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AVIATION AND AEROSPACE

Peter Le, Charles A. Weisenbach, Emily H. L. Mills, Lanie Monforton, Micah J. Kinney. *Exploring the Interaction Between Head-Supported Mass, Posture, and Visual Stress on Neck Muscle Activation*. pp. 365–381.

Objective: Assess neck muscle activity for varying interactions between helmet, posture, and visual stress in a simulated "helo-hunch" posture. **Background:** Military aviators frequently report neck pain (NP). Risk factors for NP include head-supported mass, awkward postures, and mental workload. Interactions between these factors could induce constant low-level muscle activation during helicopter flight and better explain instances of NP. **Method:** Interactions between physical loading (helmet doffed/donned), posture (symmetric/asymmetric), and visual stress (low/high contrast) were studied through neck muscle electromyography (EMG), head kinematics, subjective discomfort, perceived workload, and task performance. Subjects (n = 16) performed eight 30-min test conditions (varied physical loading, posture, and visual stress) while performing a simple task in a simulated "helo-hunch" seating environment. **Results:** Conditions with a helmet donned had fewer EMG median frequency cycles (which infer motor unit rotation for rest/recovery, where more cycles are better) in the left cervical extensor and left sternocleidomastoid. Asymmetric posture (to the right) resulted in higher normalized EMG activity in the right cervical extensor and left sternocleidomastoid and resulted in less lateral bending compared with neutral across all conditions. Conditions with high visual stress also resulted in fewer EMG cycles in the right cervical extensor. **Conclusion:** A complex interaction exists between the physical load of the helmet, postural stress from awkward postures, and visual stress within a simulated "helo-hunch" seating environment. **Application:** These results provide insight into how visual factors influence biomechanical loading. Such insights may assist future studies in designing short-term administrative controls and long-term engineering controls.

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Mengcheng Wang, Chuan Zhao, Alan Barr, Hao Fan, Suihuai Yu, Jay Kapellusch, Carisa Harris Adamson. *Hand Posture and Force Estimation Using Surface Electromyography and an Artificial Neural Network*. pp. 382–402.

Objective: The purpose of this study was to develop an approach to predict hand posture (pinch versus grip) and grasp force using forearm surface electromyography (sEMG) and artificial neural networks (ANNs) during tasks that varied repetition rate and duty cycle. **Background:** Prior studies have used electromyography with machine learning models to predict grip force but relatively few studies have assessed whether both hand posture and force can be predicted, particularly at varying levels of duty cycle and repetition rate. **Method:** Fourteen individuals participated in this experiment. sEMG data for five forearm muscles and force output data were collected. Calibration data (25, 50, 75, 100% of maximum voluntary contraction (MVC)) were used to train ANN models to predict hand posture (pinch versus grip) and force magnitude while performing tasks that varied load, repetition rate, and duty cycle. **Results:** Across all participants, overall hand posture prediction accuracy was 79% (0.79 ± .08), whereas overall hand force prediction accuracy was 73% (0.73 ± .09). Accuracy ranged between 0.65 and 0.93 based on varying repetition rate and duty cycle. **Conclusion:** Hand posture and force prediction were possible using sEMG and ANNs, though there were important differences in the accuracy of predictions based on task characteristics including duty cycle and repetition rate. **Application:** The results of this study could be applied to the development of a dosimeter used for distal upper extremity biomechanical exposure measurement, risk assessment, job (re)design, and return to work programs.

Hongwei Hsiao, Richard Whisler, Bruce Bradtmiller. *Needs and Procedures for a National Anthropometry Study of Law Enforcement Officers*. pp. 403–418

Objectives: This research aims to determine the need and extent for a national anthropometry survey of law enforcement officers (LEOs) via an exploratory investigation of anthropometric changes of LEOs in four decades and comparisons of the LEO data with three existing military and civilian anthropometry sources. **Background:** The best available anthropometric dataset of LEOs is 45 years old and has largely become outdated due to demographic changes. Assessing the extent of anthropometric changes of LEOs through a sample and evaluating the differences of the sample against existing anthropometric datasets is a step toward ascertaining the necessity for a national LEO anthropometry study. **Method:** Thirty-two body dimensions of 67 regional male LEOs and seven female LEOs were measured, and the data of males were compared with the best available LEO anthropometry data from 1975 and three recent non-LEO anthropometry databases. **Results:** Anthropometric dimensions were significantly different between this LEO study and existing data sources, especially in chest circumference and body weight. Most of the significant differences are important differences for LEO protective gear and vehicle design. **Conclusion:** The study confirmed that the existing 45-year-old LEO dataset and recent Army and civilian datasets would not be suitable for armor and equipment design for the current LEO population. **Application:** The study results are useful in supporting the decision of investing in a national LEO anthropometry survey and for equipment manufacturers to recognize the distinctiveness of LEO anthropometry from other populations and the magnitude of anthropometry changes of LEOs over the past 45 years.

Alysha R. Meyers, Steven J. Wurzelbacher, Edward F. Krieg, Jessica G. Ramsey, [...]. *Work-Related Risk Factors for Rotator Cuff Syndrome in a Prospective Study of Manufacturing and Healthcare Workers*. pp. 419–434.

Objective: This prospective study assessed the risk of developing rotator cuff syndrome (RCS) with separate or specific combinations of biomechanical exposures measures, controlling for individual confounders. **Background:** Compared with other musculoskeletal disorders, rates of work-related shoulder musculoskeletal disorders have been declining more slowly. **Method:** We conducted up to 2 years of individual, annual assessments of covariates, exposures, and health outcomes for 393 U.S. manufacturing and healthcare workers without RCS at baseline. Task-level biomechanical exposures assessed exposure to forceful exertions (level, exertion rates, duty cycles), vibration, and upper arm postures (flexion, abduction). Hazard ratios (HRs) were calculated with Cox proportional hazard models. **Results:** We observed 39 incident RCS cases in 694 person-years (incidence rate = 5.62 per 100 person-years). Adjusting for confounders, we found increased risk of incident RCS associated with forceful hand exertions per minute for three upper arm posture tertiles: flexion ≥45° (≥28.2% time, HR = 1.11, CI [1.01, 1.22]), abduction ≥30° (11.9–21.2%-time, HR = 1.18, CI [1.04, 1.34]), and abduction >60° (≥4.8% time, HR = 1.16, CI [1.04, 1.29]). We failed to observe statistically significant effects for other interactions or any separate measures of biomechanical exposure. **Conclusion:** This study highlights the importance of assessing combinations of exposure to forceful repetition and upper arm elevation when developing interventions for preventing RCS. **Application:** Based on these results, interventions that reduce exposure to forceful repetition (i.e., lower force levels and/or slower exertion rates) may reduce the risk of RCS, especially when upper arm elevation cannot be avoided.

SangHoon Yoon, Thierry Lefrançois-Daignault, Julie N. Côté. *The Effect of Cycling While Typing on Patterns of Upper Body Muscle Activation*. pp. 435–449

Objective: To investigate the effect of one's sex and pedaling intensity on upper body muscle activation patterns during typing while cycling. **Background:** Females are at a higher risk for computer work-related musculoskeletal disorders, and mobile workstations have been suggested to induce healthier muscular patterns compared with sitting. However, the neuromuscular characteristics of performing computer work in a cycling workstation have not been investigated. **Method:** Twenty-two participants (10 females) completed a 60-min computer typing task while pedaling on a cycle ergometer at two different intensities (25%, 4% heart rate reserve). Surface electromyography (EMG) was recorded from seven muscles of the upper body. Effects of time, sex, and intensity were assessed for muscle activation (RMS), activation variability (CV), and normalized mutual information (NMI) via generalized estimating equations. **Results:** With time, neck/shoulder CV increased in males during higher pedaling intensity, whereas in females it decreased during lower intensity. In females, RMS of neck/shoulder and NMI of neck/shoulder muscle pairs were lower, whereas forearm RMS was 34.2% higher with higher intensity cycling compared with lower intensity. Lower back RMS decreased 28.3% in the initial half of the task in females, but in males it increased 14.4% in the later half. **Conclusion and application:** Cycling workstation showed a sex- and intensity-specific EMG response. These differing responses should be considered when implementing the use of cycling workstation and may be important for preventing/managing sex-specific muscle fatigue and musculoskeletal disorders.

COGNITION

Man Wu, Qin Gao, Yang Liu. *Exploring the Effects of Interruptions in Different Phases of Complex Decision-Making Tasks*. pp. 450–481.

Objective: The study aims to examine the effects of interruptions in major phases (i.e., problem-identification, alternative-development, and evaluation-and-selection) of complex decision-making tasks. **Background:** The ability to make complex decisions is of increasing importance in workplaces. Complex decision-making involves a multistage process and is likely to be interrupted, given the ubiquitous prevalence of interruptions in workplaces today. **Method:** Sixty participants were recruited for the experiment to complete a procurement task, which required them to define goals, search for alternatives, and consider multiple attributes of alternatives to make decisions. Participants in the three experimental conditions were interrupted to respond to messages during one of these three phases, whereas participants in the control condition were not interrupted. The impacts of interruptions on performance, mental workload, and emotional states were measured through a combination of behavioral, physiological, and subjective evaluations. **Results:** Only participants who were interrupted in the evaluation-and-selection phase exhibited poorer task performance, despite their positive feelings toward interruptions and confidence. Participants who were interrupted in the problem-identification phase reported higher mental workload and more negative perceptions toward interruptions. Interruptions in the alternative-development phase led to more temporal changes in arousal and valence than interruptions in other phases. **Conclusion:** Interruptions during the evaluation-and-selection phase undermine overall performance, and there is a discrepancy between behavioral outcomes and subjective perceptions of interruption effects. **Application:** Interruptions should be avoided in the evaluation-and-selection phase in complex decision-making. This phase information can be either provided by users or inferred from coarse-grained interaction activities with decision-making information systems.

ENVIRONMENTAL DESIGN

Caleb C. Burruss, Elizabeth Bjornsen, Kaitlin M. Gallagher. *Examining Potential User Experience Trade-Offs Between Common Computer Display Configurations*. pp. 482–494.

Objective: To determine how ultrawide (UW) and dual displays configurations can influence neck biomechanics and performance compared to a single display. **Background:** Studies have assessed neck kinematics and performance when using dual displays, but these studies have used screen sizes smaller than today's display size, have inconsistent participant placement, and few have assessed these two variables together. **Methods:** Seventeen participants completed five tasks on six display configurations. Neck kinematics and performance were tracked for each configuration. **Results:** Centered configurations produced significantly different median neck rotation angles compared to secondary configurations ($p < .001$) for three of the tasks. A 34" curved UW display with a longer viewing distance produced similar neck kinematics to a single 24" display with the potential to also reduce screen interactions. When compared to single, the benefit of secondary versus centered monitors was dependent on the type of task being performed. Users may prefer the UW, centered dual, and secondary dual configurations over the single display. **Conclusion:** The benefit of secondary versus centered displays is dependent on the type of task being performed. Dual displays are still beneficial but should be used with a monitor arm to switch between centered and secondary configurations as necessary. Future work should look at larger UW displays to see if these results hold compared to dual display configurations. **Application:** The

results can be used to make evidence-based guidelines for displays based on size and task. Researchers can use this information to design future studies looking at specific configurations.

HEALTH CARE/HEALTH SYSTEMS

Marc Friberg, Carl-Oscar Jonson, Victor Jaeger, Erik Prytz. *The Effects of Stress on Tourniquet Application and CPR Performance in Layperson and Professional Civilian Populations*. pp. 495–507.

Objective: The purpose of this study was to compare laypeople's and professional first responders' ability to perform tourniquet application and cardiopulmonary resuscitation (CPR) during calm and stressful circumstances. **Background:** Life-threatening bleeding is a major cause of death that could be prevented by fast and appropriate first aid interventions. Therefore, laypeople are now being trained in bleeding control skills, transforming them from bystanders to immediate responders. However, critics have questioned whether laypeople are able to perform during more stressful conditions. **Method:** Twenty-four laypersons and 31 professional first responders were tested in two conditions: a calm classroom scenario and a stressful scenario consisting of paintball fire and physical exertion. Stress and workload were assessed along with task performance. **Results:** The experimental manipulation was successful in terms of eliciting stress reactions. Tourniquet application performance did not decline in the stressful condition, but some aspects of CPR performance did for both groups. First responders experienced higher task engagement and lower distress, worry and workload than the laypeople in both the calm and stressful conditions. **Conclusion:** Stress did not affect first responders and laypeople differently in terms of performance effects. Stress should therefore not be considered a major obstacle for teaching bleeding control skills to laypeople. **Application:** Tourniquet application can be taught to laypeople in a short amount of time, and they can perform this skill during stress in controlled settings. Concerns about laypeople's ability to perform under stress should not exclude bleeding control skills from first aid courses for civilian laypeople.

HUMAN-COMPUTER INTERACTION, COMPUTER SYSTEMS

Anahita Sanandaji, Cindy Grimm, Ruth West, Christopher A. Sanchez. *Developing and Validating a Computer-Based Training Tool for Inferring 2D Cross-Sections of Complex 3D Structures*. pp. 508–528.

Objective: Developing and validating a novel domain-agnostic, computer-based training tool for enhancing 2D cross-section understanding of complex 3D structures. **Background:** Understanding 2D cross-sections of 3D structures is a crucial skill in many disciplines, from geology to medical imaging . It requires a complex set of spatial/visualization skills including mental rotation, spatial structure understanding, and viewpoint projection. Prior studies show that experts differ from novices in these skills. **Method:** We have developed a novel training tool for inferring 2D cross-sections of 3D structures using a participatory design methodology. We used a between-subject study design, with 60 participants, to evaluate the training tool. Our primary effectiveness evaluation was based on pre- and postspatial tests that measured both cross-section abilities and specific spatial skills: viewpoint, mental rotation, and card rotation. **Results:** Results showed significant performance gains on inferring 2D cross-sections for participants of the training group. Our tool improves two other spatial skills as well: mental rotation and viewpoint visualization. **Conclusion:** Our training tool was effective

not only in enhancing 2D cross-section understanding of complex 3D structures, but also in improving mental rotation and viewpoint visualization skills. **Application:** Our tool can be beneficial in different fields such as medical imaging, biology, geology, and engineering. For example, an application of our tool is in medical/research labs to train novice segmenters in ongoing manual 3D segmentation tasks. It can also be adapted in other contexts, such as training children, older adults, and individuals with very low spatial skills.