age of 31.3 (SD=8.9), 50% of which were between 18 and 29 years old, and 95% were under 49. Regarding the HSSI, 88 WLFFs (24.6%) were classified in the safe level, 142 (39.6%) in the caution level, and 128 (35.8%) in the danger level. The average self-reported physical exertion while building fire lines during real wildfires was 7.4 (SD = 2.0) and 5.9 (SD = 2.1) during training. 318 WLFFs (89.1%) reported experiencing intense physical effort during their work, with 5 WLFFs (1.4%) stating that the level of exertion was so extreme that they could not continue their tasks. Furthermore, 306 (85.7%) said ambient heat affected their job performance, including 11 (3.1%) who reported that the heat was so intense that they had to stop working. WLFFs building fire lines during real wildfire events had increased odds of heat strain (OR: 1.22, CI: 1.08–1.39). WLFFs performing fire line construction during real wildfire events (OR: 1.13, CI: 1.02–1.27) and those walking with equipment on a slope (OR: 1.127, CI: 1.02–1.25) had increased odds of musculoskeletal pain. Other tasks, such as building fire lines during training, hose operations, rescue operations, and walking with equipment on flat terrain, showed positive but non-statistically significant associations with musculoskeletal pain.

Conclusions: A high proportion of Chilean WLFFs reported experiencing heat strain. Those who reported associated their heavy workload and high environmental temperatures. Further analysis will investigate other factors that may contribute to heat strain among WLFFs.

The Only Way Is Up: Active Knee Exoskeleton Reduces Muscular Effort in Quadriceps During Weighted Stair Ascent

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Introduction: Firefighters consistently rank stair ascent with gear, which can weigh over 35 kg, as their most demanding activity [1]. Weighted stair climbing requires dynamic motions and large knee torques, which can cause exhaustion in the short term, and overuse injuries in the long term. An active knee exoskeleton could potentially alleviate the physical demand on the wearer by injecting positive energy at key phases of the gait cycle. Similar devices [2] have reduced the metabolic cost for various locomotion activities in previous studies. However, no information is available on the effect of active knee exoskeletons on muscular effort during prolonged weighted stair ascent. Here we show that knee exoskeleton assistance can reduce the net muscular effort in the lower limbs when ascending several flights of stairs while wearing additional weight.

Methods: In this study, eight participants climbed stairs for three minutes at a constant pace while wearing a 9.1 kg vest with and without exoskeletons. Kinematic and electromyographic (EMG) data from both lower limbs were collected to assess user effort. The exoskeletons provided assistive knee extension torque based on thigh angle and angular velocity. To mitigate fatigue effects, half the participants completed the exoskeleton trial first, while the other half began without the devices. Key outcome measures, including peak knee extension speed and quadriceps muscle activation, were analyzed using MATLAB.

Results: Most notably, the average peak quadriceps muscle activation was reduced by 32%. Additionally, a 52% increase in knee extension speed at the start of the gait cycle was observed during the exoskeleton condition.

Conclusions: These findings suggest that active knee exoskeletons can significantly reduce the quadricep's muscular effort during weighted stair ascent. Also, the increase in knee extension speed could help the user ascend stairs faster. This technology shows the potential to aid firefighters by preserving energy for fighting fires and reducing long-term overexertion injuries.

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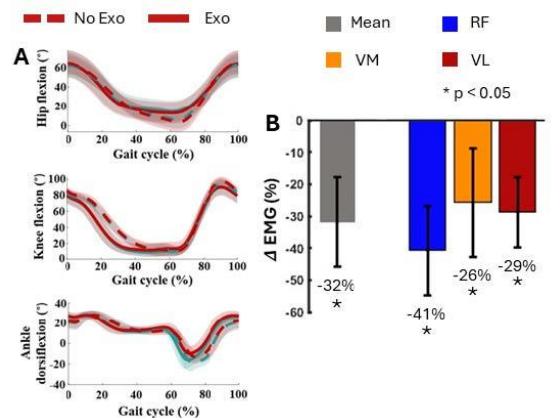
Fig. 1 (A) Lower-limb joint kinematics during stair ascent. Dashed red lines indicate trials without exoskeletons and solid red lines show trials with exoskeletons. (B) Change in the mean peak muscle activation per stride of the rectus femoris (RF), vastus medialis (VM), vastus lateralis (VL) quadricep muscles. EMG data is normalized by the mean peak activation during the no-exoskeleton trial. Asterisks below the bar plots indicate statistically significant differences between the two testing conditions (p < 0.05).

Ergonomic Assessment in an Exotic Fauna Exhibit

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Introduction: Occupational Safety and Health (OSH) in animal care settings, particularly in zoos, is a critical yet often overlooked area. In the United States, more than 2 million people are engaged in occupational activities that involve animals[1]; animal care and health professionals (ACHPs) are among the 200,000 workers employed in animal care and services[1-3]. This study addresses the identification and mitigation of workplace hazards that impact workers handling non-domestic animals. Despite the currently identified risks associated with this profession, many workers remain unprotected by formal OSH programs, making this a global occupational health challenge. The most common type of injury in zookeepers is related to an encounter with a major animal, followed by a back injury[4]; the two areas of the body most frequently involved are the lower back and the upper extremities[5].

Methods: A quantitative observational approach was used to assess the manual material handling (MMH) demands associated with lifting bales of hay, grass, and alfalfa among zookeepers at the fauna exhibit. The tools used to evaluate ergonomic risk were Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), Strain Index (SI), Back Compressive Forces (BCF), and NIOSH-NRLE to assess extreme posture and the main MMH task after a Job Hazard Analysis was done. One zookeeper from the giraffe's enclosure volunteered for the study (N=1). Hand calculations were made for risk estimation through ergonomic instruments.

Results: REBA= 7, moderate risk; the task should be investigated and changed soon. RULA= 7, the high ergonomic risk to the upper body; the task should be investigated so changes can be implemented. Strain index 6.5-6.75; some risk of developing musculoskeletal disorder of the distal upper extremity. BCF = 602lbs; tolerable risk for most healthy workers and does not require immediate investigation. NIOSH Revised Lifting Equation resulted in a Composite Lifting Index of 2.78, which is defined as a moderate risk lift, and changes should be considered.

Conclusions: Analysis with multiple ergonomic assessment tools showed an overall high level of ergonomic stress and risk of developing musculoskeletal disorders for workers involved in this task (except for back compressive force). Abatements need to be implemented to optimize worker performance and decrease the likelihood of work-related injuries.

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The Design of a Lower-Back Support Exoskeleton for Ergonomic Support

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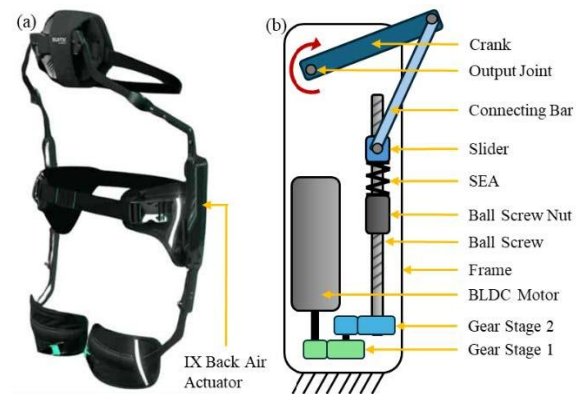3 Department of Biomedical Engineering at the University of Utah, Salt Lake City, UT

Introduction: Workplace injuries cost the United States over 160 billion dollars annually [1]. Of these workplace injuries, approximately 29% are musculoskeletal disorders (MSDs) [2]. Previous research has shown that both passive and active exoskeletons can reduce muscle activation for a wide variety of tasks, increase lifting endurance, and decrease the risk of MSDs [3], [4]. Passive exoskeletons tend to be low-profile but have less ability to adapt to multiple movements and use cases, whereas powered exoskeletons can be controlled to benefit multiple movements at the expense of larger size. Here, we propose the design of a low-profile and high torque-density, powered hip and back support exoskeleton to assist with ergonomics in a range of workplace tasks. By assisting the lower back and hips, we aim to reduce muscle effort in lifting tasks, reduce the risk of MSD, and reduce the exertion required for ambulation.

Methods: Our goal was to design a powered exoskeleton matching the size and profile of popular passive exoskeletons while also providing as large a percentage of the biological torque as possible for a wide range of activities. The exoskeleton actuator consists of a DC motor, two-stage gear reduction, ball screw, and offset slider-crank mechanism with a series elastic element, as shown in Figure 1. To define the desired torque-speed profile for the device, we collected hip joint torque and velocity data for a variety of use cases: walking, stair ascent, stair descent, and weighted squatting [5]. We scaled the torque-speed to a percentage of the values for the average US male to represent the general population. We then modeled the actuator kinematics in MATLAB. We constrained the size of the actuator to match an existing passive exoskeleton and optimized the remaining parameters to fit the hip torque-speed profiles as closely as possible.

Figure 1. (a) IX Back Air (SuitX, USA) [6] (b) Conceptual design of the exoskeleton actuator with labeled components.

Results: Through the simulation, we designed an actuator capable of providing 34 Nm of torque, which is approximately 35% of the biological torque required for the squatting and stooping movements for an average US male. Furthermore, it can provide up to 31%, 87%, and 35% of the torque required for walking, stair ascent, and stair descent, respectively. The actuator is compatible with exoskeleton interfaces from the on-market IX Back Air (SuitX, USA), which allows for easy donning and doffing. The device adds just 2.8 cm laterally to the body and does not interfere with sitting.

Conclusions: Our results suggest that the proposed exoskeleton will be able to provide a large portion of assistance to the user for a variety of tasks. Furthermore, the placement of the device laterally on the hips will aid in the device's low-profile design, preventing the device from hindering the users' movement outside of the design profiles. As such, the device will help reduce the chance of injury to the wearer and improve capabilities for the designed tasks.