

Ergonomics– rok 2022, ročník 65

Číslo 10



Daofei Li & Linhui Chen. *Mitigating motion sickness in automated vehicles with vibration cue system.* Pages: 1313-1325.

Motion sickness is very common in road transport. To guarantee ride comfort and user experience, there is an urgent need for effective solutions to motion sickness mitigation in semi- and fully-automated vehicles. Considering both effectiveness and user-friendliness, a vibration cue system is proposed to inform passengers of the upcoming vehicle movement through tactile stimulation. By integrating the motion planning results from automated driving algorithms, the vibration cueing timing and patterns are optimised with the theory of motion anticipation. Using a cushion-based prototype of a vibration cue system, 20 participants were invited to evaluate this solution in two conditions of driving simulator experiments. Results show that the proposed vibration cue system could also help participants to comprehend the cues and to generate motion anticipation. The participants' motion sickness degrees were significantly lowered. This research may serve as one foundation for detailed system development in practical applications. **Practitioner Summary:** In automated vehicles, passengers engaging in non-driving tasks are apt to severe motion sickness. A vibration cue system and cueing strategy are proposed and optimised to inform passengers of the upcoming vehicle movement. Simulator experiments of 20 participants proved its effectiveness in promoting motion anticipation and reducing motion sickness.

HIGHLIGHTS

- Vibration cues to inform the passenger of upcoming movement.
- User-friendly and having no direct disturbance to non-driving tasks.
- Cueing strategy is based on the planned movement from an automated driving algorithm.
- Consider the temporal matching between motion anticipation and actual movement.
- Average success rate of generating motion anticipation reaches 89%.

- **Keywords:** Automated vehicle, motion sickness, driving simulator, vibration cue, motion anticipation

Lisa Bergauer, Ezequiel D. Kataife, Federico G. Mileo, Tazio R. Roche, Sadiq Said, Donat R. Spahn, David W. Tscholl & Doreen J. Wetli. [*Physicians' perceptions of two ways of algorithm presentation: graphic versus text-based approach.*](#) Pages: 1326-1337.

Acute bleeding during surgery or after trauma harms patients, and challenges involved physicians. Protocols and cognitive aids can help in such situations. This dual-centre study investigated physicians' opinions regarding two ways to present cognitive aids, graphic 'Haemostasis Traffic Light' and text-based, using the example of a coagulation management algorithm to identify the strengths and limitations of both presentation modalities. Using qualitative research methods, we identified recurring answer patterns and derived major topics and subthemes through inductive coding. Eighty-four physicians participated. We assigned each half randomly to one of the cognitive aids (graphic/text-based) and determined 447 usable statements. We qualitatively deduced the importance of having a cognitive aid for physicians. Furthermore, it is noticeable that the graphic group made more positive comments (154 of 242 (64%) statements), while the text-based participants made more negative annotations (126 of 205 (61%) statements), suggesting a generally stronger approval of this cognitive aid. **Practitioner summary:** This qualitative study provides an overview of physicians' positive and negative perceptions regarding two presentation ways for a coagulation management algorithm. Participants perceived the graphic method created according to user-centred design principles more positively. The analysis reveals components that an ideal algorithm should have to help streamline the decision-making process.

- **Keywords:** Algorithms, cognitive aid, decision-making, graphic presentation, qualitative research, user-centred design

David Rempel & Jim Potvin. [*A design tool to estimate maximum acceptable manual arm forces for above-shoulder work.*](#) Pages: 1338-1351.

There is a need for design criteria for above-shoulder work to prevent shoulder fatigue and supraspinatus injuries. A tool is developed to estimate maximum acceptable manual arm forces for above-shoulder work based on 25th % female strength with adjustments for supraspinatus tendon impingement and shoulder fatigue. The tool equations are presented along with tables of maximum acceptable manual arm forces in 77 locations in the 3 D space above the shoulder that accommodates a 50th % female reach. The largest acceptable anterior force, 140.3 N, occurs at shoulder height, 0.5 m anterior to the shoulder. The largest acceptable superior force, 84.4 N, occurs at shoulder height, 0.1 m anterior and 0.2 m medial to the shoulder. The new tool provides design criteria for arm exertions at a higher level of detail than prior ergonomic tools, making it useful for engineers. Based on sensitivity analyses, the tool is robust to parameter assumptions. **Practitioner summary:** Above-shoulder work is associated with increased risk for shoulder fatigue and injuries. A new tool is developed that estimates maximum acceptable manual arm forces for work at or above shoulder height. The tool can be used to design acceptable above-shoulder work so that it can be accomplished by most workers.

KEY POINTS

- A new design tool is introduced that estimates maximum acceptable hand forces for specific locations above the shoulder.

- This above-shoulder tool is based on a 50th percentile female anthropometry and 25th percentile female manual arm strength.
- These base strengths are multiplied by scaling factors that adjust for subacromial impingement and fatigue.
- The tool was shown to be robust based on sensitivity analysis.
- **Keywords:** Overhead work, rotator cuff, musculoskeletal disorders, work design

Mengcheng Wang, Hao Fan, Suihuai Yu, Xiao Zhao, Long Wang, Wenhua Li, Lei Wang, Mingjiu Yu, Jianjie Chu, Shuai Zhang & Dengkai Chen. *Effects of variations in the tragus expansion angle on physical comfort for in-ear wearables.* Pages: 1352-1372.

Tragus expansion angle (TEA) is an angular variable that quantifies the outward degree of expansion of the tragus cartilage induced by in-ear wearables (designed with hard materials) fitted into the external ear. It is a physical factor that directly influence user's comfort experience during interaction with in-ear wearables. This study was aimed at quantifying the effects of variations in TEA on physical comfort. TEA was measured and normalised employing a measuring device and Tragus Expansion Index (TEI) proposed in this study. Physical (dis)comfort was assessed using a rating scale designed based on the 5-point Likert and Borg-CR10 scales. Comparatively, the comfort range of variations in TEA was similar for both genders. Males could endure a higher level of variations in TEA compared to females. A quantitative relationship between variations in TEA and (dis)comfort ratings was established using TEI values and GaussAmp function, which can be employed for ergonomic design purposes. **Practitioner summary:** This study provides an empirical and available source for quantifying the effects of variations in the tragus expansion angle on physical comfort, including quantitative tools and (dis)comfort rating models, which could be used as a reference for improving the fit, comfort and functional capacity of in-ear wearable devices.

- **Keywords:** In-ear wearables, physical comfort, tragus expansion angle, quantitative analysis, ergonomic design

Robert E. Larson, Sarah T. Ridge, Dustin Bruening, A. Wayne Johnson & Ulrike H. Mitchell. *Healthcare worker choice and low back force between self-chosen and highest bed height when boosting a patient up in bed.* Pages: 1373-1379.

Healthcare workers have a high rate of low back injury due to patient handling tasks. These workers receive training in patient handling methods such as adjusting bed height, but often ignore them. In this study, 35 healthcare workers completed patient boosts at a self-chosen bed height and again with the bed in a higher standardised position. Motion capture and force data were collected for analysis. Given the choice, less than half of participants adjusted the bed at all and none of them moved the bed to the highest position (99.1 cm). The self-chosen bed position yielded significantly higher low back force than the higher position at L4-L5 and L5-S1 ($p = 0.02$, $p = 0.01$ respectively). Low back forces can be reduced by raising the bed prior to engaging in patient handling tasks, which is a simple step that can reduce forces placed on healthcare workers' low backs. **Practitioner summary:** Healthcare workers experience high rates of low back pain secondary to patient handling tasks. In this cross-sectional crossover study, healthcare workers consistently chose a low bed height when boosting a patient, which resulted in higher low back loads compared to the highest bed height.

- **Keywords:** Musculoskeletal disorders, manual handling, safety culture, biomechanics, health care ergonomics

Nic Saraceni, Amity Campbell, Peter Kent, Leo Ng, Leon Straker & Peter O'Sullivan. *Does intra-lumbar flexion during lifting differ in manual workers with and without a history of low back pain? A cross-sectional laboratory study.* Pages: 1380-1396.

Advice to limit or avoid a flexed lumbar curvature during lifting is widely promoted to reduce the risk of low back pain (LBP), yet there is very limited evidence to support this relationship. To provide higher quality evidence this study compared intra-lumbar flexion in manual workers with (n = 21) and without a history of LBP (n = 21) during a repeated lifting task. In contrast to common expectations, the LBP group demonstrated less peak absolute intra-lumbar flexion during lifting than the noLBP group [adjusted difference -3.7° (95%CI -6.9 to -0.6)]. The LBP group was also further from the end of range intra-lumbar flexion and did not use more intra-lumbar range of motion during any lift condition (both symmetrical and asymmetrical lifts and different box loads). Peak absolute intra-lumbar flexion was more variable in the LBP group during lifting and both groups increased their peak absolute intra-lumbar flexion over the lift repetitions. This high-quality capture of intra-lumbar spine flexion during repeated lifting in a clinically relevant cohort questions dominant safe lifting advice. **Practitioner summary:** Lifting remains a common trigger for low back pain (LBP). This study demonstrated that people with LBP, lift with less intra-lumbar flexion than those without LBP. Providing the best quality in-vivo laboratory evidence, that greater intra-lumbar flexion is not associated with LBP in manual workers, raising questions about lifting advice.

- **Keywords:** Posture, lifting, low back pain, LBP, manual handling

Madison Reddie & Matthew B. Parkinson. *A comparison of approaches to reweighting anthropometric data.* Pages: 1397-1409.

The objective of this work is to identify the most effective techniques for reweighting anthropometric data such that it accurately represents a target user population. Seven methods are compared, including uniform weighting, stratification and permutations of nearest neighbour (NN) reweighting. The analysis illuminates the performance of existing and novel approaches to reweighting data specifically for approximating body size and shape ('anthropometry'). While uniform weighting and stratified sampling are often used in this field, the present analysis indicates that lower-order NN approaches will produce more representative results. Although anthropometric data are crucial to the design of artefacts, tasks and environments, finding appropriate representative data is challenging. Designers and ergonomists are unlikely to find data that are simultaneously accessible, up-to-date, detailed and from the relevant population. The application of new statistical weights – reweighting – is one useful strategy for meeting this shortfall. This research indicates the best methods for reweighting and provides guidance for sampling strategies in future data collection efforts. **Practitioner Summary:** Reweighting anthropometric data is one strategy for matching available data to a target user population. Stratified sampling is often used as the method for calculating weights, but it has been shown to produce inaccurate estimates. This research examines seven strategies and finds low-order NN approaches are the more accurate methods.

- **Keywords:** Anthropometry, design for human variability, weighting, reweighting, binning, clustering, NHANES, CAESAR

Svein O. Tjosvoll, Trine M. Seeberg, Marius S. Fimland, Øystein Wiggen & Silje E. Jahren. [Classification of kneeling and squatting in workers](#)

wearing protective equipment: development and validation of a rule-based model using wireless triaxial accelerometers. Pages: 1410-1420.

Several professions in industries, such as petroleum, manufacturing, construction, mining, and forestry require prolonged work tasks in awkward postures, increasing workers' risks for musculoskeletal pain and injury. Therefore, we developed and validated a rule-based model for classifying unilateral and bilateral kneeling and squatting based on 15 individuals wearing personal protective equipment and using three wireless triaxial accelerometers. The model provided both high sensitivity and specificity for classifying kneeling (0.98; 0.98) and squatting (0.96; 0.91). Hence, this model has the potential to contribute to increased knowledge of physical work demands and exposure thresholds in working populations with strict occupational safety regulations. **Practitioner summary:** Our results indicate that this rule-based model can be applied in a human-factors perspective enabling high-quality quantitative information in the classification of occupational kneeling and squatting, known risk factors for musculoskeletal pain, and sick leave. This study is adapted for working populations wearing personal protective equipment and aimed for long-term measurements in the workplace.

- **Keywords:** Validation study, occupational health and safety, physical exposure, human activity recognition, accelerometry

Scott McLean, Lauren Coventon, Caroline F. Finch & Paul M. Salmon. *Incident reporting in the outdoors: a systems-based analysis of injury, illness, and psychosocial incidents in led outdoor activities in Australia.* Pages: 1421-1433.

Incident reporting systems are a fundamental component of safety management, however, most systems used in practice are not aligned with contemporary accident causation models. This article presents an analysis of a National Incident Dataset (NID) for adverse incidents occurring in the Australian Led Outdoor Activity (LOA) sector. The aim was to investigate the adverse Injury, Illness, and Psychosocial incidents reported to the NID. In total, 1657 injuries, 532 illnesses, and 146 psychosocial incidents were analysed from 357,691 program participation days. The findings show that the rate of incidents per 1000 program participant days in LOAs was 4.6 for injury, 1.5 for illness, and 0.04 for psychosocial incidents, and incident severity was predominately minor. The analysis of systemic contributory factors demonstrates that incidents in LOA are systemic in nature, with multiple levels of the LOA system identified as contributing to adverse incidents. For example, contributory factors were identified across local government (facilities), schools (communication), parents (communication), LOA management (policies and procedures), people involved in the incidents (mental and physical condition), and the environment (terrain) and equipment (clothing). This study presents an assessment of the current state of safety in the Australian LOA sector and demonstrates the utility of applying systems ergonomics methods in practice. **Practitioner summary:** This article presents an analysis of 1657 injury, 532 illness, and 146 psychosocial incidents occurring in the Australian Led Outdoor Activity (LOA) sector, using a systems ergonomics method. The findings demonstrate the incident characteristics and how decisions and actions from across the system contribute to adverse incidents in LOAs.

- **Keywords:** Led outdoor activitiesafetyincident reportingAcciMapsystms analysis

Dustin T. Weiler, Aloysius J. Lingg, Brendan R. Eagan, David W. Shaffer & Nicole E. Werner. *Quantifying the qualitative: exploring epistemic network analysis as a method to study work system interactions.* Pages: 1434-1449.

Studying interactions faces methodological challenges and existing methods, such as configural diagramming, have limitations. This work demonstrates Epistemic Network Analysis (ENA) as an analytical method to construct configural diagrams. We demonstrated ENA as an analytical tool by applying this method to study dementia caregiver work systems. We conducted 20 semi-structured interviews with caregivers to collect caregiving experiences. Guided by the Patient Work System model, we conducted a directed content analysis to identify work system components and used ENA to study interactions between components. By using ENA to create configural diagrams, we identified five frequently occurring interactions, compared work system configurations of caregivers providing care at home and away from home. Although we were underpowered to determine statistically significant differences, we identified visual and qualitative differences. Our results demonstrate the capability of ENA as an analytical method for studying work system interactions through configural diagramming.

Practitioner summary: A new methodology, Epistemic Network Analysis (ENA), was presented to better support the study of work system interactions through configural diagramming. ENA was applied to qualitative data to demonstrate the capabilities of this method to construct configural diagrams of the work system. This study successfully demonstrated that ENA can visually represent and describe work system configurations.

- **Keywords:** Socio-technical system interactions, ergonomics tools and methods, configural diagram, epistemic network analysis, dementia caregiving