

## **Ergonomics– rok 2021, ročník 64**

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**Jay M. Kapellusch, Stephen S. Bao, Elizabeth J. Malloy, Matthew S. Thiese, Andrew S. Merryweather & Kurt T. Hegmann. *Validation of the Revised Strain Index for Predicting Risk of Incident Carpal Tunnel Syndrome in a Prospective Cohort*. Pages: 1369-1378**

The Revised Strain Index (RSI), a model that quantifies physical exposure from individual hand/wrist exertions, tasks, and multi-task jobs, was used to quantify exposure for 1372 incident-eligible manufacturing, service and healthcare workers. Workers were followed for an average of 2.5 years (maximum 6 years) and had an average carpal tunnel syndrome (CTS) incidence rate of 4.6 per 100 person-years. Exceeding the a-priori RSI limit of 10.0 showed increased risk of CTS (Hazard Ratio (HR) = 1.45, 95% CI: 1.11–1.91,  $p = 0.01$ ). There also was a dose-response relationship using proposed low (RSI  $\leq 8.5$ , HR = 1.00), medium (HR = 1.42 (95% CI: 0.96–2.09,  $p = 0.08$ )), and high limits (RSI > 15, HR = 1.79 (95% CI: 1.19–2.69,  $p = 0.01$ ), respectively. RSI as a continuous variable showed CTS risk increased steadily by between 1.9% and 3.3% per unit increase in RSI ( $p \leq 0.03$ ). These results suggest that the RSI is a useful tool for surveillance as well as for job intervention/design and continuous improvement processes. **Practitioner Summary** The Revised Strain Index (RSI) quantifies physical exposure from individual hand/wrist exertions, tasks, and multi-task jobs. Increased cumulative RSI scores (i.e. daily exposure score) are associated with increased risk of carpal tunnel syndrome (CTS). The RSI is potentially useful as a risk surveillance and intervention design tool.

- **Keywords:** Risk assessment, job design, surveillance, job rotation, exposure measurement

**Ambra Giustetto, Fabio Vieira Dos Anjos, Francesca Gallo, Rossella Monferino, Giacinto Luigi Cerone, Massimo Di Pardo, Marco Gazzoni & Margherita Micheletti Cremasco. *Investigating the effect of a passive trunk exoskeleton on local discomfort, perceived effort and spatial distribution of back muscles activity*. Pages: 1379-1392**

This study aimed at determining the effect of a passive exoskeleton on local perceived discomfort, perceived effort and low back muscles' activity. Thirteen volunteers

performed two simulated working tasks with and without the exoskeleton. In the static task, the exoskeleton decreased the lumbar perceived discomfort, the perceived effort and the level of low back muscles' activity (~10%) while increasing discomfort in the chest and feet. The percent decrease in EMG amplitude was correlated with the percent increase in perceived effort with exoskeleton. For the dynamic task, the exoskeleton increased the discomfort in the chest and decreased the level of back muscle activity (~5%). Current findings suggest exoskeleton is effective in reducing the back load while increasing the perceived discomfort at non-targeted body regions in both working tasks. The concurrent increase of discomfort in non-targeted areas probably led to a higher perceived effort despite the reduction of low back muscle activity. **Practitioner summary:** This study provided insights into exoskeleton effects on local discomfort, perceived effort and muscle activity. Overall, the potential benefits of passive exoskeleton should be considered alongside its adverse effects on the non-targeted body regions that can lead to an increase of perceived effort despite the reduction of back muscle activity.

- **Keywords:** Industrial exoskeleton, perceived discomfort, perceived effort, high-density surface electromyography

**Maximilian J. Stanglmeier, Florian Schulte, Gunther Schaubberger, Raphael J. Bichler, Ansgar Schwirtz & Florian K. Paternoster. *Effect of legroom proportions and individual factors for sitting with crossed legs: implications on the interior design of automated driving vehicles.* Pages: 1393-1404**

Sitting with crossed legs is a commonly adopted sitting posture in everyday situations. Yet, little is known about suitable design criteria to facilitate such a position inside a vehicle. This study is aimed at determining how much space is necessary for crossing the legs while considering legroom restrictions, anthropometric measures, and individual flexibility. More specifically, 3D-kinematics of an ankle-on-knee leg-crossing task and the easiness to move ratings of 30 participants were assessed with restrictions of the legroom (2 heights × 3 distances) as well as without restrictions. Functional regression models revealed adaptations to a legroom restriction in the execution of movement, which occurred mainly in the knee joint and increased with more restricted legroom proportions. Therefore, the present study suggests a distance of 120% of the buttock-knee length between the dashboard and the occupant, as it requires only moderate adaptations and does not affect the perceived easiness of move. **Practitioner Summary:** This research investigated how much space is needed to cross the legs while sitting in a vehicle, finding that the movement execution is affected by legroom proportions, as well as individual anthropometry and flexibility. The study further presents the use of predicted motion traces to determine spatial requirements of movements.

- **Keywords:** Sitting posture, motion analysis, biomechanics, ergonomics, movement space, functional regression

**Cor-Jacques Kat, Jacques Schalk Jooste, Catharina Cornelia Grant, Piet J. Becker & Pieter Schalk Els. *Cardiovascular response to whole-body vibration on an automobile seat.* Pages: 1405-1415**

The study aim was to determine whether a relationship exists between the cardiovascular response, measured by HR and HRV and the magnitude of whole-body vibration. Cardiovascular response of sixty male participants in four groups, was measured during three states i.e. (1) no vibration, (2) a reference vibration and (3) an alternative vibration. The reference vibration was the same for all groups with the alternative vibrations different for each group. Weighted vertical seat vibration was  $0.66 \text{ m}\cdot\text{s}^{-2}$ , root-

mean-square for the reference and 0.70, 0.73, 0.76, and 0.79 m.s<sup>-2</sup>, root-mean-square for the alternative vibrations. Vibrations only differed in magnitude with the difference between alternative vibrations based on relative difference thresholds. Nonparametric tests compared cardiovascular indicators between groups at State 3 adjusted for state of departure i.e. State 2. No significant differences between groups were found for most of the indicators, suggesting no relationship between cardiovascular response and the magnitude of whole-body vibration. **Practitioner summary:** The cardiovascular response to the magnitude of whole-body vibration on an automobile seat was investigated. Results suggest that no relationship exists between the magnitude and cardiovascular response and that the latter may not be as effective as other objective measures (e.g. acceleration) in evaluating the human's response to whole-body vibration.

- **Keywords:** Whole-body vibration, cardiovascular response, heart rate, heart rate variability, ride comfort

**Anirudh Sripada, Pavlo Bazilinskyy & Joost de Winter. *Automated vehicles that communicate implicitly: examining the use of lateral position within the lane.* Pages: 1416-1428**

It may be necessary to introduce new modes of communication between automated vehicles (AVs) and pedestrians. This research proposes using the AV's lateral deviation within the lane to communicate if the AV will yield to the pedestrian. In an online experiment, animated video clips depicting an approaching AV were shown to participants. Each of 1104 participants viewed 28 videos twice in random order. The videos differed in deviation magnitude, deviation onset, turn indicator usage, and deviation-yielding mapping. Participants had to press and hold a key as long as they felt safe to cross, and report the perceived intuitiveness of the AV's behaviour after each trial. The results showed that the AV moving towards the pedestrian to indicate yielding and away to indicate continuing driving was more effective than the opposite combination. Furthermore, the turn indicator was regarded as intuitive for signalling that the AV will yield. **Practitioner Summary:** Future automated vehicles (AVs) may have to communicate with vulnerable road users. Many researchers have explored explicit communication via text messages and led strips on the outside of the AV. The present study examines the viability of implicit communication via the lateral movement of the AV.

- **Keywords:** Automated driving, implicit communication, vehicle movement, vulnerable road users, crowdsourcing

**Bryan Reimer, Bruce Mehler, Mauricio Muñoz, Jonathan Dobres, David Kidd & Ian J. Reagan. *Patterns in transitions of visual attention during baseline driving and during interaction with visual-manual and voice-based interfaces.* Pages: 1429-1451**

Voice interfaces reduce visual demand compared with visual-manual interfaces, but the extent depends on design. This study compared visual demand during baseline driving with driving while using voice or manual inputs to place calls with Chevrolet MyLink, Volvo Sensus, or a smartphone. Mean glance duration and total eyes-off-road-time increased when using manual input compared with baseline driving; only eyes off road time increased with voice input. Confusion matrices developed with hidden Markov modelling characterise the similarity of glance sequences during baseline driving and while making phone calls. Glance sequences with the MyLink voice interface were misclassified as baseline driving more frequently than the other voice interfaces. Conversely, glance sequences with the Sensus and smartphone voice interfaces were more often misclassified as manual phone calling. Thus, the MyLink voice interface not

only reduced the overall visual demand of placing calls, but produced glance patterns more similar to driving without another task. **Practitioner Summary:** The attention map and confusion matrix methodologies provide ways of characterising similarities and differences in glance behaviour across secondary task conditions, complementing traditional temporally based metrics (e.g. mean glance duration, long duration glances) while addressing some of the limitations of total-eyes-off-road-time (TEORT) for comparing secondary task behaviour to baseline driving.

- **Keywords:** Driving safety, smartphones, glance measures, total eyes-on-road time, hidden Markov models

**Malk Kanaan & Nadine Marie Moacdieh. *How do we react to cluttered displays? Evidence from the first seconds of visual search in websites.* Pages: 1452-1464**

Display clutter is known to degrade search performance and lead to differences in eye movement measures in different contexts. The goal of this study was to determine whether these differences in eye movements could be detected in the first few seconds of a search task using a realistic display, both with or without time pressure. Participants were asked to search for image or word targets in 40 website screenshots. Time pressure was introduced for half the trials. Clutter algorithms were used to classify the websites as low- or high-clutter. Performance, subjective, and eye-tracking metrics were collected. Results showed that people's attention allocation within the first 3 s of search is different when viewing high-clutter websites. In particular, people's spread of attention was larger in high-clutter websites. The results can be used to detect whether a person is struggling with clutter early on after they view a display. **Practitioner summary:** Eye-tracking metrics showed that people react differently to a cluttered website in a variety of conditions. These differences were evident within the first 3 s of the search. The eye-tracking metrics identified can be used to detect people struggling with clutter as soon as they look at a website.

- **Keywords:** Display clutter, visual search, eye tracking, websites, interface design

**Farhad Azimi Yancheshmeh, S. Hossein Mousavizadegan, Amin Amini, Andrew P. Smith & Reza Kazemi. *An investigation of the effects of different shift schedules on the fatigue and sleepiness of officers on oil tankers during cargo handling operations.* Pages: 1465-1480**

Cargo handling is an operation, which requires a high level of performance from the officer of the watch (OOW). This study aimed to investigate the effect of different shift schedules on sleep quality, cognitive performance, and sleepiness of 139 OOWs on oil tankers with 4on-8off shifts, during the first shift of cargo handling. Sleep quality (Pittsburgh Sleep Quality Index (PSQI)), level of sleepiness (the Karolinska Sleepiness Scale (KSS)), Psychomotor Vigilance Task (PVT), and Arrow Flanker task performance were examined. The results showed that OOWs with (00:00-04:00, 12:00-16:00) and (04:00-08:00, 16:00-20:00) shifts had impaired cognitive performance and higher sleepiness during the cargo handling operation, and they also experienced impaired sleep quality. The results demonstrated that the circadian rhythm and homeostatic sleep drive have a greater impact on cognitive performance and sleepiness than time on shifts. These results suggest that allocating rest hours immediately before the cargo handling operation may reduce the risk of fatigue. **Practitioner Summary:** To the best of our knowledge, this maritime field study shows for the first time the prevalence of seafarers' sleepiness and cognitive performance while on duty during cargo handling, using a pre-post shift comparison between three different shifts. The results show the negative effects of keeping watch at night on sleep quality, sleepiness, and the impaired cognitive performance both in the day and the night shifts.

- **Keywords:** Shift schedule, Officer of Watch (OOW), cargo handling operation, cognitive performance, sleepiness sleep

**Yuval Steinman, Eric Groen & Monique H. W. Frings-Dresen. *Exposure to hypoxia impairs helicopter pilots' awareness of environment.* Pages: 1481-1490**

The purpose of the present study was to determine how hypoxia effects awareness of environment (AoE) in helicopter pilots operating at high altitude. Eight helicopter crews flew two operational flights in a flight simulator while breathing gas mixtures of 20.9% (equivalent to 0 m altitude) and 11.4% (equivalent to 4572 m or 15,000 ft altitude) oxygen in a single blinded, counterbalanced, repeated measures study. Each flight included five missions, during which environment items were introduced that the crews needed to be aware of, and respond to. In the 4572 m simulation, the crews missed overall 28 AoE items compared to 12 in the 0 m simulation ( $Z = -1.992$ ;  $p = .046$ ). In contrast, the crews' technical skills were not significantly effected by hypoxia. Remarkably, the majority of pilots did not notice they were hypoxic or recognise their hypoxia symptoms during the simulation flight at 4572 m. **Practitioner summary** We show that hypoxia has a detrimental effect on helicopter pilot's AoE and alertness. This can lead to an increased risk for flight safety. To mitigate this risk we recommend performing hypoxia training in a flight simulator, developing wearable systems for physiological monitoring of pilots and re-evaluating current altitude regulations.

- **Keywords:** Pilots, non-technical skills, flight simulator, hypoxia, alertness

**Tina Schröppel, Felix Endress, Ina Köpken, Jörg Miehling & Sandro Wartzack. *Structured ergonomic guidance in early design phases by analysing the user-product interaction.* Pages: 1491-1506**

Gathering information for an early, proactive integration of ergonomic user requirements is challenging due to the unstructured character of available knowledge. Knowledge acquisition and processing is therefore costly and time-consuming. This contribution presents and evaluates InProCo, an approach for structured ergonomic guidance that aims to improve accessibility and clarity of ergonomic requirements in early design phases by providing interaction-based ergonomic properties. InProCo reduces the complexity of gathering knowledge and provide a novel way to describe interactions. Within a three-stage evaluation process, a survey assessed standard interactions for completeness, the output given by the graphical user interface of the approach (GUI) was evaluated for correctness and the knowledge base was validated by comparing the approaches output with properties identified by participants within a one-day workshop. The results showed that there are enough predefined standard interactions, the output of the GUI is valid and the knowledge base contains high quality data. **Practitioner Summary:** InProCo is an approach that provides structured interaction-based ergonomic properties to improve accessibility and clarity of ergonomic requirements in early design phases. This contribution presents and evaluates InProCo building the prerequisite for further use in an industrial context.

- **Keywords:** User-product interaction, early design stages, ergonomic requirements, knowledge base, ergonomics methods in design