The Effect of Back Belt on Maximum Displacement and Center of Pressure Velocity in Different Lifting Styles

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ABSTRACT

Purpose: Mechanical loading is said to be an important factor in the development of low back pain (LBP). One of the main concerns in manual material handling (MMH) tasks is lifting loads, as this activity is present in most jobs. Despite the controversy about their effectiveness, belts are used in industry as either protective or assistive devices in manual load handling. The present investigation aimed to determine whether a commonly used back belt could improve maximum center of pressure displacement (COPMD) and center of pressure velocity (COPV) as the balance parameters during each of three common styles of lifting (squat, semi-squat, stoop).

Methods: Twenty healthy female subjects participated in this study who were selected by non-probability convenience sampling. The participants stood barefoot on the force plate. They lifted a box, weighting 4.53 kg (10 pound). The subjects were instructed to bend their knees (squat) or their lumbar (stoop) or both their knees and lumbar (semi-squat), to grasp the box handles, and to lift the load to the level of greater trochanter height. Half of the subjects performed the 3 trials with wearing belt at first try and the other half performed the trials without wearing the belt at first try.

Results: The mean of maximum displacement and velocity showed that there was a trend of increase in these variables in all 3 styles of lifting (squat, semi-squat and stoop) after wearing belt. One-way ANOVA with repeated measures results for COPMD and COPV showed that 'Belt condition' significantly affected the dependent variables.

Conclusion: Wearing belt may decrease stability caused by increased COPMD and COPV.

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1. Introduction

Low back injury incurs great direct and indirect costs to society because of lost wages and productivity [1]. At least half of the general population will experience low back pain at some point in their life [2]. The exact causes for most LBP conditions are not known. Mechanical loading is said to be an important factor in the development of LBP [3]. One of the main concerns in manual materials handling (MMH) tasks is lifting loads, as this activity is present in most jobs [4]. Three most common techniques for lifting are as follows: 1) the squat lift, with the knees deeply flexed at the start of the lift and the trunk held as erect as possible; 2) the stoop lift, with the knees fully extended and the trunk flexed at the beginning of the lift; and 3) the semi-squat, an intermediate position in which the knees are flexed but not as much as in the squat position. Despite the controversy about their effectiveness, belts are used in industry as either protective or assistive devices in manual load handling activities. The mechanism by which a lumbar belt decreases injury is unknown. Recent article reviews indicated a general lack of evidence indicating the benefits of wear-

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Table 1. Average age and physical characteristics of the subjects.

Age(y)	Height(m)	Weight(kg)	Body mass index(kg/m²)
23.65 (± 2.2)	162.05(± 5.5)	57.00(± 7.2)	21.73(± 1.7)

Standard deviations are in parentheses.

ing belts in industrial and occupational settings [5-8]. As some articles showed, belts may prevent back pain by an increase in abdominal pressure, thus decreasing the force required by the back muscles [9], an increase in spinal rigidity by limiting end range movement, thereby minimizing shearing forces [10], or an increased proprioceptive awareness [10, 11]. No article yet investigates the effect of back belt through balance parameter. Assessment of human postural or balance control is of frequent interest to researchers and clinicians. Many variables have been developed from force platform signals to quantify postural steadiness. Center of pressure (COP) is the most common variable and is defined as the point of application of the ground reaction forces under the feet [12]. The COP can be directly computed from force platform measurements.

Table 2. Reliability of COPMD.

	Average ICC	Lower bound	Upper bound	SEM
Squat	0.89	0.57	0.97	0.54
Semi-squat	0.87	0.67	0.94	0.68
Stoop	0.92	0.69	0.98	0.62

The aim of the present investigation was to determine whether a commonly used back belt can improve maximum center of pressure displacement (COPMD) and center of pressure velocity (COPV) as the balance parameters during each of the 3 common styles of lifting.

2. Materials and Methods

Participants

Twenty healthy female subjects participated in this study . Their ages ranged from 20 to 27 years (average 23.65 years). The characteristics [age (23.65 (± 2.2)), height (162.05 (± 5.5)), weight (57.00 (±7.2)), BMI (21.73(± 1.7))] of subjects are presented in Table 1. Participants were recruited from students of Tehran University of Medical Sciences (TUMS). They were excluded from the study if they reported history of musculoskeletal injury and or surgery, cardiovascular disease, neurologic disease, and history of back pain since six months ago. The subjects were informed of the experimental protocol and given the written consent form prior to their participation. The study and consent forms were approved by the Ethics Committee of TUMS.

Experimental design

This study is a kind of interventional study. All tests were performed in the motor control and biomechanics lab of TUMS. Each participant visited the lab two times; the first time for familiarization with the tests and completion of an informed consent and the second time for performing the main tests. The experiment consisted of squat, semi-squat, and stoop lifting, with and without back belt (6 tasks). Many types of lumbar belts with various designs are available. The belt used in our study is a lumbosacral belt with straps crossing at the back and fastened in front and had 4 pliable support splints at the back for extra stability. This kind of belt was selected due to our familiarity with and its availability. The order of lifting techniques was randomized between subjects to minimize the effects of learning. Half of the subjects performed the 3 trials with wearing the belt first and the other half performed the trials without wearing the belt first.

Subjects lifted a box, weighting 4.53 kg (10 Pounds), which corresponds to a lifting index of 1 according to 1994 NIOSH1-Recommended Weight [4] and is suggested to ensure a low risk lifting [13]. The box was placed 30 cm in front of their toes for semi-squat and stoop lifting, and 45cm for squat lifting, with two handles placed symmetrically 15 cm above the floor. Outlines

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1. US National Institute for Occupational Safety and Health(NIOSH)

Table 3. Results for 1-way ANOVA with repeated measures of COMMD and COPV.

	Sum of squares	df	Mean square	F	Sig.	Observed power
COMMD	29.45	1	29.45	12.76	0.002	0.923
COPV	61.74	1	61.74	5.88	0.025	0.634

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of their feet were traced to ensure that foot placement was constant across trials. The participants stood barefoot on the force plate, their ankle joint lined up along the mediolateral axis of the force plate. They performed symmetrical lifting movements at a self-selected lifting velocity. The subjects were instructed to bend their knees (squat) or their lumbar (stoop) or both their knees and lumbar (semi-squat), to grasp the box handles, and to lift the load to a greater trochanter height. The full sequence was practiced 2 to 3 times until the subject indicated that she was comfortable with the procedure. Subjects rested approximately 2 minutes between each trial to minimize the possibility of fatigue.

Data Collection and Analysis

A 6 channel strain gauge force plate (Bertec Columbus, Ohio, USA) collected ground reaction forces and torques in 3 planes. Anteroposterior (AP) and mediolateral (ML) displacement of COP were measured along the Y and X axes of the force platform, respectively. Recordings always lasted for 10 seconds (according to pilot study such duration was enough for finishing each of the trials). Data were stored on a computer for off-line analysis. COP velocity was calculated using a program written in Excel environment and reflected the displacement of COP from onset of the motion toward maximum displacement per its time epoch. Sampling frequency was 1000 Hz. All signals were filtered (cut off frequency of 10 Hz, fourth order Butterworth filter) and stored. All 6 tasks (3 lifting type × 2 belt condition) were performed 3 times to test for reliability. Intraclass Correlations Coefficient (ICC) was used to determine the reliability of the force plate measures for each task. The data of the third repetition have been analyzed (because of high ICC and familiarity effect, it seems the third repetition data were the best to analyze). After passing normality test of Kolmogorov-Smirnov, statistical analysis system software was used to compute 1-way analysis of variance (ANOVA) with repeated measures to test for differences in COPV and COPMD in anteroposterior direction. Significant statistical difference was set at a minimum of $P < 0.05$.

3. Result

An ICC between 0.8 and 1.0 was interpreted as almost perfect [14], thus ICC of COPMD in our study considered high (Table 2). One-way ANOVA with repeated measures results for COPMD ($df = 1$, $F = 12.76$, $P = 0.002$) and COPV ($df = 1$, $F = 5.88$, $P = 0.025$) are presented in Table 3 that showed 'Belt condition' significantly affected the dependent variables ($P < 0.05$). There was a trend of increase in the mean of maximum displacement and velocity in all 3 types of lifting (squat, semi-squat and stoop) after wearing belt (Table 4).

4. Discussion

The present study aimed to evaluate the effects of back belt on postural parameters in 3 common types of lifting with and without using belt. This study represents a first step toward investigating belt condition in different lifting styles through postural parameters. Clinicians often use postural-control assessments to evaluate risk of injury, initial deficits resulting from injury, and the level of improvement after intervention for an injury; these assessments can be conducted with instrumented

Table 4. Average COPMD and COPV.

	Displacement	Velocity
Squat without belt	9.78(1.8)	2.86(0.8)
Squat with belt	10.95(1.4)	3.26(0.7)
Semi-squat without belt	7.25(2.1)	8.34(3.9)
Semi-squat with belt	7.7(1.8)	9.09(3.4)
Stoop without belt	6.00(2.0)	8.19(3.4)
Stoop with belt	7.32(2.5)	11.35(6.6)

Standard deviations are in parentheses.

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equipment such as a force platform [15]. The results of this study demonstrated that there was a significant trend of increased COPMD and COPV as postural-control parameters, in 'Belt condition'. A higher degree of movement of the COP determine an increase in postural instability [16]. According to this, our study suggests that this belt may not help individuals to have more stabilized posture, which may be considered as an effective feature of back belt. These results are in agreement with recent reviews showed a general lack of evidence indicating the benefits of wearing lifting belts in industrial and occupational settings [5-8].

In sum, the results indicate that back belt may not control maximum COP displacement and its velocity as postural-control parameters, thus may decrease stability.

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