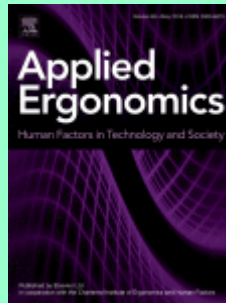


## **Applied Ergonomics - rok 2023, Volume 108**

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**Xiaoqun Yu, Seonghyeok Park, Shuping Xiong. *Trunk range of motion: A wearable sensor-based test protocol and indicator of fall risk in older people.* 103963.**

Conventionally, trunk range of motion (TROM) requires manual measurement by an external health professional with a general-purpose goniometer. This study aims to propose a convenient test protocol to assess TROM based on a single wearable sensor and to further investigate the relationship between TROM and fall risk of older people. We first explored the optimal sensor position by comparing TROMs from four representative locations (T1, T12, L5 and sternum) and optical motion capture system (golden reference). A follow-up experiment was conducted to evaluate the relationship between TROM and fall risk. The results showed that T12 achieved the minimum root mean square error ( $3.8 \pm 2.2^\circ$ ) against the golden reference and the non-faller group had significantly higher TROMs than the faller group. These findings suggest that the newly proposed protocol is convenient yet valid and TROM can be a promising indicator of fall risk in older people.

- **Keywords:** Range of motion; Fall risk; Wearable sensor

**Jie Zhang, Fang Fu, Xinyu Shi, Yan Luximon. *Modeling 3D geometric growth patterns and variations of Children's heads.* 103933.**

To design high-quality head/face-related products for children, it is essential to be able to construct 3D geometric models of their head growth patterns and variations. However, compared to 3D anthropometric analysis of adults' heads, this is still an underexplored research area. This study developed a framework for modeling the 3D geometric growth patterns and sex-specific variations of children's heads. To analyze these variations, the entire heads of 793 children (395 females and 398 males) ages 5–17 were scanned, and one global and two sex-specific statistical shape models (SSMs) were constructed. The first principal component in these SSMs, contributing more than 65% to the total explained variations, was highly related to overall head sizes. To model growth patterns, expected average heads for different ages and per-vertex growth rates were computed. Our results showed that the entire female head basically reaches its mature size at age 13–14, whereas in males it continues to increase until age 16–17. This study therefore provides valuable references for children's head/face-related product design, including the development of a more accurate sizing system and improvements in product fit and function.

- **Keywords:** Children's head modeling; Head growth patterns; Head variations analysis; Statistical shape modeling

**Martina Lorenzino, Flavia D'Agostin, Sara Rigutti, Massimo Bovenzi, Carlo Fantoni, Luigi Bregant. *Mood regulates the physiological response to whole-body vibration at low intensity.* 103956.**

In the present study we evaluated the relationship between human vibrational comfort and psychophysiological processes. We exposed twenty-one participants to three levels of whole-body vibration at low intensity inside a full-scale mock-up of a ship cabin. Autonomic Nervous System (ANS) activity, mood and well-being state during each level of vibration exposure were measured. We found that a positive affective state determined greater changes in ANS activity in response to vibration variations compared to a negative affective condition. Furthermore, we found that variations of the vibration intensity did not always determine variations of the comfort experience at physiological and psychological level. The relevance of our findings is a challenge for comfort design research showing a gap between guidelines for comfort design and evidence based on psychophysiological responses to environmental stimulation.

- **Keywords:** Psychophysiology; Comfort; Whole-body vibration

**Stela Xavier Terra, Tarcisio Abreu Saurin, Flávio Sanson Fogliatto, Ana Maria Muller de Magalhães. *Burnout and network centrality as proxies for assessing the human cost of resilient performance.* 103955.**

The extra effort of healthcare professionals to provide care is a manifestation of resilient performance (RP), usually going unnoticed due to successful outcomes. However, it is not clear how the human cost of RP can be assessed. This study addresses this gap by investigating the relationships between proxies of RP and its human cost. The proposed approach was tested in a 29-bed intensive care unit (ICU). The centrality of each professional in the advice-seeking social network was considered as the proxy of their contribution to system resilience. A resilience score was calculated for each professional as the product of three network centrality metrics (in-degree, closeness, and betweenness) and two non-network attributes, namely their availability and reliability. Professionals' burnout was the proxy of the human cost of RP, assessed through the Maslach Burnout Inventory, composed of 22 items divided into a triad of emotional exhaustion, depersonalization, and personal accomplishment. Both questionnaires, for social network analysis and burnout, included socio-demographic questions and were answered by 99.0% of the professionals. Results indicated a weak correlation between emotional exhaustion and the resilience score ( $p = 0.008$ ). This score was also weakly correlated with working overtime ( $p = 0.005$ ). Overall, findings provided initial evidence that RP as measured in our study matters to burnout, and that the two proxies are exemplars of applying a more general reasoning that might be valid for other proxies.

- **Keywords:** Resilience; Burnout; Social network analysis; Healthcare; Intensive care unit

**Marcos Figueiredo, Sara Eloy, Sibila Marques, Luís Dias. *Older people perceptions on the built environment: A scoping review.* 103951.**

As the world ages, the built environment requires special attention to assist this growing part of society and therefore the update of urban design guidelines and urban policies is required. The goal of this study is to provide an overview of existing literature regarding emotions and perceptions from older people related to the outdoor built environment. A scoping review was performed using empirical studies in 12 scientific databases in a fourteen-year period (2007–2021) involving people at least 60 years old and outdoor

built environment perceptions. Collected evidence identified 52 papers following the PRISMA procedure. Studies reported basic emotions (e.g., fear, joy) and space perceptions (e.g., walkability, accessibility) regarding the outdoor built environment as sidewalks, streets, and greenery. Our study reinforces the importance of analyzing older people perceptions regarding the outdoor built environment so that architects, urban planners, and decision makers have information to design solutions that fit older people needs.

- **Keywords:** Age-friendly cities; Built environment; Scoping review

**Sara Eloy, Marina Andrade, Luís Dias, Miguel Sales Dias. *The impact of sound in people's behaviour in outdoor settings: A study using virtual reality and eye-tracking.* 103957.**

This paper presents an analysis of space perception and how visual cues, such as landmarks and sound, are perceived and impact people's behaviour while exploring a given outdoor space. The primary goal of the research is to investigate how auditory sensations and visual stimuli influence people's behaviour in outdoor built environments. Our technique compares people's perception of the built environment in different conditions: the real world and a replicated virtual world. As a case study, a university campus was used, and four experimental conditions were designed. The study followed a between-subjects design, and the data collection included gaze data acquired from an eye-tracking device as well as self-reports. The study concludes that sound influences human behaviour in such settings. More specifically conclusions are that: i) human behaviour in virtual replications of the real space, including both visual and sound stimuli, is tendentially more similar to human behaviour in the real world than in simulations omitting sound; and ii) there is a difference in human behaviour when people explore the same virtually replicated outdoor space, by varying the presence of sound. This study is particularly useful for researchers working on the comparison between human behaviour in virtual and real environments, related to visual and sound stimuli.

- **Keywords:** Sound; Outdoor spaces; Gaze

**Valeria Tatano, Rosaria Revellini. *An alternative system to improve accessibility for wheelchair users: The stepped ramp.* 103938.**

Ramps are one of the main solutions for people with motor disabilities to overcome small disparities in height, both across cities and inside buildings. To permit the autonomous use of ramps, they must satisfy specific requisites. In particular, the slopes must not be excessively steep but adhere to the values identified in regulations and validated by scientific research. In historic cities, however, the placement of ramps is often complicated by a lack of space required for their length. In Venice, in particular, its urban morphology often makes it impossible to conform to the required slopes. For this reason, a specific ramp, known as "stepped ramp", has been designed by technicians of the City of Venice with a steeper slope than allowed by regulations. It offers many possibilities but even some key problems. This paper presents a scientific analysis of ten different ramps to evaluate the structures that directly influence the feeling of comfort or discomfort of a wheelchair user with assistance, as well as the coefficients of friction of the different flooring surfaces. This study aims to understand objectively if this solution is efficient to improve accessibility in some specific circumstances, where it is not possible to follow the regulations using flat ramps.

- **Keywords:** Stepped ramp; Urban accessibility; Wheelchair user

**William H. Sharp, Kenneth M. Jackson, Tyler H. Shaw. *The frequency of positive and negative interactions influences relationship equity and trust in automation.* 103961.**

The purpose of this study was to 1) examine whether frequency of positive and negative interactions (manipulated via reliability) with a computer agent had an impact on an individual's trust resilience after a major error occurs and 2) empirically test the notion of relationship equity, which encompasses the total accumulation of positive and negative interactions and experiences between two actors, on user trust on a separate transfer task. Participants were randomized into one of four groups, differing in agent positivity and frequency of interaction, and completed both a pattern recognition task and transfer task with the aid of the same computer agent. Subjective trust ratings, performance data, compliance, and agreement were collected and analyzed. Results demonstrated that frequency of positive and negative interactions did have an impact on user trust and trust resilience after a major error. Additionally, it was shown that relationship equity has an impact on user trust and trust resilience. This is the first empirical demonstration of relationship equity's impact on user trust in an automated teammate.

- **Keywords:** Relationship equity; Trust; Trust resilience; Automation; Human-computer team; Trust measurement

**Tianhao Xu, Kuldeep Singh, Prashanth Rajivan. *Personalized persuasion: Quantifying susceptibility to information exploitation in spear-phishing attacks.* 103908.**

Many cyberattacks begin with a malicious email message, known as spear phishing, targeted at unsuspecting victims. Although security technologies have improved significantly in recent years, spear phishing continues to be successful due to the bespoke nature of such attacks. Crafting such emails requires attackers to conduct careful research about their victims and collect personal information about them and their acquaintances. Despite the widespread nature of spear-phishing attacks, little is understood about the human factors behind them. This is particularly the case when considering the role of attack personalization on end-user vulnerability. To study spear-phishing attacks in the laboratory, we developed a simulation environment called SpearSim that simulates the tasks involved in the generation and reception of spear-phishing messages. Using SpearSim, we conducted a laboratory experiment with human subjects to study the effect of information availability and information exploitation end-user vulnerability. The results of the experiment show that end-users in the high information-availability condition were 2.97 times more vulnerable to spear-phishing attacks than those in the low information-availability condition. We found that access to more personal information about targets can result in attacks involving contextually meaningful impersonation and narratives. We discuss the implications of this research for the design of anti-phishing training solutions.

- **Keywords:** Spear phishing; Security awareness; Cyber security; Deceptive strategies; Social engineering attacks

**Hossein Hamidi Shishavan, Jennifer Garza, Robert Henning, Martin Cherniack, Liane Hirabayashi, Erika Scott, Insoo Kim. *Continuous physiological signal measurement over 24-hour periods to assess the impact of work-related stress and workplace violence.* 103937.**

Work-related stress has long been recognized as an essential factor affecting employees' health and wellbeing. Repeated exposure to acute occupational stressors puts workers at high risk for depression, obesity, hypertension, and early death. Assessment of the effects of acute stress on workers' wellbeing usually relies on subjective self-reports,

questionnaires, or measuring biometric and biochemical markers in long-cycle time intervals. This study aimed to develop and validate the use of a multiparameter wearable armband for continuous non-invasive monitoring of physiological states. Two worker populations were monitored 24 h/day: six loggers for one day and six ICU nurses working 12-hr shifts for one week. Stress responses in nurses were highly correlated with changes in heart rate variability (HRV) and pulse transit time (PTT). A rise in the low-to high-frequency (LF/LH) ratio in HRV was also coincident with stress responses. HRV on workdays decreased compared to non-work days, and PTT also exhibited a persistent decrease reflecting increased blood pressure. Compared to loggers, nurses were involved in high-intensity work activities 45% more often but were less active on non-work days. The wearable technology was well accepted by all worker participants and yielded high signal quality, critical factors for long-term non-invasive occupational health monitoring.

- **Keywords:** Continuous blood pressure; Heart rate variability; Pulse transit time; Wearable; Work-related stress

**Kurt E. Beschorner, Anna B. Randolph. *Friction performance of resilient flooring under contaminant conditions relevant to healthcare settings.* 103960.**

Flooring is among the factors known to influence slip and fall risk. Slips are common in the healthcare industry, where resilient flooring is prevalent. This study assessed coefficient of friction (COF) across resilient flooring products specific to conditions relevant to healthcare. The COF for eleven resilient flooring surfaces were tested in their dry condition and under six contaminant conditions. Data was analyzed using ANOVA and principal component analysis. The COF was strongly influenced by the contaminant condition ( $p < 0.001$ ) with hand sanitizer and canola oil having the lowest COF values. COF was also influenced by the flooring product ( $p < 0.001$ ) although to a lesser extent than the contaminant condition. The contaminants differentially affected the friction performance across the flooring products (interaction effect  $p < 0.001$ ). These effects were described by the first two principal components. This study reveals high slipping potential for certain contaminants on resilient flooring and that flooring influences friction performance in contaminant-specific ways.

- **Keywords:** Flooring; Slips; Trips, and falls; Coefficient of friction

**Aaron Edelman, Stefan Stümper, Tibor Petzoldt. *The interaction between perceived safety and perceived usefulness in automated parking as a result of safety distance.* 103962.**

Improved safety and traffic efficiency are among the proclaimed benefits of automated driving functions. In many scenarios, traffic safety and efficiency can be somewhat contradictory, especially in the perception of a user. In order for potential users to accept the automated system, it is necessary to find the optimal system configuration. Therefore, it is important to understand how the factors underlying acceptance develop and interact. In this study, seven safety distances of an automated parking system were implemented resulting in parking manoeuvres of varying efficiency (in terms of required moves). Participants experienced each configuration twice and rated their perceived safety and perceived usefulness. The results show that maximizing safety distances results in high perceived safety, yet also a diminished perceived usefulness due to reduced efficiency. On the other hand, maximum efficiency leads to a lower perceived safety and thus, a reduced rating of perceived usefulness. Furthermore, in some participants, perceived safety increased gradually, while for others, a threshold effect could be observed. The results demonstrate that the specification of a sole system characteristic can have multiple effects. These have to be considered to maximize acceptance.

- **Keywords:** Automated driving; Automated parking; Perceived safety; Perceived usefulness; Acceptance; Driver behaviour modelling

**Alessandro Chiarotto, Heike Gerger, Rogier M. van Rijn, Roy G. Elbers, Karen Sogaard, Erin M. Macri, Jennie A. Jackson, Alex Burdorf, Bart W. Koes. *Physical and psychosocial work-related exposures and the occurrence of disorders of the elbow: A systematic review.* 103952.**

This systematic review updates a previous systematic review on work-related physical and psychosocial risk factors for elbow disorders. Medline, Embase, Web of Science, Cochrane Central and PsycINFO were searched for studies on associations between work-related physical or psychosocial risk factors and the occurrence of elbow disorders. Two independent reviewers selected eligible studies and assessed risk of bias (RoB). Results of studies were synthesized narratively. We identified 17 new studies and lateral epicondylitis was the most studied disorder (13 studies). Five studies had a prospective cohort design, eight were cross-sectional and four were case-control. Only one study had no items rated as high RoB. Combined physical exposure indicators (e.g. physical exertion combined with elbow movement) were associated with the occurrence of lateral epicondylitis. No other consistent associations were observed for other physical and psychosocial exposures. These results prevent strong conclusions regarding associations between work-related exposures, and the occurrence of elbow disorders.

- **Keywords:** Work-related risk factors; Lateral epicondylitis; Medial epicondylitis

**Tingru Zhang, Xing Liu, Weisheng Zeng, Da Tao, Guofa Li, Xingda Qu. *Input modality matters: A comparison of touch, speech, and gesture based in-vehicle interaction.* 103958.**

Innovative input devices are being available for in-vehicle information systems (IVISs). While they have the potential to provide enjoyable driving by enabling drivers to perform non-driving related tasks (NDRTs) in more natural ways, the associated distracting effects should be paid with more attention. The purpose of this exploratory study was to compare the effects of three novel input modalities, i.e., touchscreen-based interaction (TBI), speech-based interaction (SBI), and gesture-based interaction (GBI), on driving performance and driver visual behaviors. Moreover, we examined if the influence of different modalities would be moderated by the difficulty level of NDRTs. A total of 36 participants were invited to a simulated driving experiment where they were randomly assigned to one of the four groups (TBI, GBI, SBI or baseline) and completed three driving trials. The results showed that TBI led to the worse driving performance, as indicated by the significantly prolonged reaction time, reduced minimum time-to-collision, and increased variations in both longitudinal and lateral vehicle control. The deteriorated driving performance could be attributed, at least partially, to the intense visual demand induced by looking towards the touchscreen, as indicated by more and longer off-the-road glances. The adverse impacts of GBI were relatively smaller, but it still posed great crash risk by leading to a shorter minimum time-to-collision and less stable vehicle control compared to the baseline. SBI, although not completely equivalent to the baseline group, showed the minimum influence on driving and visual performance. Only very few interaction effects were found, suggesting that the effects of modality were quite robust across different NDRTs. It was concluded that SBI and GBI provided safer alternatives to in-vehicle interaction than TBI.

- **Keywords:** In-vehicle information system; Gesture; Touchscreen; Speech; Driver distraction

**Duncan T. Ritchie, Christopher Doyle. *Ergonomic impact of prehospital clinicians using body armour: A qualitative study.* 103947.**

Armed crime constitutes a significant number of offences in England. The associated healthcare burden forms 32% of the workload of London HEMS, requiring these clinicians to use body armour. Much research has explored the ergonomic impact of body armour in police and military populations however the impact on prehospital clinicians is not known. The aim of this study is to explore the perceptions of prehospital clinicians of wearing body armour. Focus groups were conducted until theoretical saturation was reached, utilising hermeneutic phenomenology. Problems with the comfort, safety, time, hygiene, coverage, and female fit of armour were identified. Clinicians feel hot in summer, time to respond to scenes is increased and the fit for females is poor. Consideration should be given to sourcing specific female-fit armour and to the interoperability with the rest of the protective clothing. A redesign of uniform could provide greater flexibility to mitigate some of the issues.

- **Keywords:** Body armour; Emergency medical services; Focus groups

**Kaitlyn L. Hale-Lopez, Molly H. Goldstein, Abigail R. Wooldridge. *Sociotechnical system design to support disaster intervention development teams.* 103948.**

Teams are critical in developing effective responses to various disasters and crises. This study defines a new type of response team: a disaster intervention development team, charged with rapidly developing emergent and innovative interventions to aid disaster response. In this case study, we analyzed the SHIELD Enterprise, a disaster intervention development team that developed and deployed a diagnostic testing system for community surveillance and diagnosis to respond to the COVID-19 infectious disease outbreak. We conducted interviews with 27 team members to identify the work system barriers and facilitators they experienced and to analyze the influence on team performance to inform sociotechnical system design for future teams. We identified 215 barriers and 238 facilitators, which we inductively categorized into eight overarching groups, i.e., categories, that included ambiguity, team processes, technology, design and project requirements, knowledge and expertise, organization, task work and environment. Our findings led to eight sociotechnical system design principles to support future disaster intervention development teams.

- **Keywords:** Macroergonomics; Disaster response; COVID-19 pandemic; Work system analysis

**David Lim, Mark Wiggins, Meredith Porte, Piers Bayl-Smith, Kim M. Curby, Kirk N. Olsen, Melanie Taylor. *Virtual reality lifeguarding scenarios as a potential training solution for pool lifeguards.* 103954.**

**Background:** Ensuring that pool lifeguards develop the skills necessary to detect drowning victims is challenging given that these situations are relatively rare, unpredictable and are difficult to simulate accurately and safely. Virtual reality potentially provides a safe and ecologically valid approach to training since it offers a near-to-real visual experience, together with the opportunity to practice task-related skills and receive feedback. As a prelude to the development of a training intervention, the aim of this research was to establish the construct validity of virtual reality drowning detection tasks. **Method:** Using a repeated measures design, a total of 38 qualified lifeguards and 33 non-lifeguards completed 13 min and 23 min simulated drowning detection tasks that were intended to reflect different levels of sustained attention. During the simulated tasks, participants were asked to monitor a virtual pool and identify any drowning targets with accuracy, response latency, and dwell time recorded. **Results:** During the simulated

scenarios, pool lifeguards detected drowning targets more frequently and spent less time than non-lifeguards fixating on the drowning target prior to the drowning onset. No significant differences in response latency were evident between lifeguards and non-lifeguards nor for first fixations on the drowning target. **Conclusion:** The results provide support for the construct validity of virtual reality lifeguarding scenarios, thereby providing the basis for their development and introduction as a potential training approach for developing and maintaining performance in lifeguarding and drowning detection. **Application:** This research provides support for the construct validity of virtual reality simulations as a potential training tool, enabling improvements in the fidelity of training solutions to improve pool lifeguard competency in drowning detection.

- **Keywords:** Visual search; Virtual reality; Drowning; Lifeguards; Water safety; Training simulation

### **Hongwei Hsiao. *Assessment of challenges in patrol vehicles and with equipment among law enforcement officers.* 103946.**

Understanding the challenges Law Enforcement Officers (LEOs) have encountered with their vehicle and equipment and the correlation between equipment configuration and LEO body dimensions is critical for improving vehicle/equipment specifications to better accommodate today's LEOs. 974 LEOs participated in a study on their vehicle, equipment, and body measurements at 12 sites across the U.S. 88% participants reported discomfort/pain at the end of a shift. The most affected body areas were the lower back and hips. Handguns, radios, and handcuffs on duty belt and seat adjustment were associated with the discomfort/pain. 41% LEOs identified inadequate seat adjustment. Stature, buttock-popliteal length, eye height (sitting), knee height (sitting), shoulder-grip length, popliteal height, sitting height, hip breadth, and body weight were key parameters associated with seat adjustment needs. A third of officers experienced neck pain associated with the use of in-vehicle mobile data terminals and more fore/aft adjustment was needed.

- **Keywords:** Police; Vehicle equipment; Duty belts