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Jim R. Potvin, Vincent M. Ciriello, Stover H. Snook, Wayne S. Maynard & George E. Brogmus. [The Liberty Mutual manual materials handling \(LM-MMH\) equations](#). Pages: 955-970.

We summarise more than 40 years of Liberty Mutual psychophysical research on lifting, lowering, pushing, pulling and carrying, including the 7 studies used to develop the 1991 Liberty Mutual Tables and 12 subsequent studies. Predictive equations were developed based on 612 mean maximum acceptable loads (MALs), representing 388 unique conditions from 123 female and 149 male participants, starting with a maximum reference load that is scaled based on frequency, height, distance (vertical for lift & lower, horizontal for push, pull and carry tasks) and horizontal reach (for lift & lower tasks). Representative coefficients of variation are provided to allow for the calculation of MALs for any percentile. Each equation performed well and, overall, they explained 90% of the variance in MAL values, with RMS differences of 6.7% and 4.8% of the full range for females and males, respectively. We propose that these equations replace the 1991 Liberty Mutual Tables. **Practitioner summary:** We propose predictive equations to replace the 14 manual materials handling tables in Snook and Ciriello (1991). These equations are based on 12 more publications, matched the empirical data well, are easier to use and allow for both a wider range and more specific inputs than the tables.

- **Keywords:** Psychophysics, lifting, lowering, pushing, pulling, carrying, acceptable loads

Thomas Gus Almonroeder, Lauren Harding, Brooke Seubert, Hanni Cowley & Thomas Kernozek. *The effects of incremental changes in rucksack load on lower extremity joint Kinetic patterns during ruck marching*. Pages: 971-982.

Injuries are often attributed to ruck marching. Therefore, it is important to examine how load carriage influences gait mechanics. The purpose of this study was to examine how subtle changes in rucksack load influence joint torque patterns during marching. Fourteen Army ROTC cadets marched with light, moderate, and heavy rucksack loads. Kinetic and kinematic data were recorded via an instrumented treadmill and motion capture system and principal component analysis was used to analyse the joint torque

waveforms. Cadets exhibited moderate-large increases in knee extension torques during early stance (effect sizes ≥ 0.45) and small-moderate increases in ankle plantarflexion torques during push off (effect sizes ≥ 0.23) with each incremental increase in rucksack load. The lighter load also resulted in lower hip extension torques during early stance and flexion torques during late stance, vs. the moderate and heavier loads (effect sizes ≥ 0.23). It appears that subtle changes in rucksack load influence marching mechanics.

Practitioner Summary: The purpose of this study was to examine how relatively subtle changes in rucksack load influence marching mechanics. Army ROTC cadets marched with relatively light, moderate, and heavy rucksack loads. Our results indicate that even subtle changes in rucksack load influence joint torque patterns of the hip, knee, and ankle.

- **Keywords:** Biomechanics, gait, load carriage, military medicine, principal component analysis

Jang-Ho Park & Divya Srinivasan. *The effects of prolonged sitting, standing, and an alternating sit-stand pattern on trunk mechanical stiffness, trunk muscle activation and low back discomfort.* Pages: 983-994.

Sit-stand desks continue to be a popular intervention for office work. While previous studies have reported changes in subjective measures, there is limited understanding of how sit-stand work differs from prolonged sitting or standing work, from a biomechanical standpoint. The objective of this study was to investigate the effects of prolonged sitting, prolonged standing, and a sit-stand paradigm on changes in trunk stiffness, low back discomfort, and trunk muscle activation. Twelve healthy participants performed 2 h of computer-based tasks in each protocol, on three different days. The sit-stand protocol was associated with a significant increase in trunk stiffness and a decrease in muscle activation of lumbar multifidus and longissimus thoracis pars thoracis, compared to both prolonged sitting and standing. Both sitting and standing were associated with increased low back discomfort. These findings may be worth exploring in more detail, for why alternating sit-stand patterns may help alleviate low back pain. **Practitioner summary:** We explored changes in objective and subjective measures related to low back discomfort following prolonged sitting, standing, and alternating sit-stand patterns. Alternating sit-stand pattern was associated with increased trunk stiffness and decreased back muscle activity. Hence, sit-stand desks may have benefits in terms of preventing/mitigating low back pain.

- **Keywords:** Sit-stand desk low back pain, office work, spinal stability, trunk extensor muscle activation

Xingda Qu, Xinyao Hu & Da Tao. *Gait initiation differences between overweight and normal weight individuals.* Pages: 995-1001.

Accidental falls often occur during gait initiation. Excess body weight has been identified as a risk factor for accidental falls. This study aimed to examine the differences of gait initiation between overweight and normal-weight individuals. Fourteen overweight and 14 normal-weight young adults participated in the study. They were instructed to perform the gait initiation task under single-task and dual-task conditions. Dependent variables for the assessment of gait initiation included spatial-temporal measures and postural stability measures. The results showed that overweight could compromise postural stability during gait initiation, primarily by decreasing margin of stability in the anterior-posterior direction. Cognitive task interference with gait initiation was found to be similar between the overweight and normal weight groups. The findings from the present study can aid in better understanding the mechanisms associated with increased fall risks among overweight individuals. They also highlight the importance of overweight control in fall prevention. **Practitioner summary:** Overweight was found to compromise

postural stability during gait initiation, primarily by decreasing margin of stability in the anterior–posterior direction. The findings highlight the importance of overweight control in fall prevention.

- **Keywords:** Falls, excess body weight, gait, postural stability, dual-task condition

Katie A. Goggins, Delphine Chadeaux, Marco Tarabini, Marc Arsenault, W. Brent Lievers & Tammy Eger. *Four degree-of-freedom lumped parameter model of the foot-ankle system exposed to vertical vibration from 10 to 60 Hz with varying centre of pressure conditions. Pages: 1002-1017.*

Modelling the foot-ankle system (FAS) while exposed to foot-transmitted vibration (FTV) is essential for designing inhibition methods to prevent the effects of vibration-induced white-foot. K-means analysis was conducted on a data set containing vibration transmissibility from the floor to 24 anatomical locations on the right foot of 21 participants. The K-means analysis found three locations to be sufficient for summarising the FTV response. A three segment, four degrees-of-freedom lumped parameter model of the FAS was designed to model the transmissibility response at three locations when exposed to vertical vibration from 10 to 60 Hz. Reasonable results were found at the ankle, midfoot, and toes in the natural standing position (mean-squared error (ϵ) = 0.471, 0.089, 0.047) and forward centre of pressure (COP) (ϵ = 0.539, 0.058, 0.057). However, when the COP is backward, the model does not sufficiently capture the transmissibility response at the ankle (ϵ = 1.09, 0.219, 0.039). **Practitioner summary** The vibration transmissibility response of the foot-ankle system (FAS) was modelled with varying centre of pressure (COP) locations. Modelling the FAS using three transmissibility locations and two foot segments (rearfoot and forefoot) demonstrated reasonable results in a natural standing and forward COP position to test future intervention strategies.

- **Keywords:** Foot-ankle vibration model, foot-transmitted vibration, vibration-induced injury, standing vibration

Graciela Rodríguez Vega, Ulises Zaldívar Colado, Xiomara Penélope Zaldívar Colado, Dora Aydee Rodríguez Vega & Enrique Javier de la Vega Bustillos. *Comparison of univariate and multivariate anthropometric accommodation of the northwest Mexico population. Pages: 1018-1034.*

Ergonomic workstation design is crucial to prevent work-related musculoskeletal disorders. Many researchers have proposed multivariate analysis for human accommodation. However, no multivariate anthropometric analysis exists for the Mexican population. This study compares common multivariate human accommodation approaches (e.g. principal component and archetypal analyses) and clustering techniques (e.g. *k*-means and Ward's algorithm) with the classical percentile-based univariate accommodation approach, using the Chi-squared goodness-of-fit test and the McNemar's test. The theoretical accommodation percentage obtained by multivariate approaches was higher than those obtained by the percentile univariate approach considering the central 98% data. *k*-means and archetypal analysis obtained similar and the highest accommodation values, followed by Ward's algorithm and principal component analysis. The study findings can be deployed to assess the design of workstations in Mexico, such as electronic components assembly and crew designs, and the effects of different anthropometric measurements in human accommodation. **Practitioner summary:** Products and workplaces design are commonly based on the classical univariate approach, using the extreme percentiles. In this study, multivariate approaches were tested on dimensions for sitting workstations, and results showed a bigger accommodation level in comparison to the univariate 1%–99% approaches.

- **Keywords:** General ergonomics, industrial ergonomics, anthropometry, standards, workstation design

Christopher J. Parker, Steven George Hayes, Kathryn Brownbridge & Simeon Gill. *Assessing the female figure identification technique's reliability as a body shape classification system.* Pages: 1035-1051.

This paper demonstrates the effects of slight differences in measurement definitions on resultant body shape classification. Ergonomic researchers consider the Female Figure Identification Technique (FFIT) a 'gold standard' body shape classification system to describe variation in a population's 3D profile. Nevertheless, researchers use FFIT without a scientific basis or considering their ergonomic suitability. This paper rigorously evaluates FFIT, focussing on ergonomics, garment construction, and scientific research applications. Through analysing 1,679 3D Body Scans, we assess the level of agreement between the FFIT's body shape classification when measurements placed following FFIT's or SizeUK's guidance. We establish how different interpretations of FFIT's measurement placement cause the same body to be categorised into different shapes - in up to 40% of cases. FFIT omits shoulder measurements that have little relationship to body shape yet are vital in garment construction. Using FFIT with different datasets and definitions, therefore, leads to inconsistent conclusions about shape differences. **Practitioner Summary:** To increase the effectiveness of body shape classification, research must appraise current systems through statistics. This paper demonstrates how current body definitions are too unspecific and exclude relevant body morphology for garment construction. Our paper suggests alternative anthropometrics and demographics for inclusion in a more advanced model.

- **Keywords:** Body shape, 3D body scanning, clothing fit, measurement, anthropometrics

Jenny Burbage, Alex J Rawcliffe, Samantha Saunders, Louise Corfield & Rachel Izard. [*The incidence of breast health issues and the efficacy of a sports bra fit and issue service in British Army recruits.*](#) Pages: 1052-1061.

Increasing retention of female recruits throughout Basic Training (BT) is a key priority for the British Army. The aims of this study were two-fold; (i) quantify breast health issues and sports bra usage within female British Army recruits, and (ii) assess the influence of professionally fitted sports bras on breast health and bra fit issues across 13 weeks of BT. A survey was completed by 246 female recruits that identified the incidence of breast health issues during BT. Subsequently, 33 female recruits were provided with professionally fitted sports bras during Week-1 of BT. Recruits completed a survey in Week-1 (Pre) and Week-13 (Post). There was a high incidence of bra issues during BT, which did not reduce following the implementation of professionally fitted sports bras. The authors recommend further research into the specific functional requirements of breast support relative to the demands of BT and the needs of the female recruit. **Practitioner Summary:** The British Army have a duty of care to ensure female recruits are equipped sufficiently for the demands of training. Despite the implementation of a sports bra fitting and issue service bra fit issues remained high. Further research into the specific functional requirements of breast support during training is recommended.

- **Keywords:** Military recruits, basic training, sports bra, education, women

Dirk Stelling, Michael Hermes, Gerrit Huelmann, Justin Mittelstädt, Dominik Niedermeier, Kevin Schudlik & Holger Duda. *Individual differences in the temporal progression of motion sickness and anxiety:*

the role of passengers' trait anxiety and motion sickness history. Pages: 1062-1071.

The objective of the study is to show that trait anxiety and motion sickness history are responsible for different temporal progressions of sickness in passengers. The level of in-flight anxiety and in-flight sickness severity was monitored for 124 passengers in a full-motion cabin simulator during a short-haul flight with four different flight segments. Four groups with different characteristics in trait anxiety and motion sickness susceptibility showed different profiles of in-flight sickness development. High trait anxiety was responsible for high in-flight anxiety and a constantly high level of motion sickness, while passengers with just a motion sickness history showed an increase in motion sickness severity over time. We suggest that trait anxiety and motion sickness susceptibility interact and have an impact on the temporal progression of in-flight sickness severity. The analysis of temporal developments of anxiety and sickness are fruitful for understanding the origins of motion sickness, research and individual treatments. **Practitioner summary:** In a full-motion cabin simulator study with 124 passengers the level of in-flight anxiety and in-flight sickness severity was monitored. Trait anxiety and motion sickness history were found to have different impacts on the temporal progression of individual sickness severity.

- **Keywords:** Motion sickness, anxiety, individual differences, vestibular processes, psychological stress

Erin L. Stevens, Adam Hulme & Paul M. Salmon. The impact of power on health care team performance and patient safety: a review of the literature. Pages: 1072-1090.

Communication failure within health care teams is a major cause of patient harm across health care settings. Factors which contribute to communication failure include actual or perceived 'power'. Whilst a great deal of ergonomics research has focussed on teamwork in health care, the role of power in relation to measurable patient safety and performance outcomes remains relatively unknown. This article presents the findings from a review of the literature on power within multidisciplinary health care team settings. Following a systematic literature search, nineteen studies were evaluated in terms of research design, methods and analyses across the included studies. The main impacts resulting from power imbalances include negative effects on team collaboration, decision-making, communication and overall performance. Wider patient safety research, and more specifically the ergonomics discipline, is encouraged to address the complex interplay between power and teamwork in the health care sector. **Practitioner Statement:** We conducted a review of studies focussed on the influence of power on teamwork in health care. The findings show that power can have negative impacts on collaboration, decision-making, communication, and team performance. We conclude that power represents an important area for ergonomics, both in health care and other settings.

- **Keywords:** Health care ergonomics, patient safety, Health and Safety, socio-technical systems