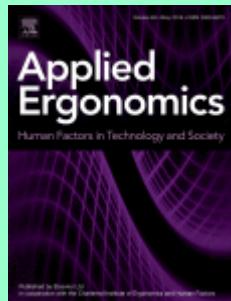


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R. Lamontagne, A. Delisle, M.E. Major. *Prevention of musculoskeletal disorders among animal research technicians: Understanding difficulties and their determinants through a work activity analysis.* 103792.

This study aimed at understanding animal research technicians (ART) work activity to identify difficulties encountered by workers and their determinants which may increase musculoskeletal disorders (MSD) risks. The methods for the work activity analysis combined interviews, observations, events and operations chronicles as well as inclinometry. From the work activity analysis of the three main tasks (changing mouse cages, preparation of water bottles and unloading dirty material), difficulties such as awkward postures, heavy load handling, repetitiveness, high workload, supplementary tasks, interruptions and difficult social interactions emerged. The work activity analysis further allowed the identification of determinants of these difficulties. Some are related to the physical, organizational or social work environment, and others to the interdependence between these determinants. Such an improved understanding of ART work activity will lead to solutions best suited for MSDs prevention in this understudied setting.

- **Keywords:** Musculoskeletal disorders; Work activity analysis; Animal research technicians

Sami Mecheri, Franck Mars, Régis Lobjois. *Gaze and steering strategies while driving around bends with shoulders.* 103798.

The installation of shoulders on rural roads to create more forgiving roads encourages drivers to cut corners on right-hand bends, but the underlying mechanisms are poorly understood. Since eye movements and steering control are closely coupled, this study investigated how the presence of a shoulder influences drivers' gaze strategies. To this end, eighteen drivers negotiated right-hand bends with and without a shoulder on a simulated rural road. In the presence of a shoulder, participants modified their visual sampling of the road by directing their gaze further inside the bend. At the same time, their lane position was deviated inward throughout the bend and the vehicle spent more time out of the lane. These results suggest that the shoulder influences the visual processes involved in trajectory planning. Recommendations are made to encourage drivers to keep their eyes and vehicle in the driving lane when a shoulder is present.

- **Keywords:** Bends; Paved shoulder; Steering strategies; Visual control of steering; Driving simulator

Aitor Pinedo-Jauregi, Tyler Quinn, Aitor Coca, Gaizka Mejuto, Jesús Cámará. Physiological stress in flat and uphill walking with different backpack loads in professional mountain rescue crews. 103784.

This study aimed to determine the interactive physiological effect of backpack load carriage and slope during walking in professional mountain rescuers. Sixteen mountain rescuers walked on a treadmill at 3.6 km/h for 5 min in each combination of three slopes (1%, 10%, 20%) and five backpack loads (0%, 10%, 20%, 30%, and 40% body weight). Relative heart rate (%HRmax), relative oxygen consumption (%VO₂max), and rating of perceived exertion (RPE, Borg 1–10 scale) were compared across conditions using two-way ANOVA. Significant differences in %VO₂max, %HRmax, and RPE across slopes and loads were found where burden increased directly with slope and load (main effect of slope, $p < 0.001$ for all; main effect of load, $p < 0.001$ for all). Additionally, significant slope by load interactions were found for all parameters, indicating an additive effect ($p < 0.001$ for all). Mountain rescuers should consider the physiological interaction between slope and load when determining safe occupational walking capacity.

- **Keywords:** Load carriage; Physiology; Physical work capacity; Backpack and slope walking

Chia-Fen Chi, Davin Sigmund, Yu-Chieh Lin, Colin G. Drury. The development of a scenario-based human-machine-environment-procedure (HMEP) classification scheme for the root cause analysis of helicopter accidents. 103771.

The current study analyzed the root causes of 22 helicopter accidents/incidents that took place between 1998 and 2019. Each root cause was coded using three commonly used classification models in aviation HFACS, ATSB, and IATA to identify recurring factors for better targeting of future prevention strategies. The frequency analysis revealed that not following procedure (22 observations), training inadequate or unavailable (17), inadequate regulatory oversight (17), inadequate procedure guidance (16), company management absent or deficient (10) and incorrect manuals/charts/checklists (9) were the most frequent contributing factors. Since none of the existing models could summarize the root causes of 22 occurrences effectively, a scenario-based human-machine-environment-procedure (HMEP) classification scheme was proposed to use organizational influences, people management, technical failure, procedure and document, and environment as the first-layer subcategories. The HMEP scheme was additionally applied to the analysis and coding of 4 helicopter accidents in the USA published by the NTSB. The HMEP scheme revealed that NTSB had identified a significantly greater number of root causes in the manufacturer design, manufacturing & documentation. Overall, HMEP can be used to guide the data collection during accident investigation and subsequently to aggregate aviation accidents to derive recurring factors and compare accident patterns in an efficient manner.

- **Keywords:** Procedures and documentation; Safety management; ATSB; HFACS; IATA

Chunlei Chai, Jinlei Shi, Changxu Wu, Youcheng Zhou, Wei Zhang, Jing Liao. When to use vibrotactile displays? A meta-analysis for the role of vibrotactile displays in human-computer interaction. 103802.

Objective: This study aims to investigate the benefits of unimodal tactile displays relative to other modal displays and the performance gains of adding redundant tactile displays by integrating empirical studies. **Background:** Tactile displays have attracted increasing attention in recent years due to their unique advantages. Synthesizing experimental data is necessary to analyze the performance benefits of tactile displays for

participants and better help practitioners in utilizing them. **Method:** Five meta-analyses were conducted. Two meta-analyses compared the participants' performance between tactile and other modal displays (visual vs. tactile and auditory vs. tactile). Three meta-analyses examined the performance gains of adding redundant tactile displays based on other modal displays (visual vs. visual + tactile, auditory vs. auditory + tactile, and visual + auditory vs. visual + auditory + tactile). The related moderator variables, the types of presented information and concurrent tasks, were analyzed. **Results:** Little evidence shows the performance difference between tactile and auditory displays. Tactile displays are more beneficial than visual displays for presenting alert information or in the situation with a visual concurrent task. The performance gains of adding redundant tactile displays to other modal displays also depend on the specific type of presented information and the concurrent task. **Conclusion:** When using tactile displays to convey information, interface designers should consider the specific type of presented information and the concurrent tasks. **Applications:** The present study's findings can provide some implications for designers to utilize tactile displays when they construct and implement information displays.

- **Keywords:** Tactile display; Visual display; Auditory display; Redundant multimodal display; Human-computer interaction; Meta-analysis

Rosemary R. Seva, Judy Ann G. Wu, Katrina K. Chinjen, Nicole Anne Therese P. Estoista. *Effect of color properties in multiple time series graph comprehension.* 103808.

Multiple time series graphs are used prevalently in representing business and research data, but the use of color properties to visualize them to enhance comprehension is limited. This study explored the effect of hue and lightness in representing 4-time series data in relation to response time (RT) and accuracy. Two types of palettes were developed for each experiment: monochrome and multi-hue. The three sets of monochrome palettes created were red, green, and blue, while four equidistant hues in the color wheel were used in the multi-hue palette: red, blue, green, and purple. A total of forty people participated in the two experiments. Participants performed two tasks for both experiments: maximum and discrimination tasks. The monochrome experiment showed the primacy of green in terms of RT and accuracy in the discrimination task. RT and accuracy were significantly affected by lightness in the multi-hue experiment. For both tasks, RT was longer for 20% lightness and lowest at 60% lightness. Accuracy results were also consistent with RT. In the discrimination task, participants made more errors in 20% lightness and the highest accuracy for 60% and 80%.

- **Keywords:** Color; Data and knowledge visualization; Graphics recognition and interpretation; Time series analysis

Arthur van der Have, Marco Rossini, Carlos Rodriguez-Guerrero, Sam Van Rossum, Ilse Jonkers. *The Exo4Work shoulder exoskeleton effectively reduces muscle and joint loading during simulated occupational tasks above shoulder height.* 103800.

Introduction: Excessive physical shoulder musculoskeletal loading (muscle and joint contact forces), known to contribute to work-related shoulder disorders, can be reduced by a passive shoulder exoskeleton during quasi-static tasks. However, its effect on neighboring joints i.e. elbow, lower back, hip, and knee and its effect on joint contact forces have not been investigated. Furthermore, the effect of the exoskeleton's assistance versus movement adaptation when wearing the exoskeleton on musculoskeletal loading remains unexplored. **Methods:** 3D motion capture and ground reaction forces were measured while 16 participants performed 5 simulated occupational tasks with and without the exoskeleton. A musculoskeletal modeling workflow was used

to calculate musculoskeletal loading. Shoulder muscle fatigue was quantified using surface EMG. In addition, exoskeletons usability was quantified using the system usability scale. **Results:** When wearing the passive shoulder exoskeleton, shoulder and elbow musculoskeletal loading decreased during the high lift and overhead wiring task, without increasing the musculoskeletal load at the back, hip and knee. In contrast, musculoskeletal loading in the shoulder, as well as in the knee increased while lifting a box from the ground to knee height and from elbow height to shoulder height. When wearing the exoskeleton, muscle activity of the Trapezius descendens, Deltoideus medius and Biceps brachii were reduced during the high lift. **Conclusion:** The passive shoulder exoskeleton reduces musculoskeletal loading in the lower back, shoulder and elbow during simulated occupational tasks above shoulder height. In contrast, for tasks below shoulder height, the use of the exoskeleton needs to be critically reviewed to avoid increased musculoskeletal loading also in neighboring joints due to altered movement execution when wearing the exoskeleton.

- **Keywords:** Passive shoulder exoskeleton; Full-body musculoskeletal modeling; Simulated occupational tasks; Muscle fatigue

Yunxian Pan, Qinyu Zhang, Yifan Zhang, Xianliang Ge, Xiaoqing Gao, Shiyan Yang, Jie Xu. *Lane-change intention prediction using eye-tracking technology: A systematic review.* 103775.

The aim of this study is to identify the best practices and future research directions for driver lane-change intention (DLCI) prediction using eye-tracking technologies based on a systematic literature review. We searched five academic literature databases and then conducted an in-depth review, structured coding, and analysis of 40 relevant articles. The literature on DLCI prediction is summarized in terms of input features, feature extraction and prediction time windows, labeling methods, and machine learning algorithms. The results show that eye tracking data features along with other data sources can be useful inputs for the prediction of DLCI. Major challenges in this line of research include determining the optimal time window for feature extraction and developing and evaluating the appropriate machine learning algorithm. Suggestions for future research and practice for DLCI prediction in intelligent vehicles are discussed.

- **Keywords:** Systematic review; Driver lane change intention; Advanced driver assistance system; Eye tracking; Machine learning

Jiaqing Song, Yuwei Wang, Xiaojiang An, Shu Ma, Duming Wang, Tian Gan, Hongqi Shi, Zhen Yang, Hongyan Liu. *Novel sonification designs: Compressed, iconic, and pitch-dynamic auditory icons boost driving behavior.* 103797.

With the development of connected vehicles, in-vehicle auditory alerts enable drivers to effectively avoid hazards by quickly presenting critical information in advance. Auditory icons can be understood quickly, evoking a better user experience. However, as collision warnings, the design and application of auditory icons still need further exploration. Thus, this study aims to investigate the effects of internal semantic mapping and external acoustic characteristics (compression and dynamics design) on driver performance and subjective experience. Thirty-two participants (17 females) experienced 15 types of warnings — (3 dynamics: mapping 0 vs. 1 vs. 2) × (5 warning types: original iconic vs. original metaphorical vs. compressed iconic vs. compressed metaphorical auditory icon vs. earcon) — in a simulator. We found that compression design was effective for rapid risk avoidance, which was more effective in iconic and highly pitch-dynamic sounds. This study provides additional ideas and principles for the design of auditory icon warnings.

- **Keywords:** Auditory icons; Compression design; Dynamics; Semantics; Collision warnings

Dario Lampe, Barbara Deml. Reducing passive driver fatigue through a suitable secondary motor task by means of an interactive seating system. 103773.

Objective: The primary objective of the study was to evaluate the effect of a secondary motor task induced by an interactive seating system (IASS) on passive driver fatigue in a monotonous simulated driving task. The effect was compared to that of a state-of-the-art massage seating system (MS), which may reduce monotony through additional tactile stimuli. The secondary objective was to compare the user experience of both systems.

Method: The independent variables were three conditions: one with the IASS, another with the MS, and a control without intervention. The study included seven dependent variables in total: a rating of subjective fatigue, three parameters measuring lane keeping ability, and three parameters reflecting fatigue-related eye movements. The duration of the simulator ride was 40 min in each condition. The study included thirty-five subjects. **Results:** The assessment of subjective fatigue and lane keeping showed that the use of the IASS resulted in significantly lower passive driver fatigue compared to the massage and control conditions. The alerting effects of the IASS were also reflected by an increased eyelid distance. Frequency and duration of blinks, however, showed no clear patterns of fatigue over time in any of the conditions. Thus, both parameters did not seem be suitable to capture passive driver fatigue in this study. Regarding user experience, the subjects preferred the IASS over the MS as well. **Conclusion:** The IASS showed a strong potential as an effective measure against passive driver fatigue within monotonous driving situations. The MS, on the other hand, induced no measurable effects.

- **Keywords:** Interactive seating system; Active seating; Mental fatigue; Sustained attention; Driver vigilance; Passive driver fatigue; Partial automation

Anne Silla, Annika Dressler, Esko Lehtonen, Ari Virtanen, Johannes Mesimäki, Jan Grippenkoven. Potential of auxiliary strobe lights on train locomotives to improve level crossing safety. 103767.

Inattentiveness of road users on approach to passive railway crossings represents a major threat to level crossing safety. An auxiliary strobe light system installed on trains in addition to existing headlights may help address this issue by providing an ergonomic way of attracting human attention to the level crossing and to the train. The objective of this paper was to investigate the ergonomics and safety potential of auxiliary strobe light systems. A system was implemented on a real railway vehicle and in the virtual environment of a driving simulator. Acceptance of the system, including its usefulness and perceived benefits and drawbacks, as well as its objective effectiveness, were evaluated using questionnaires, behavioural measures, and eye tracking. The safety potential of the system was evaluated with respect to fatal level crossing accidents. The auxiliary strobe lights were preferred over normal lights and were rated as useful, reducing driving speeds, increasing visual scanning at level crossings, and thus aiding detection of a train. The system has the potential to prevent 6–30% of level crossing accidents in Europe. The results suggest that it might be worthwhile to test auxiliary strobe lights in a larger scale real-world experiment. Especially on railway lines with a high number of passive level crossings, this system can be expected to increase safety by supporting timely detection by road users and preventing accidents caused by inattentiveness.

- **Keywords:** Train visibility; Lights; Level crossing; Safety

Gimantha N. Perera, Lloyd A. Hey, Karen B. Chen, Madeline J. Morello, Brandon M. McConnell, Julie S. Ivy. Checklists in Healthcare: Operational Improvement of Standards using Safety Engineering - Project CHOISSE – A framework for evaluating the effects of checklists on surgical team culture. 103786.

The CHOISSE multi-stage framework for evaluating the effects of electronic checklist applications (e-checklists) on surgical team members' perception of their roles, performance, communication, and understanding of checklists is introduced via a pilot study. A prospective interventional cohort study design was piloted to assess the effectiveness of the framework and the sociotechnical effects of the e-checklist. A Delphi process was used to design the stages of the framework based on literature and expert consensus. The CHOISSE framework was applied to guide the implementation and evaluation of e-checklists on team culture for ten pilot teams across the US over a 24-week period. The pilot results revealed more engagement by surgeons than non-surgeons, and significant increases in surgeons' perception of communication and engagement during surgery with a small sample. Mixed methods analysis of the data and lessons learned were used to identify iterative improvements to the CHOISSE framework and to inform future studies.

- **Keywords:** Checklists; Teamwork; Surgical-safety

Rutali Joshi, Anjali Joseph, Sahar Mihandoust, Kapil Chalil Madathil, Shelia R. Cotten. A mobile application-based home assessment tool for patients undergoing joint replacement surgery: A qualitative feasibility study. 103796.

Background: Most adults prefer to age in place. However, the majority of homes are not designed to support resident needs, especially for adults undergoing joint replacement surgeries such as total knee arthroplasty (TKA) or total hip arthroplasty (THA). It is of paramount importance to proactively assess and modify the homes of adults undergoing TKA/THA such that they can safely transition home following surgery. Several tools utilize emerging technology like virtual reality, augmented reality, or teleconferencing to assess home environments. These are meant to be used by professionals like occupational therapists. However, the acceptance and uptake of simple technology like mobile applications for assessing homes proactively by residents has not been explored.

Objective: A qualitative exploratory study was conducted to evaluate the feasibility and potential acceptance of a mobile application for resident-initiated home assessment.

Methods: Semi-structured interviews were conducted with 22 patient-care partner dyads before and after THA/TKA to understand the perceived usefulness, likelihood of using a mobile application-based home assessment tool, and perceived barriers and facilitators of using the tool. **Results:** About 68% of the patient-care partner dyads interviewed for this study perceived benefits of using a mobile application-based tool. All the participants who perceived the tool to be useful showed high likelihood of using it. A comparison of responses between pre-and post-surgery interviews revealed that around 50% of participants showed an increased intention of using an assessment tool after experiencing challenges in their homes post-surgery. Participants provided recommendations for key content, potential features to include in the assessment tool, and preferred formats (e.g., checklists, visuals, and videos). **Conclusions:** To increase acceptance of a mobile application-based home assessment tool, it is crucial that residents are made aware of the home environment challenges and the importance of an assessment tool to improve their safety and independence. The content, features, formats, and usability suggestions from the participants in this study provide a framework for health mobile application and interface developers to design a home assessment tool.

- **Keywords:** Home assessment tool; Mobile application; Joint replacement surgery; Perceived usefulness; Likelihood of use

Mathilde Drouot, Nathalie Le Bigot, Emmanuel Bricard, Jean-Louis de Bougrenet, Vincent Nourrit. *Augmented reality on industrial assembly line: Impact on effectiveness and mental workload.* 103793.

Studies examining the potential of augmented reality (AR) to improve assembly tasks are often unrepresentative of real assembly line conditions and assess mental workload only through subjective measurements and leads to conflicting results. We proposed a study directly carried out in industrial settings, to compare the impact of AR-based instructions to computerized instructions, on assembly effectiveness (completion time and errors) and mental workload using objective (eye tracking), subjective (NASA-TLX) and behavioral measurements (dual task paradigm). According to our results, AR did not improve effectiveness (increased assembly times and no decrease in assembly errors). Two out of three measurements indicated that AR led to more mental workload for simple assembly workstation, but equated computer instructions for complex workstation. Our data also suggest that, AR users were less able to detect external events (danger, alert), which may play an important role in the occurrence of work accidents.

- **Keywords:** Augmented reality; Industrial assembly; Mental workload

Ester Reijnen, Lea Laasner Vogt, Jan P. Fiechter, Swen J. Kühne, Nadine Meister, Claudio Venzin, Raphael Aebersold. *Well-designed medical pictograms accelerate search.* 103799.

Two types of newly designed pharmaceutical pictograms (with and without context) were compared with an existing type of certified pictograms regarding their search efficiency. Each of the 30 participants had to search a total of 1'090 "fictitious" medical shelves for a certain box defined by the amount and type of medical instructions given (memory size) and presented among a variable number of other boxes (set size). The boxes contained the different types of pictograms mentioned above. Calculated factorial analyses on reaction time data, among others, showed that the two newly designed pictogram types make search more efficient compared to existing types of pictograms (i.e., flatter reaction time x set size slopes). Furthermore, regardless of the type of pictogram, this set size effect became more pronounced with larger memory sizes. Overall, the newly designed pictograms need fewer attentional resources and therefore might help to increase patient adherence.

- **Keywords:** Pharmaceutical pictogram system; Search efficiency; Medical instructions

Cheng-Long Deng, Chen-Yu Tian, Shu-Guang Kuai. *A combination of eye-gaze and head-gaze interactions improves efficiency and user experience in an object positioning task in virtual environments.* 103785.

Eye-gaze and head-gaze are two hands-free interaction modes in virtual reality, each of which has demonstrated different strengths. Selecting suitable interaction modes in different scenarios is important to achieve efficient interaction in virtual scenes. This study compared the movement time in an object positioning task by examining eye-gaze interaction and head-gaze interaction in various conditions. In turn, it identified the superior zones for each mode, respectively. Based on this information, we designed a combination mode – utilizing eye-gaze interaction at the acceleration phase and deceleration phase and head-gaze interaction at the correction phase – to achieve the optimal interaction mode, which has allowed us to obtain higher efficiency and subjective

satisfaction. This study provides a comprehensive analysis of the characteristics of the eye-gaze and head-gaze interaction modes and provides valuable insights into selecting the appropriate interaction modes for virtual reality applications.

- **Keywords:** Distal positioning; Gaze interaction; Movement trajectory; Virtual reality

Bernhard M. Weber, Simon Schätzle, Martin Stelzer. *Aiming performance during spaceflight: Individual adaptation to microgravity and the benefits of haptic support.* 103791.

Sensorimotor performance is known to deteriorate during spaceflight. Prior research for instance documented that targeted arm motions are performed slower and less precise in microgravity conditions. This article describes an experiment on aiming performance during different stages of a space mission. Moreover, the influence of different haptic settings of the human-machine interface (HMI) was explored. Two separate studies are presented in which the same aiming tasks were performed with a force feedback joystick: 1) A terrestrial study ($N = 20$) to explore time and haptic setting effects and 2) a space experiment ($N = 3$) with a pre-mission session, three mission sessions on board the ISS (2, 4, and 6 weeks in space), and a post-mission session. Results showed that sensorimotor performance was mainly affected in the initial phase of exposure to microgravity and this effect was moderated by astronauts' sensorimotor skills. Providing low stiffness at the HMI, however, proved to be an effective measure to maintain aiming precision in microgravity.

- **Keywords:** Microgravity; Sensorimotor performance; Haptic devices; Force feedback

A. Mazaheri, M. Forsman, R. Haettel, L.M. Rose. *Reaction force exposure for tightening tool users: A psychophysical based experimental study of electric right-angle nutrunners.* 103776.

Reaction forces from nutrunner tools constitute a risk of developing MSDs. However, recommendations for sustainable reaction force levels are lacking. The aim of this study was to inform recommendations regarding reaction load exposures from right-angle nutrunners. Through a psychophysics approach, experienced assembly workers subjectively assessed reaction loads when using a nutrunner in six combinations of tool tightening strategy, work-pace and screw-joint stiffness. Electromyography, tool and joint parameters were measured. Regardless of tightening strategy, joint stiffness and work-pace combinations, no large differences in acceptable tightening torque, peak reaction force, and handle displacement were observed. However, acceptable jerk and impulse differed substantially between the TurboTight® (high-acceleration) and QuickStep® (conventional) tightening strategies. Although the TurboTight® strategy overall showed reduced peak muscular activities compared to the QuickStep®, the participant-rated acceptable torque levels were similar, plausibly due to TurboTight's high jerk levels. Jerk and impulse are hypothesized to influence the perception of reaction loads.

- **Keywords:** Assembly work; Power tools; Electromyography; Ergonomics assessment

Tobias Hecht, Stefanie Weng, Luca-Felix Kick, Klaus Bengler. How users of automated vehicles benefit from predictive ambient light displays. 103762.

With the introduction of Level 3 and 4 automated driving, the engagement in a variety of non-driving related activities (NDRAs) will become legal. Previous research has shown that users desire information about the remaining time in automated driving mode and system status information to plan and terminate their activity engagement. In past studies, however, the positive effect of this additional information was realized when it was integrated in or displayed close by the NDRA. As future activities and corresponding items will be diverse, a device-independent and non-interruptive way of communication is required to continuously keep the user informed, thus avoiding negative effects on driver comfort and safety. With a set of two driving simulator studies, we have investigated the effectiveness of ambient light display (ALD) concepts communicating remaining time and system status when engaged in visually distracting NDRAs. In the first study with 21 participants, a traffic light color-coded ALD concept (LED stripe positioned at the bottom of the windshield) was compared to a baseline concept in two subsequent drives. Subjects were asked to rate usability, workload, trust, and their use of travel time after each drive. Furthermore, gaze data and NDRA disengagement timing was analyzed. The ALD with three discrete time steps led to improved usability ratings and lower workload levels compared to the baseline interface without any ALD. No significant effects on trust, attention ratio, travel time evaluation, and NDRA continuation were found, but a vast majority favored the ALD. Due to this positive evaluation, the traffic light ALD concept was subsequently improved and compared to an elapsing concept in a subsequent study with 32 participants. In addition to the first study, the focus was on the intuitiveness of the developed concepts. In a similar setting, results revealed no significant differences between the ALD concepts in subjective ratings (workload, usability, trust, travel time ratings), but advantages of the traffic light concept can be found in terms of its intuitiveness and the level of support experienced.

- **Keywords:** Automated driving; User information needs; Ambient light displays; Non-driving related activities

Wendy Macdonald, Jodi Oakman. The problem with "ergonomics injuries": What can ergonomists do? 103774.

Effects of psychosocial hazards on risk of musculoskeletal disorders (MSDs) are often very substantial, but workplace risk management practices focus largely on biomechanical hazards, as do the risk assessment methods used by ergonomists. Translation of research evidence into more effective workplace practices demands a more holistic risk management framework that encompasses both types of hazard. In this context, we evaluate the validity of different MSD risk assessment methods for different purposes, focusing particularly on requirements for routine workplace risk management. These include choice of fit-for-purpose assessment methods, prioritisation of hazards that are most affecting risk, and control actions as high as possible in the risk control hierarchy. Ergonomists could facilitate more effective workplace risk management by promoting: awareness of the need for change; improvements to guidance from OHS regulators; research on MSD-related workplace management issues; and professional development programs on this topic for ergonomists and other OHS practitioners.

- **Keywords:** Musculoskeletal disorders; Valid risk assessment; Workplace risk management

Abas Shkembi, Lauren M. Smith, Aurora B. Le, Richard L. Neitzel. Noise exposure and mental workload: Evaluating the role of multiple noise exposure metrics among surface miners in the US Midwest. 103772.

This study examined associations between metrics of noise exposure and mental workload. In this cross-sectional study, five occupational noise metrics computed from full-shift dosimetry were evaluated among surface mine workers in the US Midwest. Mental workload was evaluated using a modified, raw NASA-TLX and clustered with a k-means clustering algorithm. Mixed effects logistic regression and Bayesian Kernel Machine Regression (BKMR) was utilized for analysis. Average noise exposure, the difference between peak and mean noise exposure, and the number of peaks >135 dB were each strongly associated with mental workload, while the kurtosis and standard deviation of noise throughout a shift were not. An exposure-response relationship between average noise exposure and mental workload may exist, with elevated risk of high mental workload beginning at 80 dBA. These results suggest that high noise exposure may be an independent risk factor of high mental workload, and impulse events and the difference between the peak and mean noise exposure may have interactive effects with average noise exposure.

- **Keywords:** Occupational noise exposure; NASA-TLX; BKMR; Miners

Sarah Gonzalez, Paul Stegall, Stephen M. Cain, Ho Chit Siu, Leia Stirling. Assessment of a powered ankle exoskeleton on human stability and balance. 103768.

Wearable robotic systems, such as exoskeletons, are designed to assist human motion; however, they are typically only studied during level walking. Before exoskeletons are broadly integrated into unstructured environments, it will be important to evaluate exoskeletons in a broader set of relevant tasks. A balance beam traverse was used to represent a constrained foot placement task for examining balance and stability. Participants ($n = 17$) completed the task in their own shoes (Pre-Exoskeleton and Post-Exoskeleton trials), and when wearing a lower-limb exoskeleton (Dephy ExoBoot) in both powered and unpowered states. Data were collected via inertial measurement units (on the torso and feet) and analyzed on a pooled level (with data from all participants) and on an individual level (participant-specific confidence intervals). When examining pooled data, it was observed that the exoskeleton had mixed effects on stride stability metrics. When compared to the Post-Exoskeleton shoe control, it was observed that stride duration was increased when wearing the exoskeleton (both powered and unpowered states), while normalized stride length and stride speed were not affected. Despite the changes in stride stability, overall balance (as measured by torso sway) remained unaffected by exoskeleton state. On an individual level, it was observed that not all participants followed these general trends, and within each metric, some increased, some decreased, and some had no change in the Powered Exoskeleton condition when compared to the Post-Exoskeleton Shoe condition: normalized stride length (0% increased, 12% decreased, 88% no change), stride duration (35% increased, 0% decreased, 65% no change), and torso sway (0% increased, 12% decreased, 88% no change). Our findings suggest that the lower-limb exoskeleton evaluated can be used during tasks that require balancing, and we recommend that balancing tasks be included in standards for exoskeleton evaluation.

- **Keywords:** IMU; Wearable sensor; Standards development; Walking; Gait characteristics

Arkeliana Tase, Bhamini Vadhwana, Peter Buckle, George B. Hanna.
Usability challenges in the use of medical devices in the home environment: A systematic review of literature. 103769.

Background: Home care medical devices are the fastest-growing segment of the medical device industry with associated safety and usability challenges. Human factor studies in the home environment present many difficulties resulting in limited knowledge of device use in this setting. This systematic review aims to identify usability challenges reported directly by end-users in the home environment. **Methods:** A systematic review of the literature was conducted concentrating on studies involving end user reporting. Reported challenges were grouped into a) device-user, b) device use environment and c) device-user interface challenges. **Results:** 3471 studies were screened and 202 underwent full-text review. Only twelve studies had direct involvement of end users. Multiple challenges were identified, with device-user interface problems being the most common. No effective, standardised method was found to collect patient/user feedback on usability challenges in the post-market stage, leading to a knowledge gap. **Conclusions:** This study brought together multiple usability challenges reported by individual studies. Involvement of medical device end-users in usability studies is essential and their experiences must be effectively utilised in device design.