

Does wearing a non-expanding weight lifting belt change psychophysically determined maximum acceptable weights and forces

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Abstract

The most frequent and expensive cause category of compensable loss is the manual material handling (MMH). Ergonomic redesign of high-risk MMH tasks is the most effective way to minimize these losses. As an alternative to task redesign, back belts have been promoted by management and used by employees to help alleviate the physical demands of, otherwise, unacceptable tasks, despite a lack of the conclusive evidence that back belts will protect against low-back pain or low-back disability. Also, there is a concern that back belts may give the worker a false sense of confidence and encourage them to explore higher work levels. The purpose of this experiment was to investigate the effects of a back belt with maximum resistance to the circumferential expansion on psychophysically determined maximum acceptable weights (MAWs) and forces (MAFs) for a variety of lifting, lowering, pushing, pulling, and carrying tasks. Ten female and eight male industrial workers performed nine MMH tasks with and without a back belt within a larger study of 56 different tasks, which required 17 four-hour days to complete. A psychophysical methodology was used whereby the subjects were asked to select a workload they could sustain for eight hours without “straining themselves or without becoming unusually tired, weakened, overheated or out of breath.” The results revealed that the MAWs and MAFs of all tasks performed by women and all but one MAF of one task performed by men were not significantly affected by the back belt use. Based on these results, the use of a back belt did not change the perception of the subject’s physical demands of the task since they chose similar psychophysically acceptable loads.

Relevance to industry

Back belts are still commonly used in the industry despite lack of evidence that they will provide a decrease in low-back disability. This study illustrated that a worker’s perception of the task was not altered by the back belt use, thus a worker’s preference for the back belt use when job redesign has been limited or ignored should not be discouraged.

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1. Introduction

Occupational injuries associated with the manual material handling (MMH) tasks are the most frequent (36% of all claims) and costly (35% of total cost) category of compensable loss reported by the US-based workers (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 (LBD) (Snook et al., 1978; Bigos et al., 1986;

Murphy and Courtney, 2000). Further investigation reveals that a small percentage of the most costly low-back claims (10%) are responsible for a large percentage of the total cost (86%) (Hashemi et al., 1997). This same study reported that days of disability for low-back pain (LBP) were skewed towards longer durations.

To prevent these losses and reduce their severity, the redesign of MMH tasks following ergonomic principles has the advantage of accommodating the physical capabilities of a higher percentage of the industrial population, regardless if they are suffering from LBD or not (Snook et al., 1978; Benson, 1986, 1987; Snook, 1987; Ciriello and Snook, 1999; Ciriello et al., 1999). Acceptable loads and

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limits in MMH have been analyzed and established using a wide spectrum of techniques including physiological, biomechanical, subjective, observational, focus groups, psychophysical, postural analysis and a combination of the above (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; Van der Beek et al., 2005; Bust et al., 2005).

Guidelines describing maximum acceptable weights (MAWs) and forces (MAFs) have been determined using the psychophysical technique (Snook and Ciriello, 1991) and have been used extensively to redesign work places (Benson, 1986, 1987; Ciriello and Snook, 1999; Ciriello et al., 1999). These guidelines were developed without considering the use of the back belts as an independent variable. The current study was conducted to investigate the effects that back belts; in particular non-expanding back belts, may have on previous guidelines.

As an alternative to the task redesign, back belts have also been promoted by management and used by workers to help alleviate the physical demands of unacceptable jobs despite the lack of evidence that back belts will protect against LBD (Wassell et al., 2000; Van Poppel et al., 1998; Reddell et al., 1992). There is a belief that back belts will give the worker a false sense of security and encourage them to explore higher work levels (Chen, 2003; McGill, 2001; National Institute for Occupational Safety and Health (NIOSH), 1994). The purpose of this experiment was to investigate the effects of a non-expanding back belt (i.e., weightlifting belt) with maximum resistance to the circumferential expansion on psychophysically determined maximum acceptable weights and forces.

2. Method

2.1. Subjects

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

Measurement of the subject's shoulder, elbow and knuckle heights were recorded and used to establish the upper and lower limits for the lifting and lowering tasks and the heights of the pushing, pulling and carrying tasks. These measurements, along with stature, were compared to the military and industrial populations to ensure similarity with our subjects (Ciriello and Snook, 1978; Snook, 1971; Snook and Ciriello, 1974; Ciriello et al., 1990; Eastman Kodak Co. and Human Factors Section, 1986; Gordon et al., 1989; Marras and Kim, 1993). The female 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. The male subjects' mean (SD) values for the same measurements were 43.0 (12.5) years, 77.4 (11.8) kg, 170.6 (13.4) cm, 142.1 (12.2) cm, 108.8 (9.2) cm and 76.5 (7.0) cm, respectively.

2.2. MMH tasks

Subjects performed nine individual lifting, lowering, pushing, pulling and carrying tasks with a belt and the same tasks without a belt within the context of a larger experiment, which contained a total of 56 different tasks. Subjects used a 12.7 cm A-OK weight lifting belt (OK-1 Manufacturing Co., Irving, TX) made from webbed nylon. This was a non-expanding belt, providing maximum resistance to the circumferential expansion, which is important if the belt provides help in increasing intra-abdominal pressure (Harman et al., 1989; Lander et al., 1990, 1992; McGill et al., 1990).

During the lifting and lowering tasks, two plastic tote boxes equipped with external wooden handles were used. The handles were 17.8 cm long $\times$ 4.2 cm thick and devoid of any sharp edges. One box, which represented a common small industrial tote box was 33.4 cm wide, 56.2 cm long, and 16.0 cm deep. This small box was also used as a criterion box in other studies conducted by Snook and Ciriello (1991). The other box, which represented a large industrial box was 76.1 cm wide, 56.5 cm long, and 22.0 cm deep. The width represents the box distance in a plane extending away from the subjects' body while the length represents the distance from the outside end of one handle to the outside end of the other handle. The handles were placed midway along the width dimension.

Lifting and lowering tasks were performed using pneumatically activated shelves that automatically moved to a specified vertical location after a lift or lower and then returned the box to the original location. Subjects slid the boxes off the shelf, and then slid them back on during lifting and lowering. Subjects were deterred from lifting or lowering the boxes straight up or down in a vertical plane by being asked to imagine a rack of shelves above or below the box to be lifted or lowered. In most cases, this resulted in some degree of body twisting during lifting and lowering. Lifts and lowers had a vertical distance of 51 cm and were studied at three heights: between floor level and knuckle height (low lift/lower), between knee height and elbow height (mid lift), and between knuckle height and shoulder height (center lift). The midpoint of the lifting distance was also the midpoint of the overall range for the low lift and low lower, and the center lift. The midpoint for the mid lift was knuckle height. The lifting tasks were performed at frequencies of 20, 12, 4.3, and 1 min⁻¹. The lowering task had a frequency of 4.3 min⁻¹.

The extended horizontal reach lift involved lifting with arms fully extended in front of the body. To enforce this posture, a wooden barrier was placed in front of the feet and a clear plexiglas barrier (26 cm wide $\times$ 229 cm high)

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