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Dwayne van Eerd; Donald Cole; Emma Irvin; Quenby Mahood; Kiera Keown; Nancy Theberge; Judy Village; Marie St. Vincent; Kim Cullen. *Process and implementation of participatory ergonomic interventions : a systematic review. Pages 1153 – 1166.*

Participatory ergonomic (PE) interventions may vary in implementation. A systematic review was done to determine the evidence regarding context, barriers and facilitators to the implementation of participatory ergonomic interventions in workplaces. In total, 17 electronic databases were searched. Data on PE process and implementation were extracted from documents meeting content and quality criteria and synthesised. The search yielded 2151 references. Of these, 190 documents were relevant and 52 met content and quality criteria. Different ergonomic teams were described in the documents as were the type, duration and content of ergonomic training. PE interventions tended to focus on physical and work process changes and report positive impacts. Resources, programme support, ergonomic training, organisational training and communication were the most often noted facilitators or barriers. Successful PE interventions require the right people to be involved, appropriate ergonomic training and clear responsibilities. Addressing key facilitators and barriers such as programme support, resources, and communication is paramount. **Statement of Relevance:** A recent systematic review has suggested that PE has some effect on reducing symptoms, lost days of work and claims. Systematic reviews of effectiveness provide practitioners with the desire to implement but do not provide clear information about how. This article reviews the literature on process and implementation of PE.

- **Keywords:** general ergonomics; musculoskeletal disorders; participative ergonomics; risk assessment and management; systematic review

Tim Bentley; David Tappin. *Incorporating organisational safety culture within ergonomics practice. Pages 1167 – 1174.*

This paper conceptualises organisational safety culture and considers its relevance to ergonomics practice. Issues discussed in the paper include the modest contribution that ergonomists and ergonomics as a discipline have made to this burgeoning field of study and the significance of safety culture to a systems approach. The relevance of safety culture to ergonomics work with regard to the analysis, design, implementation and evaluation process, and implications for participatory ergonomics approaches, are also

discussed. A potential user-friendly, qualitative approach to assessing safety culture as part of ergonomics work is presented, based on a recently published conceptual framework that recognises the dynamic and multi-dimensional nature of safety culture. The paper concludes by considering the use of such an approach, where an understanding of different aspects of safety culture within an organisation is seen as important to the success of ergonomics projects. **Statement of Relevance:** The relevance of safety culture to ergonomics practice is a key focus of this paper, including its relationship with the systems approach, participatory ergonomics and the ergonomics analysis, design, implementation and evaluation process. An approach to assessing safety culture as part of ergonomics work is presented.

- **Keywords:** assessment of safety culture; ergonomics studies; organisational safety culture; safety climate

Guy H. Walker; Neville A. Stanton; Paul M. Salmon; Daniel P. Jenkins; Laura Rafferty. *Translating concepts of complexity to the field of ergonomics*. Pages 1175 – 1186.

Since 1958 more than 80 journal papers from the mainstream ergonomics literature have used either the words 'complex' or 'complexity' in their titles. Of those, more than 90% have been published in only the past 20 years. This observation communicates something interesting about the way in which contemporary ergonomics problems are being understood. The study of complexity itself derives from non-linear mathematics but many of its core concepts have found analogies in numerous non-mathematical domains. Set against this cross-disciplinary background, the current paper aims to provide a similar initial mapping to the field of ergonomics. In it, the ergonomics problem space, complexity metrics and powerful concepts such as emergence raise complexity to the status of an important contingency factor in achieving a match between ergonomics problems and ergonomics methods. The concept of relative predictive efficiency is used to illustrate how this match could be achieved in practice. What is clear overall is that a major source of, and solution to, complexity are the humans in systems. Understanding complexity on its own terms offers the potential to leverage disproportionate effects from ergonomics interventions and to tighten up the often loose usage of the term in the titles of ergonomics papers. **Statement of Relevance:** This paper reviews and discusses concepts from the study of complexity and maps them to ergonomics problems and methods. It concludes that humans are a major source of and solution to complexity in systems and that complexity is a powerful contingency factor, which should be considered to ensure that ergonomics approaches match the true nature of ergonomics problems.

- **Keywords:** complex systems research; complexity theory; ergonomics methods

Laura A. Rafferty; Neville A. Stanton; Guy H. Walker. *The famous five factors in teamwork : a case study of fratricide*. Pages 1187 – 1204.

The purpose of this paper is to propose foundations for a theory of errors in teamwork based upon analysis of a case study of fratricide alongside a review of the existing literature. This approach may help to promote a better understanding of interactions within complex systems and help in the formulation of hypotheses and predictions concerning errors in teamwork, particularly incidents of fratricide. It is proposed that a fusion of concepts drawn from error models, with common causal categories taken from teamwork models, could allow for an in-depth exploration of incidents of fratricide. It is argued that such a model has the potential to explore the core causal categories identified as present in an incident of fratricide. This view marks fratricide as a process of errors occurring throughout the military system as a whole, particularly due to problems in teamwork within this complex system. Implications of this viewpoint for the development of a new theory of fratricide are offered. **Statement of Relevance:** This

article provides an insight into the fusion of existing error and teamwork models for the analysis of an incident of fratricide. Within this paper, a number of commonalities among models of teamwork have been identified allowing for the development of a model.

- **Keywords:** decision making; error; fratricide; teamwork

Grégoire S. Larue; Andry Rakotonirainy; Anthony N. Pettitt. *Real-time performance modelling of a Sustained Attention to Response Task. Pages 1205 – 1216.*

Vigilance declines when exposed to highly predictable and uneventful tasks. Monotonous tasks provide little cognitive and motor stimulation and contribute to human errors. This paper aims to model and detect vigilance decline in real time through participants' reaction times during a monotonous task. A laboratory-based experiment adapting the Sustained Attention to Response Task (SART) is conducted to quantify the effect of monotony on overall performance. Relevant parameters are then used to build a model detecting hypovigilance throughout the experiment. The accuracy of different mathematical models is compared to detect in real time - minute by minute - the lapses in vigilance during the task. It is shown that monotonous tasks can lead to an average decline in performance of 45%. Furthermore, vigilance modelling enables the detection of vigilance decline through reaction times with an accuracy of 72% and a 29% false alarm rate. Bayesian models are identified as a better model to detect lapses in vigilance as compared with neural networks and generalised linear mixed models. This modelling could be used as a framework to detect vigilance decline of any human performing monotonous tasks. **Statement of Relevance:** Existing research on monotony is largely entangled with endogenous factors such as sleep deprivation, fatigue and circadian rhythm. This paper uses a Bayesian model to assess the effects of a monotonous task on vigilance in real time. It is shown that the negative effects of monotony on the ability to sustain attention can be mathematically modelled and predicted in real time using surrogate measures, such as reaction times. This allows the modelling of vigilance fluctuations.

- **Keywords:** Bayesian modelling; monotony; sustained attention; vigilance

Kristina Kindblom-Rising; Rolf Wahlström; Sirkka-Liisa Ekman; Nina Buer; Lena Nilsson-Wikmar. *Nursing staff's communication modes in patient transfer before and after an educational intervention. Pages 1217 – 1227.*

The objective was to explore and describe nursing staff's body awareness and communication in patient transfers and evaluate any changes made after an educational intervention to promote staff competence in guiding patients to move independently. In total, 63 nursing staff from two hospitals wrote weekly notes before and after the intervention. The topics were: A) reflect on a transfer during the last week that you consider was good and one that was poor; B) reflect on how your body felt during a good and a poor transfer. The notes were analysed with content analysis. The results showed five different communication modes connected with nursing staff's physical and verbal communication. These communication modes changed after 1 year to a more verbal communication, focusing on the patient's mobility. The use of instructions indicated a new or different understanding of patient transfer, which may contribute to a development of nursing staff's competence. **Statement of Relevance:** The present findings indicate that patient transfer consists of communication. Therefore, verbal and bodily communication can have an integral part of training in patient transfer; furthermore, the educational design of such programmes is important to reach the goal of developing new understanding and enhancing nursing staff's competence in patient transfer.

- **Keywords:** changes; communication; educational intervention; patient transfer

Idsart Kingma; Gert S. Faber; Jaap H. van Dieën. *How to lift a box that is too large to fit between the knees. Pages 1228 – 1238.*

Many studies compared lifting techniques such as stoop and squat lifting. Results thus far show that when lifting a wide load, high back loads result, irrespective of the lifting technique applied. This study compared four lifting techniques in 11 male subjects lifting wide loads. One of these techniques, denoted as the weight lifters' technique (WLT), is characterised by a wide foot placement, moderate knee flexion and a straight but not upright trunk. Net moments were calculated with a 3-D linked segment model and spinal forces with an electromyographic-driven trunk model. When lifting the wide box at handles that allow a high grip position, the WLT resulted in over 20% lower compression forces than the free, squat and stoop lifting technique, mainly due to a smaller horizontal distance between the L5/S1 joint and the load. When lifting the wide box at the bottom, none of the lifting techniques was clearly superior to the others. **Statement of Relevance:** Lifting low-lying and large objects results in high back loads and may therefore result in a high risk of developing low back pain. This study compares the utility of a WLT, in terms of back load and lumbar flexion, to more familiar techniques in these high-risk lifting tasks.

- **Keywords:** biomechanics; compression; lifting technique; low-back load; spine

André Plamondon; Denys Denis; Alain Delisle; Christian Larivière; Erik Salazar. *Biomechanical differences between expert and novice workers in a manual material handling task. Pages 1239 – 1253.*

The objective was to verify whether the methods were safer and more efficient when used by expert handlers than by novice handlers. Altogether, 15 expert and 15 novice handlers were recruited. Their task was to transfer four boxes from a conveyor to a hand trolley. Different characteristics of the load and lifting heights were modified to achieve a larger variety of methods by the participants. The results show that the net moments at the L5/S1 joint were not significantly different ($p > 0.05$) for the two groups. However, compared with the novices, the experts bent their lumbar region less (experts 54° (SD 11°); novices 66° (SD 15°)) but bent their knees more (experts approx. 72° (SD approx. 30°); novices approx. 53° (SD approx. 33°), which brought them closer to the box. The handler's posture therefore seems to be a major aspect that should be paid specific attention, mainly when there is maximum back loading. **Statement of Relevance:** The findings of this research will be useful for improving manual material handling training programmes. Most biomechanical research is based on novice workers and adding information about the approach used by expert handlers in performing their tasks will help provide new avenues for reducing the risk of injury caused by this demanding physical task.

- **Keywords:** ergonomic intervention; expert; low back load; lifting; manual material handling

Yaw-Huei Hwang; Yen-Ting Chen; Jao-Yu Yeh; Huey-Wen Liang. *Effects of passive computer use time and non-computer work time on the performance of electronic activity monitoring. Pages 1254 – 1262.*

This study aimed to examine the effects of passive and non-computer work time on the estimation of computer use times by electronic activity monitoring. A total of 20 subjects with computers were monitored for 3 h. Average relative error for total computer use time estimation was about 4%, given that non-computer work time was 20% of the 3-h monitored period. No significant impact of passive computer use time was found in this

study. Non-computer work time of 40% or less is suggested as criteria for the application of electronic activity monitoring to ensure reliability in the physical work loading assessment. **Statement of Relevance:** This research studied the criteria of non-computer work time for the appropriate use of electronic activity monitoring to ensure reliability in the assessment of physical work loading. It is suggested that it should be set to 40% or less of the 3-h monitoring period.

- **Keywords:** computer work; electronic activity monitoring; non-computer work time; passive computer use time

Karen N. Gregorczyk; Leif Hasselquist; Jeffrey M. Schiffman; Carolyn K. Bensek; John P. Obusek; David J. Gutekunst. *Effects of a lower-body exoskeleton device on metabolic cost and gait biomechanics during load carriage. Pages 1263 – 1275.*

This study investigated the effects on metabolic cost and gait biomechanics of using a prototype lower-body exoskeleton (EXO) to carry loads. Nine US Army participants walked at 1.34 m/s on a 0% grade for 8 min carrying military loads of 20 kg, 40 kg and 55 kg with and without the EXO. Mean oxygen consumption ($\dot{V}O_2$) scaled to body mass and scaled to total mass were significantly higher, by 60% and 41% respectively, when the EXO was worn, compared with the control condition. Mean $\dot{V}O_2$ and mean $\dot{V}O_2$ scaled to body mass significantly increased with load. The kinematic and kinetic data revealed significant differences between EXO and control conditions, such as walking with a more flexed posture and braking with higher ground reaction force at heel strike when wearing the EXO. Study findings demonstrate that the EXO increased users' metabolic cost while carrying various loads and altered their gait biomechanics compared with conventional load carriage. **Statement of Relevance:** An EXO designed to assist in load bearing was found to raise energy expenditure substantially when tested by soldiers carrying military loads. EXO weight, weight distribution and design elements that altered users' walking biomechanics contributed to the high energy cost. To realise the potential of EXOs, focus on the user must accompany engineering advances.

- **Keywords:** backpack loads; exoskeleton; gait biomechanics; load carriage; metabolic cost

Aaron Petersen; Warren Payne; Matthew Phillips; Kevin Netto; David Nichols; Brad Aisbett. *Validity and relevance of the pack hike wildland firefighter work capacity test : a review. Pages 1276 – 1285.*

Fighting wildland fire is a physically demanding occupation. Wildland firefighters need to be physically fit to work safely and productively. To determine whether personnel are fit for duty, many firefighting agencies employ physical competency tests, such as the pack hike test (PHT). The PHT involves a 4.83-km hike over level terrain carrying a 20.4-kg pack within a 45-min period. The PHT was devised to test the job readiness of US wildland firefighters but is also currently used by some fire agencies in Australia and Canada. This review discusses the history and development of the PHT with emphasis on the process of test validation. Research-based training advice for the PHT is given, as well as discussion of the risks associated with completing the PHT. Different versions and modifications to the PHT have emerged in recent years and these are discussed with regard to their validity. Finally, this review addresses the relevance and validity of the PHT for Australian and Canadian wildland firefighters. **Statement of Relevance:** This paper reviews the history, development and validity of the PHT, an internationally recognised and utilised wildland firefighter work capacity test. It is concluded that while the PHT has general content validity for US wildland firefighters, verification of its reliability, criterion and construct validity is still needed.

- **Keywords:** firefighter; pack hike test; physical employment standards; work capacity