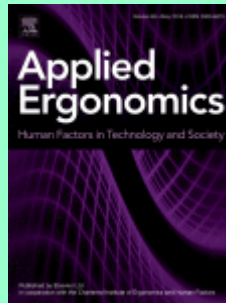


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Yaar Harari, Avital Bechar, Raziel Riemer. *Workers' biomechanical loads and kinematics during multiple-task manual material handling.* 102985.

This study investigated the biomechanical loads and kinematics of workers during multiple-task manual material handling (MMH) jobs, and developed prediction models for the moments acting on a worker's body and their peak joint angles. An experiment was conducted in which 20 subjects performed a total of 3780 repetitions of a box-conveying task. This task included continuous sequential removing, carrying and depositing of boxes weighing 2–12kg. The subjects' motion was captured using motion-capture technology. The origin/destination height was the most influencing predictor of the spinal and shoulder moments and the peak trunk, shoulder and knee angles. The relationship between the origin/destination heights and the above parameters was nonlinear. The mass of the box, and the subject's height and mass, also influenced the spinal and shoulder moments. A tradeoff between the moments acting on the L5/S1 vertebrae and on the shoulder joint was found. Compared to the models developed in similar studies that focused on manual material handling (albeit under different conditions), the high-order prediction equation for peak spinal moment formulated in the present study was found to explain between 10% and 48% more variability in the moments. This suggests that using a high-order equation in future studies might improve the prediction.

- **Keywords:** Manual material handling; Spinal moments; Shoulder moments; Joint angle

Martin Krampell, Ignacio Solís-Marcos, Magnus Hjälm Dahl. *Driving automation state-of-mind: Using training to instigate rapid mental model development.* 102986.

The automotive industry is chugging along towards full autonomy, with a yet unknown time of arrival. The next call, however, is partial driving automation. At this interim station lurks many dangers, there-among them issues surrounding the partial performance of the driving task. Despite their potential for increased safety, these systems come with many inherent limitations and caveats, and their safe use depend on drivers correctly understanding their new role. Training is proposed as a potentially effective method of introducing drivers to the central aspects in this human-automation interaction. A proof-of-concept training program designed to introduce drivers to a partial automation system was developed. The effects of training were then evaluated through a between-group mixed-methods simulator experiment. Results indicate that trained drivers both self-report and exhibit an improved understanding of the automation

system. They also report a significantly higher inclination to retake control in critical situation, than do their untrained counterparts.

- **Keywords:** Human-automation interaction; Driver training; Driving experience

Maral Babapour Chafi, Mette Harder, Christina Bodin Danielsson. *Workspace preferences and non-preferences in Activity-based Flexible Offices: Two case studies.* 102971.

Activity-based Flexible Offices (AFOs) are innovations in workspace design that are being increasingly implemented in organisations. While most studies investigate satisfaction and perceived work support in AFOs, employees' workspace preferences are not addressed in the literature. The aims of this study were to (i) identify workspace preferences and non-preferences in AFOs, and (ii) investigate whether employees' workstation choices support their activities and align with their preferences. Two Swedish municipalities participated in the study. Data collection involved 27 semi-structured interviews and annotations on architectural drawings. The results showed that the interviewees preferred workstations that were both desirable and functional, and avoided workstations that were undesirable. This was due to functional, social, emotional and symbolic aspects of the workspaces as well as their physical structure and stimuli. The approach used in this paper can be adopted for improving the design of AFOs, thereby mitigating the stress of finding a suitable workstation.

- **Keywords:** Activity-based working (ABW); Workspace design; Artefact ecology

Dominique Engome Tchupo, Jung Hyup Kim, Gretchen A. Macht. *Fuzzy cognitive maps (FCMs) for the analysis of team communication.* 102979.

Communication in teams plays a vital role in team success. This work proposes Fuzzy Cognitive Maps (FCMs) as a formalized, team communication methodology for the analysis of content and flow, simultaneously, of naturalistic team communication in a structured environment. Several methods of analysis of team communication exist. Few of them, however, analyze the flow and content of communication simultaneously, and none with teams using naturalistic language. Team communication data is coded for flow and content (through speech acts), then turned into FCMs for visual and statistical analysis. Results show that when using the FCM methodology both flow and content of communication can be diagrammed at the individual level, however, when assessing at the team level, what is illustrated is the flow of content. The application of different statistical analyses to the FCM output provides the opportunity to answer various questions on team communication. This study demonstrates that by using speech acts (SAs) as nodes, FCMs can illustrate and analyze team communication flow and content for naturalistic language. The FCM methodology is a powerful tool for studying team communication, and further incremental work could advance knowledge in team communication dynamics and provide contributions to graph theory. This method provides a visual overview of team communication dynamics in a naturalistic language setting, thus allowing for the study of intra-team dynamics and inter-team dynamics simultaneously.

- **Keywords:** Communication analysis; Team mental models; Naturalistic language analysis

C.C. Roossien, R. Heus, M.F. Reneman, G.J. Verkerke. *Monitoring core temperature of firefighters to validate a wearable non-invasive core thermometer in different types of protective clothing: Concurrent in-vivo validation.* 103001.

This study aims (1) to test the validity of a new non-invasive core thermometer, Cosinuss°, in rest and (2) during firefighting simulation tasks, against invasive temperature pill and inner-ear temperature and (3) to compare the change in core temperature of firefighters when working in two types of protective clothing (traditional turnout gear versus new concept). 11 active firefighters performed twice a selection of tasks during their periodic preventive medical examination and a fire-extinguishing task. Without correction no correlation between the Cosinuss° and thermometer pill ($ICC \leq 0.09$, $p \geq 0.154$, $LoA \geq 1.37$) and a moderate correlation between Cosinuss° and inner-ear infrared ($ICC = 0.40$, $p = 0.044$, $LoA \pm 1.20$) was observed. With individual correction both correlations were excellent ($ICC \geq 0.84$, $p = 0.000$, $LoA \leq 0.30$). However, during and after working all correlations were poor and non-significant ($ICC \leq 0.38$, $p \geq 0.091$, $LoA \geq 1.71$). During firefighting tasks, the Cosinuss° is invalid for measuring the core temperature. No differences in heat development in the two types of protective clothing was proven.

- **Keywords:** Ambient conditions; Core temperature; Heat stress; Physical activity

Karen S. Young, Sudhakar Rajulu. *Changes in seated height in microgravity.* 102995.

Many physiological factors, such as spinal elongation, bone atrophy, and muscle loss, occur when humans are exposed to a microgravity environment. These physiological changes can result in slight to drastic changes in body dimensions. Any drastic change in body dimensions is critical information for current and future space hardware designers. These changes can affect accommodation, safety, and performance of a crewmember while in space. This study measured the overall change in seated height and stature for crewmembers exposed to a microgravity environment. Seated height data were obtained from 29 crewmembers that included 8 International Space Station increment crew (2 females and 6 males) and 21 Shuttle crew (1 female and 20 males). The results indicate that all participating crewmembers experienced statistically significant change in seated height. The corresponding change, 6% from preflight, should be considered for vehicle designs as the necessary seated microgravity adjustment.

- **Keywords:** Anthropometry; Astronaut; Spinal elongation; NASA

Jonas Larsson, Magnus Dencker, M. Charlotte Olsson, Ann Bremander. *Development and application of a questionnaire to self-rate physical work demands for ground combat soldiers.* 103002.

Purpose: The aim of the present study was to identify the most physically demanding work tasks for Swedish ground combat soldiers through the development and application of a questionnaire survey. This is the first in a series of studies aiming to describe the development process and validation of physical selection standards in the Swedish armed forces. **Methods:** Based on procedural documentation, combat manuals and job analyses, a questionnaire was developed that defined and rated the perceived physical strain of 30 work tasks for ground combat soldiers. To assess validity, an expert focus group was used and psychometric analysis performed. The questionnaire was then distributed to 231 ground combat soldiers, of whom 165 responded (71%). **Results:** The questionnaire was validated in three steps to achieve face and content validity, and internal consistency was acceptable (Cronbach's alpha ≥ 0.95). Of the 30 work tasks included in the survey, transport of wounded was rated as the most demanding task for both aerobic capacity and strength. Other highly demanding tasks for aerobic capacity included combat movement (low/high crawl), dismounted attack in close country, urban and rough terrain and carrying heavy loads. There were no gender differences for either aerobic or strength demands in the top five most challenging tasks based on proportions. **Conclusions:** This study identified the most physically demanding tasks performed in the Swedish ground combat forces. Almost all the physically demanding tasks found in

the present study contain elements of lifting and carrying, which require muscular strength and muscular endurance, with no gender differences.

- **Keywords:** Ground combat soldiers; Work-demands; Physical demand; Aerobic capacity

F. Masci, J. Rosecrance, A. Mixco, I. Cortinovis, A. Calcante, S. Mandic-Rajcevic, C. Colosio. *Personal and occupational factors contributing to biomechanical risk of the distal upper limb among dairy workers in the Lombardy region of Italy.* 102796.

Biomechanical overload in the wrist flexor and extensor muscles, together with awkward hand positions during work activities, can result in occupational wrist and hand disorders. Dairy workers, specifically those that work in the milking parlor, are exposed to highly repetitive and forceful exertions of the upper limb throughout their work shift. There are very few studies that have investigated the determinants that contribute to the risk of distal upper limb musculoskeletal disorders among dairy workers. The purpose of the present study was to identify the variables affecting the biomechanical overload of the distal upper limb among milking parlor workers, define risk profiles, and propose possible interventions to reduce the high physical loads to the distal upper limb during milking activities. Forty male workers from the three most common milking parlor systems in Lombardy Italy were recruited to participate in this study. Multiple correspondence analysis of personal characteristics and occupational risk factors, followed by cluster analysis, led to the identification of three distinct groups of workers. Low, medium and high risk profiles were assigned to each group based on the risk assessments performed using the Strain Index and electromyography of the distal upper limb. The main risk determinants were workstation characteristics, work organization and milking routine. A well-organized milking routine, milking cluster weight below 2.4 kg or the use of supporting arms for the milking cluster may reduce the risk of biomechanical overload.

- **Keywords:** Dairy workers; Risk assessment; Strain index; Surface electromyography

Ananth Vijendren, Gavin Devereux, Aaron Tietjen, Kathy Duffield, Vincent Van Rompaey, Paul Van de Heyning, Matthew Yung. *The Ipswich Microbreak Technique to alleviate neck and shoulder discomfort during microscopic procedures.* 102679.

Neck and shoulder disorders are a considerable health problem amongst frequent microscope users. We aimed to investigate the neck and shoulder discomfort experienced during prolonged microscopic activity and to assess the benefits of minibreaks. A prospective crossover study was performed on 17 healthy volunteers sitting still while looking down a bench with and without the Ipswich Microbreak Technique (IMT). We used a subjective measure of time to fatigue and pain in the neck and shoulder regions as well as objective readings from a surface electromyogram (sEMG). The IMT delayed the sensation of pain in the neck and shoulder region while reducing the overall sEMG muscle activation. In conclusion, IMT is a useful strategy in reducing and delaying the pain in neck and shoulder from prolonged working under the microscope. This technique can be incorporated in other activities that involve a sustained stationary position.

- **Keywords:** Mini-breaks; Micropauses; Neck pain; Microscope; Work-related musculoskeletal disorders

SPECIAL SECTION: CONSIDERING SEX AND GENDER IN ERGONOMICS: EXPLORING THE "HOWS" AND "WHYS";

Silvana Salerno, Claudia Giliberti. *Non-vehicle commuting in Italy: need for ergonomic action for women's lower limbs?* 102982.

Introduction: The aim of this paper is to examine gender differences in the occurrence of accidents among workers while walking to or from their workplace (non-vehicle commuting accidents). We have previously found that the lower limb is more often injured at work among women, compared to men, so the paper concentrates on lower limb injuries. **Methods:** Using the records of the National Institute for Insurance against Injuries at Work (INAIL), we focused on the non-vehicle commuting accidents of women and men recognized as work-related for the period 2013-2017. In particular, we examined the gender difference by work sector and type of trauma suffered with particular attention to lower limb injuries. **Results:** The rate of non-vehicle commuting accidents (n. 60,936) among women was significantly higher than for men (1.29‰ vs 0.40‰ men, $p < 0.001$) for the period studied. Lower limb injuries (50.5% for women and 43.7% for men, $p < 0.001$) constituted the large majority of these injuries. In particular, dislocation of the ankle (78% for women vs 65.5% for men, $p < 0.001$), bruise of the knee (71.2% for women vs 54.9% for men, $p < 0.001$) and fracture of the foot (41% for women vs 33.6% for men, $p < 0.001$) were all significantly higher among women. The work sectors with higher injury rates were: Transport and Warehouse, Public Administration, Health and care services and Wholesale and retail trade. This result may be due to wear and tear from conditions at work. The women injured were on the average, a decade older than men (50-59 vs 40-49 years old). **Conclusions:** Non-vehicle commuting represents an important, albeit neglected, preventable risk for women workers, causing lower limb trauma particularly at the ankle, the foot and the knee. These areas may be particularly injury-prone among women in specific sectors, due to the work environment. Effective prevention of these injuries requires gender-oriented ergonomic actions at work and in the commuting environment.

- **Keywords:** Non-vehicle commuting accidents; Lower limb; Women

R.R. Habib, M. Ziadee, E. Abi Younes, H. Harastani. *Syrian refugee child workers: Gender differences in ergonomic exposures and musculoskeletal health.* 102983.

This study explores sex/gender-related differences in ergonomic exposures and musculoskeletal disorders for 4090 working Syrian refugee children (>8-≤18 years) in the Bekaa Valley, Lebanon (n = 2107 males; n = 1983 females). Data was collected on demographic, occupational, and socioeconomic indicators and musculoskeletal disorders. Results revealed that children engaged in strenuous work. Ergonomic exposures differed by sex/gender, with girls more likely to engage in repetitive movements and boys in heavy lifting. Girls bore a double burden of work inside and outside their households and were more prone to wrist and hand pain. More girls reported working under pressure to finish their job on time while more boys reported that their salary is based on finishing a specific number of items per day. Syrian refugee child workers need immediate protection to safeguard their health. Interventions could target children of legal age for work in safer conditions and keep younger children out of work.

- **Keywords:** Child labor; Sex/gender; Refugee; Ergonomics

Mélanie Lefrançois, Isabelle Probst. *"They say we have a choice, but we don't": A gendered reflection on work-family strategies and planning systems of atypical schedules within male-dominated occupations in Canada and Switzerland.* 103000.

For parents working in the transportation industry, atypical schedules are often a daily puzzle. Schedule planning systems allowing workers to choose shifts may affect job strenuousness and work-family balance (WFB) for both female and male workers. How could ergonomic interventions related to the implementation of those systems better consider gender dynamics regarding WFB strategies, and minimize inequities among workers? This article presents a joint analysis of two independent case studies related to ergonomic interventions in transport companies in Canada and Switzerland. Direct observation and semi-structured interviews shed light on the characteristics of schedule planning systems and their interaction with men's and women's WFB strategies. Issues related to each step of the planning process (shift construction, schedule choice, day-to-day schedule management) are discussed to inform interventions aimed at facilitating WFB, and ultimately gender equity, in atypical schedule contexts.

- **Keywords:** Atypical schedules; Ergonomic intervention; Work-family balance; Gender

SPECIAL SECTION: 50 YEARS OF APPLIED ERGONOMIC

Nathalie Bonnardel, John Didier. *Brainstorming variants to favor creative design*. 102987.

The design process in preventive and prospective ergonomic contexts requires creativity. However, user-centered methods are not usually aimed at supporting creative design. We therefore devised two variants of the seminal brainstorming technique to favor ideation during design activities. One variant encouraged participants to focus on the evocation of ideas, like the seminal technique, whereas the other emphasized the evocation of constraints related to the design problem. To analyze the effects of these variants on creative design, we conducted three studies: one with future designers (Study 1), one with future generalist teachers (Study 2), and one with future teachers specializing in creative activities (Study 3). Depending on the study, participants were provided with idea evocation instructions, constraint evocation instructions, or no specific instructions. Results allowed us to identify the best conditions for promoting creativity in design, depending on the individual's specialty or the complexity of the design task.

- **Keywords:** Creativity; Design; Brainstorming