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Aaron P. J. Roberts, Leonie V. Webster, Paul M. Salmon, Rhona Flin, Eduardo Salas, Nancy J. Cooke, Gemma J. M. Read & Neville A. Stanton. *State of science: models and methods for understanding and enhancing teams and teamwork in complex sociotechnical systems*. Pages: 161-187.

This state of the science review brings together the disparate literature of effective strategies for enhancing and accelerating team performance. The review evaluates and synthesises models and proposes recommended avenues for future research. The two major models of the Input-Mediator-Output-Input (IMOI) framework and the Big Five dimensions of teamwork were reviewed and both will need significant development for application to future teams comprising non-human agents. Research suggests that a multi-method approach is appropriate for team measurements, such as the integration of methods from self-report, observer ratings, event-based measurement and automated recordings. Simulations are recommended as the most effective team-based training interventions. The impact of new technology and autonomous agents is discussed with respect to the changing nature of teamwork. In particular, whether existing teamwork models and measures are suitable to support the design, operation and evaluation of human-nonhuman teams of the future. **Practitioner summary:** This review recommends a multi-method approach to the measurement and evaluation of teamwork. Team models will need to be adapted to describe interaction with non-human agents, which is what the future is most likely to hold. The most effective team training interventions use simulation-based approaches.

- **Keywords:** Team, teamwork, measurement, team training, interventions

Thomas J. Davidson & Penelope M. Sanderson. *A review of the effects of head-worn displays on teamwork for emergency response*. Pages: 188-218.

Head-Worn Displays (HWD) can potentially support the mobile work of emergency responders, but it remains unclear whether teamwork is affected when emergency responders use HWDs. We reviewed studies that examined HWDs in emergency response

contexts to evaluate the impact of HWDs on team performance and on team processes of situation awareness, communication, and coordination. Sixteen studies were identified through manual and systematic literature searches. HWDs appeared to improve the quality of team performance but they increased time to perform under some conditions; effects on team processes were mixed. We identify five challenges to explain the mixed results. We discuss four theoretical perspectives that might address the challenges and guide research needs—joint cognitive systems, distributed cognition, common ground, and dynamical systems. Researchers and designers should use process-based measures and apply greater theoretical guidance to uncover mechanisms by which HWDs shape team processes, and to understand the impact on team performance. **Practitioner Summary:** This review examines the effects of head-worn displays on teamwork performance and team processes for emergency response. Results are mixed, but study diversity challenges the search for underlying mechanisms. Guidance from perspectives such as joint cognitive systems, distributed cognition, common ground, and dynamical systems may advance knowledge in the area.

- Keywords: Head-mounted displays, smart glasses, emergency response, team proces, safety-critical systems

Xyle Ku, Seungju Hyun & Byounghwak Lee. *The role of death anxiety on marksmanship performance: a virtual reality simulator study*. Pages: 219-232.

Despite the well-established relationship between state anxiety and marksmanship performance, few efforts have examined the individual differences that affect the extent to which individuals experience state anxiety in combat situations. Thus, further studies are needed to increase the probability of mission accomplishment, which could ultimately serve to safely bring soldiers home. The present study examined how death anxiety, a trait-based difference affects state anxiety, which in turn affects shooting performance on a battlefield. In particular, we used a virtual reality simulator to create a realistic engagement setting in which simulated death anxiety is salient. On a sample of 99 active-duty enlisted men in the Republic of Korea Army, we found that death anxiety, and not trait anxiety, increased state anxiety, which in turn decreased marksmanship performance. Overall, the current findings highlight the role of death anxiety in combat situations. The practical implications and avenues for future research are also discussed. **Practical summary:** Soldiers encounter anxiety in threatening circumstances in which mortality is salient. We examined the role of trait death anxiety in combat situations using a virtual reality simulator. The results indicate that death anxiety increases state anxiety while decreasing marksmanship performance, which has important implications for the military.

- **Keywords:** Death anxiety, trait anxiety, state anxiety, marks, manship performance, virtual reality simulator

Jessica L. Paterson, Brad Aisbett, Katya Kovac & Sally A. Ferguson. *Informal management of health and safety risks associated with alarm response by Australian firefighters*. Pages: 233-241.

Fire-fighters use informal strategies to manage risks to health and safety during operations. It is not known whether such strategies are used during the high-risk alarm response period. The aim of this study was to determine if informal risk management strategies are employed by Australian firefighters during the alarm response procedure, and if these strategies differ between salaried and retained personnel. Forty-six metropolitan firefighters (all male; mean age 38 years ± 10 years; 22 salaried; 24 retained) participated in semi-structured group interviews. A general inductive data analysis approach revealed that firefighters use multiple informal risk management strategies. Some similar themes were reported by both salaried and retained personnel,

for example leveraging team dynamics, communication about sleep and fatigue, stress adaptation, informal debriefs, and enhancing physical preparedness. These findings could be used by fire services to tailor risk management approaches during the alarm response period. **Practitioner summary:** Identifying informal risk management strategies firefighters use during alarm response will allow their development, refinement and dissemination, and may help other firefighters and emergency service workers to manage these risks. This qualitative study reveals multiple informal strategies that firefighters employ during alarm response to keep themselves and their team-mates safe.

- **Keywords:** Risk management, alarm response, emergency services, firefighter

Tiina E. A. Mattila, Merja Perkiö-Mäkelä, Maria Hirvonen, Birgitta Kinnunen, Minna Väre & Risto H. Rautiainen. *Work exposures and mental and musculoskeletal symptoms in organic farming*. Pages: 242-252.

This study focussed on harmful exposures and mental and musculoskeletal symptoms in organic and conventional farming using interview data of Finnish farmers over the winter of 2014–2015. The data consisted of 2,169 full-time farmers, out of whom 231 (11%) practiced organic farming and 1,938 (89%) conventional farming. Exposure to poisonous and irritating substances was less frequent while exposures to vibration and mould ('smell of root cellar') were more frequent on organic farms. Mental and musculoskeletal symptoms were slightly more common among organic farmers, but the associations were not statistically significant in regression modelling. Risk factors for mental symptoms included animal production, hired labour, female gender, constant hurry, working alone, economic uncertainty, and inadequate recovery from workdays. Risk factors for musculoskeletal symptoms included older age, female gender, constant hurry, economic uncertainty, difficult working postures, heavy lifting and carrying, and inadequate recovery. Workload and recovery, managing the transition period and better follow-up of the occupational well-being were identified as concerns among organic farmers. **Practitioner summary**: Converting from conventional to organic farming has become increasingly common. Farmer interviews indicated that exposure to poisonous and irritating substances was less frequent while exposures to vibration and mould were more frequent on organic farms. Mental and musculoskeletal symptoms and risk factors were similar in both types of farming.

- **Keywords:** Occupational exposures, mental symptoms, musculoskeletal symptoms, organic agriculture, social sustainability

Annemarie F. Laudanski, Jessa M. Buchman-Pearle & Stacey M. Acker. *Quantifying high flexion postures in occupational childcare as they relate to the potential for increased risk of knee osteoarthritis*. Pages: 253-264.

High knee flexion postures, despite their association with increased incidences of osteoarthritis, are frequently adopted in occupational childcare. This study sought to define and quantify high flexion postures typically adopted in childcare to evaluate any increased likelihood of knee osteoarthritis development. Through video analysis of eighteen childcare workers caring for infant, toddler, and preschool-aged children, eight high knee flexion postures were identified and quantified by duration and frequency. An analysis of postural adoption by task was subsequently performed to determine which might pose the greatest risk for cumulative joint trauma. Childcare workers caring for children of all ages were found to adopt kneeling and seated postures for extended durations and at elevated frequencies, exceeding proposed thresholds for incidences of knee osteoarthritis development. Structured activities, playing, and feeding tasks demanded the greatest adoption of high flexion postures and should be evaluated to

minimise the potential childcare-related risks of osteoarthritis. **Practitioner summary:** High knee flexion postures (kneeling, squatting, etc.) have been associated with increased incidences of knee injury yet are commonly adopted in childcare. Childcare workers' postures were examined through video analysis revealing that proposed adoption thresholds for knee health are commonly exceeded when caring for children of all ages.

- **Keywords:** Occupational ergonomics, kneeling, squatting, high knee flexion, daycare

Gabriel Grani, Cintia de Lourdes Nahhas Rodacki, Henrique Lubas, Elisangela Franciele Resende, Rodrigo Hoinatski, Rafael Gomes Sentone, Robin Orr & Anderson Caetano Paulo. *Can training trunk musculature influence musculoskeletal pain and physical performance in military police officers?* Pages: 265-275.

To investigate the effect of a Trunk Training (TT) program on the general musculoskeletal pain (GMP) and physical performance of Military Police Officers. Twenty officers were divided into either control group (CG) or TT group (TTG). Both groups performed nine weeks of traditional physical training. However, the TTG had 25-minutes allocated to TT during each scheduled physical training period. Anthropometric, trunk endurance, and physical fitness tests were completed pre- and post-training for both groups. Both groups also answered a weekly questionnaire about their GMP. Post-training, trunk endurance performance was significantly higher ($p < 0.05$) and the GMP significantly lower ($p < 0.05$) in the TTG when compared to the CG. Improvement in side plank test scores was associated with a decreased in GMP ($r = -0.495$, $p < 0.05$). TT can reduce the perception of GMP in addition to increasing the endurance of the trunk muscles. The side plank was the only physical test associated with GMP. **Practitioner summary:** Trunk Training can reduce general musculoskeletal pain and increase the endurance of the trunk muscles without a concomitant loss in general fitness in elite Military Police Officers. This research lasted 11 weeks and presents real-world and pragmatic findings.

- **Keywords:** Low back pain, isometric exercises, tactical athlete, physical fitness, core muscle

Niclas Hoffmann, Gilbert Prokop & Robert Weidner. *Methodologies for evaluating exoskeletons with industrial applications*. Pages: 276-295.

Industrial exoskeletons are globally developed, explored, and increasingly implemented in industrial workplaces. Multiple technical, physical, and psychological aspects should be assessed prior to their daily application in various occupational environments. The methodology for evaluating these aspects is not standardised and differs in terms of focussed research objectives, used types of analyses, applied testing procedures, and use cases. The aim of this paper is to provide a matrix comparing the prevalence of different types of analyses combined with their respective research objective(s). A systematic review in the database 'Web of Science' identified 74 studies, mainly in laboratory settings, with a focus on short-term effects as well as with male-dominated samples being low representative for industrial workforces. The conducted evaluation methodologies are further discussed and compared in terms of testing procedure, sample, and research objectives. Finally, relevant aspects for prospectively evaluating industrial exoskeletons in a more harmonised and comprehensive way are suggested. **Practitioner summary:** Industrial exoskeletons are still inconsistently and insufficiently evaluated in scientific studies, which might hamper the comparability of systems, threaten the human health, and block an iterative system optimisation. Thus, a comprehensive evaluation methodology is needed with harmonised and multicriteria types of analyses.

- **Keywords:** Exoskeleton, industrial application, Evaluation, review, human-machine-interaction

Laurianne Delcor, Etienne Parizet, Julie Ganivet-Ouzeneau & Julien Caillet. *Assessment of helicopter passengers' vibration discomfort: proposal for improvement of the ISO 2631-1 standard*. Pages: 296-304.

High levels of vibration exist in helicopters and manufacturers are seeking to quantify vibration discomfort. They use the ISO 2631-1 standard, proposed for all types of transport. This study aimed to verify the validity of this index in the specific case of helicopters. Perception tests were carried out in the laboratory. Volunteers assessed the discomfort of vibratory stimuli on test benches generating vertical and triaxial vibrations. Foot, seat, and backrest accelerations were measured for each participant according to each stimulus. The ISO 2631-1 comfort indices were then compared with the evaluations given by the participants. The results showed that the standard provided a good estimate of discomfort. However, it lacks precision in estimating the discomfort of stimuli which include amplitude modulations, as can happen in helicopters. A new discomfort index is proposed based on ISO 2631-1 and allows better prediction of subjective assessments. **Practitioner Summary**: An improved index based on ISO 2631-1 standard is proposed to estimate helicopter vibratory discomfort for seated passengers. It takes into account the amplitude modulations that can appear at low frequencies in helicopters. This modification allowed a significant improvement of the accuracy of ISO 2631-1 for such stimuli.

- **Keywords:** Vibrations, perception, helicopters, metric

Wenxiu Yang, Haining Wang & Renke He. *Establishment of a finite element model based on craniofacial soft tissue thickness measurements and stress analysis of medical goggles*. Pages: 305-326.

In this study, an accurate finite element (FE) stress analysis of head-mounted products for Chinese users was performed. Using craniofacial computed tomography scans of 280 Chinese individuals, the total soft tissue thickness and thickness of the fat and muscle layers for 41 landmarks were measured. The data were used to construct FE head models (FEH). An FE stress test was conducted to analyse the wearing of medical goggles using two FE models based on one-layer (FEH 1) and three-layer (FEH 3) soft tissue material parameters. When compared with the experimental results, the modelling results for FEH 3 were more realistic than those for FEH 1. Wearing medical goggles led to stress concentration over five landmark areas, A: upper medial forehead, B: temporal, C: zygion, D: infraorbital fossa and E: rhinion, of which B, C and D caused the most discomfort during long-term goggle wear. **Practitioner summary:** A precise FE head model can reflect the complex contact pressure of a head-related product. Two FE models based on one- and three-layer soft tissue material parameters were established and tested separately with medical goggles. The model can be used to improve the comfort of head-related products.

- **Keywords:** Finite element model, comfort, soft tissue thickness, contact pressure, product design