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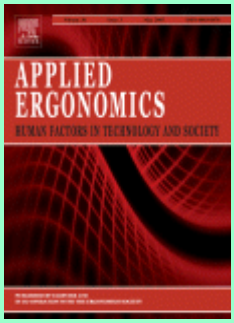


Steven L. Fischer, Elora C. Brenneman, Richard P. Wells, Clark R. Dickerson. *Relationships between psychophysically acceptable and maximum voluntary hand force capacity in the context of underlying biomechanical limitations.* Pages 813-820.

This research investigated if proportional relationships between psychophysically acceptable and maximum voluntary hand forces are dependent on the underlying biomechanical factor (i.e. whole body balance or joint strength) that limited the maximum voluntary hand force. Eighteen healthy males completed two unilateral maximal exertions followed by a 30 min psychophysical load-adjust protocol in each of nine pre-defined standing scenarios. Center of pressure (whole body balance) and joint moments (joint strength) were calculated to evaluate whether balance or joint strength was most likely limiting maximum voluntary hand force. The ratio of the psychophysically acceptable force to the maximal force was significantly different depending on the underlying biomechanical factor. Psychophysically acceptable hand forces were selected at 86.3 ± 19.7% of the maximum voluntary hand force when limited by balance (pulling exertions), 67.5 ± 15.2% when limited by joint strength (downward pressing) and 78 ± 23% when the limitation was undefined in medial exertions.

Highlights: ► Workers exerted both maximum (MVF) and psychophysically acceptable forces (PAF). ► PAF, as a percentage of MVF was highest during balance limited exertions (pulling). ► PAF, as a percentage of MVF was lowest during strength limited exertions (downward). ► PAF as a function of MVF is dependent on the underlying biomechanical weakest link.

- **Keywords:** Psychophysically acceptable force; Maximum voluntary force; Joint strength

Vassilis Papakostopoulos, Nicolas Marmaras. *Conventional vehicle display panels: The drivers' operative images and directions for their redesign.* Pages 821-828.

The proliferation of new displays in modern vehicles sets the challenge to revisit the design of the conventional display units, toward more simplified appearance. The present study aims to evaluate the usefulness of the information provided to the drivers by the conventional vehicle display units, in order to trace directions that would lead to a simplification of the future display panels. Based on the concept of operative images, two working hypotheses were formulated: (i) the experienced drivers have developed an operative image-reference (OI-R) for the display panel of their own vehicle(s), reflecting the relative importance they attribute to the information emitted by the various displays of the panel, and (ii) the experienced drivers' drawings of the display panel of their own vehicle will be guided by their OI-R for it – providing therefore traces of the content of their OI-R, while the less experienced drivers' drawings will be closer to the actual display panel of their own vehicle. The method of drawing from memory was used to obtain traces of the operative images of both experienced and less experienced non-professional drivers. The obtained 335 drawings were compared to the actual display panels, as to their overall resemblance and to specific features. The results of the data analysis are in accordance to our working hypotheses. Considering the main features of the experienced drivers' OI-R, directions for the simplification of the appearance of conventional display units are proposed.

Highlights: ► We evaluate the usefulness of the information provided to drivers by the conventional vehicle display units. ► 335 drivers drew from memory the display panel of their vehicle. ► Experienced drivers' drawings were found to be both laconic and deformed. ► We demonstrate that the deformations are functionally depended on specific display units and visual details. ► Directions for the simplification of the appearance of conventional display units are proposed.

- **Keywords:** Vehicle display units; Future display panel; Mental representations; Operative images; Drawing from memory

Toivo Niskanen, Paula Naumanen, Maria L. Hirvonen. *An evaluation of EU legislation concerning risk assessment and preventive measures in occupational safety and health.* Pages 829-842.

The European Council Directive 89/391/EC of 12 June 1989 is concerned with the introduction of measures to encourage improvements in the occupational safety and health. For example, it deals with risk assessment and preventive measures. The Finnish

legislation enacts the risk assessment and prevention measures in a similar way as the EU Directive 89/391/EC. The aim of this study was to examine: 1) the implementation of risk assessment process as a part of OSH management, and 2) the effectiveness of the OSH legislation concerned with risk assessment. The quantitative method involved an online questionnaire. The respondents were employers (N = 1478), workers (N = 1416) and occupational care (OHC) professionals' units (N = 469). Three quarters of the employer respondents and two thirds of the workers and OHC service providers felt that the EU legislative provisions have promoted the engagement of the management. According to the study, improvement is needed in ensuring the cooperation between employers and workers. The combined variables of Risk Assessment Process revealed positive impacts both on Cooperation and Management Measures and on the Concrete Preventive Measures among the employers and the workers. The combined variables of Use of Documents of Risk Assessments highlighted positive impacts on both the Exploiting of Results of Risk Assessments in Planning and Management and on the Exploiting of Results of Risk Assessment in Cooperation and Technology.

Highlights: ► The aim of the survey was to examine the implementation of the EU Directive 89/391/EU. ► The respondents were employers (N = 1478), workers (N = 1416) and OHC units (N = 469). ► Risk assessment process positively impacts on the concrete preventive measures. ► Risk assessment process positively impacts on the cooperation and management. ► Use of risk documents positively impacts on the cooperation and information.

- **Keywords:** EU; Directive; Legislation; Risk; Health; Safety; Evaluation

Sunwook Kim, Maury A. Nussbaum, Bochen Jia. *The benefits of an additional worker are task-dependent: Assessing low-back injury risks during prefabricated (panelized) wall construction.* Pages 843-849.

Team manual material handling is a common practice in residential construction where prefabricated building components (e.g., wall panels) are increasingly used. As part of a larger effort to enable proactive control of ergonomic exposures among workers handling panels, this study explored the effects of additional workers on injury risks during team-based panel erection tasks, specifically by quantifying how injury risks are affected by increasing the number of workers (by one, above the nominal or most common number). Twenty-four participants completed panel erection tasks with and without an additional worker under different panel mass and size conditions. Four risk assessment methods were employed that emphasized the low back. Though including an additional worker generally reduced injury risk across several panel masses and sizes, the magnitude of

these benefits varied depending on the specific task and exhibited somewhat high variability within a given task. These results suggest that a simple, generalizable recommendation regarding team-based panel erection tasks is not warranted. Rather, a more systems-level approach accounting for both injury risk and productivity (a strength of panelized wall systems) should be undertaken.

Highlights: ► Team manual material handling is a common practice in residential construction. ► We assess effects of an additional worker on injury risks during team-based tasks. ► Use of an additional worker generally reduces the level of ergonomic risk. ► The magnitude of benefits from using an additional worker is task-dependent. ► Application in practice should consider cumulative exposures and productivity.

- **Keywords:** Team lifting; Risk assessment; Prevention through design; Biomechanics

Wan-Fu Huang, Chih-Fu Wu. *Evaluation of a knee-kicker bumper design for reducing knee morbidity among carpet layers.* Pages 850-858.

Carpet layers have a high prevalence of occupational knee morbidity. One of the main causes is that they need to frequently 'kick' the bumper on the rear end of the knee kicker with one knee when laying a carpet. Considering the bumper's marked effects on kicking force transmission and safety, this study aims to improve the design of the knee-kicker bumper by reducing the risk factors. An improved pendulum-type impact-testing platform was designed as an evaluative apparatus, with the impulse and the coefficient of restitution serving as evaluative criteria. The newly developed bumper has improved firmness from drilled blind holes and an increase in effective forward force of 15%–138%, which implies lower operational demands and a lighter knee burden (i.e., less kicking energy results in the same work efficiency), and a softer contact surface that enhances operating comfort. The newly designed kicker was positively reviewed by subjects.

Highlights: ► Serious knee injuries frequently result with the use of a knee-kicker. ► Working carpet layers frequent use of the knee as a hammer. ► An improved pendulum-type impact tester was designed as an evaluative apparatus. ► The newly developed bumper has improved firmness from drilled. blind holes. ► An increase in effective forward force of 15%–138%, implying a lighter knee burden.

- **Keywords:** Knee-kicker; Impact-testing platform; Bumper

C.D. McKinnon, J.P. Callaghan, C.R. Dickerson. *Evaluation of the influence of mobile data terminal location on physical exposures during simulated police patrol activities.* Pages 859-867.

Prolonged occupational police driving combined with use of an in-vehicle computer elicits awkward, sustained postures in a scenario that lacks the adjustability to accommodate many mobile officer anthropometries and job-specific components.

Twenty participants performed simulated police patrol sessions at five mobile data terminal (MDT) locations and using two seats: standard police vehicle seat and modified seat designed for police use.

An MDT location self-selected prior to the session reduced perceived discomfort by up to 50% in the low back ($p < .0001$) and 68% in the right shoulder ($p < .0001$) compared to other tested locations, including the most common currently used location recorded from a representative police force. Muscle activity was lowest at the self-selected and current MDT locations for all muscles, significantly so for posterior deltoid ($p < .0001$) and supraspinatus ($p < .0001$). The modified seat reduced low back discomfort from the standard seat by 28% ($p < .0001$). Combining a self-selected MDT location and modified driver seat generated lower discomfort and physical loading than the currently used configuration.

- **Keywords:** Police officers; Occupational driving; Mobile data terminals

Brenda Lobb, Gregory R. Woods. *In search of a representative sample of residential building work.* Pages 868-875.

Most research investigating injuries in construction work is limited by reliance on work samples unrepresentative of the multiple, variable-cycle tasks involved, resulting in incomplete characterisation of ergonomic exposures. In this case study, a participatory approach was used including hierarchical task analysis and site observations of a typical team of house builders in New Zealand, over several working days, to obtain a representative work sample. The builders' work consisted of 14 goal-defined jobs using varying subsets of 15 task types, each taking from less than 1 s to more than 1 h and performed in a variety of postures. Task type and duration varied within and between participants and days, although all participants spent at least 25% of the time moving from place to place, mostly carrying materials, and more than half the time either

reaching up or bending down to work. This research has provided a description of residential building work based on a work sample more nearly representative than those previously published and has demonstrated a simple, low-cost but robust field observation method that can provide a valid basis for further study of hazard exposures.

Highlights: ► We analyse the work of prefabricated house builders. ► We develop a simple, robust, reliable field observation method. ► We collect a representative work sample. ► A representative work sample allows better estimation of ergonomic exposures.

- **Keywords:** Construction; Observations; Ergonomic exposures; Hierarchical task analysis; Participatory

Diana E. De Carvalho, Jack P. *Callaghan. Influence of automobile seat lumbar support prominence on spine and pelvic postures: A radiological investigation.* Pages 876-882.

Background

The use of lumbar supports has been associated with decreased reports of low back pain during driving exposures. However, there has been limited work investigating whether lumbar supports actually change spine and pelvic postures at the level of the vertebrae.

Purpose

To investigate the effectiveness of a lumbar support in changing radiological measures of lumbar spine and pelvic postures and to examine the impact of support excursion magnitudes on these postures.

Methods

Eight male subjects were recruited with no history of back injury, pathologies or low back pain within the past 6 months. Radiographs were taken in four postures: standing, and sitting with 0 cm, 2 cm and 4 cm lumbar support prominence (LSP).

Results

Lumbar lordosis angle increased from 20° with no support to 25° with 2 cm support and 30° with 4 cm support. Lumbar lordosis angles were significantly different between 0 cm support and 4 cm support ($p < 0.0001$) and between 2 cm support and 4 cm support

(p = 0.0256). Increasing lumbar support reduced the flexion at intervertebral disc joints throughout the lumbar spine, however, these remained significantly different from upright standing (p > 0.001) with the exception of L1/L2 in 4 cm support (p = 0.1381) and L5/S1 for all seated postures (p = 0.0687). All measures of pelvic posture were significantly different in sitting compared to standing (p < 0.0001), however, the lumbar support had no significant impact on seated pelvic posture.

Conclusions

Lumbar supports were shown to impact the vertebral rotations of the lumbar spine yet had no effect on pelvis postures. Increasing support from the current maximum of 2 cm–4 cm resulted in increased lumbar lordosis. The changes were mostly imparted at the upper lumbar spine joints with the most marked change being exhibited at the approximate level of the lumbar support apex: in the L2/L3 joint.

Highlights: ► Increasing lumbar support results in increased radiographic lumbar lordosis. ► The lumbar support tested in this study had no impact on pelvic posture. ► Low back posture with the support can be considered healthier for the user. ► However, there is potential for increased strains at the lumbopelvic junction. ► Further work will determine the effect of this support during prolonged driving.

- **Keywords:** Automobile seats; Low back pain; Lumbar spine biomechanics

Nikunj Velani, Ollie Wilson, Ben J. Halkon, Andy R. Harland. *Measuring the risk of sustaining injury in sport a novel approach to aid the re-design of personal protective equipment.* Pages 883-890.

Despite the possibilities offered by new approaches in design and advances in materials and manufacturing methods, few items of Personal Protective Equipment (PPE) used in sport have seen significant change for many decades. A major reason for this is the tradition and conservative attitudes associated with many sports, although the absence of appropriate tools and techniques to assist the design and development process has also played a large part. The aim of this study was to develop the first stage of a method of identifying specific regions of the human anatomy that are at the greatest risk of sustaining injury during participation in sports in which the player is subjected to multiple ballistic impacts. It is proposed that the findings could be used to confirm future designs of sports PPE. Previous studies have identified the amount and the location of the protection provided by current commercially available products but, until now, no evidence has been reported to determine what protection is required based on an understanding of the likely impact and the anatomy of the athlete.

Using the leg and cricket as examples of an anatomical feature and a sporting application respectively, the severity and probability of injury due to ball impacts typically observed in play are quantified, with respect to their location on the leg, to estimate the level of risk in that region. Results show that the level of risk is greatest in the shin regions of the front leg, suggesting that this region should be offered the greatest degree of protection, as is generally the case in commercially available leg guard designs. Conversely, however, the inner region of the mid shin of the back leg is at the lowest risk, suggesting that protection in this region might be substantially reduced, a feature which is certainly not included in current product; such a reduction may significantly enhance the ergonomic performance of the leg guard design.

The findings of this preliminary study indicate that the method offers the potential to quantify the relative risk of sustaining injury, in a sports specific application, as a function of location on the body and is thus a potentially useful design tool for design engineers of sports PPE. Given the embryonic nature of this approach, however, a number of assumptions and additional considerations is presented which reveal that, whilst the technique offers additional design insight, further research is required before it should be applied to equipment design.

Highlights: ► A method to analyse the risk of sustaining a severe impact injury within sports. ► We employ the commonly used risk equation. ► Leg and cricket leg guard used as examples of location and sporting application. ► Areas requiring greatest protection and a reduced amount of protection highlighted. ► Easily employable at other anatomical locations to allow more ergonomic PPE design.

- **Keywords:** Risk; Personal protective equipment; Design

Varun Chaturvedi, Adarsh Kumar, J.K. Singh. *Power tiller: Vibration magnitudes and intervention development for vibration reduction.* Pages 891-901.

The operators of power tiller are exposed to a high level of vibration originating from the dynamic interaction between the soil and the machine. The vibration from the power tiller is transmitted from the handle to hands, arms and shoulders. In the present study, experiments were conducted in three operational conditions i.e. transportation on farm roads, tilling with cultivator and rota-tilling with rota-vator. The highest vibration values were observed in x-direction in all the experiments. The maximum vibration rms values for x-direction were 5.96, 6.81 and 8.00 ms^{-2} in tilling with cultivator, transportation and rota-tilling respectively. Three materials were used for intervention development to reduce vibration magnitude. The maximum reduction of 25.30, 31.21 and 30.45% in

transportation; 23.50, 30.64 and 20.86% in tilling with cultivator and 24.03, 29.18 and 25.52% in rota-tilling were achieved with polyurethane (PU), rubber and combination of PU and rubber intervention. It was found that the maximum vibration reductions were achieved with the rubber in all three operational conditions. The average exposure time for occurrence of white finger syndrome increased by 28–50% with incorporation of intervention in different operations. Physiological and postural parameters also improved with incorporation of interventions.

Highlights: ► The vibration magnitudes of power tiller measured and found to be very high. ► Polyurethane, rubber and combination of both used for intervention development. ► Interventions enhanced the exposure time for occurrence of white finger syndrome. ► Physiological and postural parameters improved with interventions.

- **Keywords:** Power tiller; Hand-arm vibration; Intervention; Rubber; Polyurethane; India

Olivier Thuong, Michael J. Griffin. *The vibration discomfort of standing people: Relative importance of fore-and-aft, lateral, and vertical vibration.* Pages 902-908.

Few studies have compared the discomfort caused by vibration in different directions, and few have investigated the vibration discomfort of standing people. This study was designed to compare the discomfort experienced by standing people exposed to sinusoidal vibration in the fore-and-aft, lateral, and vertical directions. Using the method of magnitude estimation, 12 subjects estimated the discomfort caused by 4-Hz sinusoidal vibration at 10 different magnitudes. At 4 Hz, subjects were less sensitive to lateral vibration than to fore-and-aft vibration (K_y/K_x = 0.71), and more sensitive to vertical vibration than to horizontal vibration (K_z/K_x = 1.95; K_z/K_y = 2.77). Previous findings showing how the discomfort of standing people depends on the frequency of fore-and-aft, lateral, and vertical vibration were used to define frequency weightings that reflect relative sensitivity to vibration in each direction. The frequency weightings differ from those appropriate for seated people, and differ from the weightings for standing people in

current standards that were mostly derived from understanding of the discomfort of seated people.

Highlights: ► Shows how direction of vibration affects the vibration discomfort of standing people. ► Shows vibration discomfort is different in seated and standing people. ► Standards for predicting vibration discomfort of seated and standing people can be improved.

- **Keywords:** Vibration; Discomfort; Standing

Jun Li, Xiaofang Guo, Yunyi Wang. Temperature rating prediction of Tibetan robe ensemble based on different wearing ways. Pages 909-915.

Each piece of Western clothing has a unique temperature rating (TR); however, based on different wearing ways, one Tibetan robe ensemble can be used in various environments of the Tibetan plateau. To explain this environmental adaptation, thermal insulations and TR values of Tibetan robe ensembles in three typical wearing ways were measured by manikin testing and wearing trials, respectively. The TR prediction models for Tibetan robe ensembles were built in this research. The results showed that the thermal insulations of Tibetan robe ensembles changed from 0.26 clo to 0.91 clo; the corresponding TRs ranged from 9.90 °C to 16.86 °C because of different wearing ways. Not only the thermal insulation, but also the ways of wearing Tibetan robes was important to determining their TR values. The three TR models and a triangle area for each piece of Tibetan clothing explained its positive adaptation into the environment; this was different from the current TR models for Western clothing.

Highlights: ► Thermal insulations and temperature ratings (TR) of Tibetan robe ensembles in three wearing ways were investigated. ► The TR prediction models of Tibetan robe ensembles in different wearing ways were designed. ► There was a triangle area for each Tibetan robe ensemble due to three different wearing ways in the plot of the TR prediction model. ► This triangle area explained the environmental adaptation of Tibetan clothing.

- **Keywords:** Tibetan robe; Temperature rating; Way of wearing

B. Aisbett, A. Wolkow, M. Sprajcer, S.A. Ferguson. *"Awake, smoky, and hot": Providing an evidence-base for managing the risks associated with occupational stressors encountered by wildland firefighters.* Pages 916-925.

To curtail the spread of wildfire, firefighters are often required to work long hours in hot, smoky conditions with little rest between consecutive shifts. In isolation, heat, smoke, and sleep disruption can have a detrimental impact on cognitive and physical abilities. Far less is known, however, about the combined impact that heat, smoke, and sleep disruption can have on firefighters' performance during wildfire suppression or on human performance in general. The available literature, though scant, suggests that audio and visual tracking may be degraded after sustained heat exposure following one night of sleep deprivation. Exposure to heat and carbon monoxide, in contrast, appears to have only limited impact on cognitive performance, even after physical exercise. Heat and carbon monoxide exposure does, however, increase physiological exertion to a given work or exercise bout. To the authors' knowledge, there are no published studies that have explored the impacts of heat exposure following sleep disruption on physical work performance, sleep disruption and smoke exposure on physical or cognitive work, or the combined impacts of sleep disruption, smoke and heat exposure on cognitive or physical work. While more integrative research is needed, the current review provides a summary of the available evidence and an indication of the degree of confidence agencies can have in the research. This will allow both the scientific community and agencies to make informed recommendations regarding the management of wildland firefighters' health and safety on the fireground.

Highlights: ► Wildland firefighters face multiple occupational stressors that place them at increased risk. ► Sleep restriction, heat and smoke impact physical and mental performance. ► In combination these stressors are likely to have a bigger impact on health and safety. ► We provide guidance to policy makers managing the OHS risks for firefighters.

- **Keywords:** Heat; Fatigue; Work; Sleep; Firefighter

Li-Ping Hsiao, Chiung-Yu Cho. *The effect of aging on muscle activation and postural control pattern for young and older computer users.* Pages 926-932.

A lot of older adults try to learn to use computers and might use different ways to perform a computer task compared to younger people. Fifteen healthy young and 15 healthy older adults participated in this study and all performed a series of mouse tasks. A three dimensional motion capture system and electromyographic analysis were used to obtain kinematic and kinetic data during performing the computer tasks. Three-way analysis of variance with repeated measures on task and time factors was used to analyze all dependent measurements. Older adults had higher RMS of forearm muscles

compared to the young adults. The RMS of the finger extensor was highest when performing a dragging task. Compared with young adults, the older adults had greater cranial-cervical angle and neck flexion, but smaller head flexion, shoulder angle, elbow angle and ulnar deviation. Consequently, the older adults might have a greater risk of developing musculoskeletal disorder.

Highlights: ► We compare postures and EMGs between young & old computer users during performing mouse tasks. ► Older adults had higher RMS of forearm muscle and greater cranial-cervical and neck flexion angles. ► The RMS of the finger extensor was highest when performing a dragging task. ► The older computer users might be at a greater risk of musculoskeletal disorder.

- **Keywords:** Aging; Posture control; Muscle activity

Andreia Sousa, João Manuel R.S. Tavares, Rui Macedo, Albano Manuel Rodrigues, Rubim Santos. *Influence of wearing an unstable shoe on thigh and leg muscle activity and venous response in upright standing.* Pages 933-939.

Purpose

To quantify the effect of unstable shoe wearing on muscle activity and haemodynamic response during standing.

Methods

Thirty volunteers were divided into 2 groups: the experimental group wore an unstable shoe for 8 weeks, while the control group used a conventional shoe for the same period. Muscle activity of the medial gastrocnemius, tibialis anterior, rectus femoris and biceps femoris and venous circulation were assessed in quiet standing with the unstable shoe and barefoot.

Results

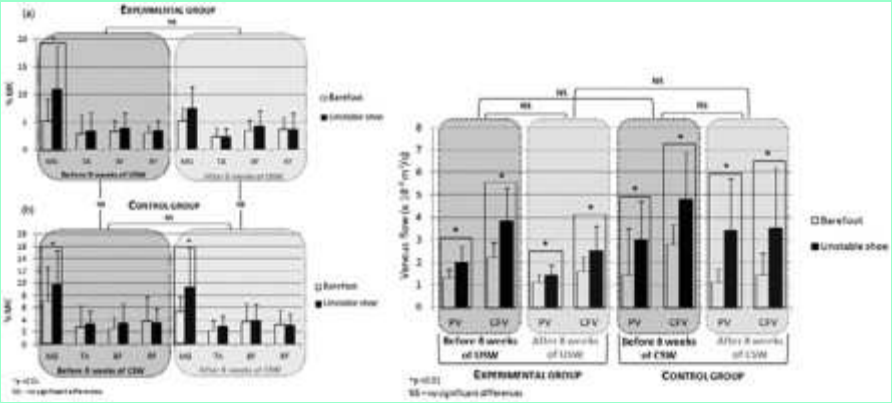
In the first measurement there was an increase in medial gastrocnemius activity in all volunteers while wearing the unstable shoe. On the other hand, after wearing the unstable shoe for eight weeks these differences were not verified. Venous return increased in subjects wearing the unstable shoe before and after training.

Conclusions

The unstable shoe produced changes in electromyographic characteristics which were advantageous for venous circulation even after training accommodation by the neuromuscular system.

Graphical abstract

On the left: Values for mean and standard deviation of medial gastrocnemius (MG), tibialis anterior (TA), biceps femoris (BF) and rectus femoris (RF) muscles activity (% MIC) during standing with and without the unstable shoe before and after 8 weeks of unstable shoe wearing (USW) by the experimental group (a) and the same period of conventional shoe wearing (CSW) by the control group (b). On the right: mean and standard deviation values of venous velocity at the common femoral (CFV) and popliteal (PV) veins during standing with and without the unstable shoe before and after 8 weeks of USW by the experimental group and 8 weeks of CSW by the control group.



Highlights: ► Unstable shoe usage leads to a short and long term increase of venous flow in upright standing. ► Unstable shoe usage promotes short and long term changes in muscle activation, mainly at the ankle joint, in upright standing. ► Unstable shoe wearing produce changes in EMG characteristics that are advantageous for venous circulation during upright standing. ► Unstable shoe wearing can be used as a prophylactic measure for preventing venous insufficiency.

- **Keywords:** Electromyography; Haemodynamics; Muscle pumps

Anja Katharina Huemer, Mark Vollrath. *Learning the Lane Change Task: Comparing different training regimes in semi-paced and continuous secondary tasks.* Pages 940-947.

For road safety it is paramount that distraction by in-vehicle systems is limited. To reach this aim the Lane Change Task (LCT; Mattes, 2003) was developed. It is used as a test procedure to measure distraction due to secondary tasks in driving. The LCT is

implemented as an ISO standard (ISO 26022: 2010) with the aim to provide an objective criterion for designing human–machine interactions (HMI) in a way which is not detrimental to driving. As different baseline performance in the LCT could not be sufficiently explained in recent studies, comparisons of different training regimes were conducted in order to examine training influences on LCT performance. Discriminable performance improvements in LCT were found depending on the secondary task used. A training regime of at least ten runs of LCT in single-task mode is recommended for effective training. This training should be supplemented by a training of the secondary tasks examined. An additional exploration of a dual-task situation is recommended.

Highlights: ► Training effects on performance in the Lane change test (LCT) was examined. ► They were examined in single and in dual-task mode and with different secondary tasks. ► To reach a stable LCT performance at least ten runs of LCT are needed. ► This training should be supplemented by training the secondary task to be examined.

- **Keywords:** Driver distraction; Lane Change Task (LCT); Surrogate Reference Task (SuRT); Critical Tracking Task (CTT); Dual-task practice

L.B.de M. Guimarães, J.L.D. Ribeiro, J.S. Renner. *Cost–benefit analysis of a socio-technical intervention in a Brazilian footwear company.* Pages 948-957.

This article presents a costs–benefits analysis of a macroergonomic intervention in a Brazilian footwear company. Comparing results of a pilot line (composed by 100 multiskilled workers organized in teams) with eight traditional lines (still working in a one human being/one task model) the intervention showed to be worth pursuing since achieved gains were higher than intervention costs: there was a reduction in human resource costs (80% reduction in industrial accidents, 100% reduction in work-related musculoskeletal disorders or WMSD, medical consultations and turnover, and a 45.65% reduction in absenteeism) and production improvement (productivity increased in 3% and production waste decrease to less than 1%). The net intervention value of the intervention was around U$ 430,000 with a benefit-to-cost ratio of 7.2. Moreover, employees who worked in the pilot line understood that their quality of work life improved, compensating the anxiety brought up by the radical changes implemented.

Highlights: ► The macroergonomic intervention in a shoe manufacturer was worth undertaking. ► Workers got more satisfied with their work. ► Accidents, WMSD risk, medical consultations, turnover and absenteeism decreased. ► Production increased and

waste (rework and spoilage) decreased. ▸ The benefit-to-cost ratio of the intervention was 7.2.

- **Keywords:** Cost–benefit analysis; Work organization; Socio-technical system; Participative ergonomics; Shoes manufacturing

Marieke H.A.H. Van den Oord, Yuval Steinman, Judith K. Sluiter, Monique H.W. Frings-Dresen. *The effect of an optimised helmet fit on neck load and neck pain during military helicopter flights.* Pages 958-964.

The main purpose of this study was to improve the helmet fit of military helicopter aircrew members and evaluate its effect on the experienced helmet stability (helmet gliding), neck load, neck pain, hot spots (pressure points), irritation/distraction, and overall helmet comfort during night flights. A within-subject design was used over a three-month period that consisted of two consecutive interventions of optimising the fit of the aircrew's helmets: 1) a new helmet fit using a renewed protocol and 2) replacement of a thermoplastic inner liner with a viscoelastic foam inner liner. A total of 18 pilots and loadmasters rated the outcome measures using the Visual Analogue Scales immediately after their night flights, for three night flights in total per measurement period. The optimised helmet fit resulted in a significant decrease in the experienced helmet gliding, neck load and pressure points, a decrease trend in the experienced neck pain and irritation/distraction, and a significant increase in the experienced overall helmet comfort during flight. These results demonstrate the importance of achieving an optimised helmet fit for military helicopter aircrew and that an optimised helmet fit might have implications for both health and safety concerns.

Highlights: ▸ We examined the effect of an optimised helmet fit during military night flights. ▸ An optimised helmet fit increased helmet stability and decreased neck load. ▸ An optimised helmet fit increased comfort and aircrews were less distracted in-flight. ▸ An optimised helmet fit might have implications for both health and safety concerns.

- **Keywords:** Helicopter aircrew; Flight helmet; Neck load

Yen-Hui Lin, Chih-Yong Chen, Min-Hsien Cho. Yen-Hui Lin, Chih-Yong Chen, Min-Hsien Cho*. Influence of shoe/floor conditions on lower leg circumference and subjective discomfort during prolonged standing.* Pages 965-970.

Many occupations require workers to stand for prolonged periods, which can cause both discomfort and pain. This study examines the effects of different shoe and floor

conditions on standing discomfort in the workplace and laboratory. Two experiments were conducted. Experiment 1 enrolled 10 subjects who performed a computer task under two floors and shoe conditions while standing for 4 h in a laboratory. Experiment 2 involved 14 subjects who stood for 4 h throughout their shift on two different floors in a real work situation (i.e., a field experiment). Analytical results demonstrate that floor type and time standing significantly affected subjective ratings for leg discomfort and circumferential shank measurements in both the laboratory and field studies. Shoe condition significantly affected subjective ratings for leg discomfort. We conclude that shoe/floor conditions and prolonged standing influence worker lower extremity discomfort during prolonged standing. These analytical findings suggest that common ergonomic interventions, such as modifying the flooring on which workers stand might some what alleviate leg edema for workers standing for 4 h shifts in laboratory and field settings. Nevertheless, prolonged standing for even 1 h without rest showed negative effects and should be avoided when possible.

Highlights: ► Floor type affected subjective leg discomfort and shank circumference. ► Time standing increased subjective leg discomfort and shank circumference. ► Shoe condition significantly affected subjective leg discomfort. ► Prolonged standing for even 1 h without rest showed negative effects.

- **Keywords:** Prolonged standing; Shoe/floor conditions; Subjective ratings of leg discomfort; Circumference