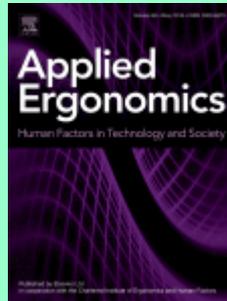


Applied Ergonomics - rok 2022, Volume 98

January



Jack T. Dennerlein, Jennifer M. Cavallari, Jeong Ho (Jay) Kim, Nicholas H. Green. *The effects of a new seat suspension system on whole body vibration exposure and driver low back pain and disability: Results from a randomized controlled trial in truck drivers.* 103588.

Through a randomized controlled trial, we evaluated the effects of an electro-magnetic active seat suspension that reduces exposure of a long-haul truck driver to whole body vibration (WBV) on low back pain (LBP) and disability. Among 276 drivers recruited from six trucking terminals of a major US trucking company, 135 eligible drivers were assigned to either having an Active Seat (Intervention: $n = 70$) – the BoseRide® electro-magnetic active seat – or Passive Seat (reference: $n = 65$) – a new version of their current seat (passive air suspension seat) – installed in their truck via block (terminal) randomization. Low back pain (LBP) severity, on a 0–10 scale and the Oswestry LBP Disability Index were collected before and 3-, 6-, 12-, 18-, and 24-months post seat installation. LBP severity and LBP disability scores were significantly lower post seat installation in both groups. At 3 months, LBP severity decreased -1.4 [95% CI: -2.1 to -0.7 ; $n = 46$] for drivers in the Active Seat arm, and -1.5 [95% CI: -2.3 to -0.8 ; $n = 41$] for drivers in the Passive Seat arm. In a subset of drivers, WBV exposures were collected before and after the seat installation. WBV exposures significantly decreased post seat installation for Active Seat ($p < 0.01$) but not for Passive Seat ($p = 0.15$). While the new seat-suspension technology reduced WBV exposures, LBP appeared to be improved by multiple factors. These results were limited by the secondary prevention approach and the longer-term loss to follow up due to large rates of driver turnover typical for the industry.

- **Keywords:** Whole body vibration; Work related musculoskeletal disorders; Transportation; Professional drivers

Annie Yu, Sachiko Sukigara. *Evaluation of the design and materials of anti-vibration gloves: Impact on hand dexterity and forearm muscle activity.* 103572.

Many anti-vibration gloves are available in the market but there are lacks of understanding of their effectiveness in facilitating various hand movements. This study addresses the knowledge gap through a wear trial with five types of anti-vibration gloves made of chloroprene rubber and spacer fabric. Surface electromyography of three forearm muscles of 16 male subjects was conducted during gripping, key pinching, woodblock transporting, screw inserting and screw driving tasks. The correlation between

the compression properties of the gloves and hand performance was also evaluated. The results show that hand dexterity is inhibited and more muscle activity is needed to carry the woodblocks with the spacer fabric glove without special design features. A thicker glove can reduce the demand of the flexor digitorum superficialis muscle when using an impact driver. A thinner dorsal side and tailored padding can enhance hand dexterity. The findings can be used as a reference for designing anti-vibration gloves.

- **Keywords:** Anti-vibration gloves; Spacer fabric; Hand performance; Wear trials; EMG; Muscle activity

Songpo Li, Mary L. Cummings, Benjamin Welton. *Assessing the impact of autonomy and overconfidence in UAV first-person view training.* 103580.

With the rapid rise in unmanned aerial vehicles (UAVs) for military and civil first-person applications like infrastructure inspection, there is an increased need for skilled UAV operators. However, research on effective training of UAV pilots has not kept pace with the demand. How much autonomy should be onboard, how much training, and how much control humans should have are still points of debate. To help fill this gap, this paper examines how different training programs and levels of control autonomy affect training outcomes for people operating a UAV in inspection tasks with high onboard autonomy. Results revealed a cost-benefit trade space in that those top performers with both lower-level teleoperation and higher-level supervisory control training could achieve the best performance, but with higher variability, as compare to those who received just supervisory control training. Another important finding was that those trainees who were overconfident were more likely to spend too much time micro-controlling the UAV, and also 15 times more likely to crash. Given that commercial UAV licensing is expected to significantly increase in the next few years, these results suggest more work is needed to determine how to mitigate overconfidence bias both through training and design.

- **Keywords:** Supervisory control; Drone; UAV; Pilot training

Hang Zhou, Brett R.C. Molesworth, Marion Burgess, Julie Hatfield. *The effect of broadband noise on learning and dynamic decision-making and how cognitive workload and sex moderate its effect.* 103604.

The aim of this research was to examine how broadband noise which is present in many workplaces affects dynamic decision-making. The effect of potential moderating factors, cognitive workload and sex, were also examined. Forty-eight participants (24 females) with an average age of 27.38 years (SD = 12.34) were asked to complete a dynamic decision-making task over three consecutive-days. Independent variables were Noise (Broadband - 0dBA vs. 75dBA above background) and Cognitive Workload (Low vs. High, manipulated via presence of a secondary task). Among females, broadband noise significantly impaired performance in low workload, but significantly improved performance in high workload. In contrast, among males broadband noise had no significant effect on overall performance. From an applied perspective, understanding the interaction between noise, cognitive workload and sex allows for the design of a training environment to ensure maximum performance by all staff.

- **Keywords:** Noise; Dynamic decision-making; Safety; Cognitive workload

Adolfo Villalobos, Alejandro Mac Cawley. *Prediction of slaughterhouse workers' RULA scores and knife edge using low-cost inertial measurement sensor units and machine learning algorithms.* 103556.

The high prevalence of work-related musculoskeletal disorders (WRMSDs) has been a concern in the meat-processing industry, owing to the manual nature of the work and the

high upper-limb and neck exposure to movements that can lead to WRMSD. The ability to perform an accurate and fast assessment of WRMSDs remains a challenge in industrial environments. Most assessment methodologies rely on standard survey-based methods, which are time- and labor-intensive. In this paper, we present an application of inertial measurement units (IMUs) to measure human activity, and the use of artificial intelligence and machine learning techniques to perform task classification and ergonomic assessments in workplace settings. We present the results obtained by using simple low-cost IMUs worn on slaughterhouse worker wrists to capture information on their movements. We describe the use of this information to detect the risk factors of the wrists/hands that can lead to WRMSDs. The results indicate that by using low-cost IMU-based sensors on the wrists of slaughterhouse workers, we can accurately classify the sharpness of the knife and predict the worker RULA score.

- **Keywords:** Work-related musculoskeletal disorders; Machine learning; Sensors; RULA scores; Slaughterhouse workers

M. Sujan, N. Bilbro, A. Ross, L. Earl, M. Ibrahim, G. Bond-Smith, A. Ghaferi, L. Pickup, P. McCulloch. *Failure to rescue following emergency surgery: A FRAM analysis of the management of the deteriorating patient.* 103608.

Background: Failure to rescue (FTR) denotes mortality from post-operative complications after surgery with curative intent. High-volume, low-mortality units have similar complication rates to others, but have lower FTR rates. Effective response to the deteriorating post-operative patient is therefore critical to reducing surgical mortality. Resilience Engineering might afford a useful perspective for studying how the management of deterioration usually succeeds and how resilience can be strengthened.

Methods: We studied the response to the deteriorating patient following emergency abdominal surgery in a large surgical emergency unit, using the Functional Resonance Analysis Method (FRAM). FRAM focuses on the conflicts and trade-offs inherent in the process of response, and how staff adapt to them, rather than on identifying and eliminating error. 31 semi-structured interviews and two workshops were used to construct a model of the response system from which conclusions could be drawn about possible ways to strengthen system resilience. **Results:** The model identified 23 functions, grouped into five clusters, and their respective variability. The FRAM analysis highlighted trade-offs and conflicts which affected decisions over timing, as well as strategies used by staff to cope with these underlying tensions. Suggestions for improving system resilience centred on improving team communication, organisational learning and relationships, rather than identifying and fixing specific system faults. **Conclusion:** FRAM can be used for analysing surgical work systems in order to identify recommendations focused on strengthening organisational resilience. Its potential value should be explored by empirical evaluation of its use in systems improvement.

- **Keywords:** Failure to rescue; Emergency surgery; Patient safety; FRAM; Resilience engineering

Joel M. Mumma, Ellen Jordan, Oluwateniola Ayeni, Noah Kaufman, Marisa J. Wheatley, Amanda Grindle, Jill Morgan. *Development and validation of the discomfort of cloth Masks-12 (DCM-12) scale.* 103616.

During the COVID-19 pandemic, the use of face masks by the public has helped to slow the spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the community. Cloth masks have been recommended because of their effectiveness, availability, and reusability. Like other types of face masks, however, user discomfort while wearing cloth masks is thought to engender behaviors that limit the effectiveness of cloth masks as source control (e.g., adjusting or removing one's mask temporarily

while in public). To design cloth masks that are more tolerable, a measurement instrument for assessing subjective user discomfort is needed. Across two studies, we identified and confirmed a two-dimensional factor structure underlying the discomfort of cloth masks – discomfort related to the breathability and discomfort related to the tightness of the mask against the face and head. Additionally, we provide replicable evidence that both factor-subscales predict the self-reported frequencies of problematic mask-wearing behaviors.

- **Keywords:** COVID-19; Cloth face masks; Discomfort

Katie A. Goggins, Emily J. Tetzlaff, Wesley W. Young, Alison A. Godwin. *SARS-CoV-2 (Covid-19) workplace temperature screening: Seasonal concerns for thermal detection in northern regions. 103576.*

Workplace temperature screening has become standard practice during the SARS-CoV-2 pandemic. The objective was to determine the consistency of four temperature devices during exposure to simulated and actual environmental conditions reflective of a workplace. An infrared (IR) digital thermometer (accuracy(A) \pm 0.2), IR laser thermometer (A \pm 1), and thermal imaging camera (A \pm 0.3) were used to measure forehead and tympanic (digital only) temperatures. The first experiment was conducted in a controlled simulated environment (–20 to 20 °C) with three participants (32-YOF, 27-YOM, 20-YOF). The second experiment used actual outdoor conditions (–0.48 to 45.6 °C) with two participants (32-YOF, 27-YOM). The tympanic measurement was the least impacted by environmental temperature (mean(\pm SD)): simulated (36.8(\pm 0.18) °C) and actual (36.9(\pm 0.16) °C). The thermal imaging camera had the lowest RMSE values (0.81–0.97 °C), with outdoor temperatures ranging from 0 to 45 °C. Environmental temperature influenced forehead temperature readings and required a resting period in a thermoneutral environment (5–9 min (–20 to –10 °C) to immediate (15–20 °C)).

- **Keywords:** Screening protocols; Environmental temperature; Infrared camera; Infrared thermometer; Forehead temperature

Rich C. McIlroy, Victoria A. Banks, Katie J. Parnell. *25 Years of road safety: The journey from thinking humans to systems-thinking. 103592.*

Research into road safety has evolved from individual level component analysis to a much broader, systemic approach that acknowledges the fusion of 'socio' and 'technical' system elements. Over the past four decades, Professor Neville Stanton has contributed to over 179 journal articles, book chapters and conference papers in the field of road safety. The journey from 'thinking humans' to 'systems thinking' is demonstrated in this paper through the novel application of the Risk Management Framework (RMF) to the categorisation of research activities. A systematic review of Neville's contributions to the field of road safety demonstrates that over the years, his research activities have evolved from investigating single technological or human performance aspects in isolation (e.g., in-vehicle information design and workload) through to the holistic analysis of much broader systems (e.g., investigating road safety as a whole). Importantly, this evolution goes hand in hand with a change in the focus and emphasis of recommendations for improvements to safety. Going forward, Neville has helped pave the way for fundamental changes and improvements to be made to road safety systems around the world.

- **Keywords:** Road safety; Human factors methods; Sociotechnical systems; Risk management framework

Amelia Klarich, Thomas Z. Noonan, Chris Reichlen, St Marie J. Barbara, Laura Cullen, Priyadarshini R. Pennathur. *Usability of smart infusion pumps: A heuristic Evaluation. 103584.*

Although smart infusion pumps were built to eliminate medication errors, new types of usability errors have arisen. The purposes of this study were to determine potential risks when using smart pumps during secondary medication administration and to identify opportunities for design improvements. We observed and analyzed nurses when they interacted with smart pumps and heuristically evaluated the smart pump to identify usability problems. Forty-three usability problems were identified with the smart pump. The usability problems have the potential to create high cognitive burden on nurses and to increase the likelihood of mistakes. We discuss design and process improvement recommendations for each major finding from this study.

- **Keywords:** Infusion pump safety; Medication errors; Roller clamp; Smart infusion pump; Smart pump usability; Human factors evaluation

Xuanxuan Zhang, Mark C Schall, Howard Chen, Sean Gallagher, Gerard A. Davis, Richard Sesek. *Manufacturing worker perceptions of using wearable inertial sensors for multiple work shifts.* 103579.

Wearable inertial sensors may be used to objectively quantify exposure to some physical risk factors associated with musculoskeletal disorders. However, concerns regarding their potential negative effects on user safety and satisfaction remain. This study characterized the self-reported daily discomfort, distraction, and burden associated with wearing inertial sensors on the upper arms, trunk, and dominant wrist of 31 manufacturing workers collected over 15 full work shifts. Results indicated that the workers considered the devices as generally comfortable to wear, not distracting, and not burdensome to use. Exposure to non-neutral postures (discomfort, right arm, $\beta = 0.02$; trunk, $\beta = -0.01$), non-cyclic tasks (distraction, $\beta = -0.26$), and higher body mass indices (discomfort, $\beta = 0.05$; distraction, $\beta = 0.02$) contributed to statistically significant ($p < 0.05$), albeit practically small increases in undesirable ratings. For instance, for each additional percentage of time working with the right arm elevated $\geq 60^\circ$, self-reported discomfort ratings increased 0.02 cm on a standard 10 cm visual analog scale. Female workers reported less discomfort and distraction while wearing the sensors at work than males (discomfort, $\beta = -0.93$; distraction, $\beta = -0.3$). In general, the low ratings of discomfort, distraction, and burden associated with wearing the devices during work suggests that inertial sensors may be suitable for extended use among manufacturing workers.

- **Keywords:** Wearables; User experience; Musculoskeletal disorders; Inertial Measurement Unit; Exposure assessment; Field measurement

Brett Pollard, Lina Engelen, Fabian Held, Richard de Dear. *Activity space, office space: Measuring the spatial movement of office workers.* 103600.

A key to the development of more effective interventions to promote movement and reduce physical inactivity in office workplaces may be to measure and locate individual's spatial movement. Using an activity space estimation method, high resolution location data collected from 15 office workers over 12 days were used to estimate and analyse the location and extent of their daily spatial movement whilst in an office work-based setting. The results indicated that the method, kernel density estimation, combined with location data offers significant opportunities to not only measure and compare spatial movement behaviours but also simultaneously identify the locations where the behaviours occur. Combined with other data streams, this method will allow researchers to further investigate the influence of different environmental characteristics on these behaviours, potentially leading the development of more effective, longer lasting interventions to promote movement and reduce stationary behaviour, ultimately improving the health of office workers.

- **Keywords:** Office; Spatial behaviour; Physical inactivity; Home range; Activity space; Sensors

Hanjun Park, Sunwook Kim, Maury A. Nussbaum, Divya Srinivasan. *Effects of using a whole-body powered exoskeleton during simulated occupational load-handling tasks: A pilot study.* 103589.

Whole-body powered exoskeletons (WB-PEXOs) can be effective in reducing the physical demands of heavy occupational work, yet almost no empirical evidence exists on the effects of WB-PEXO use. This study assessed the effects of WB-PEXO use on back and leg muscle activities during lab-based simulations of load handling tasks. Six participants (4M, 2F) completed two such tasks (load carriage and stationary load transfer), both with and without a WB-PEXO, and with a range of load masses in each task. WB-PEXO use reduced median levels of muscle activity in the back (~42–53% in thoracic and ~24–43% in lumbar regions) and legs (~41–63% in knee flexors and extensors), and mainly when handling loads beyond low-moderate levels (10–15 kg). Overall, using the WB-PEXO also reduced inter-individual variance (smaller SD) in muscle activities. Future work should examine diverse users, focus on finding effective matches between WB-PEXO use and specific tasks, and identify applications in varied work environments.

- **Keywords:** Human augmentation; Occupational exoskeleton; Electromyography

Dedy Ariansyah, John Ahmet Erkoyuncu, Iveta Eimontaite, Teegan Johnson, Anne-Marie Oostveen, Sarah Fletcher, Sarah Sharples. *A head mounted augmented reality design practice for maintenance assembly: Toward meeting perceptual and cognitive needs of AR users.* 103597.

Head Mounted Display (HMD) based Augmented Reality (AR) is being increasingly used in manufacturing and maintenance. However, limited research has been done to understand user interaction with AR interfaces, which may lead to poor usability, risk of occupational hazards, and low acceptance of AR systems. This paper uses a theoretically-driven approach to interaction design to investigate the impact of different AR modalities in terms of information mode (i.e. video vs. 3D animation) and interaction modality (i.e. hand-gesture vs. voice command) on user performance, workload, eye gaze behaviours, and usability during a maintenance assembly task. The results show that different information modes have distinct impacts compared to paper-based maintenance, in particular, 3D animation led to a 14% improvement over the video instructions in task completion time. Moreover, insights from eye gaze behaviours such as number of fixations and transition between Areas of Interest (AOIs) revealed the differences in attention switching and task comprehension difficulty with the choice of AR modalities. While, subjective user perceptions highlight some ergonomic issues such as misguidance and overreliance, which must be considered and addressed from the joint cognitive systems' (JCSs) perspective and in line with the predictions derived from the Multiple Resources Model.

- **Keywords:** Augmented reality; Head-mounted display; Eye gaze behaviours; Joint cognitive system; Usability; Multiple resource model

Stephanie Champion, Christopher Barr, Belinda Lange, Lucy K. Lewis, Michael P. Russo, Anthony Maeder, Susan Gordon. *Chair design for older immobile people: Comparison of pressure mapping and manual handling outcomes.* 103581.

The number of older adults unable to transfer or ambulate independently is increasing. High support chairs enable people experiencing loss of mobility to be mobile, but current chair designs are associated with global functional loss and pressure ulcers. This pilot

study compared the functionality of a traditional design high support chair to a new design of motorised high support chair: 1) a motion laboratory study compared joint angles and pressure at the hip, knee, ankle, elbow and spine when pushing each chair, and 2) a pressure mapping study compared the interface pressure when older people with limited mobility used the chairs. Significant reduction in joint angles for the person pushing the chair (degree difference range -3.6 to 14.2) and decreased seated pressure (w/kg difference range -0.2 to 2.1) for the seated user were identified for the motorised chair. Longitudinal investigations are required to determine if the significant differences identified in this pilot study result in less manual handling injuries and pressure areas.

- **Keywords:** Gait analysis; Aged; Pressure mapping; Occupational injuries; Moving and lifting patients

Johanna Roche, Alinda G. Vos, Samanta T. Lalla-Edward, Peter R. Kamerman, WD. Francois Venter, Karine Scheuermaier. *Importance of testing the internal consistency and construct validity of the Pittsburgh Sleep Quality Index (PSQI) in study groups of day and night shift workers: Example of a sample of long-haul truck drivers in South Africa.* 103557.

Irregular work times promote inconsistent completion of the Pittsburgh Sleep Quality Index (PSQI) among shift workers. We aimed to demonstrate the importance of testing the internal consistency and construct validity of the PSQI and of the Epworth Sleepiness Scale (ESS) by presenting the methodology in a sample of long-haul truckers in South Africa. Internal consistency of the questionnaires was assessed by Cronbach's alpha (defined as raw $\alpha \geq 0.70$), and construct validity by factor analysis. 302 participants (49.3%) reported at least one night shift/week. Overall, the PSQI and ESS's alpha were 0.42 and 0.85, respectively. The factors explained 19.6% of 57.0% of the variance. The PSQI's alpha was 0.46 in night shift workers and 0.38 in non-night shift workers. In this occupational group, the PSQI must be used with caution. Testing the internal consistency and construct validity among the assessed population seems necessary. Sleep questionnaires adapted to shift workers should be preferred.

- **Keywords:** Sleep quality; Southern Africa; Truckers

Beatrice Coldewey, Annette Diruf, Rainer Röhrig, Myriam Lipprandt. *Causes of use errors in ventilation devices - Systematic review.* 103544.

A systematic review according to the PRISMA reporting standard was performed to identify causes of use errors in mechanical ventilators described in the literature. The PubMed search resulted in the inclusion of 16 papers. The errors described were systematically analyzed with regard to their causes and categorized in an adapted cause-and-effect diagram. The causes of use errors were related to specific usability issues and to the general condition that medical staff often work with different ventilators. When many devices are used, the different user interfaces are a source of use errors, since, for example, the same ventilation modes have different names. In order to avoid the identified causes for use errors in the future, this work offers manufacturers of ventilation devices design recommendations and the possibility to include the results in their risk management. In addition, standardizing user interface content across all ventilators, as in ISO 19223, can help reduce use errors.

- **Keywords:** Mechanical ventilators; User centered design; Patient safety

Ao Jiang, Bernard H. Foing, Irene Lia Schlacht, Xiang Yao, Vien Cheung, Peter A. Rhodes. *Colour schemes to reduce stress response in the hygiene area of a space station: A Delphi study.* 103573.

This paper aims to explore colour schemes to reduce stress response in the hygiene area of a space station. We conducted a two-stage exploratory Delphi-study with 30 international experts. It was found that the overall environment, stool-urine collection device, garbage collection interface and negative pressure package interface of the hygiene area most affected astronauts' experience. Remarkably, experts have highest visual requirements for the cleanliness of the overall environment and for stool and urine collection devices in the hygiene area. These tend to have low saturation and low blackness colours, while the garbage collection interface and negative pressure package interface have conspicuity and discernibility visual requirements. It was found that experts tend to choose high saturation and high brightness colours.

- **Keywords:** Colour scheme; Space station; Hygiene area; Stressor; Delphi method

P.A. Hancock. *How human factors and ergonomics save lives.* 103585.

This work is directed to an understanding as to how the knowledge of, and the application of human factors and ergonomics (HF/E) can save lives. To achieve this, the paper features an assessment of the achievements of one particular scientist, Neville Anthony Stanton, and how his body of contributions has impacted the realm of ground transportation and, in particular, driver behavior assessment. On the widest scale, it is objectively and obviously the case that Stanton is one of the most fecund scientists of our discipline ever. His impact is evident globally and results not simply from the sum total of his written and published works but through an extensive record of international scientific presentations, mutual investigative collaborations across the globe, and mentoring at all levels of the Academy and beyond. As well as mastering and elucidating the HF/E dimensions of a number of content domains, he has generated vital, and even unique tools and methods through which we can explore and understand the problem space of HF/E. Placing those attainments in context permits us a wider window upon how the discipline itself exerts practical and positive influences across the wide swath of real-world systems.

- **Keywords:** Safety; Goals; Human factors; Ergonomics; Neville Stanton

Claudine Mélan, Nadine Cascino. *Effects of a modified shift work organization and traffic load on air traffic controllers' sleep and alertness during work and non-work activities.* 103596.

A 'compressed' shift schedule (substitution of a rest day by a shift, shortening the duration of work breaks) was introduced for a better fit with aircraft traffic load. Thereafter, the company asked for a survey assessing the effects of the compressed shift system. Air traffic controllers (ATCOs) completed retrospectively a specific questionnaire assessing the effects of shift schedule (modified vs. initial) and of traffic load on fatigue, alertness (on-shift, upon awakening, during daily non-work activities), and sleep (duration, satisfaction). Work organization had marginal and unexpected effects, which might indicate ATCOs' disapproval of the intervention. Traffic load affected sleep satisfaction and alertness during work and non-work activities. Specific effects of shift included reduced sleep time prior to morning shifts compared to night shifts, whereas alertness and fatigue were rated at comparable levels for both shifts. Results suggest that shiftwork features which favor sleep loss across a work cycle have deleterious consequences on alertness and increase the need for recovery, which are further enhanced by traffic load.

- **Keywords:** Air traffic control; Shift work organization; Traffic load

Yadrianna Acosta-Sojo, Leia Stirling. *Individuals differ in muscle activation patterns during early adaptation to a powered ankle exoskeleton.* 103593.

Exoskeletons have the potential to assist users and augment physical ability. To achieve these goals across users, individual variation in muscle activation patterns when using an exoskeleton need to be evaluated. This study examined individual muscle activation patterns during walking with a powered ankle exoskeleton. 60% of the participants were observed to reduce medial gastrocnemius activation with exoskeleton powered and increase with the exoskeleton unpowered during stance. 80% of the participants showed a significant increase in tibialis anterior activation upon power addition, with inconsistent changes upon power removal during swing. 60% of the participants that were able to adapt to the system, did not de-adapt after 5 min. Muscle activity patterns differ between individuals in response to the exoskeleton power state, and affected the antagonist muscle behavior during this early adaptation. It is important to understand these different individual behaviors to inform the design of exoskeleton controllers and training protocols.

- **Keywords:** Exoskeleton; Gait; Electromyography; Co-activation; Co-contraction

Jeewon Choi, Takeru Ogawa, Shin Takesue, Satoshi Muraki, Youki Inoue, Hikari Abe, Emi Yamanoi. *Different flooring surfaces affect infants' crawling performance.* 103553.

This study assessed the influence of different types of flooring on infants' crawling motion patterns and performance. Each participating infant (range: 8.7-12.4 months) was encouraged to crawl on a tatami mat made of woven straw as well as other flooring types such as hardwood, carpet, and joint mat. Material tests were conducted to quantify the friction and shock absorption of the flooring. A three-dimensional motion capture system was used to measure spatiotemporal and kinematic variables during hands-and-knees crawling. An increased crawling rate was associated with a faster cadence of cyclic arm movements, but not with crawling stride length. Hardwood flooring had a significantly lower crawling rate and longer duration of hand-floor contact than tatami, while the crawling stride length and range of motion of joint movements were hardly affected by flooring type. The results of this study suggest a drawback of hardwood flooring in terms of infants' effective quadrupedal locomotion.

- **Keywords:** Crawling motion; Flooring; 3D motion capture

Martine A. Gilles, Clarisse Gaudez, Jonathan Savin, Aurélie Remy, Olivier Remy, Pascal Wild. *Do age and work pace affect variability when performing a repetitive light assembly task?* 103601.

This study examined whether a repetitive light assembly task could be performed according to different movement sequences identified as ways of doing (WoD), and whether the age of the participants or the work pace affected the number of WoDs selected by each participant, or the kinematic parameters for each WoDs. For two work paces, 62 right-handed men in 3 age-groups were asked to fix a handle on a base with 2 nuts without discontinuity for a period of 20 min; no assembly procedure was demonstrated. The WoDs were characterized by a cross tabulation video coding method, and by measuring vertical force applied and the parameters of upper limb kinematics, as well as these measures' approximate entropy (ApEN). Five main different WoDs were used. Although most participants varied their WoD, neither participant age nor work pace affected the number of WoD they used. However, the WoDs differed from each other by the sequence of movements and by the level of ApEn of their kinematic variables without

interfering with the production rate. Allowing operators to vary their WoDs when performing repetitive tasks could reduce strain on the locomotor system.

- **Keywords:** Repetitive task; Variability; Age; Pace

Sally Maynard, Karl A. Miller, Ashleigh Filtness. *Keeping the service running: Examining working relationships and workload of London bus network iBus controllers.* 103577.

Bus controllers are an essential part of the London bus network. Although the bus driver is the individual directly in control of the vehicle, inputs from both the controller and driver influence operations. Currently, little research has focused on the dynamic between these parties, and how it works in the day-to-day operation of a bus. In the current study, data was collected across focus groups with controllers to understand the controller-driver relationship from the controller perspective. The objectives of the research were to: investigate interactions and working relationships between bus controllers and drivers in London and to explore the effect of controller/driver relationships on workload, stress and fatigue. It is clear that the working relationship between controllers and drivers is a challenging one, with both parties often misunderstanding the role of the other. This is made worse by the nature of communication via radio including poor quality audio leading to difficult interactions. All of the participating controllers expressed being overloaded with work, leading to feelings of stress and fatigue, with shift work and irregular hours being discussed as a cause of controller fatigue. Any steps taken to improve the difficult working relationship between drivers and controllers can be seen as beneficial because they could improve efficiency, worker wellbeing, and possibly safety.

- **Keywords:** Fatigue; Sleepiness; Shift work; Bus drivers; Network iBus controllers; Focus groups; Working relationships

Sander De Bock, Jo Ghillebert, Renée Govaerts, Bruno Tassignon, Carlos Rodriguez-Guerrero, Simona Crea, Jan Veneman, Joost Geeroms, Romain Meeusen, Kevin De Pauw. *Benchmarking occupational exoskeletons: An evidence mapping systematic review.* 103582.

Objectives: To provide an overview of protocols assessing the effect of occupational exoskeletons on users and to formulate recommendations towards a literature-based assessment framework to benchmark the effect of occupational exoskeletons on the user. **Methods:** PubMed (MEDLINE), Web of Science database and Scopus were searched (March 2, 2021). Studies were included if they investigated the effect of one or more occupational exoskeletons on the user. **Results:** In total, 139 eligible studies were identified, encompassing 33, 25 and 18 unique back, shoulder and other exoskeletons, respectively. Device validation was most frequently conducted using controlled tasks while collecting muscle activity and biomechanical data. As the exoskeleton concept matures, tasks became more applied and the experimental design more representative. With that change towards realistic testing environments came a trade-off with experimental control, and user experience data became more valuable. **Discussion:** This evidence mapping systematic review reveals that the assessment of occupational exoskeletons is a dynamic process, and provides literature-based assessment recommendations. The homogeneity and repeatability of future exoskeleton assessment experiments will increase following these recommendations. The current review recognises the value of variability in evaluation protocols in order to obtain an overall overview of the effect of exoskeletons on the users, but the presented framework strives to facilitate benchmarking the effect of occupational exoskeletons on the users across this variety of assessment protocols.

- **Keywords:** Assistive device; Wearable robot; Work; Methodology design

Victor C.H. Chan, Gwyneth B. Ross, Allison L. Clouthier, Steven L. Fischer, Ryan B. Graham. *The role of machine learning in the primary prevention of work-related musculoskeletal disorders: A scoping review.* 103574.

To determine the applications of machine learning (ML) techniques used for the primary prevention of work-related musculoskeletal disorders (WMSDs), a scoping review was conducted using seven literature databases. Of the 4,639 initial results, 130 primary research studies were deemed relevant for inclusion. Studies were reviewed and classified as a contribution to one of six steps within the primary WMSD prevention research framework by van der Beek et al. (2017). ML techniques provided the greatest contributions to the development of interventions (48 studies), followed by risk factor identification (33 studies), underlying mechanisms (29 studies), incidence of WMSDs (14 studies), evaluation of interventions (6 studies), and implementation of effective interventions (0 studies). Nearly a quarter (23.8%) of all included studies were published in 2020. These findings provide insight into the breadth of ML techniques used for primary WMSD prevention and can help identify areas for future research and development.

- **Keywords:** Occupational injury; Artificial intelligence; Cluster analysis; Classification; Prediction

A.J. Carrigan, A. Charlton, M.W. Wiggins, A. Georgiou, T. Palmeri, K.M. Curby. *Cue utilisation reduces the impact of response bias in histopathology.* 103590.

Histopathologists make diagnostic decisions that are thought to be based on pattern recognition, likely informed by cue-based associations formed in memory, a process known as cue utilisation. Typically, the cases presented to the histopathologist have already been classified as 'abnormal' by clinical examination and/or other diagnostic tests. This results in a high disease prevalence, the potential for 'abnormality priming', and a response bias leading to false positives on normal cases. This study investigated whether higher cue utilisation is associated with a reduction in positive response bias in the diagnostic decisions of histopathologists. Data were collected from eighty-two histopathologists who completed a series of demographic and experience-related questions and the histopathology edition of the Expert Intensive Skills Evaluation 2.0 (EXPERTise 2.0) to establish behavioural indicators of context-related cue utilisation. They also completed a separate, diagnostic task comprising breast histopathology images where the frequency of abnormality was manipulated to create a high disease prevalence context for diagnostic decisions relating to normal tissue. Participants were assigned to higher or lower cue utilisation groups based on their performance on EXPERTise 2.0. When the effects of experience were controlled, higher cue utilisation was specifically associated with a greater accuracy classifying normal images, recording a lower positive response bias. This study suggests that cue utilisation may play a protective role against response biases in histopathology settings.

- **Keywords:** Histopathology; Cue utilisation; Response bias

Celeste E. Coltman, Brooke R. Brisbine, Richard H. Molloy, Julie R. Steele. *Can smaller body armour improve thoracolumbar range of motion and reduce interference when female soldiers perform dynamic tasks?* 103602.

Most female soldiers report that in-service body armour systems are too large. We investigated whether a smaller prototype body armour system could improve thoracolumbar range of motion (ROM) and reduce interference when female soldiers performed dynamic postures. 97 female soldiers completed three ROM tasks and seven

dynamic postures wearing no armour, an in-service body armour system, and a smaller prototype system. Feedback on comfort of the prototype system was also obtained. Thoracolumbar ROM and dynamic posture completion were both hindered by using body armour, although the participants' performances were significantly less impeded when they wore the smaller prototype system compared to the in-service system. A smaller body armour system that is better matched to the anthropometric dimensions of female soldiers appears to improve overall fit and function. An increased range of body armour sizes and female-specific designs should be systematically explored to further enhance fit and function of body armour.

- **Keywords:** Range of motion; Dynamic postures; Comfort; Body armour; Female soldiers

Haroun Zerguine, Ana D. Goode, Alison Abbott, Venerina Johnston, Genevieve N. Healy. *Factors impacting workplace investment in sit-stand workstations from the perspective of purchasing decision-makers.* 103558.

This explanatory sequential mixed-method study explored the factors associated with the investment (or not) in sit-stand workstations (SSWs) and alternative initiatives to reduce prolonged sitting at work from the perspective of furniture purchasing decision-makers in Australian workplaces. Participants (n = 270) from >200 organisations across 19 industry sectors completed an online survey. Seven interviews were conducted in a sub-sample of participants from organisations without SSWs. The majority (80%) of workplaces reported having invested in SSWs. Workplaces without SSWs, opposed to those with SSWs, were more likely to be private (79.6% vs. 43.5%), of small/medium size (70.4% vs. 35.6%) and without a wellness program (57.4% vs. 22.2%) (all p < 0.05). Financial implications were the main reason for not investing in SSWs. Exercise and stretch breaks were alternative initiatives to reducing sedentary behaviour at work. Better evidence on the return on investment is needed to support purchasing decisions on SSWs.

- **Keywords:** Sit-stand workstation; Standing desk; Office-workers; Sedentary behaviour; Wellness

Christopher A.J. Anderson, Ian B. Stewart, Kelly L. Stewart, Denise M. Linnane, Mark J. Patterson, Andrew P. Hunt. *Sex-based differences in body core temperature response across repeat work bouts in the heat.* 103586.

Objective: To investigate the effects of repeated work bouts in the heat on peak body core temperature and to explore sex-based differences in body core temperature responses. **Methods:** Fourteen males and fifteen females performed four work bouts (two heavy and two moderate, alternating) in 32.5 °C Wet Bulb Globe Temperature (WBGT), each separated by 30-min seated rest in 28.0 °C WBGT. Participants wore a military combat uniform with body armour and helmet (10 kg load) during the work bouts, removing the vest and helmet during recovery periods. **Results:** Body core temperature elevation over time was faster in the first compared with subsequent work bouts of each intensity. Body core temperature elevation was similar between males and females during the first heavy work bout, then remained significantly lower in females for the remainder of the trial. **Conclusions:** Contrary to the assumed progressive elevation in strain, but in agreement with recent literature, a gradual reduction in heat storage in subsequent exercise bouts prevented a cumulative increase in heat strain in the conditions tested.

- **Keywords:** Thermoregulation; Heat stress; Military

Guy H. Walker, Alexander Eriksson, Jediah R. Clark, Mark S. Young. *Festschrift in honour of Professor Neville Stanton: A lone crusader in a world of driving simulators.* 103594.

The automotive future has always pointed to a world of intelligent co-pilots and robot cars, but perhaps no more so than Knight Rider. In this 1980's television series the fictional Knight Industries Two Thousand (KITT) was a supercomputer on wheels with 1000 megabytes of memory. The protagonist was Michael Knight, a young loner on a crusade to champion the cause of the innocent and the helpless. This was a shadowy flight into the trials and tribulations of different levels of automation, re-claiming control when automation failed, and a wilful, chatty computer co-driver. An amusing metaphor, perhaps, for the research impact made by Neville Stanton in the field of vehicle automation. Without question – to paraphrase the Knight Rider outro – “one man can make a difference”. This festschrift in Neville's honour tells the story of how.

- **Keywords:** Driver feedback; Vehicle automation

Kristina Karstad, Charlotte D.N. Rasmussen, Charlotte Lund Rasmussen, Reiner Rugulies, Karen Sjøgaard, Alex Burdorf, Andreas Holtermann. *The influence of organizational factors, eldercare worker characteristics and care situation on the use of assistive devices during resident handling in eldercare work.* 103533.

We evaluated the influence of organization, eldercare worker and care situation on the use of assistive devices during resident handling in eldercare work. We conducted a multi-level study among 20 nursing homes, 126 wards within the nursing homes, 549 eldercare workers within the wards, who performed a total of 1306 care episodes including 3695 resident handlings. The influence of organization (i.e. nursing home and ward), eldercare worker and care situation (i.e. care episode and resident handling) on the use of assistive devices was evaluated using variance components analysis and multivariate generalized linear mixed model. Nursing homes, wards, eldercare workers, care episodes and 'within care episode' all contributed to the total variance in use of assistive devices. Organizational factors and care situation factors were significantly associated with use of assistive devices. All levels of the nursing homes, but in particular care situation, influence the use of assistive devices during resident handling.

- **Keywords:** Multilevel; Healthcare; Patient handling activities

Michèle Rieth, Vera Hagemann. *Automation as an equal team player for humans? – A view into the field and implications for research and practice.* 103552.

The practical reality and feasibility of Human-Autonomy Teaming (HAT) are analyzed from an experts' point of view, considering current possibilities of various fields. We aim to find out whether the topics discussed scientifically are also practically relevant, to identify requirements for successful HAT, and to derive further research needs. Intensive guideline-based interviews with 28 experts from different industries are conducted and compared to the results of our literature review. The topics discussed scientifically are also practically relevant. Today's technology is far from being able to meet the practical requirements for successful HAT, as postulated in the literature. Contrary to the Human-Automation Interaction, the concept of HAT is hardly applied in the field. Identified key aspects for successful HAT are converted into a model. Future research needs with practical impact exist especially in the area of heterarchy, system knowledge, anticipation of mental states, and consideration of human needs and emotions.

- **Keywords:** Human-autonomy teaming; Human-automation interaction; Autonomous agent

Lesheng Hua, Chen Ling, Rick Thomas. *Effects of delayed weather radar images on pilots' spatial awareness.* 103598.

Data-linked Next Generation Weather Radar (NEXRAD) images can be delayed up to 20 min in the cockpit. Pilots' underappreciating or ignoring the time delay may be the major cause of two fatal accidents. No studies have connected spatial awareness with accidents. This study evaluated how delayed radar information affects the spatial awareness of pilots at three levels of analysis. Thirty-one student pilots and flight instructors completed three sequential estimation tasks (i.e., the current location of storms, the current relative distance to storms, and the future relative distance to storms). Fifty-four weather scenarios were developed for three factors (storm speeds, delays, displays) and presented to pilots. The results indicated that delays and the storm speed significantly affected the three levels of spatial awareness. Participants' estimation accuracy was the lowest under long delay and fast speed in the current location estimation, under medium delay and speed in the current distance estimation, and under short delay and slow speed in the future distance estimation. Spatial awareness could be high under the long delay and fast speed conditions if pilots had no time limits. Thus, pilots can process 20-min delayed radar information. However, there were no differences in estimation accuracy between the static and animation displays in any of the conditions. Well-designed features on displays, such as scale or distance measuring tools, can aid pilots' spatial estimation and support all levels of spatial awareness.

- **Keywords:** Spatial awareness; Distance estimation; NEXRAD display

Alaska White, David O'Hare. *In plane sight: Inattentional blindness affects visual detection of external targets in simulated flight.* 103578.

Aviation places significant demands on pilots' perceptual and attentional capacities. The avoidance of other objects both on the ground and in the air is critical to safe flight. Research on automobile driving has revealed the occurrence of 'inattentional blindness' (IB) whereby objects clearly located within the visual field may not be detected when drivers are concurrently engaged in another attention capturing task such as a cellphone conversation. Almost no comparable research has been conducted within the aviation domain despite the significance of both ground-based and mid-air collisions. The present study was designed to investigate the effects of diverting attentional resources away from the primary task of safely flying a simulated light aircraft from takeoff to cruising. Flight naïve students were trained to proficiency in a flight-simulator and flew two simulated flights with and without a competing attentional task. Detection of a variety of objects placed in the background was measured. The results showed that when distracted by an engaging cellphone conversation novice pilots failed to detect many of the objects located within the visual scene. Recognition accuracy was greater when pilots' attention was not diverted elsewhere. There was a reduction in time spent looking at some key flight instruments but not on others. Inattentional blindness poses significant flight safety risks and further research into both the stimulus and perceiver characteristics that promote or reduce inattentional blindness would be of significant benefit to aviation safety.

- **Keywords:** Aviation safety; Attention; Distraction; Simulation; Eye-tracking

Abigail R. Wooldridge, Pascale Carayon, Peter Hoonakker, Bat-Zion Hose, Katherine Schroer, Tom Brazelton, Ben Eithun, Deborah Rusy, Joshua Ross, Jonathan Kohler, Michelle M. Kelly, Shannon Dean, Scott Springman, Rima Rahal, Ayse P. Gurses. *Care transition of trauma*

patients: Processes with articulation work before and after handoff. 103606.

While care transitions influence quality of care, less work studies transitions between hospital units. We studied care transitions from the operating room (OR) to pediatric and adult intensive critical care units (ICU) using Systems Engineering Initiative for Patient Safety (SEIPS)-based process modeling. We interviewed twenty-nine physicians (surgery, anesthesia, pediatric critical care) and nurses (OR, ICU) and administered the AHRQ Hospital Survey on Patient Safety Culture items about handoffs, care transitions and teamwork. Care transitions are complex, spatio-temporal processes and involve work during the transition (i.e., handoff and transport) and preparation and follow up activities (i.e., articulation work). Physicians defined the transition as starting earlier and ending later than nurses. Clinicians in the OR to adult ICU transition without a team handoff reported significantly less information loss and better cooperation, despite positive interview data. A team handoff and supporting articulation work should increase awareness, improving quality and safety of care transitions.

- **Keywords:** Process mapping; Care transition; Communication and coordination

Tara N. Cohen, Douglas A. Wiegmann, Falisha F. Kanji, Myrte de Alfred, Jennifer T. Anger, Ken R. Catchpole. Using flow disruptions to understand healthcare system safety: A systematic review of observational studies. 103559.

classification systems used in observational studies of flow disruptions in clinical environments. The PRISMA methodology was applied and authors searched two databases (PubMed and Web of Science) for studies meeting the following inclusion criteria: (a) were conducted in a healthcare setting, (b) explored systems-factors leading to deviations in care processes, (c) were prospective and observational, (d) classified observations, and (e) were original research studies published in peer-reviewed journals. Thirty studies were analyzed and a variety of methods were identified for observer training, data collection and observation classification. Although primarily applied in surgery, comparable research has been successfully conducted in other venues such as trauma care, and delivery rooms. The findings of this review were synthesized into a framework of considerations for conducting rigorous methodological studies aimed at understanding clinical systems.

- **Keywords:** Systematic review; Health care; Flow disruptions; Work system deviations

Tasha C. McFarland, Alison C. McDonald, Rachel L. Whittaker, Jack P. Callaghan, Clark R. Dickerson. Level of exoskeleton support influences shoulder elevation, external rotation and forearm pronation during simulated work tasks in females. 103591.

Despite growing literature, limited research details the influence of passive upper limb exoskeletons on upper limb kinematics. Two bolting tasks and a tracing task were completed at two heights (overhead and between waist and overhead height) for four exoskeleton conditions (no exoskeleton, and 3 levels of exoskeleton assistance) by female participants. Motion capture data, ratings of perceived exertion and discomfort, and task duration were recorded. Exoskeleton condition increased minimum shoulder elevation by 35–36% ($\Delta 10.5$ – 10.7°) at 1.81 kg and 2.72 kg of support, mean shoulder external rotation by 316% ($\Delta 24.6^\circ$) at 0.91 kg of support and mean forearm pronation by 30.9% ($\Delta 14.6^\circ$) at 0.91 kg of support. Exoskeleton condition reduced ratings of perceived exertion and discomfort, but not significantly. Task duration was unaffected. Exoskeleton use at any of three different settings modestly affected some joint

kinematics for the tasks examined, which may merit consideration when deciding on occupational exoskeleton implementation.

- **Keywords:** MSD; Upper extremity; Wearable device

Jashwant Thota, Eunsik Kim, Andris Freivalds, Kyongwon Kim. *Development and evaluation of attachable anti-vibration handle.* 103571.

Blueberry production has skyrocketed in the past two decades due to an exponential increase in consumer demand around the world. Hand harvesters are used, avoiding damage to the fruit and increasing harvesting efficiency multifold when compared with that of hand-picking. The downside of these hand harvesters is their high Hand Arm Vibration (HAV), which is very dangerous for the worker and can cause hand-arm vibration syndrome (HAVS). The aim of this study is to propose a spring-based anti-vibration handle that can be attached to vibrating equipment (blueberry hand harvester). Four different parameters were measured for the developed spring-based handles: hand arm vibration, wrist posture, muscle activity, and subjective discomfort rating. Results have shown that the use of a spring-based handle can reduce HAV by 61.1%, which is within the exposure limit values (ELV) defined by the European Union.

- **Keywords:** Anti-vibration handle; Hand arm vibration; Blueberry hand shaker

Gaojian Huang, Brandon J. Pitts. *The effects of age and physical exercise on multimodal signal responses: Implications for semi-autonomous vehicle takeover requests.* 103595.

The present study examined whether the non-chronological age factor, engagement in physical exercise, affected responses to multimodal (combinations of visual, auditory, and/or tactile) signals differently between younger and older adults in complex environments. Forty-eight younger and older adults were divided into exercise and non-exercise groups, and rode in a simulated Level 3 autonomous vehicle under four different task conditions (baseline, video watching, headway estimation, and video-headway combination), while being asked to respond to various multimodal warning signals. Overall, bi- and trimodal warnings had faster response times for both age groups across driving conditions, but was more pronounced for older adults. Engagement in physical exercise was associated with smaller maximum braking force for younger participants only, and also corresponded to longer average fixation durations, compared to the non-exercise group. Findings from this research can help to guide decisions about the design of warning and information systems for semi-autonomous vehicles.

- **Keywords:** Aging; Physical exercise; Multimodal information presentation

O. Valentin, P.-A. Gauthier, C. Camier, C. Verron, C. Guastavino, A. Berry. *Perceptual validation of sound environment reproduction inside an aircraft mock-up.* 103603.

Auditory comfort evaluations are garnering increased attention in engineering and particularly in the context of air transportation. Being able to produce sound environments corresponding to various flight conditions in aircraft mock-ups would be a valuable tool to investigate acoustic comfort inside aircrafts in controlled environments. Before using such mock-ups, they must be developed and validated in physical and perceptual terms. This paper provides a perceptual validation of sound environment reproduction inside aircraft mock-up. To provide a faithfully reproduced sound environment, time, frequency and spatial characteristics should be preserved. Physical sound field reproduction approaches for spatial sound reproduction are required while

properly preserving localization cues at the listener's ears to recreate a realistic and immersing sound environment. We report a perceptual validation of a sound field reproduction system developed in an aircraft mock-up based on multichannel least-square methods and equalization. Twenty participants evaluated reproduced sound environments relative to a reference sound environment in an aircraft cabin mock-up equipped with a 41-actuator multichannel sound reproduction system. Results indicate that the preferred reproduction corresponds to the best physical reconstruction of the sound environment.

- **Keywords:** Auditory comfort; Sound environment reproduction; Multichannel equalization; Aircraft cabin; Mock-up

Xueke Wang, Steven A. Lavender, Carolyn M. Sommerich, Michael F. Rayo. *The effects of using a footrest during computer tasks varying in complexity and temporal demands: A postural and electromyographic analysis.* 103550.

Prior research has found that office workers may not be fully utilizing their chair's back support. This may be due in part to cognitive demands or other psychological stressors. Not using the back support may increase the muscle tension and contribute to muscle fatigue and discomfort. Historically, footrests have been advocated to address anthropometric disparities in office settings. In this laboratory study, it was hypothesized that a footrest may facilitate the use of the backrest and mediate the biomechanical demands on the back and neck muscles, especially when cognitive workload is elevated. Twenty participants performed computer tasks, which varied in their complexity levels, both with and without an angled footrest. Using a footrest increased workers' use of a chair's backrest, increased pelvic rotation towards the backrest, and had a corresponding change in spine flexion. However, no changes were found in the sampled electromyographic activities due to the footrest.

Caroline Simpkins, Jiyun Ahn, Feng Yang. *Effects of anterior load carriage on gait parameters: A systematic review with meta-analysis.* 103587.

Anterior load carriage is common in occupational work and daily activities. Our primary purpose was to systematically review previous work concerning the biomechanics of walking with anterior load carriage. A secondary goal was to conduct a meta-analysis on common gait parameters relevant to front load carriage. An electronic database search yielded eight qualified articles. Meta-analyses were performed for four gait variables: stride length, heel contact velocity, required coefficient of friction, double support time. When possible, subgroup analyses by age were conducted. Results suggest that walking with front load carriage may shorten the stride length, particularly among young adults, but has small effects on the other three variables. Findings should be interpreted with caution given the limited number of studies included and small sample size per study. Future work investigating these four variables and others is needed to further our understanding of the impact of front load carriage on gait.

- **Keywords:** Stride length; Heel contact velocity; Required coefficient of friction

Paul M. Salmon, Katherine L. Plant. *Distributed situation awareness: From awareness in individuals and teams to the awareness of technologies, sociotechnical systems, and societies.* 103599.

A large component of Neville Stanton's work has focused on situation awareness in domains such as defence, transport, and process control. A significant contribution has been to initiate a shift from considering individual human operator situation awareness to

considering the situation awareness of human and non-human teams, organisations, and even sociotechnical systems. Though controversial when introduced, the distributed situation awareness model has become increasingly relevant for modern day systems and problems. In this article we reflect on Stanton's contribution and point to a pressing need to consider a. The situation awareness of advanced technologies, and b. situation awareness at a sociotechnical system, societal and even global level. This is demonstrated via discussion on two contemporaneous issues: automated vehicles and the COVID-19 pandemic. It is concluded that, given advances such as artificial intelligence, the increased connectedness of society, emerging issues such as disinformation, and an increasing set of global threats, Stanton's distributed situation awareness model and associated analysis framework provide a useful toolkit for future Human Factors and Ergonomics applications.

- **Keywords:** Situation awareness; Distributed situation awareness; Distributed cognition; Systems thinking; Sociotechnical systems

Tassilo Schröder, Andreas Lindenmann, Sophia Hehmann, Andreas Wettstein, René Germann, Thomas Gwosch, Sven Matthiesen. *Use of data-driven design for the development of knob-shaped handles in the context of impedance measurements.* 103575.

It can be inferred from hand-arm impedance analyses that the grip forces of users have a great influence on the transmitted vibrations. To determine this influence on test benches, the state of research suggests a cylindrical measuring handle. Since this shape is not suitable for all power tool handles, we develop a design for a knob-shaped measuring handle. The grip force applied to an orbital sander was measured in a test person study. The recorded data was combined with a 3D scan and evaluated by an algorithm which determined the separation plane of the measuring handle to integrate the force sensors. This plane is perpendicular to the vector of the subjects' grip forces. Furthermore, it divides the knob-shaped handle of the sander primarily vertically. The determination of the separation plane enables the design of a knob-shaped measuring handle for grip force measurement to analyze the hand-arm impedance of an overlying hand position.

- **Keywords:** Hand-arm vibration; Grip force; Measuring handle

Eric D. Ryan, Megan R. Laffan, Abigail J. Trivisonno, Gena R. Gerstner, Jacob A. Mota, Hayden K. Giuliani, Brian G. Pietrosimone. *Neuromuscular determinants of simulated occupational performance in career firefighters.* 103555.

Purpose: Although firefighters are required to perform various high-intensity critically essential tasks, the influence of neuromuscular function on firefighter occupational performance is unclear. The primary aim of the current study was to identify the key neuromuscular determinants of stair climb (SC) performance in firefighters. **Methods:** Leg extension isometric peak torque (PT), peak power (PP), torque steadiness at 10% (Steadiness10%) and 50% (Steadiness50%) of PT, fatigability following 30 repeated isotonic concentric contractions at 40% of PT, percent body fat (%BF), and a weighted and timed SC task were examined in 41 (age: 32.3 ± 8.2 yrs; %BF: $24.1 \pm 7.9\%$) male career firefighters. **Results:** Faster SC times (74.7 ± 13.4 s) were associated with greater PT and PP, less fatigability, younger age, and lower %BF ($r = -0.530$ – -0.629 ; $P \leq 0.014$), but not Steadiness10% or Steadiness50% ($P \geq 0.193$). Stepwise regression analyses indicated that PP and Steadiness50% were the strongest predictors of SC time ($R^2 = 0.442$, $P < 0.001$). However, when age and %BF were included in the model, these variables became the only significant predictors of SC time ($R^2 = 0.521$, $P < 0.001$) due to age and %BF being collectively associated with all the neuromuscular

variables (excluding Steadiness10%). **Conclusions:** Lower extremity neuromuscular function, specifically PP and steadiness, and %BF are important modifiable predictors of firefighter SC performance, which becomes increasingly important in aging firefighters.

- **Keywords:** Tactical; Stair climb; Muscle strength

Ornwipa Thamsuwan, Peter W. Johnson. *Machine learning methods for electromyography error detection in field research: An application in full-shift field assessment of shoulder muscle activity in apple harvesting workers.* 103607.

This study presented an alternative technique for processing electromyography (EMG) data with sporadic errors due to challenges associated with the field collection of EMG data. The application of this technique was used to detect errors, clean and optimize EMG data in order to characterize and compare shoulder muscular load in farmworkers during apple harvesting in a trellised orchard. Surface EMG was used to take measurements from twenty-four participants in an actual field work environment. Anomalies in the EMG data were detected and removed with a customized algorithm using principal component analysis, interquartile range cut-off and unsupervised cluster analysis. This study found significantly greater upper trapezius muscle activity in farmworkers who used a ladder as compared to the alternative platform-based method where a team of mobile platform workers harvested apples from the tree tops and a second separate team of ground workers harvested apples from the tree bottoms. By comparing the unprocessed and the processed, anomaly-free EMG data, the robustness of our proposed method was demonstrated.

- **Keywords:** Anomaly detection; Electromyography; Horticulture; K-means clustering; Principle component analysis

Chris Baber, Mark S. Young. *Making ergonomics accountable: Reliability, validity and utility in ergonomics methods.* 103583.

In this paper, we discuss the ways in which Neville Stanton has challenged himself, his research colleagues, PhD students, the many co-authors and contributors to his publications, and the entire Ergonomics community to determine what it means for there to be 'consistent standards for how [Ergonomics] methods are described and reported.' Only in this way, can it be possible to make claims about whether or not a method in Ergonomics is effective. Given that he is Chartered as both an Occupational Psychologist and an Ergonomist, it is not surprising that he has been concerned with the question of the reliability and validity of Ergonomics methods. In Occupational Psychology, psychometric and personnel selection methods are expected to exhibit acceptable levels of reliability, but this is an expectation which is still somewhat alien to Ergonomics. Neville's work has been instrumental in raising this issue and in providing approaches which can be used to critically evaluate the methods we use. We think that, despite his ground-breaking work, there is still much to do in the Ergonomics community to create the situation for which he has long argued.

- **Keywords:** Methods; Reliability; Validity; Cost; Benefit