DO INDUSTRIAL BACK BELTS REDUCE STRESS IN ASYMMETRIC LIFTING?

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ABSTRACT

The systemic effects of wearing an industrial back belt for a repetitive asymmetric lifting task between knee and waist height have been investigated. Belt wearing significantly reduced the average heart rate by 5.3 beats per minute, constituting 21% reduction of the metabolic cost due to the exercise. Back belt significantly reduced the average systolic blood pressures by 9 mm of Hg. For manual material handling activities that require mild torso flexion, back belt seem to produce a favorable effect.

KEY WORDS: Back belt, manual lifting, physiological stress, heart rate, blood pressure

1. INTRODUCTION

During the last two decades use of back belt as a measure to combat back injury problems became increasingly popular in industry. However, controversy regarding the effectiveness of back belts in preventing back injuries to uninjured workers has still remained unresolved.

Several mechanisms of lower back injury reduction through the use back belts have been proposed and investigated [1]. The main risk factor for occupational lower back injury is the large lumbar compressive force that develops primarily due to the co-contraction of muscles to stabilize the trunk during manual material handling (MMH) activities. It has been proposed that a back belt can act as external passive trunk stabilizer, and thereby it may reduce the need of the co-contraction of the back muscles and lumbar compressive force. Additionally, the presence of back belt has been proposed to boost the intra-abdominal pressure (IAP), which in turn can reduce the trunk muscular activity and lumbar compressive force. Furthermore, back support belt can alter the spinal motion at the lower back, by directly restricting bending and twisting of the lower back. A large number of laboratory based biomechanical studies have investigated these localized effects, such as, spine kinematics, IAP, electromyography (EMG) of the back muscles, lumbar compressive force, and spinal stiffness for a variety of MMH tasks. Based on a systematic review and meta analysis of the results from 33 selected studies on the mechanism of action of back belts in MMH activities, Van Poppel et al [2] concluded that the existing studies provide evidence of reduction trunk motions for flexion-extension and lateral bending, but the studies did not produce enough evidence that back belts reduce trunk rotation or EMG activity of back muscles or increase IAP.

Comparatively fewer number of laboratory based studies have investigated systemic responses in terms of physiological and psychophysical stress relieving effects of industrial back belts [3-13]. None of the studies have found any significant reduction of heart rate (HR) [3,4,5] or rating of perceived exertion (RPE) [4,5] or discomfort ratings [5,6] due to back belt use. Marley and Duggasani [4] have noted a significant increase in both systolic blood pressure (SBP) and diastolic blood pressure (DBP), whereas, Rafacz and McGill [7] noted an increase in DBP due to belt effect. Increase in DBP and SBP was small (3 – 5 mm of Hg), but it has initiated the speculation on detrimental effect of back belt for the workers with hypertension. Bobick et al [3] did not find any effect on DBP or SBP. Among the positive belt effects, four studies [8-11] have found increase in the maximum acceptable weight of lift (MAWL) by roughly 1 kg when back belt was used, which is indicative of lesser stress perception by the subjects when wearing back belt. Reyna et al [11] found no effect in terms of functional lift capacity, but noticed belt increased peak torso torque production capacity at lower flexion angles. End of exercise surveys [6,9,12] have established that the subjects strongly believe that belt has a positive protecting effect. In a recent well controlled study with 33 experimental subjects, Bobick et al. [3] have observed a statistically significant reduction in oxygen consumption rate (VO2) by 0.051 liters/min. VO2 is strongly correlated with muscular work intensity, and thus indicates the stress relieving characteristic of back belt. However, Marley and Duggasani [4] and Duplesis et al [13] have not noticed any change in VO2.

One common factor for all of the above studies [3-5,7-12] that measured systemic stresses, the experimental MMH tasks involved lifting from floor or pallet level using either free-style [3], stoop [5,12,13] or squat [4,5,7,10,13] lifting, with [3] or without axial twist [4,5,7-12]. Irrespective of the lifting style employed, lifting from floor level requires a considerable reduction of the angle between thigh and torso, which should actually be resisted by the presence of the belt. The metabolic cost to overcome this extra resistance may exceed the possible saving of the torso stabilizing muscular work provided by the belt. Material handling situations that require mild torso flexion are not uncommon in industry. The grocery store check-stand operators, package delivery workers, hospital workers and warehouse workers perform handling tasks where the lift originates near waist level. Only two studies [8,11] investigated lifting between knuckle and shoulder level in terms of MAWL and maximum lift capacity. Even though the effects are found not statistically significant, belt effect increased the MAWL [8] and peak torque production capacity at low torso flexion angle [11]. Objective of this study is to investigate the effect of back belt in for an asymmetric manual material handling task performed with mild flexion at the waist level.

2. METHODS AND MATERIALS

Eight female participants with no known musculoskeletal or cardiovascular history participated after signing off an informed consent. The mean (standard deviation) of age, height, and weight were 25(10) years, 166(13) cm, and 74(12) kg, respectively. Each volunteer participated in two experimental sessions - with and without belt in randomized order, lasting for about one hour on two separate days. The belt and no-belt sessions were separated by at least two days of interval between them, to avoid any carryover muscle pain from the previous exercise session.

The experimental setup was consisted of a table set at 80 cm height, and a small platform at 31 cm height from floor, which corresponded to the average female standing elbow height and average female knee height after adding the cut out handle height (20 cm) of a plastic milk crate (30 cm x 30 x 25 cm). The horizontal distance of the move was one meter. The orientation of the table and platform required an approximately 60 degrees angle of axial twist for the participants, who were instructed not to shift their feet during the exercise. Participants transferred the plastic crate from the table to the platform at a rate of three lifts per minute for 20 minutes. The crate was brought back to table and positioned at the starting position by a research assistant at the end of each transfer by participants. To keep the relative stress level constant, the weight of the crate was adjusted to the MAWL for each participant. On the first day of the trials, the participant was instructed to determine her maximum load limit that she would be able to handle for a 1 hour continuous work at a rate of 3 lifts per minute while performing the experimental task without wearing the belt. The procedure followed to determine the MAWL was similar to that used by McCoy et al. [9]. Once the MAWL was determined, the same weight was used in both trials. MAWL for all participants varied between 9 to 12 Kg.

The belt used in the experiment was a commonly used elastic industrial back belt (Safe-T-Lift, FLA Orthopedics, Inc.). Small, medium or large sizes of the belt were used according to the waist measurement of the participants and belts were fitted to the participants according to the manufacturer's instruction. Omron digital blood pressure monitor was used to record DBP/SBP at rest and immediately after the completion of the 20 minutes of the exercise. The HR was recorded at rest, during every 1 minute for 20 minutes of exercise time, and during the recovery period using a Cateye PL-6000 HR monitor. It uses an optical sensor attached to the earlobe to count the pulse rate. A diagram was used to rate of body discomfort in a scale of 1 to 10, and administered immediately after the completion of each exercise sessions. A set of questionnaire was prepared to assess the back support belt effectiveness similar to the questionnaire used by McCoy et al. [9] and was administered at the completion of both trial sessions.

3. RESULTS AND DISCUSSION

The average working HR from the last 10 minutes of exercise, DBP and SBP in mm Hg taken immediately after the MMH task for all participants for no-belt and belt conditions are shown in table 1. Six participants experience a reduction of HR for the belt condition. The overall average HR's for all participants were 96.2 and 90.9 beats per minute (bpm) for no-belt and belt conditions, respectively, which constitutes an average reduction of 5.3 bpm from the no-belt condition. A one tailed matched paired t-test of the difference of HR revealed a significant decrease ($p = 0.035$) for wearing belt.

For most of the participants the change in DBP was not appreciable between the two conditions, with an exception of the participant #8, for whom the DBP was reduced by 20 mm Hg. SPB was lesser in case of belt condition for six of the eight participants, with the participant 7's SBP showing considerably lesser (34 mm Hg) in case of belt condition. The overall samples means for DBP/SBP were 67/114 for no-belt condition and 64/106 for belt condition, respectively. Thus the belt condition reduced DBP and SBP by 3 and 8 mm of Hg, respectively. A one-tailed matched pair *t*-test revealed that the reduction in DBP was not significant ($p = 0.156$) but the reduction in SBP was statistically significant ($p = 0.039$).

For the combined discomfort ratings for both no-belt and belt conditions, the lower back had the highest average score of 2.25, followed by the knees and upper back with score of 1.0, arms at 0.81 and shoulders at 0.75. The average discomfort rating for the lower back while wearing a belt was 2.4 versus no belt was 1.875. No systematic or significant changes in body discomfort pattern were observed between no belt and belt conditions.

The seven questions, elicited a strong favorable perception of the participants towards usefulness of wearing of back belt. Table 2 displays all questions, along with the scoring hints used and the average scores.

Table 1. Physiological responses for no-belt and belt conditions for the MMH task

Participants	Heart Rate (BPM)			DBP (mm Hg)			SBP (mm Hg)		
	No-belt	Belt	Diff	No-belt	Belt	Diff	No-belt	Belt	Diff
1	96.3	89.8	6.5	64	60	4	104	96	8
2	86.3	86.3	0	62	59	3	103	97	6
3	115.4	100	15.4	70	66	4	116	102	14
4	85.8	82.7	3.1	65	71	-6	103	111	-8
5	77.2	82.2	-5	69	67	2	108	97	11
6	107.9	93.7	14.2	65	63	2	107	101	6
7	90.3	82.6	7.7	56	60	-4	132	98	34
8	110.4	109.7	0.7	84	64	20	142	143	-1
Average difference (μ)			5.3			3			9
Standard deviation (s_d)			7.1			7.8			12.3
t-statistic ($\mu * \sqrt{8}/s_d$)			2.12			1.09			2.07
P-value of t-test (df = 7)			0.036			0.156			0.039

This study employed a repeated measure design, and thus the systemic metabolic cost allowed us to detect the changes in lifting muscle activities. The lifting muscles make a small parentage of the total body muscle mass contributing to the metabolic changes; as a result the change of metabolic cost is expected to be a small percent of the total metabolic cost. The significant reduction of HR (5.3 bpm) is indicative of reduced muscular work either due to increased passive stabilization of the torso and/or due to increased IAP induced by the action of the back belt.

Table 2. Average scores of the participants for the questionnaire eliciting their perception about the back support belt

Number	Questions and the scoring hints used	Average Scores
1	How would you rate the help given by the belt? No help (1), Some help (3), Total support (5)	4.0
2	Did you find the belt was making you too hot or uncomfortable? Not at all (1), Some what (3), Very uncomfortable (5)	1.4
3	Did the belt cut off any blood circulation? No (1), Maybe (3), Yes (5)	1.5
4	Did you feel the test time was too long to wear the belt? Not at all (1), Indifferent (3), Yes it is (5)	1.1
5	How long do you speculate the belt would remain comfortable? Less than 1 hour(1), Several hours (3), All day (5)	3.5
6	How restrictive was the belt during the exercise? Not at all (1), Somewhat (3), Very restrictive (5)	2.1
7	If your job required extended periods of manual material handling, would you choose to wear this belt if your employer made it available to you? No (1), Maybe (3), Yes (5)	4.6

The average working stress in terms of HR (working HR – resting HR) due to the MMH task without belt in our study was 27 bpm. The average reduction of 5.3 bpm due to the belt constitutes 20% reduction of the working stress, which is quite significant. Similar reduction of metabolic stress was found by Bobick et al. [3] for systemic VO2. In their study, the working VO2 increased from resting level by 478 ml/min and the reduction due to belt was 51 ml/min, which constituted 11% reduction in work stress due to the back belt. Muscular work intensity induces increase in SBP and DBP. Thus a reduction in SBP in this study is also indicative of lesser muscular work in belted condition. No change in DBP is similar to the finding by Bobick et al.[3]. Marley and Duggassani [4] found increase in DBP/SBP for higher intensity of work but found no effect for tote box weighing 7 Kg and lift frequency of 3 lifts/min. Rafacz and McGill [12] found increase in DBP for a set of isometric tasks, dynamic tasks and a MMH task, however, the specific effect for the MMH task was not reported. The strong favorable perception of the participants about the protective effect of the belt was similar to the previous studies [6,9,12]. Previous investigators found no change in body discomfort rating similar to this study [5,6].

Based on the finding of this study and previous studies based on systemic stress, it appears that industrial back belt might provide muscular stress relieving effects at the lower back, and may help in reducing incidence of occupational back pain from light MMH tasks in industry. Further investigations are needed with combinations of different work intensity and work elevations.

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