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Juan Rabal-Pelay, Cristina Cimarras-Otal, César Berzosa, Marta Bernal-Lafuente, José Luis Ballestín-López, Carmen Laguna-Miranda, Juan Luis Planas-Barraguer & Ana Vanessa Bataller-Cervero. *Spinal sagittal alignment, spinal shrinkage and back pain changes in office workers during a workday*. Pages: 1-7.

Purpose. Prolonged sitting is a risk factor for the appearance of lower back pain during work. The aim of this study was to observe changes in spinal sagittal alignment, height and the perception of back pain in office workers during a workday. *Materials and methods.* Forty-one office workers (20 women) were enrolled into a cross-sectional study. Height, sitting height and degrees of thoracic kyphosis and lumbar lordosis as well as perceived neck pain, lower back pain and upper back pain were determined, before and after an 8-h workday. *Results.* At the end of the day, workers had a significant decrease ($p = 0.000$) in height and sitting height, and upper back pain increased significantly ($p = 0.023$). In men, spinal shrinkage correlated with neck pain ($r = 0.410$, $p = 0.027$), and lumbar lordosis degrees in women correlated negatively with upper back pain at the end of the day ($r = -0.440$, $p = 0.012$). *Conclusions.* Spinal shrinkage equally affects men and women who perform the same work. There are no changes in spinal sagittal alignment throughout the workday in office workers. Office workers show significantly increased pain in the upper back at the end of the day.

- **Keywords:** occupational back pain, ergonomics, spine, seated work, sitting height

Marius D. Iftime, Adela-Eliza Dumitrascu & Valentina D. Ciobanu. *Chainsaw operators' exposure to occupational risk factors and incidence of professional diseases specific to the forestry field*. Pages: 8-19.

Purpose. This article focuses on detailed studies regarding the analysis of occupational risk factors on health and occupational disease, namely, the influence of noise, hand–arm vibration, wet bulb globe temperature (WBGT) index and exposure to particulates. *Methods*. This study measured the equivalent acoustic level (LA_{eq}), daily vibration exposure ($A(8)$), WBGT index and particulate concentration in the respirable area of the worker. The inferential analysis consisted of the application of specific statistical methods: a probability plot with 95% confidence interval, the Anderson–Darling statistic and 87th percentile estimation. A sample of 107 chainsaw operators was

medically evaluated, out of which 30 workers were suspected of having professional pathologies and were hospitalized in the university clinic. *Results.* The measurements highlight: exceeding the legal limit for noise exposure; 13% of cases exceeding the limit of 2.5 m/s^2 for hand–arm vibration; dust exposure generally within legal limits; WBGT shows the thermal stress of the workers. Following the medical evaluation, osteomusculoskeletal disorders (25.23%), Raynaud's syndrome (0.93%) and bilateral hearing loss (3.74%) were identified. *Conclusions*. Analysis of the levels of exposure to the risk factors, the typology and the incidence of occupational diseases requires the need to adopt new preventive measures.

- **Keywords:** chainsaw operator, exposure to risk factor, probability plot, Anderson–Darling statistic, 87th percentile estimation, occupational disease, professional pathologies

Sergio A. Useche, Boris Cendales, Francisco Alonso & Luis Montoro. *Multidimensional prediction of work traffic crashes among Spanish professional drivers in cargo and passenger transportation*. Pages: 20-27.

The aim of this study was to examine the effect of different environmental, mechanical and individual factors associated with fatalities and serious injuries caused by work traffic accidents among cargo and passenger transport drivers (CPTD) in Spain. For this cross-sectional study, national data on work traffic accidents collected in Spain during the last 3 years were analyzed through a regression modeling approach, in order to predict the severity of traffic crashes involving CPTD. Using binary logistic regression analyses, it was found that the type of road and accident, the meteorological, light and vehicle conditions, individual characteristics and risky driving behaviors significantly predict the risk of fatal work traffic accidents and serious injuries. These findings highlight the importance of combining organizational efforts with national road safety policies in order to generate a traffic safety culture among CPTD.

- **Keywords:** occupational road crashes, work traffic accidents, professional drivers, work environment, traffic safety

Krantiraditya Dhalmahapatra, Souvik Das & J. Maiti. *On accident causation models, safety training and virtual reality*. Pages: 28-44.

Inefficiency in real-time visualization and user interaction in traditional accident causation models (ACMs) necessitates the development of a dynamic ACM that can foster real-time hazard identification, accident prevention and interactive safety training. A virtual reality-based accident causation model (VR-ACM) may serve such a purpose. In this study, we performed a comprehensive literature review on different ACMs and safety training practices. The limitations of the existing models and practices are identified. A VR-ACM model is proposed comprising three modules: VR-based modelling and simulation, accident causation and safety training. Several research issues for VR-ACM are highlighted. An experimental study with 22 crane operators is presented, showing the applicability of the proposed model. The proposed VR-ACM serves as a medium for analysis of potential underlying causes of accidents, the three-dimensional perspective of visual analysis, real-time user interactions and real-time judgement and decision-making.

- **Keywords:** hazard identification, virtual reality, virtual prototype,accident causation, safety training

Burcu Felekoglu & Seren Ozmehmet Tasan. *Interactive ergonomic risk mapping: a practical approach for visual management of workplace ergonomics*. Pages: 45-61.

Current studies identify an increasing need to develop enriched tools for ergonomic risk management that can foster an atmosphere enhancing commitment of all stakeholders to create a safe and heathy work environment using ergonomic principles. In this study, a new tool for visualization of ergonomic practices in the workplace is proposed. For developing this tool, an interactive ergonomic risk mapping (intERM) methodology is introduced consisting of five steps while integrating the company's strategic vision and helping to accommodate the impacts of changes in policy and regulatory context, economic and demographic environment, technology and employment context. The proposed systematic and practical methodology is demonstrated on a real-life example. This visual and interactive tool enables prompt identification of and reaction to ergonomic risks, anticipating changes for reducing/eliminating ergonomic risks, as well as increasing company-wide awareness for ergonomic risks and enhancing engagement and ownership of stakeholders.

- **Keywords:** risk map, ergonomic risk factors, ergonomic risk mapping

Agnieszka Brochocka & Małgorzata Okrasa. *Determination of paraffin oil mist penetration at high flow rates through air-purifying respirators*. Pages: 62-67.

This article presents paraffin oil mist penetration tests of commercially available air-purifying respirators of different construction conducted using the method described by Standard No. ISO 16900-3:2012, which incorporates flow rates (up to 255 l/min) of test aerosol. The testing method reflects differences in work intensity during the use of respirators. Moreover, the experimental stand, designed according to the international specifications, is described. The results show that the higher the paraffin oil mist flow rate, the higher the penetration index, irrespective of the testing method used and the type of respirator investigated. While at high flow rates, filtering half masks of the first protection class (FFP1) met the requirements of their protection class according to European Standard No. EN 149:20001+A1:2009, filtering half masks of the second and the third protection class (FFP2 and FFP3) did not.

- **Keywords:** penetration index, paraffin oil mistair-purifying respirators, high flow rates, ISO standards

Karen Y. Ma, Alicia L. Nadon, Alison C. McDonald & Clark R. Dickerson. *Assessing potential trade-offs between the lower back and shoulders: influence of lift training intervention on joint demands*. Pages: 68-75.

Background. Many of the approaches available for modifying manual materials handling (MMH) exertion emphasize lower back protection but often do not consider how interventions affect other body regions. This study focused on the influence of lift training on resultant joint moments and muscular demand trade-offs between the lower back and shoulders during MMH tasks. *Methods.* Three recommended lifting techniques (straddle lift, pivot technique and tripod lift) were compared to a priori (untrained) self-selected lifting techniques. *Results.* Mean and cumulative resultant moments indicated that using the lifting techniques evaluated in this investigation protected the shoulders more than the lower back. Mean and peak shoulder muscle activity also decreased following training ($p < 0.05$). Although there were no peak and mean changes to lower back muscle activity ($p > 0.05$), there was a significant decrease in cumulative lower back muscle activity ($p < 0.05$). Reported perceived exertion values decreased following training across the lifting techniques for all evaluated body regions ($p < 0.05$). *Conclusion.* Overall, the recommended MMH techniques protected both the lower back and the shoulders, and no exposure trade-offs between them were identified.

- **Keywords:** manual materials handling¨, shoulder, lower back

Valentina Hartwig, Cristiano Biagini, Daniele De Marchi, Alessandra Flori, Chiara Gabellieri, Giorgio Virgili, Luca Fabiano Ferrante Vero, Luigi Landini, Nicola Vanello & Giulio Giovannetti. *Analysis, comparison and representation of occupational exposure to a static magnetic field in a 3-T MRI site*. Pages: 76-85.

The purpose of this study is to analyze exposure to the time-varying magnetic field caused by worker movements in a 3-T clinical magnetic resonance imaging (MRI) scanner. Measurements of the static magnetic field (B) in the proximity of the MRI scanner were performed to create a detailed map of the spatial gradient of B, in order to indicate the areas at high risk of exposure. Moreover, a personal exposure recording system was used in order to analyze and compare exposure to the static magnetic field during different routine procedures in MRI. We found that for all of the performed work activities, exposure was compliant with International Commission on Non-Ionizing Radiation Protection levels. However, our findings confirm that there is great variability of exposure between different workers and suggest the importance of performing personal exposure measurements and of detailed knowledge of the magnetic field spatial distribution.

- **Keywords:** magnetic resonance, electromagnetic fields, occupational exposure, exposure assessment

Arthur Felipe Echs Lucena & Fernanda Aranha Saffaro. *Guidelines for exploring construction sites in virtual reality environments for hazard identification*. Pages: 86-95.

The use of virtual reality devices for exploring construction sites is a promising alternative to anticipate problems and reduce the occurrence of work-related accidents. The present study drew comparisons between different ways of performing virtual exploration to improve workers' safety on construction sites. These comparisons allowed the proposal of guidelines for modelling and exploring construction site simulations using low-cost immersive virtual reality devices. Eight construction managers participated in two virtual reality simulations in which they had to identify hazards to the workers. Considering the volunteers' opinion, the time used and the number of hazards identified, the study concluded that the best simulation mode was one in which the user rigidly followed the guidelines of a protocol for their displacement and hazard analysis. The results of the study indicated that the procedures for virtual exploration of the construction site should be standardized, providing greater focus on hazard identification.

- **Keywords:** construction safety, Google Cardboard, visualization in engineering

Olanrewaju Timothy Dada, Simeon Oluwagbenga Fasina, Hafeez Idowu Agbabiaka, Umar Obafemi Salisu, Nathaniel Oluwaseun Ogunseye & Olanipekun Abeeb Olawale. *Occupational hazards and risks among commercial motorcyclists in the peri-urban city of Lagos, Nigeria*. Pages: 96-106.

Although a significant proportion of road hazards and their associated health risks in Nigeria involve motorcycles, relatively little research explores whether commercial motorcyclists have unique seasonal accident experiences. This article analyses survey data from 241 commercial motorcyclists in selected terminals in Ifo, Nigeria, to explore how road hazards and health risks experienced differ from one season to another. The study established that seasonality of motorcycle hazards and health risks cannot be assumed across the terminals and routes as some were dominant in either rainy or dry seasons or both. In particular, most motorcycle hazards and health risks were less likely caused by seasonal variation but by human errors and road conditions. The results

underscore the importance of collecting commercial motorcyclists' perceptual data because many experience hazards and health risks that are burdensome to them.

- **Keywords:** public transport, commercial motorcycle accidents, road hazard, health risk

John Ngoy Kalenga. *Estimating the injury rates and causes of fatalities in the Japanese mining industry, 1924–2014*. Pages: 107-117.

This article investigates the trends in injury rates and causes of fatalities in the Japanese mining industry. Accident data were collected from the Japan Statistics Yearbooks released by the Bureau of the Prime Minister. These data were analyzed to estimate the injury rates and accident causes in the Japanese mining industry. In Japan, the median injury, severe injury and fatality rates were 129.25, 5.44 and 2.99/1000 workers, respectively. A collapsing roof in an underground mine was the principal cause of fatal accidents, accounting for a median value of 21/1000 worker deaths during the entire period under study. In comparison with the accident experience of the USA and the Democratic Republic of Congo, countries with substantial mining industries, the median values of the fatality rates were 0.58 and 0.28/1000 workers, respectively. We conclude that Japanese mineworkers were most exposed to the risk of accidents during the prewar era.

Keywords: mining industry, occupational safety, industrial accidents, injury rates, fatal accidents, USA, Democratic Republic of Congo, Japan

Qing Zheng, Ying Ke & Hongfu Wang. *Design and evaluation of cooling workwear for miners in hot underground mines using PCMs with different temperatures*. Pages: 118-128.

Cooling workwear using phase change materials (PCMs) was designed for miners in hot underground mines. A new arrangement of PCM packs was introduced that used 15 °C PCMs as the inner layer and 23 °C PCMs as the outer layer (15&23). Its performance was investigated using thermal manikin and human subject tests by comparison with clothing without PCMs (CON), with 15 °C PCMs (15&15) and with melted PCMs (mPCM) in a climate chamber (30 °C, 80% relative humidity). The PCM cooling workwear significantly increased the manikin heat loss, attenuated the rise of skin temperatures and improved thermal sensation and comfort. The cooling duration was extended in 15&23 as compared with 15&15. The added PCMs did not affect the perceptual exertion and body mobility. In summary, cooling workwear using PCMs with different temperatures can be an effective option for miners' personal cooling in a hot and humid environment.

- **Keywords:** mining work, wear, phase change material, thermal manikin, physiological responses, movement comfort, heat hazard

Mohammed Said Obeidat, Nadah Faris Altheeb, Amer Momani & Nader Al Theeb. *Analyzing the invisibility angles formed by vehicle blind spots to increase driver's field of view and traffic safety*. Pages: 129-138.

A driver's field of view is an essential requirement for decreasing traffic crashes and increasing safety. This article improves driver safety by analyzing factors that affect the invisibility angles formed by a vehicle's A and B pillars. An experiment was conducted with 117 participants. Two models were developed, each associated with one invisibility angle. In the A-pillar invisibility model, the age, weight, waist circumference, torso angle and distance between eyes and windshield were significant. For the B-pillar model, the age, gender, stature, waist depth, waist breadth, torso angle and distance between steering wheel and abdomen were significant. Some of these factors increase the

invisibility angle(s), including age, stature, torso angle, distance between windshield and eyes, and distance between steering wheel and abdomen. Other factors decrease the invisibility angle(s), including weight, waist circumference, waist depth and waist breadth. In addition, gender significantly affects the invisibility angle.

- **Keywords:** driving posture, traffic, obstruction, blind spots, body mass index

Metin Bayram. *Factors affecting employee safety productivity: an empirical study in an OHSAS 18001-certified organization*. Pages: 139-152.

Objective. The purpose of the study is to examine the relationships between safety behaviours (safety compliance and safety participation), their determinants (safety motivation and knowledge of safety) and their antecedent (safety training) affecting employee safety productivity, an economic benefit of occupational health and safety (OHS). *Methods.* The study was carried out with employees participating in the basic OHS training, which is mandatory every 2 years for all personnel due to the related legal obligation. The data required for the research purpose were collected by surveying 453 employees. The collected data were then tested using the methods of exploratory factor analysis and confirmatory factor analysis. *Results.* The findings of the analyses showed that safety training, safety knowledge, safety motivation and safety compliance affect the improvement of employee safety productivity, one of the economic benefits of OHS. The study also suggested that safety participation does not influence the improvement of employee productivity. Furthermore, a new scale concerning employee safety productivity has been brought to the safety literature. *Conclusion.* It is suggested that organizational managers wishing to increase employee safety productivity focus particularly on training regarding the safety knowledge, skills, motivation and compliance of employees.

- **Keywords:** employee safety productivity, safety compliance, safety knowledge, safety motivation, safety participation, safety training

Philémon Marcel-Millet, Gilles Ravier, Michael R. Esco & Alain Groslambert. *Does firefighters' physical fitness influence their cardiac parasympathetic reactivation? Analysis with post-exercise heart rate variability and ultra-short-term measures*. Pages: 153-161.

Purpose. This study assessed the influence of firefighters' physical fitness on performances and parasympathetic reactivation in rescue interventions, and tested the validity of post-exercise ultra-short-term heart rate variability. *Methods*. Twenty-four firefighters were assigned to two groups based on their fitness and performed three simulated interventions. The mean completion time was recorded. The post-exercise root mean square of successive differences of R–R intervals (LnRMSSD) was determined from both criterion (between 5 and 10 min) and ultra-short-term (every 1-min segment from minutes 0–6) analyses. *Results*. Completion time was better for the highest fitness group in the three simulated interventions while post-exercise LnRMSSD was not influenced by the firefighters' fitness. Reliability between ultra-short-term and criterion analyses differed between the segments tested; minute 5–6 revealed the highest intra-class correlations (0.86–0.97). Concerning sensitivity of both analyses, the criterion analysis revealed differences between the three rescue interventions and the fitness test, but these results were not observed with ultra-short-term measures. *Conclusions*. Fitness was associated with firefighters' performances but not with parasympathetic reactivation in the firefighting intervention. The ultra-short-term measures do not seem to be a suitable post-exercise LnRMSSD analysis because of the low sensitivity to reveal differences among exercise conditions.

- **Keywords:** vagal, recovery, firefighting, performance

Mathieu Jonathan Pascal Bussier & Heap-Yih Chong. *Relationship between safety measures and human error in the construction industry: working at heights*. Pages: 162-173

In recent years, falling from heights has been reported as the primary cause of fatalities within the Australian construction industry. While there is substantial literature exploring safety and human error in an attempt to decrease the occurrences of accidents through the implementation of organizational and physical hazard-related strategies, little attention has been brought towards the impact of psychological distress on the relationship between human error and safety measures. Therefore, this article aims at examining the relationship between safety measures and human error with the objective of identifying the impact of psychological distress among workers working at heights within the construction industry on the relationship. This study found that human error can occur as a result of psychological distress and therefore provides a foundation for future research to explore whether proper implementation of psychological safety measures could decrease the occurrence of human failures and accidents when working at heights.

- **Keywords:** safety measures, human error, psychological distress, falls from heights, prevention strategies, psychological safety measures, structural equation modelling, Australia

Dhanjee Kumar Chaudhary, Sanjay Kumar Palei, Vivekanand Kumar & Netai Chandra Karmakar. *Whole-body vibration exposure of heavy earthmoving machinery operators in surface coal mines: a comparative assessment of transport and non-transport earthmoving equipment operators*. Pages: 174-183.

Purpose. Two groups of heavy earthmoving equipment operators, transport equipment (dumper) operators and non-transport equipment (drill and shovel) operators, in coal mines are assessed comparatively for their vibration magnitude and possible health consequences. *Methods.* Whole-body vibration exposure measurements were recorded according to Standard No. ISO 2631-1. Measurements were carried out at the operator–seat interface with a tri-axial seat pad accelerometer using a vibration analyser, followed by a questionnaire survey. The binary logistic regression model was used to comparatively assess the two groups of operators. *Results*. The binary logistic regression analysis revealed that the risk of lower back pain is 4.06 times greater (95% confidence interval [1.36, 12.08]) in transport equipment operators compared to non-transport operators. The daily vibration dose value of the transport equipment operators was 2.92 times greater than their counterparts (95% confidence interval [0.94, 9.09]). However, non-transport equipment operators belonging to the high driving experience category presented a value 5.26 times higher than the transport equipment operators. *Conclusion.* Transport equipment operators are more vulnerable to vibration hazards than their counterparts, as is evident from the vibration magnitude as well as from the symptoms of lower back pain.

- **Keywords:** whole-body vibration, musculoskeletal disorders, transport equipment operators, non-transport equipment operators, coal mine

Muhammad Khan, Kashif Muhmood, Shumaila Noureen, Hafiz Zahid Mahmood & Rafi Amir-ud-Din. *Epidemiology of respiratory diseases and associated factors among female textile workers in Pakistan*. Pages: 184-198.

Objective. The study aimed to estimate the prevalence of byssinosis and other respiratory symptoms among women textile workers and the associated risk factors in 18

spinning mills of Faisalabad and Lahore districts of Punjab, Pakistan. *Method*. In this case–control study of 1054 female workers, we used the dose–response function to measure the association between dust level and respiratory disorders in cotton textile workers. *Results*. Working overtime and long working hours per week are significantly associated with self-reported symptoms of byssinosis. Women's age, marital status and wages were significantly associated with mitigating actions (seeing the doctor), while the education of the women was significantly associated with averting action (use of a mask). *Conclusion*. Regulating working hours and ensuring employees' compliance with the safety standards are expected to mitigate the health problems of female workers.

- **Keywords:** textile sector, female labor force, occupational health, sickness absence

Johanna Abendroth, Andrea Heiss, Thomas Jacobsen, Stefan Röttger & Jens Kowalski. *Job mobility and job performance: beliefs about social and occupational (dis)advantages as mediators*. Pages: 199-212.

Background. Modern working conditions require an increased amount of spatial mobility from employed personnel. Research suggests that different types of job mobility might exert negative effects on well-being and health, and additionally have different costs and benefits for the work and the social domains. *Methods*. Using data from 3191 members of the German Armed Forces, we investigated the effects of four different types of job mobility (long-distance commuters, overnighters, residential mobiles and multi-mobiles) in contrast to non-mobiles on employees' subjective job performance as an occupationally relevant outcome. Moreover, we expected beliefs about social and occupational advantages and disadvantages to mediate the effects of job mobility on subjective job performance. *Results*. A single concrete event during relocation had fewer negative consequences compared to the effects of circular mobility or multi-mobility. Moreover, beliefs about occupational and social advantages and disadvantages were differently associated with the different types of job mobility and partially mediated the direct effects of job mobility on job performance. *Conclusions*. Not all types of job mobility are an impairment and extra-organizational stress. Rather, the evaluation and perception of occupational and social (dis)advantages is crucial for the effects of different types of job mobility on organizational relevant outcomes.

- **Keywords:** job mobility, beliefs, job performance, mediation

Asraf Ahmad Qamruddin, Nik Rosmawati Nik Husain, Mohd Yusof Sidek, Muhd Hafiz Hanafi, Zaidi Mohd Ripin & Nizam Ali. *Musculoskeletal complications of hand–arm vibration syndrome among tyre shop workers in Kelantan, Malaysia*. Pages: 213-222.

Objectives. Exposure to hand–arm vibration (HAV) is associated with hand–arm vascular syndrome (HAVS), which is characterized by musculoskeletal complications. However, evidence on this matter has been inconclusive. Therefore, this study aimed to determine and compare the prevalence of musculoskeletal complications of HAVS between a high-exposure ($\geq 5\,m \cdot s^{-2}$) group and a low–moderate-exposure ($< 5\,m \cdot s^{-2}$) group and to explore the factors associated with the musculoskeletal complications of HAVS among tyre shop workers in Kelantan, Malaysia. *Methods*. A cross-sectional study involving 200 tyre shop workers was carried out. HAV was measured by a vibration meter. The workers were divided into two exposure groups – according to their 8-h time-weighted average, $A(8)$, of vibration exposure – and compared. *Results*. Almost half of the workers reported musculoskeletal complications of the upper limbs and neck. Only the lifetime vibration dose (LVD) was significantly associated with the development of musculoskeletal complications. *Conclusion*. The high-exposure group had a higher prevalence of musculoskeletal complications. Only the LVD was significantly associated

with complications. However, all factors of the work system, such as ergonomics, handgrip force and posture, might contribute to the development of musculoskeletal complications of HAVS and should be included in assessments.

- **Keywords:** hand–arm vibrationhand–arm vibration syndromemusculoskeletal diseasesoccupational health

Farideh Golbabaei, Ahad Heydari, Gholamreza Moradi, Habibollah Dehghan, Amirhossein Moradi & Peymaneh Habibi. *The effect of cooling vests on physiological and perceptual responses: a systematic review*. Pages: 223-255.

Humans in hot environments are exposed to health risks and thermal discomfort which seriously affect their physical, physiological and mental workload. This study aimed to assess the effects of using cooling vests (CVs) on physiological and perceptual responses in the workplace. Three main databases were searched using subject headings and appropriate Mesh terms. The article has been written according to the preferred reporting items for systematic reviews checklist. A total of 23,837 studies were identified for screening and 63 studies were eligible for data extraction. A statistically significant difference was observed in body temperature among hybrid cooling garments (HBCGs), phase-change materials (PCMs) and air-cooled garments (ACGs) at 31.56–37 °C (60% relative humidity), evaporative cooling garments at 25.8–28.1 °C and liquid cooling garments at 35 °C (49% relative humidity) compared to without CVs ($p < 0.001$). HBCGs (PCMs and ACGs) are effective means in hot, moderate, humid or dry environments.

- **Keywords:** systematic reviewcooling vestsphysiological responsesperceptual responses

Ghislaine Grand. *Safety net ageing: level of confidence in the degradation evaluation*. Pages: 256-268.

Safety net performance, only evaluated at the design stage, must last throughout the net's life: the net should effectively retain a person if he accidentally falls. Standard No. NF EN 1263-1:2015, which defines the safety requirements applicable to such nets, proposes calculating a coefficient to take into account the ageing deterioration and make it possible to determine the breaking energy for a new net, established from a natural or artificial ageing test. This study presents a comparative analysis between coefficients obtained for three types of nets aged naturally and those from samples of the same nets subjected to two cycles of artificial ageing. Standard No. NF EN ISO 4892-2:2013 therefore appears to be an interesting alternative to the currently proposed cycle. Otherwise, this study shows, for the same conditions of natural ageing, an underestimation of the effect of ageing when calculated from samples as opposed to from a whole net.

- **Keywords:** safety netfall from height, artificial ageing, natural ageing, mechanical test, deterioration coefficient, breaking energy

Bilge Basakci Calik, Nesrin Yagci, Mucahit Oztop & Derya Caglar. *Effects of risk factors related to computer use on musculoskeletal pain in office workers*. Pages: 269-274.

Purpose. Work-related musculoskeletal disorders (WMSDs) are increasing due to overuse of desktop computers. This investigation examined musculoskeletal pain in office workers. *Methods*. Sociodemographic factors were recorded for 362 participants (female, 50.8%; male, 49.2%; mean age 37.35 ± 8.43 years). Participants were questioned for their daily working time, computer usage time and years, whether musculoskeletal pain

was related to their job and whether pain disturbed their activities of daily living (ADLs). Working postures were observed and pain severity was evaluated by visual analog scale. *Results*. Participants more frequently had upper back pain (69.6%), neck pain (65.2%) and lower back pain (LBP) (64.1%) during the last 12 months; 60.5% of participants reported pain after they started work. LBP (32.9%), back pain (28.2%) and neck pain (22.9%) restricted participants' daily life. We found positive correlations between daily computer use and neck/upper back, and LBP. *Conclusions*. The most painful areas of participants using desktop computers were the upper back, neck, lower back and shoulder, and the pain in these regions affected ADLs negatively. This pain mostly occurred after the current job and these individuals experience more intense pain. Ergonomic approaches could reduce WMSDs and make workers more independent in ADLs and prevent chronicity.

- **Keywords:** musculoskeletal painoffice workercomputer use

Shazed Mohammad Tashrif, Wen Cong Lim, Yang Miang Goh, Xinping Hu & Soo Jin Adrian Koh. *Experimental validation of an energy balance approach for design of horizontal lifeline systems*. Pages: 275-288.

The energy balance approach is one of the design approaches approved in fall protection standards Z359.6, Z259.16 and SS 607 to ensure that horizontal lifeline systems (HLLSs) are adequately designed. However, this study found that theoretical calculations predicting the total fall distance (hTFD) and maximum arrest load (MAL) using an energy balance approach need to be corrected before they can be used safely. Based on the data from 48 drop tests, the authors determined that energy balance calculations differ significantly from the empirical hTFD and MAL values of HLLSs. As a result, further correction factors are introduced into the theoretical calculations to estimate hTFD and MAL conservatively. These correction factors are estimated from a regression equation derived based on experimental results and theoretical calculations.

- **Keywords:** horizontal lifeline, personal fall arrest system, fall from height, safety, accidents, drop test, personal protective equipment, work at height

Steven Burcat, Brian Yue, Alexander Slocum & Tal Cohen. *Investigation of abrasive saw kickback*. Pages: 289-304.

Saw kickback can cause fatal injuries, but only woodcutting saws have regulations and assessment methodologies for kickback. These regulations do not apply to abrasive cutting saws, as their cutting mechanism and dominant kickback mode differ from those of woodcutting saws. This work combines theoretical and experimental tools to investigate abrasive saw kickback. A theoretical model based on frictional engagement during a pinch-based kickback event is shown to predict resultant kickback energy in good agreement with experimental measurements. These measurements were obtained using a specialized machine that generates pinch-based kickback events and measures resultant kickback energy. Upon validating the model, two representative saws, a circular cutoff saw and a chainsaw, were tested using the prototype machine to evaluate their comparative kickback risk. This work demonstrates that pinch-based kickback is a potential safety risk for abrasive cutting saw operators and provides a testing machine design and analytical framework for evaluating this risk.

- **Keywords:** kickback, safety, saws

Jing Li, Zhen Wang, Yaru Qin, Ruikang Qi, Gui Fu, Baochang Li & Lei Yang. *Study on the influence of an underground low-light environment on human safety behavior*. Pages: 305-314.

Objective. This study aimed to research the impact that a coal mine lighting environment has on human safety behavior in an underground coal mine. *Methods.* We built a coal mine lighting simulation experiment system including both general lighting and local lighting divided into six different illumination gradients (0, 10, 30, 50, 75 and 100 lx) to test and analyze the effects of general illumination gradients on human fatigue, attention, reaction and eye–hand coordination with SPSS version 22.0. *Results*. Illuminance has a significant effect on human fatigue, attention, reaction ability and eye–hand coordination ability. Specifically, human fatigue is negatively correlated and the other indicators are positively correlated with the increase of illuminance. Notably, attention distribution ability seems to be most significantly influenced by illuminance according to this study, followed by human fatigue, reaction and eye–hand coordination ability. *Conclusion.* The results of the study indicate that illumination of the general lighting environment is expected to be controlled at a gradient of at least 50–75 lx or above in the coal mine environment where there is both general lighting and local lighting to reduce the incidence of accidents.

- **Keywords:** coal mine, lighting, safety behavior, t test

Pia Niessen, Christopher Stockinger & Ilka Zoeller. *Analyzing the effect of social interaction on job demands and health in the example of flexible shiftwork*. Pages: 315-323.

In the literature, shiftwork-related stress is often connected with health complaints. However, it has been shown that these are not equally distributed. Further reasons must exist as to why stress resulting from shiftwork only affects health in some cases. In a study with 653 employees working in highly flexible shiftwork conditions, an examination was made of the factors affecting the relationship between job demands and health status. The results show that satisfaction with leadership influences whether unevenly distributed work and time pressure have a significant impact on health. The factor of other people living in the household significantly influences whether time pressure and emotional stress lead to health complaints. The study concluded that the impact of social interaction as a resource is not limited to the workplace. Social interaction, as a personal resource, can be helpful in both the professional and private spheres.

- **Keywords:** shift, work, job demands, job resources, leadership, social interaction

Pascal Lamy & Nellie Perrin. *Approach to analyse hazardous situations tied to recurrent production dysfunctions, by observing the work situation*. Pages: 324-332.

When using a machine or automated system, dysfunctions such as jamming of a part can occur and disturb the normal production process. To solve this dysfunction, the operator may place himself in a hazardous situation. We propose an approach to identify these potentially hazardous situations by observing the work situation. The feasibility of this approach was tested on an oil pump assembly line. The approach comprises two phases: a detection phase of both the dysfunction and the response of the operator to solve it, followed by an analysis phase aimed at envisaging hazard scenarios and evaluating their associated risks. A cause and effect relationship between the dysfunction, the operator's response and the risks incurred has been established. The results of the risk analysis of the proposed approach complete the initial analysis of the risks of the workstation performed by the company to take into account the impacts of production dysfunctions.

- **Keywords:** machine, dysfunction, work situation, risk analysis

Gaudez Clarisse, François Cail & Wild Pascal. *Comparing learning during the familiarization phase with a slanted mouse and a vertical mouse when performing a repeated pointing–clicking task*. Pages: 333-342.

Purpose. Vertical and slanted mouse models have been developed to reduce forearm pronation. Discomfort, performance and stresses have been analyzed with these mice in previous studies but not learning during the familiarization phase. *Methods*. Eighteen females performed repeated pointing–clicking tasks with a standard mouse used as a reference followed by a slanted mouse and a vertical mouse in a randomized order. The duration of each task was measured. For each participant–mouse combination, changes in duration upon repeating the task were analyzed using a statistical model including a log-linear slope followed by a plateau. We consider that when the plateau is reached, the participant is familiar with the task. *Results*. For both the slanted mouse and the vertical mouse, the plateau is reached after about 30 repetitions of the task. The duration of the plateau was similar for these two mouse models. For the vertical mouse only, the slope increased significantly when used second versus when used first. *Conclusion*. Learning speed appeared slower with the vertical mouse than with the slanted mouse. In light of these findings and those of previous studies, decision-makers and employees should consider the slanted mouse rather than the vertical mouse.

- **Keywords:** computer mouse, vertical mouse, learning, duration, pointing–clicking task

Getnet Engeda Birhane, Li Yang, Jichao Geng & Junqi Zhu. *Causes of construction injuries: a review*. Pages: 343-353.

This article aims to identify the causes of construction injuries (CIs), summarize them into categories, provide input in a concise form for reference and recommend possible solutions. A total of 967 peer-reviewed papers were retrieved, and 42 papers were finally identified and analyzed in detail. Causes of CIs were categorized into four major factors– management commitment factors, behavioral factors, psychological factors and demographic factors – and each reviewed separately. The main finding of the study is that management commitment and behavioral factors are the main sources of CIs. The finding regarding experience and age is the contribution of this article. Thus, further joint research needs to be conducted using mixed methods to provide better and in-depth understanding of the association between the empirical findings and accident causation theories to design effective safety policies. Further, the public body responsible for safety implementation should design mass-media awareness advertisements to increase general public awareness.

- **Keywords:** work-related injuries, construction injury, causes of injury, human behavior

Jie Yang, Faming Wang, Guowen Song, Rui Li & Uday Raj. *Effects of clothing size and air ventilation rate on cooling performance of air ventilation clothing in a warm condition*. Pages: 354-363.

Effects of clothing size and air ventilation rate on the cooling performance of three air ventilation jackets (size small, medium and large) were investigated. Two ventilation rates were chosen: low ventilation (12 L/s) and high ventilation (20 L/s). A significant difference in the dry heat loss at the upper body excluding the head and hands (UBody) was noted among the three sizes ($p < 0.05$). The ventilation rate significantly increased the total UBody heat loss and thereby reduced UBody's apparent evaporative resistance ($p < 0.05$). Clothing size showed varied impact on the UBody heat loss and the impact varied with air ventilation rates. Air ventilation could greatly reduce predicted core temperatures, mean skin and UBody temperatures in both sizes small and large . In

contrast, clothing size had almost no impact on predicted thermophysiological responses in high ventilation. This work may be useful for designing and improving high-performance air ventilation clothing.

- **Keywords:** heat stress, personal cooling, clothing size, forced convection, thermal manikin, physiological responses

Marta Znajmiecka-Sikora & Monika Sałagacka. *Analysis of the relationship between psychological gender and risk perception style and attitudes towards safety in a group of women and men*. Pages: 364-375.

The aim of the research was to analyse the relationship between psychological gender and risk perception style and the manifestation of pro-safe attitudes. The study involved 507 people in the age range 20–64 years, including 257 women and 250 men. Variables were measured using the following methods: Znajmiecka-Sikora's questionnaire of attitudes towards safety (PwB), Zaleśkiewicz's questionnaire of the individual risk perception style (SIRI) and Lipińska-Grobelny and Gorczycka's scale of masculinity and femininity (SMiK). The obtained results prove that psychological gender significantly differentiates risk perception style and attitudes towards safety. The feminine dimension has been shown to strengthen safe attitudes and minimize risk-taking, while the masculine dimension weakens attitudes towards safety and strengthens risk propensity.

- **Keywords:** psychological gender, risk perception style, attitudes towards safety

Edda Maria Capodaglio. *Participatory ergonomics for the reduction of musculoskeletal exposure of maintenance workers*. Pages: 376-386.

Exposure to musculoskeletal disorders (MSDs) is a prevalent risk among those working in the maintenance of machinery and equipment for industry. Participatory ergonomics (PE) in the workplace embodies a solid strategy for the implementation of MSD prevention programs. This practical case describes a PE project implemented to improve MSD prevention strategies for the safety of maintenance workers. Experienced workers and maintenance workers employed in an Italian company for the industrial processing of wool have been actively involved in the risk assessment, in the proposal of improvement interventions and in the proposal of new preventive strategies. Ergonomic training and guidance helped the workers to have a proactive role in the prevention process. PE can help in the preventive management of critical activities of maintenance, through the empowerment of workers, the identification of targeted and feasible solutions and by using ergonomics as a basis for improving health and safety at work.

- **Keywords:** maintenance work, participatory ergonomics,musculoskeletal disorders, risk assessment, preventive measures

Mohsen Sadeghi Yarandi, Mohammad Ghasemi & Ali Ghanjal. *The relationship between individual, physical and psychosocial risk factors with musculoskeletal disorders and related disabilities in flight security personnel*. Pages: 387-397.

Purpose. The purpose of this study was to investigate the relationship between individual, physical and psychosocial risk factors with musculoskeletal disorders and related disability in flight security personnel. *Methods*. The study was conducted among 316 employees in Iran flight security. To study the prevalence of musculoskeletal disorders, lifestyle, occupational stress, mental workload and disability, the Cornell questionnaire, Walker lifestyle questionnaire, job content questionnaire, NASA task load index and pain disability questionnaire were used, respectively. Data were analyzed using independent-sample *t* test, one-way analysis of variance, χ^2 test and multiple logistic

regression. *Results*. A total 68.35% of participants had musculoskeletal disorders in at least one of their body parts. There was a significant relationship between the parameters of increased age, higher work experience, high body mass index, gender and educational level and the prevalence of musculoskeletal disorders. Also, some components related to healthy lifestyle, occupational stress and mental workload had significant association with mentioned disorders ($p < 0.05$). *Conclusion*. The parameters of lifestyle, occupational stress and mental workload are among the most important risk factors for the prevalence of work-related musculoskeletal disorders and related disabilities in flight security personnel. Therefore, corrective measures through controlling individual, physical and psychosocial risk factors are necessary.

- **Keywords:** musculoskeletal disorders, occupational stress, mental workload, lifestyle, flight security personnel

Gonzalo Bravo, Carlos Viviani, Martin Lavallière, Pedro Arezes, Marta Martínez, Iman Dianat, Sara Bragança & Héctor Castellucci. *Do older workers suffer more workplace injuries? A systematic review*. Pages: 398-427.

Aging populations are a dramatically increased worldwide trend, both in developed and developing countries. This study examines the prevalence of fatal and non-fatal work-related injuries between young (<45 years old) and older (≥45 years old) workers. A systematic literature review aimed at examining studies comparing safety outcomes, namely fatal and non-fatal injuries, between older and younger workers. Results show that 50% of the reviewed papers suggest that fatal injuries are suffered mainly by older workers, while the remaining 50% show no differences between older and younger workers. Regarding non-fatal injuries, 49% of the reviewed papers found no relationship between workers' age; 31% found increased age as a protective factor against non-fatal injuries; and 19% showed that older workers had a higher risk of non-fatal injuries than younger ones. This review suggests that older workers experience higher rates of fatal injuries, and younger workers experience higher rates of non-fatal injuries.

- **Keywords:** elderly, prevention, work, aging, safety

Rasoul Ahmadpour-geshlagi, Neda Gillani, Saber Azami–Aghdash, Mostafa Javanmardi, Seyed Shamseddin Alizadeh & Saeid Jalilpour. *Investigating the status of accident precursor management in East Azarbaijan Province Gas Company*. Pages: 428-439.¨

Purpose. The accident precursor reporting system is a key point in preventing accidents and proper functioning of this system is critical. In the present study, the accident precursor reporting system in the Iranian East Azarbaijan Province Gas Company was investigated. *Methods.* This quantitative–qualitative study used field survey and document review methods to determine how the company was reporting. Qualitative content analysis approaches were used to analyze the reporting system over a 3-year period. From 1209 accident precursor reports, 2271 codes were extracted. Finally, these codes were reduced to three clusters: 996 (43.86%), 447 (19.68%) and 828 (36.46%) codes related to near misses, unsafe conditions and unsafe acts, respectively. A χ^2 test was used to investigate the reporting process. *Results.* Reporting rates varied by time (e.g., people reported more accident precursors in the first 6 solar months), by area (some areas had higher reporting rates than others) and by type of job (operational jobs had the highest reporting rate [73.16%] compared to non-operational jobs [26.84%]). *Conclusion.* It was suggested that policy-makers should improve the accident precursor reporting system. Changes to the current reporting system are essential to help in the prevention of future unpleasant accidents.

- **Keywords:** accident precursor, near miss, unsafe actun, safe condition, reporting

Fakhradin Ghasemi, Hamed Aghaei, Taleb Askaripoor & Farhad Ghamari. *Analysis of occupational accidents among nurses working in hospitals based on safety climate and safety performance: a Bayesian network analysis*. Pages: 440-446.

Purpose. This study aimed to analyze causal relationships among safety climate dimensions, safety performance dimensions and occupational accidents for nurses working in hospitals. *Methods.* Data were gathered from questionnaires filled in by nurses from three public hospitals. To analyze interactions among variables, a Bayesian network (BN) analysis was conducted. Using the function of BN 'belief updating', variables with the highest influences on occupational accidents were determined. *Results*. A total of 211 nurses participated in this study. They were mainly female and married. The results showed that 39.3% of nurses experienced occupational accidents during the last 12 months before the study. Less than half of the nurses had an acceptable safety performance. Safety participation had the highest influence on occupational accidents, followed by safety compliance. Reporting of errors had the highest score among the safety climate dimensions. Training of nurses was necessary for improving both safety compliance and safety participation, and thereby reducing occupational accidents. *Conclusion.* The effect of safety participation on occupational accidents among nurses was higher than that of safety compliance. Among the safety climate dimensions, supervisors' attitude to safety and safety training had the highest effects on both nurses' safety performance and occupational accidents.

- **Keywords:** Bayesian networks, hospital nurses, safety behavior

Olivier Doutres, Franck Sgard, Jonathan Terroir, Nellie Perrin, Caroline Jolly, Chantal Gauvin & Alessia Negrini. *A critical review of the literature on comfort of hearing protection devices: analysis of the comfort measurement variability*. Pages: 447-458.

Objective. This article proposes a comprehensive literature review of past works addressing hearing protection device (HPD) comfort with the aim of identifying the main sources of variability in comfort evaluation. *Methods*. A literature review of study samples was performed: documents were hand searched and Internet searched using PubMed, Web of Science, Google Scholar, ProQuest Dissertations and Theses Professional, Scopus or Google search engines. While comfort constructs and measurement methods are reviewed for both earplugs and earmuff HPD types, results and analyses are provided for earplugs only. *Results*. The literature shows that the multiple sources of the perceived comfort measurement variability are related to the complexity of the concept of comfort and to the various physical and psychosocial characteristics of the triad 'environment/person/earplug', which differ from one study to the other. *Conclusions*. Considering the current state of knowledge and in order to decrease comfort measurements variability, it is advised to: (a) use a multidimensional construct of comfort and derive a comfort index for each comfort dimension;, (b) use exhaustive and valid questionnaires; (c) quantify as many triad characteristics as possible and use them as independent or control variables; (d) assess the quality of the earplug fitting and the attenuation efficiency.

- **Keywords:** earplug, hearing protection device, comfort, measurement variability, literature review

Filippo Marciano, Pier Paolo Mattogno, Anna Codenotti, Paola Cocca, Marco Maria Fontanella & Francesco Doglietto. *Work-related musculoskeletal disorders among endoscopic transsphenoidal surgeons:*

***a systematic review of prevalence and ergonomic interventions*. Pages: 459-468.**

Endoscopic transsphenoidal surgery is a surgical technique introduced in the last 20 years for the treatment of skull base pathologies and, in particular, pituitary tumours. Although the prevalence of work-related musculoskeletal disorders is usually significantly higher in endoscopists and minimally invasive surgeons compared to other surgical and medical specialties, reviews on the prevalence of disorders among neurosurgeons dedicated to endoscopic transsphenoidal surgery are not available. This article performs a systematic review to identify the work-related musculoskeletal disorders among transsphenoidal neurosurgeons, their prevalence and the ergonomic interventions proposed to reduce risk factors and prevent disorders. The results show that the ergonomics of transsphenoidal neurosurgeons is an under-investigated topic. Indeed, specific prevalence data are not available. In addition, only a few papers suggest interventions and guidelines, but without objective assessment of the outcomes to confirm the ergonomic benefit. Based on these gaps in the literature, a future research agenda is proposed.

- **Keywords:** work-related musculoskeletal disorders, endoscopic skull base surgery, neurosurgery, minimally invasive surgery, endoscopic pituitary surgery

Jinwoo Lee, Ian Phillips & Zena Lynch. *Causes and prevention of mobile crane-related accidents in South Korea*. Pages: 469-478.

Mobile cranes account for a considerable proportion of crane-related accidents in South Korea. The authors used descriptive and non-parametric statistics to analyse 245 fatal accidents in South Korea from 2007 to 2016. The results showed that human error and crane problems were the main cause of accidents; riggers accounted for the largest number of deaths. To reduce the number of mobile crane fatalities, the authors made recommendations in four areas: educational aspects, mobile crane aspects, technical aspects and other issues. Firstly, business owners need to establish a systematic education system suitable for workers in mobile crane operations. Secondly, efforts should be made to tighten the quality of safety inspections of cranes and supervision of workplaces. Thirdly, efforts should be made to develop more human error-free equipment. Lastly, it is necessary to develop a systematic accident reporting system containing more detailed information to allow a fuller understanding of accident causation.

- **Keywords:** mobile crane, accident, fatality, safety, causal factor

Yong Chen. *The development and validation of a human factors analysis and classification system for the construction industry*. Pages: 479-493.

Human factors significantly contribute to accidents and vary with the industries in which they exist. However, there are few analytical methods for human factors in the construction industry. Based on the prevalent human factor analysis and classification system (HFACS), the present study proposes a HFACS for the construction industry (HFACS-CI). Compared with the HFACS, the HFACS-CI develops Level 5 with classifications including 'the attitude of owner' and 'the regulation of engineering firm', and adds classifications, i.e., 'management for change' and 'management for subcontractors', to Level 4. Its validation is verified by application to the 2016 platform collapse in Fengcheng, Jiangxi, China. Finally, utilizing the $\chi 2$ test and Apriori algorithm to explore the causalities among the classifications of the HFACS-CI, 'the attitude of owner', 'the regulation of engineering firm' and 'organizational climate' are identified as the human factors that may create conditions for the occurrence of other human factors.

- **Keywords:** human factors, construction industry, causalities

Yu-Chun Tseng & Hong-Te Hsu. *Investigating the influence of experiential training on the ability to anticipate risks of caught-in accidents*. Pages: 494-500.

Caught-in accidents are the most common type of occupational accidents in Taiwan's manufacturing industry. Although the law stipulates that, as a control measure, specific machinery and equipment must comply with safety standards before leaving the factory, caught-in accidents are still reported. Therefore, education and training are important. We referred to Kirkpatrick's four-level model for analysis and chose a film manufacturer as the study subject. Workers were divided into three groups to evaluate the effectiveness of different training methods: (a) without safety/health education and training (control group); (b) with traditional lecture teaching; (c) with practical experiential training. Although statistically significant overall, only the group with practical experiential training showed statistically significant differences in graph selection and occupational accident videos compared to the group without safety/health education and training. Therefore, we suggest using traditional indoor lectures and practical experiential training for risk anticipation in enterprises to improve their performance.

- **Keywords:** caught-in accidents, experiential training, ability to anticipate risks

Mehdi Jahangiri, Hadi Kolahi & Fatemeh Dehghani. *Training through fit test and its role in knowledge, attitude and performance of workers regarding respiratory protective equipment: a case study in a petrochemical company*. Pages: 501-506.

Background. Providing workers with respiratory protective equipment (RPE) is not enough to protect them. RPE should be selected correctly, worn properly and fitted adequately. The aim of the present study was to assess the effect of training through fit test (TTFT) on knowledge, attitude and performance (KAP) of workers regarding a respiratory protection program. *Methods*. This cross-sectional study was conducted on 110 respirator users in a petrochemical wastewater treatment plant. A structured questionnaire was developed to assess the KAP of workers before any intervention. After that, all participants were trained with a 15-min video-based training intervention and then the qualitative fit test was performed. Participants who failed in the fit test were retrained and the test was repeated. To assess the effect of TTFT, the KAP questionnaire was completed after 3 months. SPSS version 22.0 was used to analyze data. *Results.* There was a significant difference between knowledge, attitude and some of the unsafe behavior before and after TTFT. There was no person with a poor or very poor knowledge status after TTFT. *Conclusion.* TTFT could improve some unsafe behaviors associated with the user seal check. Moreover, TTFT could be considered an opportunity to improve workers' KAP regarding RPE.

- **Keywords:** knowledge, attitude, performance, training, fit test, respiratory protection program

Johannes C. Ayena & Martin J.-D. Otis. *Dimensional reduction of balance parameters in risk of falling evaluation using a minimal number of force-sensitive resistors*. Pages: 507-518.

Purpose. As the instrumented insole is available for a wide commercial range in the retail trade, this study aims to reduce its overall cost using fewer sensors by carrying out an effective risk of falling evaluation. *Methods.* We compared the effect of reducing balance parameters using four and three force-sensing resistors (FSRs) of an instrumented insole. Data were previously collected among elderly participants during a Timed Up and Go (TUG) test. *Results.* While reducing the number of balance parameters, during sit-to-

stand and stand-to-sit activities, the risk scores using four FSRs were not significantly different compared with three FSRs. Parameter reduction did not show any significant loss of information among the study population using four FSRs. For certain configurations of three FSRs, a significant effect of information loss was found in the study participants, revealing the importance of investigating the sensor locations in the process. *Conclusions.* We conclude that it is feasible to estimate a risk index during a TUG test not only after reducing the number of needed sensing units from four to three FSRs but also after reducing the number of balance parameters. The three FSRs should be located at strategic positions to avoid a significant loss of information.

- **Keywords:** falls, Timed Up and Go test, elderly

Sanpatchaya Sirisawasd, Sasitorn Taptagaporn, Chaweewon Boonshuyar & Poramet Earde. *Comparison of musculoskeletal load using two devices for manual height adjustment of the hospital bed*. Pages: 519-527.

Objectives. Patient manual handling in bed causes lower back pain (LBP) among Thai nurses. This study aims to develop an extension device for manual height adjustment of the hospital bed, and to evaluate its efficiency in preventing LBP among Thai nurses. *Methods.* Eleven participants were enrolled for electromyography measurement in eight right muscles. Subsequently, 56 volunteer nurses were recruited by convenience sampling for observational risk assessment by rapid entire body assessment (REBA) and satisfaction evaluation. The characteristics of the participants, percentage of maximum voluntary contraction (%MVC) of each muscle, REBA scores and satisfaction in using the device were analyzed by descriptive statistics, multivariate analysis of variance, paired *t* test and Wilcoxon signed-rank test, respectively. *Results.* %MVC values of the six muscles, i.e., biceps brachii, deltoideus, trapezius, latissimus dorsi, erector spinae and hamstring, were found to have a 4–18% decrease. The REBA scores decreased for both left and right when using the extension device, and all participants were more satisfied with the extension device than the hand crank of the hospital bed. *Conclusions.* The use of the extension device for manual height adjustment of the hospital bed developed from this study helps to prevent LBP among healthcare workers across settings.

- **Keywords:** ergonomics, hospital bed, extension device, lower back pain, Thai nurses

Rejoice Selorm Wireko-Gyebi, Rudith Sylvana King, Imoro Braimah & Anne Mette Lykke. *Local knowledge of risks associated with artisanal small-scale mining in Ghana*. Pages: 528-535.

Artisanal small-scale mining is associated with disease, injury, environmental and social risks. These risks negatively impact human health and the environment. This study assesses miners' awareness and perceptions of the risks associated with their activity in three main districts in Ghana. Using the convenience sampling approach, 148 miners participated in the study in addition to key informant interviews and focus group discussions. The study revealed that the miners were generally not aware of the risks associated with their work. There were no statistically significant differences between the miners' socio-economic characteristics and disease, environmental and social risks. However, the study showed significant differences between the miners' level of education and awareness of injury risk. A common perception among 41% of the miners was that death in artisanal small-scale mining was normal. It is recommended that relevant state institutions empower miners through training and education to enhance their knowledge of risks.

- **Keywords:** risk, artisanal small-scale mining, awareness, perception

Whitney Brown, Evangelos Pappas, Bridget Foley, Joshua R. Zadro, Kate Edwards, Martin Mackey, Debra Shirley, Alexander Voukelatos & Emmanuel Stamatakis. *Do different sit–stand workstations influence lumbar kinematics, lumbar muscle activity and musculoskeletal pain in office workers? A secondary analysis of a randomized controlled trial*. Pages: 536-543.

Purpose. This study investigated the effect of different sit–stand workstations on lumbar spine kinematics, lumbar muscle activity and musculoskeletal pain. *Methods.* Thirty-two office workers were randomized to one of three sit–stand workstations (Group 1, ratio of minutes spent sitting to standing each hour at work 40:20, $n = 8$; Group 2, 30:30, $n = 6$; Group 3, 20:40, $n = 7$) and a control group (usual sitting, $n = 11$). Intervention groups (Groups 1, 2 and 3) were collapsed into one group for analysis ($n = 21$). Data on lumbar kinematics and muscle activity were only collected for 25 participants due to equipment availability. *Results.* Participants in the intervention group had lower overall lumbar spine flexion angles during the workday compared to the control group (mean difference 10.6°; 95% confidence interval [−18.1, −3.2]; $p = 0.008$; Cohen's $d = 1.5$). There were no between-group differences for the remaining kinematic measures (i.e., mean flexion angle in standing and sitting, mean side flexion angle in standing and sitting, and percentage of time in upright sitting), muscle activity or presence of musculoskeletal pain. *Conclusions.* Sit–stand workstations reduced overall lumbar spine flexion angles over the course of a workday but had no effect on other kinematic measures, lumbar spine muscle activity or musculoskeletal pain.

- **Keywords:** sit–stand, electromyography, lumbar spine, kinematics, musculoskeletal pain, ergonomics

Matin Rostami, Mohsen Razeghi, Hadi Daneshmandi, Jafar Hassanzadeh & Alireza Choobineh. *Cognitive and skill performance of individuals at sitting versus standing workstations: a quasi-experimental study*. Pages: 544-554.

Objectives. This study aimed to assess cognitive and skill performance at sitting and standing workstations among students from Shiraz University of Medical Sciences. *Methods.* Forty students (20 females and 20 males) participated in this quasi-experimental study. Tests were performed among randomly selected participants over two consecutive days: day 1, the Beck depression inventory and Beck anxiety inventory were used to assess the severity of depression and anxiety in the study participants, respectively, and Raven's general intelligence test was used to measure intelligence quotient; day 2, five performance assessment tests (cognitive performance assessment tests '*n*-back', 'Stroop' and 'advanced reaction time'; skill performance assessment tests 'two-arm coordination' and 'Purdue pegboard') were randomly selected and presented to individuals at each workstation (sitting and standing workstations). At the end of each sitting and standing position, the comfort of the workstation was measured using a visual analog scale. *Results.* No statistically significant difference was shown between sitting and standing positions in terms of '*n*-back', 'Stroop', 'advanced reaction time', 'two-arm coordination' and 'Purdue pegboard'. Participants were more comfortable in sitting positions and more easily distracted in standing positions. *Conclusions.* Sitting and standing positions had no significant effects on participants' cognitive and skill performance.

- **Keywords:** cognitive performance, sedentary behavior, sitting, standing, skill performance

Vahid Gharibi, Mohammad Hossein Ebrahimi, Esmaeel Soleimani, Narges Khanjani, Anahita Fakherpour & Majid Bagheri Hosseinabadi. *The role of*

***oxidative stress in pulmonary function in bakers exposed to flour dust*. Pages: 555-561.**

Objective. This study aimed to determine the effect of exposure to flour dust on pulmonary function and the role of oxidative stress. *Methods.* This case–control study was conducted on 163 bakery workers (exposed group) and 177 administrative workers (unexposed group). Pulmonary function and flour dust exposure were measured by spirometry and NIOSH 0500 and 0600 methods. Oxidative stress indices including malondialdehyde (MDA), nitric oxide (NO) and total antioxidant capacity (TAC) were measured in serum samples. *Results.* The mean respirable and total dust exposure of bakery workers were 2.5 ± 1.72 and 6.53 ± 3.26 mg/m^3. The forced vital capacity (FVC) and forced expiratory volume in the first 1 s (FEV1) were significantly lower in the exposed group than in the unexposed group. The levels of MDA and NO were higher in smokers than in non-smokers in the exposed group. The most important variables that predicted FVC and FEV1 were MDA, NO and TAC. With increased exposure to respirable dust, the levels of MDA ($\beta = 3.39$, $p < 0.001$) and NO ($\beta = 16.48$, $p < 0.001$) increased and total antioxidant levels decreased ($\beta = -0.37$, $p < 0.001$). *Conclusions.* Exposure to flour dust may impair pulmonary function by increasing oxidative stress and weakening antioxidant defense.

- **Keywords:** bakers, lung function, oxidative stress, respirable dust

Shengke Zeng. *Security cameras in taxicabs with three rows of seating*. Pages: 562-571.

Taxicab security cameras are widely used to deter crimes against taxicab drivers in two-row-seating taxicabs. Some of these cameras have difficulty for use in three-row-seating taxicabs due to increased distance between the camera and the third-row seats. This project tested five sample taxicab security cameras with different image-sensor pixel counts to determine their utility for three-row-seating taxicabs. The cameras videotaped a normalized camera resolution test chart mounted in the third-row seat of a simulated three-row-seating taxicab in both daylight and dark (with infrared radiation) conditions. The resolution of each camera was measured and compared with the resolution threshold for customer facial identification. A dome-mounted camera with a standard-definition image-sensor is suggested as an effective camera in sustaining high camera resolution with small data file size for facial identification in the third-row seats. The image-sensors with at least 1280×720 pixels are suggested for windshield-mounted cameras in three-row-seating taxicabs for facial identification.

- **Keywords:** taxicab-driver homicide, taxicab security cameras, three-row-seating taxi, cabs, camera resolution, facial identification, computer facial recognition

Stanley M. Maduagwu, Nasir M. Galadima, Chuka I. Umeonwuka, Cornelius M. Ishaku, Olutunde O. Akanbi, Olabode A. Jaiyeola & Chiamaka Ann Nwanne. *Work-related musculoskeletal disorders among occupational drivers in Mubi, Nigeria*. Pages: 572-580.

Background. Studies on work-related musculoskeletal disorders (WMSDs) among drivers in northern Nigeria are modest. *Objectives*. This survey determined the prevalence of risk factors, onset of WMSDs and experience of ergonomic training, coping strategies and treatment options adopted by drivers. *Methods*. This cross-sectional survey utilized an adapted version of the standardized Nordic musculoskeletal questionnaire for examining WMSDs among drivers. Descriptive and χ^2 statistics were employed to summarize and analyze data, respectively; the significance level was set at $p < 0.05$. *Results*. The prevalence of WMSDs among the respondents was 21.2%. The annual prevalence of the various WMSD domains was lower back pain (34%), neck pain (18.9%), upper back pain

(22.3%), shoulder pain (18.2%), knee pain (14.9%), ankle pain (17%), wrist pain (7.5%), elbow pain (7.5%) and hip/thigh pain (15.1%). χ^2 analysis showed that age ($p = 0.006$), marital status ($p = 0.027$) and educational level ($p = 0.018$) were significantly associated with prevalence of WMSDs. The majority of the drivers (92.5%) had no ergonomic training while 77.4% did not seek treatment. *Conclusions*. Adequate sensitization on health-seeking behavior and coping strategies through seminars and workshops should be conducted to improve health-seeking behavior and coping strategies of occupational drivers.

- **Keywords:** work-related musculoskeletal disorders, occupational drivers, Nordic musculoskeletal questionnaire, annual prevalence

Paola Ochoa Pacheco, Miguel Pina e Cunha & António Cunha Meneses Abrantes. *The impact of empowerment and technology on safety behavior: evidence from mining companies*. Pages: 581-589.

Major technological advances that are being introduced in the global mining industry have an impact on work and employee attitudes toward safety. The objective of this study was to analyze the impact of empowerment and technology on safety behavior. The research design was cross-sectional, and the sample was composed of 403 employees in mining companies. To measure safety behavior we used Neal, Griffin and Hart scales, and psychological empowerment was measured using the Spreitzer scale. The results indicated high levels of empowerment on safety behavior and medium levels of technology's promotion and prevention factors in the employees surveyed. Also, the study revealed that the meaning dimension of empowerment and the promotion technology factor positively affect safety behavior. A further contribution of the study is in the design of a scale to measure the impact of technology on safety behavior, as there are no known scales for this.

- **Keywords:** empowerment, technology, safety, mining, scale

María del Carmen Rey-Merchán, Jesús M. Gómez-de-Gabriel, Juan-Antonio Fernández-Madrigal & Antonio López-Arquillos. *Improving the prevention of fall from height on construction sites through the combination of technologies*. Pages: 590-599.

Fall from height is a cause of concern in the construction sector. Appropriate use of a harness can be the difference between an incident or a critical accident. Monitoring the proper use of a harness in the workplace using Bluetooth Low Energy (BLE) devices is a recent and effective approach. The aim of this article is to identify typical limitations in a BLE monitoring system in order to propose solutions according to the existing literature. Alternative solutions found in the literature showed that the integration of BLE with other technologies such as building information modeling, radio-frequency identification or the global positioning system can improve the effectiveness of current monitoring approaches based only on BLE and reduce rates of fall from height accidents. For correct integration, both technological factors (cost, compatibility, data transmission) and cultural factors (social acceptance, procedures, etc.) must be taken into account.

- **Keywords:** construction safety, fall from height, harness, beacon, safety at work

Rashid Heidarimoghadam, Iraj Mohammadfam, Mohammad Babamiri, Ali Reza Soltanian, Hassan Khotanlou & Mohammad Sadegh Sohrabi. *What do the different ergonomic interventions accomplish in the workplace? A systematic review*. Pages: 600-624.

Introduction. Improving well-being and overall system performance are the ultimate goals of ergonomics, which are achieved through ergonomic interventions. This systematic review aimed to answer the question of what different ergonomic interventions accomplish in the workplace. *Method*. The systematic review followed PRISMA guidelines. Ergonomic interventions in workplaces focusing on any ergonomics health outcomes or productivity were identified in electronic databases up to June 1, 2019. *Results*. The 1635 articles collected from the literature screening stage were screened for their relevance to this study by the authors independently. The full-text review identified 22 papers qualified for inclusion in this systematic review. Most of the interventions implemented in the analyzed articles were ergonomic training programs, participatory ergonomics and workstation designs. The highlight results showed that interventions such as feedback, participatory ergonomics in short-term follow-ups and job rotation along with ergonomic guidelines did not significantly affect the risk of psychosocial factors. A significant reduction of musculoskeletal disorders in the upper limbs was reported with workplace improvements. *Conclusion.* There was no specific study method or intervention approach found to influence ergonomic outcomes. A multicomponent intervention program can be used to improve the impact of interventions on employees' health and system productivity.

- **Keywords:** organizational, ergonomic, intervention, systematic review

Tuğba Eskişar & Özge Akboğa Kale. *Evaluation of pile driving accidents in geotechnical engineering*. Pages: 625-634.

Pile driving accidents that occurred between 1984 and 2018 were selected from the Occupational Safety and Health Administration database, producing 84 cases. To evaluate the causes of accidents, pile driving stages were presented and the potential hazards were discussed. Two models were necessary to link the accidents with workers' behavior. An accident type model and a workers' behavior model were developed. The accident type model was related to physical factors leading to accidents, and the workers' behavior model determined the occupational behavior under the act of the incident. Among fatal accidents, unsafe site conditions had the highest frequency at 26.9%. Among non-fatal accidents, both poor attitudes toward safety and unsafe methods had the highest frequency at 28.1%. Furthermore, a map presenting work-specific accident frequencies in pile driving operations was created. Consequently, project-specific countermeasures should be taken regarding the root causes of accidents, leading to vigorous strategies to develop safety measures.

- **Keywords:** construction industry, work accidents, pile driving, geotechnical site works, mapping

Aylin Adem & Metin Dağdeviren. *Ranking the health precautions for the 'new normal' after the COVID-19 outbreak in production environments*. Pages: 635-643.

Objectives. With the outbreak of coronavirus (COVID-19) about a year ago and its quick spread all around the world, some serious decisions had to be made like halting production temporarily. The world now tries to take back its normal pace thanks to some medical improvements. However, the 'new normal' is unlikely to follow the old habits in which COVID-19 never appeared. In production environments, a number of new precautions should be defined to prevent a spread of COVID-19 disease among employees in the new normal period. The aim of this study is to propose an analytical approach to define these new precautions and prioritize them. *Methods*. To determine the precautions, open archive publications of the Turkish Health Ministry and the World Health Organization, and the opinions of occupational physicians and academicians were considered. Twenty-five precautions were specified under three main headings. The Pythagorean fuzzy analytical hierarchy process was employed to gain the rank of

precautions. *Results*. The most critical precautions and sub-precautions were determined as organizational precautions and developing an appropriate working model to ensure social distance. *Conclusion*. Using the determined order of measures, the managers are able to apply them, starting from the most effective ones.

- **Keywords:** COVID-19, occupational health and safety, new normal, decision-making, manufacturing environments

Fazel Rajabi, Hamidreza Mokarami, Rosanna Cousins & Mehdi Jahangiri. *Structural equation modeling of safety performance based on personality traits, job and organizational-related factors*. Pages: 644-658.

Purpose. This study investigated the relationship between three selected personality traits and contextual factors with safety performance. *Methods.* This cross-sectional study was carried out among the operational staff of a gas refinery ($n = 487$) in Iran. Structural equation modeling was used to model the factors affecting safety performance based on personality traits and job and organizational-related factors including consideration of future safety consequence, safety locus of control and impulsiveness, safety climate, job insecurity and role overload, and mediator roles of safety knowledge and safety motivation. *Results.* Structural equation modeling results indicated that consideration of future safety consequence was directly correlated with safety performance. Impulsiveness and safety locus of control were indirectly associated with safety performance through the mediator role of safety knowledge and motivation. Furthermore, job insecurity and role overload were partially and directly correlated with safety performance. Moreover, safety climate had a significant relationship with safety performance. *Conclusion.* Consideration of future safety consequence is a valid personality trait for predicting safety performance. It can therefore be used as an indicator in the employee selection process. Moreover, improving employee safety performance necessitates increased safety knowledge and motivation as well as improved occupational characteristics and safety climate.

- **Keywords:** safety performance, personality traits, occupational characteristics, gas refinery

Jianhao Wang, Gui Fu & Mingwei Yan. Analysis of a catastrophic commercial coach crash based on an improved accident causation model: cause classification and lessons learned. Pages: 659-671.

Introduction. This study aimed to perform an in-depth analysis of a catastrophic coach crash that occurred on the Chinese expressway, and thus draw useful lessons to avoid similar mistakes. *Methods.* Various causes were identified from the investigation report based on a proposed accident causation model, which provides a universal pathway for accident analysis from the individual level to the organizational level. *Results.* Driver error in an emergency affected by fatigue and speeding led directly to the crash. Accordingly, drivers in coaches should be monitored effectively and their unsafe acts must be corrected in a timely manner to avoid the formation of unsafe habits. Based on individual flaws, weaknesses in the construction of the organizational safety management system and safety culture were further deduced and discussed. *Conclusion.* The work and rest system, as well as the dynamic monitoring system for drivers, should be perfected strictly according to the regulations. Additionally, external factors regarding deficiencies in the design and management of the expressway and the supervision of the transportation company also had great impact on this crash. In summary, more efforts should be taken regarding root causes at the organizational level, regardless of internal or external factors.

- **Keywords:** transportation safety, accident analysis, accident causation model, unsafe actroot cause

Karina Andrea Ramírez-Sepúlveda, Martha Yojana Gómez-Arias, Andrés A. Agudelo-Suárez & Diana Milena Ramírez-Ossa. *Musculoskeletal disorders and related factors in the Colombian orthodontists' practice*. Pages: 672-681.

Objective. This study aimed to characterize the symptoms of musculoskeletal disorders (MSDs) and their related factors in a group of orthodontists in the city of Medellín (Colombia). *Methods.* A cross-sectional study was conducted in a sample of 100 orthodontists. A survey provided sociodemographic and work-related information. MSDs were recorded through the Nordic questionnaire. Descriptive and bivariate analyses were carried out by determining the prevalence of MSD symptoms by anatomical zone and selected variables. *Results.* Prevalence of MSDs was 81% for males and 88% for females. Anatomical regions were the neck (males 44%, females 59%), shoulders (males 44%, females 48%), lower back–lumbar zone (males 63%, females 51%), elbow–forearm (males 15%, females 15%) and wrist–hand (males 32%, females 51%). The frequency of symptoms was higher in males >41 years old, with more than a work contract or females who worked >40 h per week, and in orthodontists (males–females) who reported higher work-related dissatisfaction levels. *Conclusions*. A high prevalence of MSDs was found among orthodontists, with differences in the frequency of symptoms related to sociodemographic and work-related factors. Preventive strategies related to health and work safety would be advisable considering the particular needs of this dentist group.

- **Keywords:** musculoskeletal disorders, orthodontist, symptoms, sociodemographic factors, work-related factors