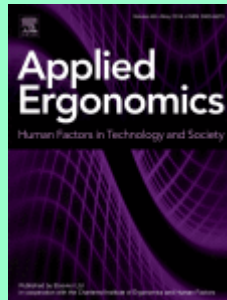


Applied Ergonomics - rok 2018, Volume 66

January 2018



Robert F. Granzow, Mark C. Schall, Mathew F. Smidt, Howard Chen, Nathan B. Fethke, Rong Huangfu. Characterizing exposure to physical risk factors among reforestation hand planters in the Southeastern United States. Pages 1-8.

Abstract: Low back and neck/shoulder pain are commonly reported among reforestation hand planters. While some studies have documented the intensive cardiovascular demands of hand planting, limited information is available regarding exposures to physical risk factors associated with the development of musculoskeletal disorders (MSDs) among hand planters. This study used surface electromyography (EMG) and inertial measurement units (IMUs) to characterize the muscle activation patterns, upper arm and trunk postures, movement velocities, and physical activity (PA) of fourteen Southeastern reforestation hand planters over one work shift. Results indicated that hand planters are exposed to physical risk factors such as extreme trunk postures (32.5% of time spent in $\geq 45^\circ$ trunk flexion) and high effort muscle exertions (e.g., mean root-mean-square right upper trapezius amplitude of 54.1% reference voluntary exertion) that may place them at increased risk for developing MSDs. The findings indicate a need for continued field-based research among hand planters to identify and/or develop maximally effective interventions.

- **Keywords:** Musculoskeletal disorders; Posture; Physical activity; Low back; Shoulder; Inertial measurement unit

John L. Pape, Jean-Michel Brismée, Phillip S. Sizer, Omer C. Matthijs, Kevin L. Browne, Birendra M. Dewan, Stéphane Sobczak. Increased spinal height using propped slouched sitting postures: Innovative ways to rehydrate intervertebral discs. Pages 9-17.

Background: Upright and slouched sitting are frequently adopted postures associated with increased intradiscal pressure, spinal height loss and intervertebral disc pathology. **Objectives:** To examine the effects of two sustained propped slouched sitting (PSS) postures on spinal height after a period of trunk loading. **Methods:** Thirty-four participants without a history of low back pain (LBP) were recruited (age 24.4 ± 1.6 years). Subjects sat in (1) PSS without lumbar support and (2) PSS with lumbar support for 10 min, after a period of trunk loading. Spinal height was measured using a stadiometer. **Results:** Mean spinal height increase during PSS without lumbar support was 2.94 ± 3.63 mm and with lumbar support 4.74 ± 3.07 mm. **Conclusions:** Both PSS with and without lumbar support significantly increased spinal height after a period of

trunk loading ($p < 0.001$). Such PSS postures can provide a valuable alternative to upright sitting and may be recommended for recovering spinal height in the working environment following periods of loading.

- **Keywords:** Spine; Ergonomics; Sitting posture

Moritz Körber, Eva Baseler, Klaus Bengler. [Introduction matters: Manipulating trust in automation and reliance in automated driving.](#) **Pages 18-31.**

Trust in automation is a key determinant for the adoption of automated systems and their appropriate use. Therefore, it constitutes an essential research area for the introduction of automated vehicles to road traffic. In this study, we investigated the influence of trust promoting (Trust promoted group) and trust lowering (Trust lowered group) introductory information on reported trust, reliance behavior and take-over performance. Forty participants encountered three situations in a 17-min highway drive in a conditionally automated vehicle (SAE Level 3). Situation 1 and Situation 3 were non-critical situations where a take-over was optional. Situation 2 represented a critical situation where a take-over was necessary to avoid a collision. A non-driving-related task (NDRT) was presented between the situations to record the allocation of visual attention. Participants reporting a higher trust level spent less time looking at the road or instrument cluster and more time looking at the NDRT. The manipulation of introductory information resulted in medium differences in reported trust and influenced participants' reliance behavior. Participants of the Trust promoted group looked less at the road or instrument cluster and more at the NDRT. The odds of participants of the Trust promoted group to overrule the automated driving system in the non-critical situations were 3.65 times (Situation 1) to 5 times (Situation 3) higher. In Situation 2, the Trust promoted group's mean take-over time was extended by 1154 ms and the mean minimum time-to-collision was 933 ms shorter. Six participants from the Trust promoted group compared to no participant of the Trust lowered group collided with the obstacle. The results demonstrate that the individual trust level influences how much drivers monitor the environment while performing an NDRT. Introductory information influences this trust level, reliance on an automated driving system, and if a critical take-over situation can be successfully solved.

- **Keywords:** Automated driving; Trust in automation; Reliance

Wen-Ruey Chang, Xu Xu. [Identification of heel strike under a slippery condition.](#) **Pages 32-40.**

Kinematics at heel strike instant (HSI) has been used to quantify slip severity. However, methods to identify HSI remain ambiguous and have not been evaluated under slippery conditions. A glass force plate was used to observe the contact interface between shoe and floor under slippery conditions. HSIs identified from the video captured beneath the force plate and from the force plate and kinematics were compared. The results showed that HSIs identified with the video were closer to those identified with the normal force threshold (NFT) ($9.0 \text{ ms} \pm 5.5 \text{ ms}$) than were most of those identified with kinematics. Slips with a longer distance travelled between NFT HSI and video HSI had a larger heel horizontal velocity ($>0.8 \text{ m/s}$) and a smaller foot angular velocity ($<100 \text{ deg/s}$) at the NFT instant, and were still part of the forward swing. The results show that improved methods are needed over NFT to identify HSI, especially under slippery conditions.

- **Keywords:** Heel contact; High speed camera; Kinematics; Force plate

Amy Z.Q. Chung, Ann Williamson. [Theory versus practice in the human factors and ergonomics discipline: Trends in journal publications from 1960 to 2010](#). Pages 41-51.

The research-practice gap has been highlighted as a barrier to effective practice in human factors and ergonomics (HFE). There is also evidence of a theory-research gap that may be limiting the scientific evidence base of HFE. The purpose of this study was to examine trends in journal publications, especially relating to the research-practice gap and the involvement of theory over time. A content analysis was conducted on 425 journal articles published in Human Factors, Ergonomics, and Applied Ergonomics from 1960 to 2010. Results showed evidence of growth in applied research with increasing collaborative research between research and industry, larger research teams, and more empirical research—especially on applied problems. While there has been a corresponding increase in the involvement of theory in HFE publications, around half of the publications failed to acknowledge theory. This calls into question whether the HFE discipline may be missing the benefits of theory to guide research and subsequent practice, and to enhance the development of new ideas.

- **Keywords:** Research publications; Theory; Practice

Amitava Halder, Kalev Kuklane, Chuansi Gao, Michael Miller, Mattias Delin, Johan Norén, Karl Fridolf. [Limitations of oxygen uptake and leg muscle activity during ascending evacuation in stairways](#). Pages 52-63.

Stair ascending performance is critical during evacuation from buildings and underground infrastructures. Healthy subjects performed self-paced ascent in three settings: 13 floor building, 31 floor building, 33 m stationary subway escalator. To investigate leg muscle and cardiorespiratory capacities and how they constrain performance, oxygen uptake (VO₂), heart rate (HR) and ascending speed were measured in all three; electromyography (EMG) in the first two. The VO₂ and HR ranged from 89 to 96% of the maximum capacity reported in the literature. The average highest VO₂ and HR ranged from 39 to 41 mL·kg⁻¹·min⁻¹ and 162 to 174 b·min⁻¹, respectively. The subjects were able to sustain their initial preferred maximum pace for a short duration, while the average step rate was 92–95 steps·min⁻¹. In average, VO₂ reached relatively stable values at ≈37 mL·kg⁻¹·min⁻¹. EMG amplitudes decreased significantly and frequencies were unchanged. Speed reductions indicate that climbing capacity declined in the process of fatigue development. In the two buildings, the reduction of muscle power allowed the subjects to extend their tolerance and complete ascents in the 48 m and 109 m high stairways in 2.9 and 7.8 min, respectively. Muscle activity interpretation squares were developed and proved advantageous to observe fatigue and recovery over time.

- **Keywords:** Physical capacity; Stair climbing; Oxygen consumption; Electromyography; Muscle fatigue

M.W. Hill, M.J. Duncan, S.W. Oxford, A.D. Kay, M.J. Price. [Effects of external loads on postural sway during quiet stance in adults aged 20–80 years](#). Pages 64-69.

The purpose of this study was to investigate the effects of holding external loads on postural sway during upright stance across age decades. Sixty-five healthy adults (females, n = 35), aged 18–80 years were assessed in four conditions; (1) standing without holding a load, holding a load corresponding to 5% body mass in the (2) left hand, (3) right hand and (4) both hands. The centre of pressure (COP) path length and anteroposterior and mediolateral COP displacement were used to indirectly assess postural sway. External loading elicited reductions in COP measures of postural sway in older age groups only (P < 0.05). No changes were observed in younger or intermediate

aged adults ($P > 0.05$). Holding external loads during standing is relevant to many activities of daily living (i.e. holding groceries). The reduction in postural sway may suggest this type of loading has a stabilising effect during quiet standing among older adults.

- **Keywords:** Functional balance; External loads; Grocery bags; Postural stability; Age-related changes

Lauren A. Murphy, Yueng-hsiang Huang, Michelle M. Robertson, Susan Jeffries, Marvin J. Dainoff. [*A sociotechnical systems approach to enhance safety climate in the trucking industry: Results of an in-depth investigation.*](#) **Pages 70-81.**

The purpose of this study was to develop a methodology that extends safety climate beyond an overall score by using the framework of macroergonomics to examine the entire system in a more comprehensive manner. The study is discussed in two papers: one paper describes the study methodology in detail (Murphy, Robertson, Huang, Jeffries, & Dainoff, in press), and the current paper describes the results of the study. Multiple methods were combined to create a systems approach, and those methods include the critical incident technique, contextual inquiries with functional role diagrams, and affinity mapping. Key informants in the trucking industry identified 19 themes that affect safety. The themes ranged from balancing work and family/personal time, the company's policy vs. practice, respecting the job of the driver, and active listening and meaningful feedback. The most prominent themes were related to the workers and their activities; the internal environment, including psychosocial job design elements; and organizational design. Such information can be used to design interventions to change the safety climate of an organization in order to reduce negative safety outcomes.

- **Keywords:** Macroergonomics; Safety climate; Sociotechnical systems theory

Lauren A. Murphy, Michelle M. Robertson, Yueng-hsiang Huang, Susan Jeffries, Marvin J. Dainoff. [*A sociotechnical systems approach to enhance safety climate in the trucking industry: Development of a methodology.*](#) **Pages 82-88.**

The systems approach is increasingly used as a framework within which to examine safety climate. Utilizing a macroergonomics approach to design work systems can help identify aspects of human-technology-organization interfaces that impact workers' perceptions of safety, both positively and negatively. Such an approach also supplements traditional uses of safety climate as a leading indicator of safety and helps expand research toward an approach that can determine problems impacting safety. The purpose of this study was to develop a methodology that extends safety climate beyond just an overall score by using the framework of macroergonomics to examine the entire system in a more comprehensive manner. The proposed methodology can be used as a way to identify gaps in the specific work system, and this information can be used to design interventions to change the safety climate, and ultimately the culture, of an organization in order to reduce negative safety outcomes.

- **Keywords:** Macroergonomics; Safety climate; Sociotechnical systems theory

Shilei Lu, Bo Pang, Yunfang Qi, Kun Fang. [*Field study of thermal comfort in non-air-conditioned buildings in a tropical island climate.*](#) **Pages 89-97.**

The unique geographical location of Hainan makes its climate characteristics different from inland areas in China. The thermal comfort of Hainan also owes its uniqueness to its

tropical island climate. In the past decades, there have been very few studies on thermal comfort of the residents in tropical island areas in China. A thermal environment test for different types of buildings in Hainan and a thermal comfort field investigation of 1944 subjects were conducted over a period of about two months. The results of the survey data show that a high humidity environment did not have a significant impact on human comfort. The neutral temperature for the residents in tropical island areas was 26.1 °C, and the acceptable temperature range of thermal comfort was from 23.1 °C to 29.1 °C. Residents living in tropical island areas showed higher heat resistance capacity, but lower cold tolerance than predicted. The neutral temperature for females (26.3 °C) was higher than for males (25.8 °C). Additionally, females were more sensitive to air temperature than males. The research conclusions can play a guiding role in the thermal environment design of green buildings in Hainan Province.

- **Keywords:** Tropical island; Thermal comfort temperature; Thermal neutral temperature; Non-air-conditioned buildings; Building energy efficiency

Jessica A. Dobson, Diane L. Riddiford-Harland, Alison F. Bell, Julie R. Steele. [*Are underground coal miners satisfied with their work boots?*](#) **Pages 98-104.**

Dissatisfaction with work boot design is common in the mining industry. Many underground coal miners believe their work boots contribute to the high incidence of lower limb injuries they experience. Despite this, the most recent research to examine underground coal mining work boot satisfaction was conducted over a decade ago. This present study aimed to address this gap in the literature by assessing current mining work boot satisfaction in relation to the work-related requirements for underground coal mining. 358 underground coal miners (355 men; mean age = 39.1 ± 10.7 years) completed a 54-question survey regarding their job details, work footwear habits, foot problems, lower limb and lower back pain history, and work footwear fit and comfort. Results revealed that underground coal miners were not satisfied with their current mining work boots. This was evident in the high incidence of reported foot problems (55.3%), lower back pain (44.5%), knee pain (21.5%), ankle pain (24.9%) and foot pain (42.3%). Over half of the underground coal miners surveyed believed their work boots contributed to their lower limb pain and reported their work boots were uncomfortable. Different working roles and environments resulted in differences in the incidence of foot problems, lower limb pain and comfort scores, confirming that one boot design cannot meet all the work-related requirements of underground coal mining. Further research examining the interaction of a variety of boot designs across the different underground surfaces and the different tasks miners perform is paramount to identify key boot design features that affect the way underground coal miners perform. Enhanced work boot design could improve worker comfort and productivity by reducing the high rates of reported foot problems and pain amongst underground coal miners.

- **Keywords:** Boots; Mining; Pain

Emilene Zitkus, Patrick Langdon, P. John Clarkson. [*Gradually including potential users: A tool to counter design exclusions.*](#) **Pages 105-120.**

The paper describes an iterative development process used to understand the suitability of different inclusive design evaluation tools applied into design practices. At the end of this process, a tool named Inclusive Design Advisor was developed, combining data related to design features of small appliances with ergonomic task demands, anthropometric data and exclusion data. When auditing a new design the tool examines the exclusion that each design feature can cause, followed by objective recommendations directly related to its features. Interactively, it allows designers or clients to balance design changes with the exclusion caused. It presents the type of information that

enables designers and clients to discuss user needs and make more inclusive design decisions.

- **Keywords:** Ergonomic task demands; Design practice; Inclusive design tool; Design for all; Universal design

K. Hamouda, S. Rakheja, K.N. Dewangan, P. Marcotte. [Fingers' vibration transmission and grip strength preservation performance of vibration reducing gloves](#). Pages 121-138.

The vibration isolation performances of vibration reducing (VR) gloves are invariably assessed in terms of power tools' handle vibration transmission to the palm of the hand using the method described in ISO 10819 (2013), while the nature of vibration transmitted to the fingers is ignored. Moreover, the VR gloves with relatively low stiffness viscoelastic materials affect the grip strength in an adverse manner. This study is aimed at performance assessments of 12 different VR gloves on the basis of handle vibration transmission to the palm and the fingers of the gloved hand, together with reduction in the grip strength. The gloves included 3 different air bladder, 3 gel, 3 hybrid, and 2 gel-foam gloves in addition to a leather glove. Two Velcro finger adapters, each instrumented with a three-axis accelerometer, were used to measure vibration responses of the index and middle fingers near the mid-phalanges. Vibration transmitted to the palm was measured using the standardized palm adapter. The vibration transmissibility responses of the VR gloves were measured in the laboratory using the instrumented cylindrical handle, also described in the standard, mounted on a vibration exciter. A total of 12 healthy male subjects participated in the study. The instrumented handle was also used to measure grip strength of the subjects with and without the VR gloves. The results of the study showed that the VR gloves, with only a few exceptions, attenuate handle vibration transmitted to the fingers only in the 10–200 Hz and amplify middle finger vibration at frequencies exceeding 200 Hz. Many of the gloves, however, provided considerable reduction in vibration transmitted to the palm, especially at higher frequencies. These suggest that the characteristics of vibration transmitted to fingers differ considerably from those at the palm. Four of the test gloves satisfied the screening criteria of the ISO 10819 (2013) based on the palm vibration alone, even though these caused amplification of handle vibration at the fingers. The fingers' vibration transmission performance of gloves were further evaluated using a proposed finger frequency-weighting W_f apart from the standardized W_h -weighting. It is shown that the W_h weighting generally overestimates the VR glove effectiveness in limiting the fingers vibration in the high (H: 200–1250 Hz) frequency range. Both the weightings, however, revealed comparable performance of gloves in the mid (M: 25–200 Hz) frequency range. The VR gloves, with the exception of the leather glove, showed considerable reductions in the grip strength (27–41%), while the grip strength reduction was not correlated with the glove material thickness. It is suggested that effectiveness of VR gloves should be assessed considering the vibration transmission to both the palm and fingers of the hand together with the hand grip strength reduction.

- **Keywords:** Anti-vibration glove; Vibration transmissibility; Hand-transmitted vibration; Hand-arm vibration; Finger vibration; Frequency-weighting

Sarah-Louise Donovan, Paul M. Salmon, Timothy Horberry, Michael G. Lenné. [Ending on a positive: Examining the role of safety leadership decisions, behaviours and actions in a safety critical situation](#). Pages 139-150.

Abstract: Safety leadership is an important factor in supporting safe performance in the workplace. The present case study examined the role of safety leadership during the Bingham Canyon Mine high-wall failure, a significant mining incident in which no fatalities

or injuries were incurred. The Critical Decision Method (CDM) was used in conjunction with a self-reporting approach to examine safety leadership in terms of decisions, behaviours and actions that contributed to the incidents' safe outcome. Mapping the analysis onto Rasmussen's Risk Management Framework (Rasmussen, 1997), the findings demonstrate clear links between safety leadership decisions, and emergent behaviours and actions across the work system. Communication and engagement based decisions featured most prominently, and were linked to different leadership practices across the work system. Further, a core sub-set of CDM decision elements were linked to the open flow and exchange of information across the work system, which was critical to supporting the safe outcome. The findings provide practical implications for the development of safety leadership capability to support safety within the mining industry.

- **Keywords:** Safety leadership; Decisions; Behaviours; Actions; Systems-thinking; Mining

Leticia Bergamin Januario, Pascal Madeleine, Marina Machado Cid, Afshin Samani, Ana Beatriz Oliveira. [*Can exposure variation be promoted in the shoulder girdle muscles by modifying work pace and inserting pauses during simulated assembly work?*](#) **Pages 151-160.**

This study investigated the acute effects of changing the work pace and implementing two pause types during an assembly task. Eighteen healthy women performed a simulated task in four different conditions: 1) slow or 2) fast work pace with 3) passive or 4) active pauses every two minutes. The root mean square (RMS) and exposure variation analysis (EVA) from the trapezius and serratus anterior muscles, as well as the rate of perceived exertion (RPE) from the neck-shoulder region, were observed. Decreased RMS and RPE as well as more variable muscle activity (EVA) were observed in the slow work pace compared with the fast one. The pause types had a limited effect, but active pauses resulted in increased RMS of the clavicular trapezius. The findings revealed the importance of work pace in the reduction of perceived exertion and promotion of variation in muscle activation during assembly tasks. However, the pause types had no important effect on the evaluated outcomes.

- **Keywords:** Surface electromyography; Neck-shoulder; Work; Assembly task

Maryam Zahabi, David Kaber. [*Identification of task demands and usability issues in police use of mobile computing terminals.*](#) **Pages 161-171.**

Crash reports from various states in the U.S. have shown high numbers of emergency vehicle crashes, especially in law enforcement situations. This study identified the perceived importance and frequency of police mobile computing terminal (MCT) tasks, quantified the demands of different tasks using a cognitive performance modeling methodology, identified usability violations of current MCT interface designs, and formulated design recommendations for an enhanced interface. Results revealed that "access call notes", "plate number check" and "find location on map" are the most important and frequently performed tasks for officers. "Reading plate information" was also found to be the most visually and cognitively demanding task-method. Usability principles of "using simple and natural dialog" and "minimizing user memory load" were violated by the current MCT interface design. The enhanced design showed potential for reducing cognitive demands and task completion time. Findings should be further validated using a driving simulation study.

- **Keywords:** Mobile computer terminal; Decision tree analysis; Cognitive modeling; Interface design; Driver distraction

P.J. Barron, K. Burgess, K. Cooper, A.D. Stewart. [The effect of pitched and vertical ladder ergometer climbing on cardiorespiratory and psychophysical variables.](#) Pages 172-176.

This study aimed to assess whether modifying the pitch of a 75° ladder ergometer to vertical had a cardiorespiratory or psychophysical effect on climbing. Nine male participants climbed a ladder ergometer at 75° and subsequently at 90°, adjusted for an equivalent vertical climb rate, completing three climbing bouts at different vertical speeds. One participant dropped out being unable to complete the climb under the 90° condition. Each was monitored for heart rate (HR), $\dot{V}O_2$ and rating of perceived exertion (RPE). Results showed vertical climbing induced higher $\dot{V}O_2$ (mean increase 17.3%), higher HR (mean increase 15.8%), and higher RPE at all speeds and that moving from 75° to vertical exacerbates the effect of speed on the cardiorespiratory response to climbing. This may be explained by increased force production required to maintain balance in a vertical climbing position when the body's centre of mass is not above the feet.

- **Keywords:** Ladder ergometer; Pitched ladder climbing; Vertical ladder climbing; Ladder climbing physiology

Jia-Hua Lin, Alex Kirlik, Xu Xu. [New technologies in human factors and ergonomics research and practice.](#) Pages 179-181.

Camilla Grane. [Assessment selection in human-automation interaction studies: The Failure-GAM2E and review of assessment methods for highly automated driving.](#) Pages 182-192.

Highly automated driving will change driver's behavioural patterns. Traditional methods used for assessing manual driving will only be applicable for the parts of human-automation interaction where the driver intervenes such as in hand-over and take-over situations. Therefore, driver behaviour assessment will need to adapt to the new driving scenarios. This paper aims at simplifying the process of selecting appropriate assessment methods. Thirty-five papers were reviewed to examine potential and relevant methods. The review showed that many studies still relies on traditional driving assessment methods. A new method, the Failure-GAM2E model, with purpose to aid assessment selection when planning a study, is proposed and exemplified in the paper. Failure-GAM2E includes a systematic step-by-step procedure defining the situation, failures (Failure), goals (G), actions (A), subjective methods (M), objective methods (M) and equipment (E). The use of Failure-GAM2E in a study example resulted in a well-reasoned assessment plan, a new way of measuring trust through feet movements and a proposed Optimal Risk Management Model. Failure-GAM2E and the Optimal Risk Management Model are believed to support the planning process for research studies in the field of human-automation interaction.

- **Keywords:** Human-automation interaction; Highly automated driving; Assessment methods