

Human Factors – rok 2017, roč. 59

Číslo 7 (November)



ACCIDENTS, HUMAN ERROR

Marcus Yung, Rahim Manji, Richard P. Wells. *Exploring the Relationship of Task Performance and Physical and Cognitive Fatigue During a Daylong Light Precision Task*. pp. 1029–1047.

Objective: Our aim was to explore the relationship between fatigue and operation system performance during a simulated light precision task over an 8-hr period using a battery of physical (central and peripheral) and cognitive measures. **Background:** Fatigue may play an important role in the relationship between poor ergonomics and deficits in quality and productivity. However, well-controlled laboratory studies in this area have several limitations, including the lack of work relevance of fatigue exposures and lack of both physical and cognitive measures. There remains a need to understand the relationship between physical and cognitive fatigue and task performance at exposure levels relevant to realistic production or light precision work. **Method:** Errors and fatigue measures were tracked over the course of a micropipetting task. Fatigue responses from 10 measures and errors in pipetting technique, precision, and targeting were submitted to principal component analysis to descriptively analyze features and patterns. **Results:** Fatigue responses and error rates contributed to three principal components (PCs), accounting for 50.9% of total variance. Fatigue responses grouped within the three PCs reflected central and peripheral upper extremity fatigue, postural sway, and changes in oculomotor behavior. **Conclusion:** In an 8-hr light precision task, error rates shared similar patterns to both physical and cognitive fatigue responses, and/or increases in arousal level. **Application:** The findings provide insight toward the relationship between fatigue and operation system performance (e.g., errors). This study contributes to a body of literature documenting task errors and fatigue, reflecting physical (both central and peripheral) and cognitive processes.

- **Keywords:** fatigue, errors, performance, low-load work, work measurement

BIOMECHANICS, ANTHROPOMETRY, WORK PHYSIOLOGY

Benjamin Steinhilber, Florian Reiff, Robert Seibt, Monika A. Rieger, Peter Martus, Bernhard Kraemer, Ralf Rothmund. *Ergonomic Benefits From a*

Laparoscopic Instrument With Rotatable Handle Piece Depend on the Area of the Operating Field and Working Height. pp. 1048–1065.

Objective: To evaluate the effect of a laparoscopic instrument with a 360° rotatable handle piece (rot-HP) on biomechanical stress and precision in different areas of a simulated operating field at two working heights. **Background:** Surgeons performing laparoscopic procedures are exposed to biomechanical stress and have an increased risk of musculoskeletal complaints. **Method:** Fifty-seven healthy subjects (27 men, median age 26) without experience in laparoscopy performed a precision task in four quadrants (A–D) of the operating field using the rot-HP or a common fixed handle piece (fixed-HP) at an individually adjusted lower or higher working height. Biomechanical stress was assessed by surface EMG, wrist joint angles, and arm postures and precision by the number of mistakes. **Results:** Using the rot-HP reduced muscle activity of the biceps brachii and flexor carpi radialis muscle. An interaction of flexor activity and area of the operating field occurred with the lowest activity in Quadrant C. Wrist joint angles were more neutral using the rot-HP, especially when the lower working height was applied and in Quadrants B and C. However, increased wrist dorsal flexion occurred in Quadrant A while using the rot-HP. Arm postures and precision were less affected. **Conclusion:** The rot-HP allows some reductions of stresses in the arm and hand region, whereas the stress in the shoulder neck region is not modified. **Application:** The instrument's position and the working height may have to be considered as mediatory factors when describing the effectiveness of an ergonomic handle design for laparoscopic instruments.

- **Keywords:** laparoscopy, ergonomic handle piece, physical stress, sEMG

Kristina M. Gruevski, Joanne N. Hodder, Peter J. Keir. Upper Extremity Muscle Activity During In-Phase and Anti-Phase Continuous Pushing Tasks. pp. 1066–1077.

Objective: To determine the effect of anti-phase, in-phase bimanual and unimanual simulated industrial pushing tasks and frequency on upper extremity muscle activity. **Background:** Research investigating symmetrical (in-phase) and asymmetrical (anti-phase) pushing exertions is limited despite a high prevalence in industry. **Methods:** Fifteen female participants completed five pushing tasks using a dual handle apparatus at three frequencies: 15 cycles per minute (cpm), 30 cpm, and self-selected. Tasks included two bimanual symmetrical pushes (constrained and unconstrained), two bimanual asymmetrical pushes (reciprocating and continuous), and one right unimanual push. Surface electromyography (EMG) from the right anterior, middle, and posterior deltoid (AD, MD, and PD); right and left trapezius (RT and LT); right pectoralis major (PM); and right and left external obliques (REO and LEO) was collected and normalized to maximum voluntary effort. **Results:** There was a task by frequency interaction in the AD, MD, PD, and RT ($p < .005$), where activity in AD, MD, and PD was highest in the continuous task at 15 cpm, but activity was similar across task in 30 cpm and self-selected. Muscle activity coefficient of variation was lowest during continuous task across all frequencies. **Conclusion:** Continuous, anti-phase pushes and constrained, in-phase pushes had the highest muscle activity demands and the least amount of variability in muscle activity and therefore may present the greatest risk of injury. **Application:** Anti-phase pushing is known to have a greater cognitive demand, and this study demonstrated that it also has a greater physical demand when performed continuously.

- **Keywords:** work-related musculoskeletal disorders, coordinated action, repetition, electromyography

Jill Burns, Cuisle Forde, Sara Dockrell. Energy Expenditure of Standing Compared to Sitting While Conducting Office Tasks. pp. 1078–1087.

Objectives: This study aimed to investigate the energy expenditure of common office-based tasks. The objectives were to: (a) test the classification of tasks as sedentary or light-intensity physical activity and (b) compare the energy expenditure of tasks under two postural conditions (sitting and standing). **Background:** The sedentary nature of office work has been highlighted as a health risk, and strategies to reduce sedentary behavior at work have been developed. However, there is limited evidence to guide the utilization of sit-stand workstations in the workplace for metabolic health benefits. **Method:** A repeated measures laboratory-based study compared the energy expenditure of common office tasks in sitting and standing using indirect calorimetry ($n = 22$). Four standardized tasks (sitting/standing quietly, reading, typing, sorting paper) under two postural conditions (sitting, standing) were performed in a randomized order. **Results:** The mean energy expenditure for all tasks in sitting and standing was <1.5 METs. There were no significant differences in the energy expenditure of doing the same task in sitting compared to standing. In a repeated measures ANOVA, task ($p < .001$) had a greater influence on METs expended than posture ($p = .030$). **Conclusion:** The study confirmed that the difference in energy expenditure of tasks carried out in sitting compared to standing is negligible. **Application:** The ubiquitous use and utility of sit-stand workstations in the workplace needs to be reviewed. Notwithstanding the potential benefits of movement that may occur naturally, this study confirmed that standing as opposed to sitting does not produce a clinically important increase in energy expenditure.

- **Keywords:** sitting, standing, energy expenditure, occupational, sit-stand workstation

Victoria MacDonald, Katherine Wilson, Michael W. L. Sonne, Peter J. Keir. *Grip Type Alters Maximal Pinch Forces in Syringe Use.* pp. 1088–1095.

Objective: The purpose of this study was to determine maximum forces during syringe use for different grips found in the field. **Background:** Prolonged syringe use in chemotherapy drug delivery is associated with pain and injury in nurses and technicians. **Method:** Twenty healthy female hospital workers generated isometric maximum voluntary force using a 30 cc syringe with four pinch grips (chuck, chuck variation, thenar, two-handed). Both dominant and nondominant hands were used with the syringe plunger fixed in wide (8.3 cm) and narrow (2.5 cm) grip spans. Participants were encouraged to position the apparatus in the most comfortable position and exert a maximal effort for 5 seconds. **Results:** Significant interaction effects were found: Grip Span \times Pinch Type, Hand \times Pinch Type, and Grip Span \times Hand \times Pinch Type ($p < .05$). The results demonstrated that the thenar (103.6 ± 22.9 N) and two-handed (104.7 ± 17.1 N) pinches produced the highest forces. **Conclusion:** Thenar and two-handed pinch grips may be the preferred pinch type to lower the relative efforts required to use a syringe and may be one strategy to assist with reduction of musculoskeletal disorder risk associated with syringe use. **Application:** Determining maximal syringe press forces allows workers and ergonomists to develop better strategies for managing the cumulative loads during drug delivery and mixing.

- **Keywords:** pinch strength, biomechanics, thumb, syringe, grip

COGNITION

Michael A. Rupp, Richard Sweetman, Alejandra E. Sosa, Janan A. Smither, Daniel S. McConnell. *Searching for Affective and Cognitive Restoration: Examining the Restorative Effects of Casual Video Game Play.* pp. 1096–1107.

Objective: We investigated the effects of a passive break, relaxation activity, and casual video game on affect, stress, engagement, and cognitive performance. **Background:** Reducing stress and improving cognitive performance is critical across many domains.

Previous studies investigated taking a break, relaxation techniques, or playing a game; however, these methods have not been compared within a single experiment. **Method:** Participants completed a baseline affective and cognitive assessment (ACA), which included the Positive and Negative Affect Schedule, shortened version of the Dundee Stress State Questionnaire, and backward digit-span. Next, participants completed a vigilance task, followed by another ACA. Participants were then assigned at random to complete a break or relaxation activity or play a casual video game, followed by a final ACA. **Results:** Participants who played the casual video game exhibited greater engagement and affective restoration than the relaxation condition. The break condition slightly decreased affect and prevented cognitive restoration. **Conclusion:** Playing a casual video game even briefly can restore individuals' affective abilities, making it a suitable activity to restore mood in response to stress. However, future research is needed to find activities capable of cognitive restoration. **Application:** Many activities in life require sustained cognitive demand, which are stressful and decrease performance, especially for workers in performance-critical domains. Our research suggests some leisure activities are better than others for restoring fatigued affective processes.

- **Keywords:** fatigue, stress, cognition, vigilance, mindfulness, guided relaxation

HEALTH CARE/HEALTH SYSTEMS

Judy Edworthy, Scott Reid, Siné McDougall, Jonathan Edworthy, Stephanie Hall, Danielle Bennett, James Khan, Ellen Pye. *The Recognizability and Localizability of Auditory Alarms: Setting Global Medical Device Standards.* pp. 1108–1127.

Objective: Four sets of eight audible alarms matching the functions specified in IEC 60601-1-8 were designed using known principles from auditory cognition with the intention that they would be more recognizable and localizable than those currently specified in the standard. **Background:** The audible alarms associated with IEC 60601-1-8, a global medical device standard, are known to be difficult to learn and retain, and there have been many calls to update them. There are known principles of design and cognition that might form the basis of more readily recognizable alarms. There is also scope for improvement in the localizability of the existing alarms. **Method:** Four alternative sets of alarms matched to the functions specified in IEC 60601-1-8 were tested for recognizability and localizability and compared with the alarms currently specified in the standard. **Results:** With a single exception, all prototype sets of alarms outperformed the current IEC set on both recognizability and localizability. Within the prototype sets, auditory icons were the most easily recognized, but the other sets, using word rhythms and simple acoustic metaphors, were also more easily recognized than the current alarms. With the exception of one set, all prototype sets were also easier to localize. **Conclusion:** Known auditory cognition and perception principles were successfully applied to an existing audible alarm problem. **Application:** This work constitutes the first (benchmarking) phase of replacing the alarms currently specified in the standard. The design principles used for each set demonstrate the relative ease with which different alarm types can be recognized and localized.

- **Keywords:** audition, auditory displays, learning, medical device technologies

SENSORY AND PERCEPTUAL PROCESSES

Samantha Horvath, Kori Macdonald, John Galeotti, Roberta L. Klatzky. *Slant Perception Under Stereomicroscopy.* pp. 1128–1138.

Objective: These studies used threshold and slant-matching tasks to assess and quantitatively measure human perception of 3-D planar images viewed through a

stereomicroscope. The results are intended for use in developing augmented-reality surgical aids. **Background:** Substantial research demonstrates that slant perception is performed with high accuracy from monocular and binocular cues, but less research concerns the effects of magnification. Viewing through a microscope affects the utility of monocular and stereo slant cues, but its impact is as yet unknown. **Method:** Participants performed in a threshold slant-detection task and matched the slant of a tool to a surface. Different stimuli and monocular versus binocular viewing conditions were implemented to isolate stereo cues alone, stereo with perspective cues, accommodation cue only, and cues intrinsic to optical-coherence-tomography images. **Results:** At magnification of 5x, slant thresholds with stimuli providing stereo cues approximated those reported for direct viewing, about 12°. Most participants (75%) who passed a stereoacuity pretest could match a tool to the slant of a surface viewed with stereo at 5x magnification, with mean compressive error of about 20% for optimized surfaces. Slant matching to optical coherence tomography images of the cornea viewed under the microscope was also demonstrated. **Conclusion:** Despite the distortions and cue loss introduced by viewing under the stereomicroscope, most participants were able to detect and interact with slanted surfaces. **Application:** The experiments demonstrated sensitivity to surface slant that supports the development of augmented-reality systems to aid microscope-aided surgery.

- **Keywords:** vision, perception-action, medical devices and technologies, radiology and medical imaging, information processing, visual displays, pictorial displays, object displays

TRAINING, EDUCATION, INSTRUCTIONAL SYSTEMS

Svyatoslav Guznov, Gerald Matthews, Joel S. Warm, Marc Pfahler.
Training Techniques for Visual Search in Complex Task Environments.
pp. 1139–1152.

Objective: The goal for this study was to evaluate several visual search training techniques in an unmanned aerial vehicle (UAV) simulated task environment. **Background:** Operators controlling remote unmanned vehicles often must perform complex visual search tasks (e.g., target search). These tasks may pose substantial demands on the operator due to various environmental factors. Visual search training may reduce errors and mitigate stress, but the most effective form of training has not been determined. **Methods:** Participants were assigned to one of four training conditions: target, cue, visual scanning, or control. After the training, the effectiveness of the training techniques was tested during a 30-minute simulated UAV flight. A secondary task manipulation was included to further simulate the demands of a realistic UAV control and target search task. Subjective stress and fatigue were also assessed. **Results:** Target training produced superior target search performances in more hits and fewer false alarms (FAs) when compared to the control condition. The visual scanning and cue trainings were moderately effective. Only target training performance was vulnerable to the secondary task load. The task was stressful, but training did not mitigate stress response. **Conclusion:** Training participants on the target and the cue appearance as well as active scanning of the visual field is promising for promoting effective target search for this simulated UAV environment. **Application:** These training techniques could be used in preparation for intelligence, surveillance, and reconnaissance (ISR) missions that involve target search, especially where target appearance change is likely.

- **Keywords:** visual search, training, stress, simulators, unmanned aerial vehicles