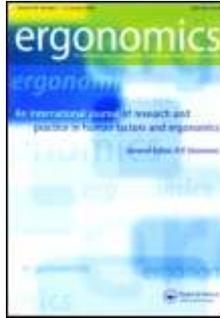


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Patrick Waterson. *A critical review of the systems approach within patient safety research.* Pages 1185–1195.

The application of concepts, theories and methods from systems ergonomics within patient safety has proved to be an expanding area of research and application in the last decade. This paper aims to take a step back and examine what types of research have been conducted so far and use the results to suggest new ways forward. An analysis of a selection of the patient safety literature suggests that research has so far focused on human error, frameworks for safety and risk and incident reporting. The majority of studies have addressed system concerns at an individual level of analysis with only a few analysing systems across multiple system boundaries. Based on the findings, it is argued that future research needs to move away from a concentration on errors and towards an examination of the connections between systems levels. Examples of how this could be achieved are described in the paper. The outcomes from the review of the systems approach within patient safety provide practitioners and researchers within health care (e.g. the UK National Health Service) with a picture of what types of research are currently being investigated, gaps in understanding and possible future ways forward.

- **Keywords:** complex systems; socio-technical systems; patient safety; health care ergonomics; work organisation

Patrick Waterson. *A systems ergonomics analysis of the Maidstone and Tunbridge Wells infection outbreaks.* Pages 1196–1205.

This paper describes a systems ergonomics analysis of the recent outbreaks of *Clostridium difficile*, which occurred over the period 2005-07 within the UK Maidstone and Tunbridge Wells NHS Trust. The analysis used documents related to the outbreak, alongside the construction of a system model in order to probe deeper into the nature of contributory factors within the Trust. The findings from the analysis demonstrate the value of looking further at cross-level and whole-system aspects of infection outbreaks. In particular, there is a need for further study of the causal relationships that exist between hospital management and clinical management levels within the system. Finally, the paper discusses ways forward and strategies that could be adopted in order to limit the outbreak of hospital-related infections and shape future research. The approach used for the system analysis described in the paper could be used by healthcare practitioners and ergonomists to probe deeper into the causes of infection outbreaks and to extend the scope of interventions aimed at preventing their occurrence.

- **Keywords:** healthcare ergonomics; complex systems; socio-technical systems; work organisation; organisational change

Paul Allen. *Perceptions of technology at sea amongst British seafaring officers. Pages 1206–1214.*

The use of Information Communication Technology is growing in the maritime industry as more systems become monitored remotely and new technologies are introduced to aid environmental awareness and increase safety. An exploratory survey was conducted as part of the EU project 'FLAGSHIP' to assess how seafarers perceive the current state of technology onboard ship and to identify areas of resistance to advancements in this area. Only 5.8% of the sample of British officers (overall n = 805) reported feeling resistant to new technology either 'quite a lot' or 'a great deal' at a general level compared to 82.8% when asked about the specific issue of training. Logistic regression analysis revealed older seafarers and those with low computer literacy to show greater resistance to new technology. Resistance was also higher on vessels with smaller crews, although a confound with vessel type is likely. Technology training for seafarers should be improved but not as a means of compensating for equipment developed without reference to user-centred design principles. Around 90% of all goods are transported by ship yet ergonomic research into the onboard environment is extremely limited. New technology is being introduced to substitute for the human element but little has been done to investigate how work processes have adapted. Seafarers' perceptions of new technology are examined here.

- **Keywords:** technology; seafaring; training; user-centred design; ships

Leon Straker; Svend Erik Mathiassen. *Increased physical work loads in modern work : a necessity for better health and performance? Pages 1215–1225.*

Shifting workforce proportions to sedentary occupations and technology developments in traditionally physically demanding occupations have resulted in low physical workloads for many workers. Insufficient physical stress is known to have detrimental short- and long-term effects on health and physical capacity. It is argued herein that many modern workers are at risk of insufficient physical workload. Further, it is argued that the traditional physical ergonomics paradigm of reducing risk by reducing physical loads ('less is better') is not appropriate for many modern occupations. It is proposed that a new paradigm is required, where 'more can be better'. The potential for work to be seen as an arena for improving physical health and capability is discussed and the types of changes to work that may be required are outlined. The paper also discusses challenges and responsibilities presented by this new paradigm for ergonomists, employers, health and safety authorities and the community. The majority of workers in affluent communities now face the significant threat to health of insufficient physical workload. Ergonomics can design work to a prescription that can not only reduce injury risk but enhance health and capacity. However, this will require a change in paradigm.

- **Keywords:** physical activity; stress; musculoskeletal injury; physical workload; health promotion

Catarina Nordander; Kerstina Ohlsson; Ingrid Åkesson; Inger Arvidsson; Istvan Balogh; Gert-Åke Hansson; Ulf Strömberg; Ralf Rittner; Staffan Skerfving. *Risk of musculoskeletal disorders among females and males in repetitive/constrained work. Pages 1226–1239.*

This paper combines epidemiological data on musculoskeletal morbidity in 40 female and 15 male occupational groups (questionnaire data 3720 females, 1241 males, physical

examination data 1762 females, 915 males) in order to calculate risk for neck and upper limb disorders in repetitive/constrained vs. varied/mobile work and further to compare prevalence among office, industrial and non-office/non-industrial settings, as well as among jobs within these. Further, the paper aims to compare the risk of musculoskeletal disorders from repetitive/constrained work between females and males. Prevalence ratios (PR) for repetitive/constrained vs. varied/mobile work were in neck/shoulders: 12-month complaints females 1.2, males 1.1, diagnoses at the physical examination 2.3 and 2.3. In elbows/hands PRs for complaints were 1.7 and 1.6, for diagnoses 3.0 and 3.4. Tension neck syndrome, cervicalgia, shoulder tendonitis, acromioclavicular syndrome, medial epicondylitis and carpal tunnel syndrome showed PRs > 2. In neck/shoulders PRs were similar across office, industrial and non-office/non-industrial settings, in elbows/hands, especially among males, somewhat higher in industrial work. There was a heterogeneity within the different settings (estimated by bootstrapping), indicating higher PRs for some groups. As in most studies, musculoskeletal disorders were more prevalent among females than among males. Interestingly, though, the PRs for repetitive/constrained work vs. varied/mobile were for most measures approximately the same for both genders. In conclusion, repetitive/constrained work showed elevated risks when compared to varied/mobile work in all settings. Females and males showed similar risk elevations. This article enables comparison of risk of musculoskeletal disorders among many different occupations in industrial, office and other settings, when using standardised case definitions. It confirms that repetitive/constrained work is harmful not only in industrial but also in office and non-office/non-industrial settings. The reported data can be used for comparison with future studies.

- **Keywords:** physical examination; questionnaire; tension neck syndrome; shoulder; upper limb

B. Rehn; T. Nilsson; R. Lundström; M. Hagberg; L. Burström. Neck pain combined with arm pain among professional drivers of forest machines and the association with whole-body vibration exposure. Pages 1240–1247.

The purpose of this study was to investigate the existence of neck pain and arm pain among professional forest machine drivers and to find out if pain were related to their whole-body vibration (WBV) exposure. A self-administered questionnaire was sent to 529 forest machine drivers in northern Sweden and the response was 63%. Two pain groups were formed; 1) neck pain; 2) neck pain combined with arm pain. From WBV exposure data (recent measurements made according to ISO 2631-1, available information from reports) and from the self-administered questionnaire, 14 various WBV exposure/dose measures were calculated for each driver. The prevalence of neck pain reported both for the previous 12 months and for the previous 7 d was 34% and more than half of them reported neck pain combined with pain in one or both arms. Analysis showed no significant association between neck pain and high WBV exposure; however, cases with neck pain more often experienced shocks and jolts in the vehicle as uncomfortable. There was no significant association between the 14 WBV measures and type of neck pain (neck pain vs. neck pain combined with arm pain). It seems as if characteristics of WBV exposure can explain neither existence nor the type of neck pain amongst professional drivers of forest machines. The logging industry is important for several industrialised countries. Drivers of forest machines frequently report neuromusculoskeletal pain from the neck. The type of neck pain is important for the decision of treatment modality and may be associated with exposure characteristics at work.

- **Keywords:** radiating pain; co-morbidity; musculoskeletal; vibration; seated

Dwayne Van Eerd; Sheilah Hogg-Johnson; Anjali Mazumder; Donald Cole; Richard Wells; Anne Moore. *Task exposures in an office environment : a comparison of methods.* Pages 1248–1258.

Task-related factors such as frequency and duration are associated with musculoskeletal disorders in office settings. The primary objective was to compare various task recording methods as measures of exposure in an office workplace. A total of 41 workers from different jobs were recruited from a large urban newspaper (71% female, mean age 41 years SD 9.6). Questionnaire, task diaries, direct observation and video methods were used to record tasks. A common set of task codes was used across methods. Different estimates of task duration, number of tasks and task transitions arose from the different methods. Self-report methods did not consistently result in longer task duration estimates. Methodological issues could explain some of the differences in estimates seen between methods observed. It was concluded that different task recording methods result in different estimates of exposure likely due to different exposure constructs. This work addresses issues of exposure measurement in office environments. It is of relevance to ergonomists/researchers interested in how to best assess the risk of injury among office workers. The paper discusses the trade-offs between precision, accuracy and burden in the collection of computer task-based exposure measures and different underlying constructs captured in each method.

- **Keywords:** ergonomic tools and methods; injury risks; office ergonomics; computer workstations; upper limb disorders

SHORT COMMUNICATION

Krishna Asundi; Peter W. Johnson; Jack T. Dennerlein. *Inertia artefacts and their effect on the parameterisation of keyboard reaction forces.* Pages 1259–1264.

Reaction force measurements collected during typing on keyboard trays contain inertia artefacts due to dynamic movements of the supporting work surface. To evaluate the effect of these artefacts, vertical forces and accelerations were measured while nine volunteers touch-typed on a rigid desk and a compliant keyboard tray. Two signal processing methods were evaluated: 1) low pass filtering with 20 Hz cut-off; 2) inertial force cancellation by subtracting the accelerometer signal. High frequency artefacts in the force signal, present on both surfaces, were eliminated by low pass filtering. Low frequency artefacts, present only when subjects typed on the keyboard tray, were attenuated by subtracting the accelerometer signal. Attenuation of these artefacts altered the descriptive statistics of the force signal by as much as 7%. For field measurements of typing force, reduction of low frequency artefacts should be considered for making more accurate comparisons across groups using work surfaces with different compliances. Direct measures of physical risk factors in the workplace can improve understanding of the aetiology of musculoskeletal disorders. Findings from this study characterise inertia artefacts in typing force measures and provide a method for eliminating them. These artefacts can add variability to measures, masking possible differences between subject groups.

- **Keywords:** exposure assessment tools; physical risk factors; work-related musculoskeletal disorders

Abid Ali Khan; Leonard O'Sullivan; Timothy J. Gallwey. *Effects of combined wrist flexion/extension and forearm rotation and two levels of relative force on discomfort.* Pages 1265–1275.

This study investigated perceived discomfort in an isometric wrist flexion task. Independent variables were wrist flexion/extension (55%, 35% flexion, neutral, 35% and 55% extension ranges of motion (ROM)), forearm rotation (60%, 30% prone, neutral, 30% and 60% supine ROM) and two levels of flexion force (10% and 20% maximum voluntary contraction (MVC)). Discomfort was significantly affected by flexion force, forearm rotation and a two-way interaction of force with forearm rotation (each $p < 0.05$). High force for 60%ROM forearm pronation and supination resulted in increasingly higher discomfort for these combinations. Flexion forces were set relative to the MVC in each wrist posture and this appears to be important in explaining a lack of significant effect ($p = 0.34$) for flexion/extension on discomfort. Regression equations predicting discomfort were developed and used to generate iso-discomfort contours, which indicate regions where the risk of injury should be low and others where it is likely to be high. Regression equations predicting discomfort and iso-discomfort contours are presented, which indicate combinations of upper limb postures for which discomfort is predicted to be low, and others where it is likely to be high. These are helpful in the study of limits for risk factors associated with upper limb musculoskeletal injury in industry.

- **Keywords:** wrist and forearm postures; musculoskeletal disorders; discomfort

Christian Krämer; Gabriel Schneider; Harald Böhm; Isabella Klöpfer-Krämer; Veit Senner. *Effect of different handgrip angles on work distribution during hand cycling at submaximal power levels. Pages 1276–1286.*

The effect of different handle angles on work distribution during hand cycling was determined. Able-bodied subjects performed hand cycling at 20% of maximum power level (mean (SD) power level: 90.0 (25.8) W) at a cadence of 70 rpm using handle angles of $\pm 30^\circ$, $\pm 15^\circ$ and 0° . The handle angle had a significant effect on work during the pull down ($p < 0.001$) and lift up ($p = 0.005$) sector, whereby the highest work was performed with handle angles of $+30^\circ$ and -15° respectively. The cycle sector had a significant effect on work ($p < 0.001$) and significantly ($p = 0.002$) higher work was performed in the pull down sector (25% higher than mean work over one cycle) as compared to the lift up sector (30% lower than mean work over one cycle). Therefore, a fixed handle angle of $+30^\circ$ is suggested to be optimal for power generation. The results of this study help to optimise the handbike-user interface. A more pronated handle angle compared to the one conventionally used was found to improve the performance of hand cycling and thereby the mobility of disabled people.

- **Keywords:** hand cycling; handle angle; work distribution

D. E. Adamo; M. Khodaei; S. Barringer; P. W. Johnson; B. J. Martin. *Low mean level sustained and intermittent grip exertions: Influence of age on fatigue and recovery. Pages 1287–1297.*

The goal of this study was to quantify localised muscle fatigue resulting from low mean levels of exertion in younger (< 40 years) and older (> 50 years) adults. Fatigue, elicited in the finger flexor muscles by intermittent (10% mean maximum voluntary contraction (MVC)) and sustained (8% MVC) handgrip exercises, was quantified by a muscle twitch force response before, immediately after and during 3 h following exercise. Despite greater mean loads, recovery time was shorter following intermittent than sustained contractions, which suggests that recovery from fatigue is more sensitive to rest within the work cycle than mean work. The more pronounced effects for younger than older individuals following the sustained exertion indicate that changes in muscle fibre type composition might predispose older individuals to be more resistant to fatigue resulting from sustained contractions of low level. Performing hand exertion tasks requiring low mean force levels contributes to similar long-lasting fatigue effects regardless of gender

and age. Intermittent periods of complete rest reduce muscle fatigue. Since fatigue was not perceived during recovery from the tested sustained and intermittent contractions, subjective evaluations may not be a reliable indicator of localised muscle fatigue.

- **Keywords:** fatigue of long duration; muscle work cycle; ageing; hand grip exertion

Stewart A. Birrell; Roger A. Haslam. *The effect of military load carriage on 3-D lower limb kinematics and spatiotemporal parameters.* Pages 1298–1304.

The 3-D gait analysis of military load carriage is not well represented, if at all, within the available literature. This study collected 3-D lower limb kinematics and spatiotemporal parameters in order to assess the subsequent impact of carrying loads in a backpack of up to 32 kg. Results showed the addition of load significantly decreased the range of motion of flexion/extension of the knee and pelvic rotation. Also seen were increases in adduction/abduction and rotation of the hip and pelvis tilt. No changes to ankle kinematics were observed. Alterations to the spatiotemporal parameters of gait were also of considerable interest, namely, an increase in double support and a decrease in preferred stride length as carried load increased. Analysing kinematics during military or recreational load carriage broadens the knowledge regarding the development of exercise-related injuries, while helping to inform the human-centred design process for future load carrying systems. The importance of this study is that limited available research has investigated 3-D lower limb joint kinematics when carrying loads.

- **Keywords:** load carriage; 3-D kinematics; spatiotemporal parameters; military

Nazim Gizem Forta; Miyuki Morioka; Michael J. Griffin. *Difference thresholds for the perception of whole-body vertical vibration : dependence on the frequency and magnitude of vibration.* Pages 1305–1310.

When seeking to reduce vibration in transport it is useful to know how much reduction is needed for the improvement to be noticeable. This experimental study investigated whether relative difference thresholds for the perception of whole-body vertical vibration by seated persons depend on the frequency or magnitude of vibration. Relative difference thresholds for sinusoidal seat vibration were determined for 12 males at three vibration magnitudes and eight frequencies (2.5, 5, 10, 20, 40, 80, 160, 315 Hz) using the three-down-one-up method in conjunction with a two-interval-forced-choice procedure. The median relative difference thresholds were in the range 9.5% to 20.3%. There appeared to be a frequency-dependence at the lowest vibration magnitude, such that higher frequencies had higher difference thresholds. The relative difference thresholds depended on the vibration magnitude only at 2.5 and 315 Hz. The influence of both vibration frequency and vibration magnitude on the measured difference thresholds suggests that vision (at 2.5 Hz) and hearing (at 315 Hz) contributed to the perception of changes in vibration magnitude.

- **Keywords:** difference thresholds; whole-body vibration

Morten Moshagen; Jochen Musch; Anja S. Göritz. *A blessing, not a curse : experimental evidence for beneficial effects of visual aesthetics on performance.* Pages 1311–1320.

The present experiment investigated the effect of visual aesthetics on performance. A total of 257 volunteers completed a series of search tasks on a website providing health-related information. Four versions of the website were created by manipulating visual

aesthetics (high vs. low) and usability (good vs. poor) in a 2 × 2 between-subjects design. Task completion times and error rates were used as performance measures. A main effect of usability on both error rates and completion time was observed. Additionally, a significant interaction of visual aesthetics and usability revealed that high aesthetics enhanced performance under conditions of poor usability. Thus, in contrast to the notion that visual aesthetics may worsen performance, visual aesthetics even compensated for poor usability by speeding up task completion. The practical and theoretical implications of this finding are discussed.

- **Keywords:** aesthetics; usability; performance; human-computer interaction; website