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The effects of box size, vertical distance, and height on lowering tasks for female industrial workers

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Abstract

The most frequent and expensive cause category of compensable loss is manual material handling (MMH). In an attempt to minimize these losses, refinement of existing MMH guidelines is a component of redesigning high risk MMH jobs. In the development of our present MMH guidelines [Snook and Ciriello, 1991. Ergonomics 34, 1197–1213] maximum acceptable weights (MAWs) of lowering were assumed to respond similarly to the parameters of lifting. Also, MAWs of lifting various vertical distances with a large box were assumed to respond in the same way as lifting various vertical distances with a small box. The purpose of this experiment was to investigate the effects of vertical distance and box size on MAWs of lifting and lowering and the effects of height on MAWs of lowering. The effects of a four component combination task on MAW were also investigated. Ten female industrial workers performed 27 variations of lifting, lowering, pushing, pulling, and carrying. A psychophysical methodology was used whereby the subjects were asked to select a workload they could sustain for 8 h without "straining themselves or without becoming unusually tired, weakened, overheated or out of breath." The results revealed that MAWs of lowering were not affected by distance of lowering, height of lowering or box size. The results also indicated that MAWs of lifting large boxes were not significantly affected by vertical distance of lift. Maximum acceptable force of push in the combination task comprised lifting, carrying, lowering and pushing was significantly reduced compared to an individual pushing task. It was concluded that our existing guidelines present a conservative estimate of the variables studied except for the combination task. In that case, recommendations are given for adjustment of MAW.

Relevance to industry: Lowering is the second most common MMH task but has been given considerably less attention in research as compared to lifting. This study investigated select variables of lowering in an effort to improve estimation of MAWs for ergonomic redesign.

Keywords: Psychophysics; Manual materials handling; Maximum acceptable weight; Lowering; Ergonomic redesign; Multiple component tasks

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1. Introduction

Manual material handling (MMH) is the most frequent (36% of all claims) and costly (35% of total cost) category of compensable loss (Leamon and Murphy, 1994; Murphy et al., 1996; Dempsey and Hashemi, 1999) and is associated with the largest proportion (63–70%) of compensable low back disability (Snook et al., 1978; Bigos et al., 1986; Murphy and Courtney, 2000). A small percentage of the most costly low back claims (10%) are reported to be responsible for a large percentage of the total cost (86%) (Hashemi et al., 1997). This same study reported days of disability for LBP to be skewed to long durations. To control these losses, ergonomic redesign of MMH tasks has the two-fold advantage of accommodating the work place to a high percentage of the industrial population with and without low back disability (Snook et al., 1978; Benson, 1986, 1987; Snook, 1987; Ciriello and Snook, 1999; Ciriello et al., 1999). Acceptable loads in MMH have been established using a wide spectrum of techniques (Kemper et al., 1990; Kivi and Mattila, 1991; Waikar et al., 1991; Burdorf et al., 1992; Waters et al., 1993; de Looze et al., 1994; Winkel and Mathiassen, 1994; Mital et al., 1997).

In this laboratory, maximum acceptable weights (MAWs) and forces (MAFs) have been determined using the psychophysical technique (Snook and Ciriello, 1991) and used extensively to redesign work places (Benson, 1986, 1987; Ciriello and Snook, 1999; Ciriello et al., 1999). However, surveys have indicated that lowering comprises 29.5% of all MMH tasks which encompass lifting, lowering, pushing, pulling, and carrying (Ciriello et al., 1999). In the development of our present MMH guideline (Snook and Ciriello, 1991), MAWs of lowering were assumed to respond similarly to the parameters of lifting. Also, MAWs of lifting various vertical distances with a large box were assumed to respond the same as lifting various vertical distances with a small box. The purpose of this experiment was to investigate the effects of vertical distance and box size on MAWs of lifting and lowering and the effects of height on MAWs of lowering. In addition, the effects of a four component combination task on MAW were included in the study to add to our knowledge of MAW adjustment in a combination task. With the above information, a more precise estimate of MAWs for the female industrial population can be determined. Lastly, criterion tasks previously performed in this laboratory (Snook and Ciriello, 1991) were replicated to establish comparisons to the present study.

2. Method

2.1. Subjects

Ten female industrial workers were recruited from local industries and examined by a nurse practitioner to ensure that they had no serious cardiovascular problems and had not experienced previous significant low back pain or musculoskeletal problems of the extremities. Before participation, written informed consent, which was approved by our Institutional Review Committee, was obtained from the subjects.

Shoulder, elbow and knuckle heights were taken to set the ranges for the lifting and lowering tasks and the heights of the pushing and pulling tasks to the individual's anthropometrics. These measurements along with stature were compared with military and industrial populations to ensure similarity with our subjects (Snook and Ciriello, 1974; Ciriello et al., 1990; Eastman Kodak Co., 1986; Gordon et al., 1989; Marras and Kim, 1993). The comparisons of the above measurements yielded a median difference of 0.6% (range 0.2–4.6%). The subjects' mean (SD) values for age, weight, stature, shoulder height, elbow height, and knuckle height were 42.9 (11.2) years, 69.6 (10.8) kg, 161.8 (3.8) cm, 133.7 (4.1) cm, 102.8 (3.3) cm, and 73.3 (3.3) cm, respectively.

2.2. MMH tasks

Subjects performed 27 variations of lifting, lowering, pushing, pulling, and carrying. During lifting and lowering tasks, two plastic boxes with external wood handles were used. The external handles are 17.8 cm long × 4.2 cm thick and devoid of sharp edges. A small box, which represented a