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Tjaša Kermavnar, Aijse W. de Vries, Michiel P. de Looze & Leonard W. O’Sullivan. *Effects of industrial back-support exoskeletons on body loading and user experience: an updated systematic review*. Pages: 685-711.

This study is an updated systematic review of papers published in the last 5 years on industrial back-support exoskeletons. The research questions were aimed at addressing the recent findings regarding objective (e.g. body loading, user performance) and subjective evaluations (e.g. user satisfaction), potential side effects, and methodological aspects of usability testing. Thirteen studies of active and twenty of passive exoskeletons were identified. The exoskeletons were tested during lifting and bending tasks, predominantly in laboratory settings and among healthy young men. In general, decreases in participants’ back-muscle activity, peak L5/S1 moments and spinal compression forces were reported. User endurance during lifting and static bending improved, but performance declined during tasks that required increased agility. The overall user satisfaction was moderate. Some side effects were observed, including increased abdominal/lower-limb muscle activity and changes in joint angles. A need was identified for further field studies, involving industrial workers, and reflecting actual work situations. **Practitioner summary:** Due to increased research activity in the field, a systematic review was performed of recent studies on industrial back-support exoskeletons, addressing objective and subjective evaluations, side effects, and methodological aspects of usability testing. The results indicate the efficiency of exoskeletons in back-load reduction and a need for further studies in real work situations.

- **Keywords:** Industrial ergonomics, equipment design, user testing, manual handling, musculoskeletal disorders

Aijse Willem de Vries, Frank Krause & Michiel Pieter de Looze. *The effectivity of a passive arm support exoskeleton in reducing muscle activation and perceived exertion during plastering activities*. Pages: 712-721.

The supportive effect of arm-support exoskeletons has been mainly studied for single postures or movements. The aim of this study is to analyse the effect of such an exoskeleton on shoulder muscle activity and perceived exertion, in six tasks of plasterers, each including multiple arm movements. The tasks of 'applying gypsum', 'screeding' and 'finishing' were performed at a ceiling and a wall, with exoskeleton (Exo) and without (NoExo). EMG was recorded of six muscles involved in upper arm elevation, four agonists and two antagonists, and plasterers rated their perceived exertion (RPE). In all tasks, the EMG amplitudes of three agonist muscles, Trapezius and Medial Deltoid, and Biceps Brachii, were lower in Exo vs NoExo, while the agonist, Anterior Deltoid, showed lower EMG values in Exo in most tasks. None of the antagonists (Triceps Brachii, Pectoralis Major) showed increased EMG values in the Exo condition. RPE's were lower in Exo condition for all tasks, except for 'applying gypsum to the wall'. Overall, the exoskeleton seems to reduce loads in realistic plastering tasks. **Practitioner summary:** Exoskeletons are an emerging technology in the field of ergonomics. Passive arm support exoskeletons have mainly been tested in lab studies using continuous overhead work, involving one posture or movement. However, in reality, working tasks generally involve multiple movements. This study investigates the effectiveness of an arm support exoskeleton in work that requires multiple arm movements, specifically in plastering. Muscle activity, as well as perceived exertion were both reduced when working with an exoskeleton.

- **Keywords:** Exoskeleton, construction, muscle activity, MSD, plastering

Jazmin Cruz, Mario Garcia, Cecilia Garza, Patricia R. DeLucia & James Yang. *Object shape affects hand grip function for heavy objects in younger and older adults. Pages: 722-732.*

Hand-grip function while lifting objects is essential for performing everyday tasks. The Box and Block Test (BBT) has been used to assess hand-grip function and dexterity, but only light objects have been used. The purpose of this study was to investigate the effects of block surface, shape, age, and sex on hand dexterity during the movement of heavy blocks in the BBT. Forty healthy participants comprised of a younger group of 10 males ($M = 22.50$ years, $SD = 2.01$) and 10 females ($M = 22.20$ years, $SD = 2.66$) between 20 and 30-years-old, and an older group of 10 males ($M = 55.80$ years, $SD = 3.19$) and 10 females ($M = 55.90$ years, $SD = 2.56$) between 50 and 60-years-old, performed the BBT using steel objects of different shapes (cylindrical and cubic) and different surfaces (plain steel, black spray-painted steel, and yellow non-slip spray-painted steel). The results indicated that repetition and shape had significant effects on the BBT score. Previous researchers have found that surface textures, age, and sex influenced hand dexterity for light objects, but these effects were not discovered in the current study. These findings suggest that shape should take priority over age, sex, and surface texture when designing tools to improve user handling. **Practitioner Summary:** Hand-grip function is critically important when performing daily grip tasks such as picking up a writing utensil, using a toothbrush, or twisting a hand tool. The shape should be considered during the design process of tools and equipment used in industry so that handling can be made for the user.

- **Keywords:** Aging, Box and Block Test (BBT), hand dexterity, grip

Nathan D. Dicks, Sean J. Mahoney, Mark Kramer, Katie J. Lyman, Bryan K. Christensen, Robert W. Pettitt & Kyle J. Hackney. *Increased velocity at VO₂max and load carriage performance in army ROTC cadets: prescription using the critical velocity concept. Pages: 733-743.*

The purpose of this study was to evaluate the effects of using the critical velocity (CV) concept to prescribe two separate high-intensity interval training (HIT) exercise programs aimed at enhancing CV and load carriage performance. 20 young adult

participants (male = 15, female = 5) underwent a 4-week training period where they exercised 2 d wk⁻¹. Participants were randomly assigned into two groups: (1) HIT or (2) Load Carriage-HIT (LCHIT). Pre- and post-training assessments included running 3-minute All-Out Test (3MT) to determine critical velocity (CV) and distance prime (D') and two load carriage tasks (400 and 3200 m). There were significant increases in CV ($p = 0.005$) and velocity at $V'_{O_{2max}}$ ($vV'_{O_{2max}}$) ($p = 0.037$) among the sample but not between training groups. Improvements were observed in 3200m load carriage performance time ($p < 0.001$) with a 9.8 and 5.4% decrease in the LCHIT and HIT groups, respectively. **Practitioner summary:** Critical velocity has shown efficacy as a marker for performance in tactical populations. With the addition of load carriage, there is a reduction in the individual's CV. The CV-concept-prescribed exercises (HIT and LCHIT) 2 days per week for 4 weeks showed improvements in CV, $vV'_{O_{2max}}$ and load carriage performance. The use of the CV concept provides a method to prescribe HIT to increase running and load carriage performances in tactical populations.

- **Keywords:** 3MT, critical velocity, high-intensity interval training, load carriage, military

Rajesh Govindan, V. H. Saran & S. P. Harsha. *Subjective discomfort analysis of human body in semi-supine posture caused by vertical sinusoidal vibration*. Pages: 744-754.

The vibration discomfort to the human body in semi-supine posture is currently evaluated as per ISO 2631-1, although it is recommended for sitting, standing and recumbent posture. The present study investigated the frequency-dependence of subjective responses of semi-supine humans to vertical vibration (0.5–1.5 m s⁻² r.m.s.) across the frequency range 2.0–16.0 Hz. The subjects (14 males) judged the discomfort caused due to sinusoidal vibration using a modified absolute magnitude estimation method. The significant variation of rate of growth of discomfort across the frequency spectra caused the shape of equivalent comfort contour to vary with the vibration magnitude. The equivalent comfort contours illustrated significant discomfort between 8.0 and 10.0 Hz. Moreover, for frequencies above 10.0 Hz, substantial vibration acceleration was required to cause discomfort of the same intensity, implying that the frequency dependence of semi-supine posture is distinct from other postures. The frequency weighting obtained for semi-supine posture suggested that the discomfort estimation based on ISO 2631-1 was relatively accurate though conservative. **Practitioner Summary:** The discomfort caused by vertical vibration to the human in semi-supine posture was quite different from other postures. The present study provided the frequency-dependence of vibration discomfort for humans in semi-supine posture. Further, it investigated the suitability of frequency weightings defined in ISO 2631-1 for the acceleration measurements.

- **Keywords:** Subjective discomfort, vibration magnitude, frequency-dependence, frequency weighting

Richard M. Kesler, Alex Mayer, Kenneth W. Fent, I-Chen Chen, A. Shawn Deaton, R. Bryan Ormond, Denise L. Smith, Andrea Wilkinson, Steve Kerber & Gavin P. Horn. [Effects of firefighting hood design, laundering and doffing on smoke protection, heat stress and wearability](#). Pages: 755-767.

Firefighter hoods must provide protection from elevated temperatures and products of combustion (e.g. particulate) while simultaneously being wearable (comfortable and not interfering with firefighting activities). The purpose of this study was to quantify the impact of (1) hood design (traditional knit hood vs particulate-blocking hood), (2) repeated laundering, and (3) hood removal method (traditional vs overhead doffing) on (a) protection from soot contamination on the neck, (b) heat stress and (c) wearability

measures. Using a fireground exposure simulator, 24 firefighters performed firefighting activities in realistic smoke and heat conditions using a new knit hood, new particulate-blocking hood and laundered particulate-blocking hood. Overall, soot contamination levels measured from neck skin were lower when wearing the laundered particulate-blocking hoods compared to new knit hoods, and when using the overhead hood removal process. No significant differences in skin temperature, core temperature, heart rate or wearability measures were found between the hood conditions. **Practitioner Summary:** The addition of a particulate-blocking layer to firefighters' traditional two-ply hood was found to reduce the PAH contamination reaching the neck but did not affect heat stress measurements or thermal perceptions. Modifying the process for hood removal resulted in a larger reduction in neck skin contamination than design modification.

- **Keywords:** Personal protective equipment, firefighting, chemical exposures, heat stress, wearability

Yueng-hsiang Huang, Wen-Ruey Chang, Janelle H. Cheung, Jin Lee, Pete Kines & Yimin He. *The role of employee perceptions of safety priorities on safety outcomes across organisational levels.* Pages: 768-777.

Research has shown that safety climate predicts safety outcomes in various occupational settings. One important component of safety climate is employees' perceived priorities of safety in an organisation relative to other operational demands (e.g. productivity or efficiency). The relationships between three dimensions of employee perceptions of safety priorities (company, supervisor, worker), employee safety behaviour and self-reported injury outcomes were examined in the current study. Survey data were collected from 858 field workers (a response rate of 89%) at a TV-cable installation company. Results showed that all three dimensions of employee perceptions of safety priorities had significant and unique positive relationships with employee safety behaviour. Furthermore, safety behaviour was a significant mediator of the relationship between the three types of perceived safety priorities and missed work days due to workplace injury. The results showed the value of addressing employee perceptions of safety priorities across organisational levels when trying to improve workplace safety and reduce costly injuries. **Practitioner Summary:** The study examined relationships between the three different organisational levels of employee perceptions of safety priorities and employee safety behaviour and injury outcomes. The results demonstrated the value of addressing employee perceptions of safety priorities held by different levels of management as well as the worker level to improve workplace safety and reduce costly injuries.

- **Keywords:** Safety priority, safety behaviour, job injury, multi-level perspective

Guillermo Hidalgo-Gadea, Annika Kreuder, Jarek Krajewski & Christian Vorstius. *Towards better microsleep predictions in fatigued drivers: exploring benefits of personality traits and IQ.* Pages: 778-792.

Fatigued driving is one of the main contributors to road traffic accidents. Poor sleep quality and lack of sleep negatively affect driving performance, and extreme states of fatigue can cause microsleep (i.e., short episodes of sleep with complete loss of awareness). Driver monitoring systems analyse biosignals (e.g., gaze, blinking, heart rate) and vehicle data (e.g., steering wheel movements, lane holding, acceleration) to detect states of fatigue and prevent accidents. We argue that inter-individual differences in personality, sensation seeking behaviour, and intelligence could improve microsleep prediction, in addition to sleepiness. We tested 144 male participants in a supervised driving track after 27 hours of sleep deprivation. More than 74% of drivers experienced microsleep, after an average driving time of 52 min. Overall, prediction models for microsleep vulnerability and driving time before microsleep were significantly improved

by conscientiousness, sensation seeking and non-verbal IQ, in addition to situational sleepiness, as individual risk factors. **Practitioner summary:** This study offers valuable insights for the design of driver monitoring systems. The use of individual risk factors such as conscientiousness, sensation seeking, and non-verbal IQ can increase microsleep prediction. These findings may improve monitoring systems based solely on physiological signals (e.g., blinking, heart rate) and vehicle data (e.g., steering wheel movements, acceleration, cornering).

- **Keywords:** Fatigued driving, microsleep, personality traits, sleep deprivation, supervised driving, driver monitoring

Joost de Winter, Pavlo Bazilinsky, Dale Wesdorp, Valerie de Vlam, Belle Hopmans, Just Visscher & Dimitra Dodou. [How do pedestrians distribute their visual attention when walking through a parking garage? An eye-tracking study.](#) Pages: 793-805.

We examined what pedestrians look at when walking through a parking garage. Thirty-six participants walked a short route in a parking garage while their eye movements and head rotations were recorded with a Tobii Pro Glasses 2 eye-tracker. The participants' fixations were then classified into 14 areas of interest. The results showed that pedestrians often looked at the back (20.0%), side (7.5%), and front (4.2%) of parked cars, and at approaching cars (8.8%). Much attention was also paid to the ground (20.1%). The wheels of cars (6.8%) and the driver in approaching cars (3.2%) received attention as well. In conclusion, this study showed that eye movements are largely functional in the sense that they appear to assist in safe navigation through the parking garage. Pedestrians look at a variety of sides and features of the car, suggesting that displays on future automated cars should be omnidirectionally visible. **Practitioner summary:** This study measured where pedestrians look when walking through a parking garage. It was found that the back, side, and wheels of cars attract considerable attention. This knowledge may be important for the development of automated cars that feature so-called external human-machine interfaces (eHMIs).

- **Keywords:** Eye-tracking, eye contact, pedestrian, driver

Vera Schellewald, Jens Kleinert & Rolf Ellegast. *Effects of two types of dynamic office workstations (DOWs) used at two intensities on cognitive performance and office work in tasks with various complexity.* Pages: 806-818

This study examines the possible effects on objective work performance while using two types of dynamic office workstations (DOWs). 20 participants each used one type with three intensities (seated, light, moderate) and completed a task battery assessing cognitive performance and office work with two levels of complexity. Repeated measures MANOVA showed a significant interaction effect for work performance between the type of workstation and intensity for the simple level and a significant main effect for intensity for the complex level. Comparing the types of DOWs to each other, accuracy of text processing differed when working sedentary. Using both devices with light and moderate intensity had a significant detrimental effect on mouse tasks compared to working sedentary, but none comparing the intensities. No further results indicated neither a detrimental nor an enhancing effect of using DOWs on cognitive performance and office-work related tasks, regardless of the intensity of use or the task complexity. **Practitioner Summary:** By using DOWs, light physical activity can be integrated while working at a desk. Results showed that using different types of DOWs with different intensities does have a detrimental effect on tasks requiring a high motor control, but not on cognitive or further office work-related tasks of various complexity.

- **Keywords:** Dynamic office workstations, intensity, complexity, work performance, cognitive performance