This study was performed to evaluate the effects of hand truck design, product load, and ramp characteristics on ergonomic stresses affecting drivers. Hand forces and working postures were recorded while experienced drivers performed ramp delivery operations using 36 combinations of hand truck (three types: two braked, one unbraked), product load (three levels: 37, 78, 151 kg), and ramp (four types: three planar surfaces sloped between 19.1 and 21.6 degrees, and one stepped surface sloped at 19.2 degrees). To supplement the quantitative data, the investigators met with a focus group of experienced drivers to discuss design features of hand trucks and ramps.

Hand forces were reduced by more than 60% with brake-equipped trucks ($p<.01$). Brakes also reduced the frictional requirements at the shoe-ramp interface. Frictional requirements were reduced with longer ramps and were lowest for the stepped surface ramp.

Based on the quantitative results and driver comments, we concluded that brakes are a very desirable feature for trucks used in ramp deliveries. We could not reach a strong conclusion regarding ramp design. The stepped-surface ramp required the lowest friction; however, some drivers were concerned that its noncontinuous surface created a tripping hazard. Although long ramps had better force and friction characteristics, drivers were concerned that they were not practical at some customer locations due to space constraints at docks.

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AN ERGONOMIC EVALUATION OF A FRICTION-FEED PULLEY SYSTEM TO REDUCE BACK INJURIES AMONG BEER KEG DELIVERYMEN. J.D. McGlothlin, NIOSH, Cincinnati, OH

Researchers from NIOSH conducted a field evaluation of friction-feed pulley system mounted on a beverage delivery truck delivering 165-lb beer kegs. The purpose of the study was to determine if there was a significant reduction in cardiovascular and biomechanical demands in using this system compared with manually lifting the kegs from the truck to the ground. It is hypothesized that if this system worked to reduce cardiovascular and biomechanical demands that the risk for back injuries would also be reduced. Heart rate data using a polar heart rate monitor was collected on three experienced beverage delivery drivers. The heart rate data was collected for one 8-hr workday on each driver. In addition, the delivery drivers were videotaped during beverage delivery and the videotapes were later analyzed in the laboratory for work risk factors and biomechanical analysis. The heart rate data and videotapes were time synchronized to observe work practices as a function of changes in heart rate. A random block statistical design was used to determine when to use and not use the friction-feed pulley system to remove the beer kegs. Analysis of the data showed a significant reduction in both heart rate (up to a 30% reduction in heart rate demand), and biomechanical demand, according to the 1993 NIOSH revised lifting formula. For this pilot study, the new friction-feed pulley system showed promise as a low-cost ergonomic solution toward reducing the potential for back injuries when removing 165-lb beer kegs from delivery trucks.

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ENERGY EXPENDITURE PREDICTION OF JOBS USING MATERIAL HANDLING DEVICES. G.B. Woolley, D.B. Chaffin, J.W. Boyle, University of Michigan, Ann Arbor, MI

A laboratory study was conducted to develop prediction equations for energy requirements of common tasks performed using material handling devices, specifically manipulators including hoists and articulated arms. This is an extension of previous work that developed prediction equations for many tasks common to manual material handling jobs. These prediction equations are used to estimate the energy requirements of the tasks involved in a job and then summed to estimate the total energy requirement of the job. Energy prediction equations for tasks involving the use of manipulators were not previously developed.

To identify specific tasks exercised when using manipulators 22 case studies at 6 manufacturing plants were evaluated. Twisting and turning, pushing and pulling, and general arm work while maneuvering inertial loads were found to be common tasks that were not adequately covered by the available prediction equations. A laboratory study was designed to measure the energy requirements of these tasks while varying specific task parameters in order to develop new prediction equations. Six subjects, males and females of distributed body weight, performed a total of 336 trials using a gantry mounted air balanced hoist. The varied task parameters included load, distance or angle moved, direction of movement, speed, and hand height.

Regression equations were developed to predict the energy required per exertion. The R^2 values varied from 0.71 to 0.78. The significant prediction parameters were angle, peak hand force, gender, and body weight for twisting and turning; body weight, stature, gender, distance, and peak hand force for pushing and pulling; and peak hand force, gender, and distance for arm work.

These additional energy prediction equations extend the capability of the present prediction equations to estimate the energy requirements of jobs requiring the movement and manipulation of inertial loads such as material handling manipulators.

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REDUCTION IN PHYSICAL DEMAND AND HEALTH CARE WORKER INJURY IN PATIENT TRANSFER. C.J. Brigham, Galson Consulting, Plymouth Meeting, PA; B.W. Sanders, Crozer-Keystone Health System, Upland, PA

Recent innovations in patient transfer equipment design, availability and use have resulted in significant reduction in both physical demand to health care workers (HCW) and to the incidence of work-related musculoskeletal disorders (WMD). In this study, a comparison of several different types of transfer techniques and equipment was made. Measurements made for horizontal transfer demonstrated a 93% reduction in sustained forces and a 67% reduction in peak forces required when comparing a draw sheet with an alternative transfer device. Over 90% of females were predicted as being capable of performing the transfer without injury with the alternative device, while less than 10% were predicted as being capable using the draw sheet. The number of staff required to perform these transfers was also reduced with the alternative device. Measurements of pushing/pulling and lifting/lowering forces were made for other transfers and compared with existing guidelines. One study hospital went from $272,000 in losses due to patient transfer in the 2 years prior to intervention to $6,000 in losses for the most recently completed 2 years. A second hospital experienced an 89% reduction in patient transfer related incidents resulting in loss cost reduction of almost $700,000.

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EFFECTIVENESS OF THE REVISED NIOSH LIFTING EQUATION TO IDENTIFY JOBS WITH ELEVATED RATES OF LOW-BACK PAIN. T.R. Waters, S. Baron, L. Piacitelli, V. Putz-Anderson, M. Sweeney, T. Skov, D. Wall, L. Fine, NIOSH, Cincinnati, OH

This report summarizes the results of a cross-sectional study of the relationship between exposure to manual lifting stressors and 1-year prevalence of low-back pain (LBP) in workers employed in manual lifting jobs. The exposure was measured with the Lifting Index (LI), a component of the revised NIOSH lifting equation. The NIOSH lifting equation has been proposed as a practical, yet valid tool for assessing the risks of LBP due to manual lifting. To date, however, there have been few studies to evaluate the effectiveness of the equation to identify jobs with elevated rates of LBP. In theory, the risk of LBP increases as the LI for a job increases above 1.0. In this study, 50 jobs from 4 industrial sites were evaluated with the NIOSH lifting equation. A symptom and occupational history questionnaire was administered to 204 persons employed in the lifting jobs and 80 persons employed in nonlifting jobs to determine 1-year prevalence of LBP. Multivariate regression analysis was used to determine if there was a relationship between the LI and reported LBP. We found that the odds ratios and 95% confidence intervals for the $0<LI<1$, $1<LI<2$, $2<LI<3$, and $LI>3$ categories were 1.14 (0.16-5.29), 1.54 (0.60-3.80), 2.45 (1.29-4.85), and 1.63 (0.66-3.95), respectively. We believe that the reduced odds ratio for jobs with an $LI>3$ is due to a "worker selection" or a "survivor effect." It was concluded that the LI appears to be a useful indicator for risk of LBP due to manual lifting, even though LBP is a common disorder.

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PREVALENCE OF BACK DISCOMFORT AND ESTIMATES OF POSTURAL LOAD IN TWO MANUFACTURING FACILITIES. W. Chen, V. Liu, UCLA Center for Occupational and Environmental Health, Los Angeles, CA

This study evaluated the association between the prevalence of back discomfort and estimates of load for the back posed by nine jobs in two manufacturing facilities. The prevalence of back discomfort was estimated through self-administered questionnaires. A total of 266 questionnaires was distributed to workers randomly selected in nine jobs in two factories. The return rate for each job ranges from 57 to 100%. Overall, 14.5% of the survey respondents experienced some discomfort at the back. Five estimates of back load due to forceful efforts and to awkward postures, i.e., back flexion, extension, twisting, and lateral bending, were derived from task information provided by supervisors

Abstracts

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