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Micaela Porta, Simona Porceddu, Giovanni M. Mura, Marcello Campagna & Massimiliano Pau. *Continuous assessment of trunk posture in healthcare workers assigned to wards with different MAPO index. Pages: 875-885.*

Healthcare professionals generally experience an above-average incidence of low back disorders (LBDs) compared with workers of other professions, and its level of risk is commonly assessed using observational methods such as the MAPO method (Movement and Assistance of Hospital Patients). In this study, we continuously monitored the trunk posture of 30 healthcare workers using a single inertial sensor to: (1) understand whether the MAPO classification is effective in adequately discriminating the risk associated with the time spent in non-neutral trunk postures and (2) characterise the variability of biomechanical exposure among workers employed in wards with the same MAPO index. The results substantially confirm the validity of the MAPO approach in discriminating among wards characterised by different levels of biomechanical exposure associated with the risk of developing LBDs. However, they also highlight the need to assess workers' exposure on an individual basis due to the high intra-group variability. **Practitioner summary:** Employing a quantitative measurement setup to monitor trunk posture along with an observational method (ie MAPO) can identify the existence of criticalities or the poor application of ergonomic recommendations given during the training of healthcare workers even in hospital wards characterised by little or no risk of developing low back disorders.

- **Keywords:** Healthcare workers, low back disorders, MAPO index, inertial sensor

Sadeem Munawar Qureshi, Nancy Purdy, Michael A. Greig, Helen Kelly, Anne vanDeursen & W. Patrick Neumann. *Developing a simulation tool to quantify biomechanical load and quality of care in nursing. Pages: 886-903.*

Nursing is a high musculoskeletal disorder (MSD) risk job with high workload demands. This study combines Digital Human Modelling (DHM) and Discrete Event Simulation (DES) to address the need for tools to better manage MSD risk. This novel approach

quantifies physical-workload, work-performance, and quality-of-care, in response to varying geographical patient-bed assignments, patient-acuity levels, and nurse-patient ratios. Lumbar loads for 86 care-delivery tasks in an acute care hospital unit were used as inputs in a DES model of the care-delivery process, creating a shift-long time trace of the biomechanical load. Peak L4/L5 compression and moment were 3574 N and 111.58 Nm, respectively. This study reports trade-offs in all three experiments: (i) increasing geographical patient-bed assignment distance decreased L4/L5 compression (8.8%); (ii) increased patient-acuity decreased L4/L5 moment (4%); (iii) Increased nurse-patient ratio decreased L4/L5 compression (10%) and moment (17%). However, in all experiments, Quality of care indicators deteriorated (20, 19, and 29%, respectively). **Practitioner Summary:** This research has the potential to support decision-makers by developing a simulation tool that quantifies the impact of varying operational and design-policies in terms of biomechanical-load and quality of care. The demonstrator-model reports: as geographical patient-bed distance, patient-acuity levels, and nurse-patient ratios increase, biomechanical-load reduces, and quality of care deteriorates.

- **Keywords:** Digital human modelling, discrete event simulation, MSD risk, human factors, healthcare ergonomics

Jesse A. Stein, Timothy C. Hepler, Justin A. DeBlauw, Cassandra M. Beattie, Chaddrick D. Beshirs, Kendra M. Holte, Brady K. Kurtz, Adrienne Hatch-McChesney, Katie M. Heinrich & Emily K. Farina. *Anthropometrics and body composition predict performance during a simulated direct-fire engagement. Pages: 904-915.*

This study determined anthropometric and body composition predictors of performance during a simulated direct-fire engagement. Healthy subjects ($N = 33$, age = 25.7 ± 7.0 yr) underwent anthropometric and body composition assessments before completing a simulated direct-fire engagement – consisting of marksmanship with cognitive workload assessment and a fire-and-move drill (16×6 -m sprints) while wearing combat load. Susceptibility to enemy fire was modelled on sprint duration. Partial correlations and multiple linear regressions established the relationships between predictors and performance outcomes, controlling for age and sex. Significance was $p \leq 0.05$. Higher percent body fat, fat mass, fight load index predicted greater susceptibility to enemy fire ($r = 0.40$ to 0.42) and lower cognitive performance ($r = -0.45$ to -0.49). Higher BMI also predicted lower cognitive performance ($r = -0.49$). Shorter stature/hand length predicted higher marksmanship accuracy ($r = -0.40$), while higher fat-free mass/fat-free mass index predicted slower reaction times ($r = 0.36$ – 0.41). These data suggest anthropometric and body composition measures modulate combat effectiveness and reinforce body composition standards in military organisations. **Practitioner summary:** This study identified field-expedient anthropometric and body composition predictors of a simulated direct-fire engagement that evaluated survivability (i.e. susceptibility to enemy fire) and lethality (i.e. marksmanship, cognitive performance) outcomes. Our findings suggest that anthropometric and body composition measures may play a role in soldier survivability and lethality during simulated direct-fire engagements.

- **Keywords:** Survivability, marksmanship, lethality, combat effectiveness, adiposity, military

Zefeng Lin, Junhong Zhang, Meng Li, Jian Wang, Xueling Zhang & Jiewei Lin. *Torque response of seated human body to sinusoidal lateral and roll dual-axis vibration. Pages: 916-926.*

The biodynamic response of 14 subjects to sinusoidal dual-axis vibration in lateral and roll directions is studied. The root mean square of human response is detected by measuring the torque at the seat pan. The effects of phase difference, magnitude, and frequency on the biodynamic responses are investigated. The consistency between human responses to dual-axis and single-axis is studied. With increasing phase difference, human response is found to reach the maximum when the vibrations are anti-phase and then decrease to the minimum when they are in-phase. Besides, the dominance of the lateral excitation is confirmed in the dual-axis vibration. Finally, the principle of equivalence between lateral-roll dual-axis vibration and roll single-axis vibration is established. With the equivalence method, the biodynamic characteristics of the human body to multi-axis vibration are expected to be measured and represented with a much simpler test and dynamic model. **Practitioner summary:** Proposed equivalence uses one index to evaluate the compound discomfort caused by the roll and lateral vibration. Overestimation of discomfort due by summing the effects of them calculated separately can be avoided. After the equivalence, evaluation of discomfort and modelling of the human body can be carried out only in roll direction.

- **Keywords:** Roll vibration, lateral vibration, sinusoidal vibration, phase difference, magnitude

Xi Lyu, Zhizhong Li, Quan Ma & Manrong She. *Effects of accessible information amount and judgment times on human diagnostic performance of nuclear power plant faults.* Pages: 927-938.

Information is key to the process of diagnosis, so it is necessary to understand how information amount may influence human performance. The current study investigated this issue through an experiment where participants diagnosed an accident in a simulated nuclear power plant. The amount of accessible information and the times of making judgments were manipulated. The results showed that increasing the amount of accessible information led the participants to seek more and think shallower, and thus decreased diagnostic accuracies, whereas no significant effects were found for multiple judgement times. The authors argue that the disadvantages of more accessible information could be attributed not simply to 'information overload', but partly to the diagnosticians' unwise choice of information processing strategies. The findings imply that system designers should restrain the ever-growing amount of information while users should make more efficient use of information rather than take in more. **Practitioner summary:** Current research on diagnosis by humans was mostly limited to outcome performance. This study empirically investigated factors influencing its detailed process. The results showed that increasing accessible information amount impaired both process and outcome performances.

- **Keywords:** Diagnosis, information amount, process performance, information processing strategy

Zanyar Karimi, Adel Mazloumi, Ali Sharifnezhad, Amir Homayoun Jafari, Zeinab Kazemi, Ahmadreza Keihani & Iraj Mohebbi. *Nonlinear analysis of postural changes related to the movement interventions during prolonged standing task.* Pages: 939-953.

This study assessed the effects of movement-based interventions on the complexity of postural changes during prolonged standing. Twenty participants, equally distributed in gender and standing work experience (SWE), completed three simulated prolonged standing sessions: without movement (control), leg exercise and footrest. The amount and complexity of variability in the centre of pressure (COP) and lumbar curvature angle were quantified using linear and nonlinear tools. Lower leg swelling and back/leg discomfort were also monitored. Participants in the SWE group showed significantly

greater postural complexity during the standing. Regular leg exercise resulted in significantly higher postural complexity and lower leg discomfort and swelling. The footrest led to significant changes in amount of COP variability. Both interventions significantly reduced back discomfort. Overall, the nonlinear analysis of postural changes provided different findings compared to linear ones, considering the standing time, interventions and standing job experience. Nonlinear results were consistent with leg discomfort and swelling. **Practitioner summary:** The effect of movement-based interventions on dynamics of postural alterations over prolonged standing were characterised using nonlinear techniques. The effect of standing work experience was also considered. Previous experience of standing jobs and leg movements increase the complexity of postural behaviour over standing period.

- **Keywords:** Nonlinear dynamics, complexity, postural control, discomfort

Ahmet Kulus, Richard P. Wells & W. Patrick Neumann. *Examining the relationship between human factors related quality risk factors and work related musculoskeletal disorder risk factors in manufacturing.* Pages: 954-975.

This study addresses the relationship between human factors (HF) related quality deficits in manufacturing and work-related musculoskeletal disorder (WMSD) risk factors in production staff. A recent systematic review identified 60 HF-related quality risk factors (QRFs) in manufacturing related to product, process and workstation design stages. We investigate the extent to which these identified QRFs are also WMSD risk factors. Each QRF was examined for its relationship with WMSD using a 0 (no relationship) to 10 (strong relationship) scale rubric. The authors rated each QRF separately and then discussed and adjusted their ratings in a review session. Results showed that average median ratings were the highest for QRFs related to product design (8/10), intermediate for QRFs related to workstation design (7/10) and the lowest for QRFs related to process design (5/10). This emphasises the significant role of HF in system design in reducing both quality deficits and risk of developing WMSDs for manufacturing personnel.

Practitioner summary: This study investigates whether human-related risk factors for product quality are also risk factors for work-related musculoskeletal disorders in manufacturing. Results showed a substantial relationship between quality risk factors and WMSD risk factors. This indicates the significant role of human factors in operations design in improving both system performance and human wellbeing.

Keywords: Human factors, product quality, work-related musculoskeletal disorder, manufacturing

Till Saßmannshausen, Peter Burggräf, Marc Hassenzahl & Johannes Wagner. *Human trust in otherware – a systematic literature review bringing all antecedents together.* Pages: 976-998.

Technological systems are becoming increasingly smarter, which causes a shift in the way they are seen: from tools used to execute specific tasks to social counterparts with whom to cooperate. To ensure that these interactions are successful, trust has proven to be the most important driver. We conducted an extensive and structured review with the goal to reveal all previously researched antecedents influencing the human trust in technology-based counterparts. In doing so, we synthesised 179 papers and uncovered 479 trust antecedents. We assigned these antecedents to four main groups. Three of them have been explored before: environment, trustee, and trustor. Within this paper, we argue for a fourth group, the interaction. This quadripartition allows the inclusion of antecedents that were not considered previously. Moreover, we critically question the practice of uncovering more and more trust antecedents, which already led to an opaque plethora and thus becomes increasingly complex for practitioners. **Practitioner**

summary: Future designers of intelligent and interactive technology will have to consider trust to a greater extent. We emphasise that there are far more trust antecedents – and interdependencies – to consider than the ethically motivated discussions about “Trustworthy AI” suggest. For this purpose, we derived a trust map as a sound basis.

- **Keywords:** Artificial intelligence, automation, robot, interaction, teaming

Anuj K. Pradhan, Ganesh Pai, Heejin Jeong & Shan Bao. *Simulator evaluation of an intersection maneuver assist system with connected and automated vehicle technologies*. Pages: 999-1014.

Intersection crashes can be potentially mitigated through vehicle-to-infrastructure (V2I) and vehicle-to-vehicle (V2V) safety management systems. It is important, however, to consider some of the human factors related aspects of such systems to maximise potential safety benefits. In this study, Intersection Manoeuvre Assistance Systems were conceptualised and evaluated in a driving simulator. The systems were designed to assist drivers with intersection manoeuvres by making use of connected infrastructure and providing real-time feedback, guidance, and active vehicle controls. The study compared drivers’ confidence, workload, glances at the instrument panel, and hazard anticipation when driving using three systems—System A (no alert or assist); System B (alert only); and System C (alert and assist). Study results show differences in drivers’ confidence in such systems and potentially degraded visual gaze behaviours. **Practitioner summary:** Connected infrastructure-based intersection management assistance systems can potentially reduce crashes. This experimental driving simulation study evaluated drivers’ perceptions and reactions to intersection management systems. Results indicate reduced confidence in automated systems, reduced visual scanning for external hazards at intersections, and increased off-road glances towards the instrument panel.

- **Keywords:** Connected vehicles, vehicle automation, human machine interface, hazard anticipation, driving simulation

Azam Maleki-Ghahfarokhi, Iman Dianat, Mahmood-reza Azghani, Mohammad Asghari-Jafarabadi & Mohamad Parnianpour. *T-shaped handle set-up: effects of handle diameter, between-handle distance, workpiece orientation, working height, and exertion direction on two-handed torque strength, usability, comfort, and discomfort*. Pages: 1015-1030.

The use of both hands is often required for force/torque exertions, particularly when using hand tools. This study investigated the effects of handle diameter (3–5 cm), between-handle distance (0.5–1.5 shoulder span (SS)), workpiece orientation (horizontal/frontal), working height (shoulder/elbow/knuckle), and exertion direction (clockwise/counter-clockwise) on maximum two-handed torque strength, usability and comfort/discomfort while using T-shaped handles. Participants ($n = 20$) performed 36 experimental conditions. The handle diameter had no significant main effect on torque strength. The 3 cm diameter handle was associated with better usability and comfort compared to other options. Higher torque values were recorded with between-handle distance of 1.0 and 1.5 SS, in frontal plane, in shoulder and knuckle heights, and in counter-clockwise direction. The between-handle distance of 1.0 SS had better comfort and higher usability than other conditions. Interactions between the between-handle distance and working height, between-handle distance and workpiece orientation, and workpiece orientation and working height were also significant. **Practitioner summary:** Effects of handle diameter, between-handle distance, workpiece orientation, working height, and exertion direction on torque exertions, and subjective measures when using T-shaped handles were evaluated. Higher levels of strength were measured

with between-handle distance of 1.0–1.5 shoulder span, and in frontal plane, in shoulder/knuckle heights, and in counter-clockwise direction.

- **Keywords:** Hand tool, handle design, upper extremity torque, workstation design

Jinwen Wu, Xuan Wang, Jiajia Li & Rixin Tang. *Effect of icon size, icon position and sex on clicking motion when operating smartphones with single hand.* Pages: 1031-1041.

Nowadays, increasingly more situations exist where smartphones are operated with one hand, requiring an in-depth understanding of human–computer interaction in single-hand scenarios. 104 volunteers (57 men, 47 women) participated in this study. We aimed to explore thumb movements with the right and left hand on smartphone touchscreens at different icon sizes (50, 80, 110 and 140 rpx) in different operation areas (a 4*7 icon matrix). The results partially conformed to Fitts' Law. The movement time (MT) significantly increased as the icon size decreased, but this effect was not found over 110 rpx. The MT increased with distance in the vertical direction, but icons with the same horizontal distance had different MTs, indicating that one-handed operation restricted the click on the same side. Additionally, subjects rated 140 rpx better than other sizes, and men clicked faster than women. Suggestions regarding one-handed interface design for different hands of different sexes are provided. **Practitioner summary:** This study investigated how icon size, position and sex influenced one-thumb click usability on touch-screen mobile phones with different hands of different sexes. The results indicate single-hand operation partially conformed to Fitts' Law. We suggested the most economical and comfortable size and the fast operation area in one-handed interface design.

- **Keywords:** One-handed thumb interaction, touch-screen mobile phone, lick gesture, interface design