นิพนธ์ต้นฉบับ
(Original article)

Effects of back belt wearing and experience in back belt usage on maximum acceptable weight of lift in male workers: psychophysical approach

ผลของการใส่และประสบการณ์ในการใช้เข็มขัดรัดหลังต่อน้ำหนักที่เหมาะสมสำหรับการยกในคนงานชาย: ประเมินโดยวิธีไซโคฟิสิกส์

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ABSTRACT: The purpose of this cross-sectional study was to investigate the effects of back belt wearing and experience in back belt usage on the maximum acceptable weight of lift (MAWOL) determined by psychophysical approach. Thirty male workers aged between 18-30 years old were recruited. Fifteen were non-experienced (NE) and the rests were experienced users (E) of back belts. MAWOL, heart rate (HR) and rating perceived exertion (RPE) at a lifting frequency of 4.3 times/min were determined. Back belt wearing and experience in back belt usage had significant effects on MAWOL. The results of the experiment found that back belt wearing can significantly increase MAWOL by 8.7 % and 12.0 % in the NE and the E group, respectively. The MAWOL of the E group was significantly higher than that of NE both in non-back belt (NB) and back belt wearing (WB) conditions. The E group had significantly lower heart rate than that of the NE group when MAWOL was determined. Even though, back belt wearing can increase weight of lift and decrease heart rate, these results should be used with cautions. Workers might have false senses of security which could lead to low back injuries.

Keywords: Back belt; Experienced users; Psychophysical; Maximum acceptable weight of lift (MAWOL)

บทคัดย่อ: การทดลองภาคตัดขวางนี้มีวัตถุประสงค์เพื่อศึกษาผลของการใส่เข็มขัดรัดหลังและประสบการณ์การใส่เข็มขัดรัดหลังต่อน้ำหนักสูงสุดที่ยกได้ (MAWOL) โดยการประเมินการไซโคฟิสิกส์ คนงานชาย 30 คนอายุระหว่าง 18-30 ปี แบ่งเป็นกลุ่มที่ไม่มี (NE), จำนวน 15 คน และมีประสบการณ์ (E) 15 คน ในการใช้เข็มขัดรัดหลัง MAWOL อัตราการเต้นหัวใจ และ ความเหนื่อย (RPE) ถูกวัดที่ความถี่ของการยกที่ 4.3 ครั้ง/นาที ผลการทดลองพบว่าการใส่เข็มขัดรัดหลังและประสบการณ์การใส่เข็มขัดรัดหลังมีผลต่อ MAWOL การใส่เข็มขัดรัดหลังสามารถเพิ่ม MAWOL ได้ร้อยละ 8.7 และร้อยละ 12.0 ได้ ในกลุ่ม NE และ E ตามลำดับ ค่า MAWOL ของกลุ่ม E มีค่ามากกว่ากลุ่ม NE อย่างมีนัยสำคัญทางสถิติ อัตราการเต้นหัวใจของกลุ่ม E มีค่าน้อยกว่ากลุ่ม NE แม้ว่าผลการทดลองจะแสดงว่าการใส่เข็มขัดรัดหลังและประสบการณ์สามารถเพิ่มค่า MAWOL ได้ แต่ควรนำไปใช้อย่างระมัดระวังเพราะอาจทำให้คนงานรับรู้ความรู้สึกปลอดภัยที่ผิดพลาด นำไปสู่อาการบาดเจ็บของหลังได้

คำสำคัญ: เข็มขัดรัดหลัง; ประสบการณ์ในการใช้; ไซโคฟิสิกส์; น้ำหนักสูงสุดที่ยกได้

1. INTRODUCTION

Exposure to manual material handling (MMH) activities is considered to be a risk factor of low back disorders[1]. Lifting is the most frequent activities among MMH; therefore, it has been widely studied in many aspects. Apart from biomechanical and physiological analysis, the psychophysics is a methodology that can also be used to examine lifting tasks[2]. When applying psychophysical approach, individuals need to identify a specified level of perceived sensation. In a lifting task, the result will be the maximum acceptable weight of lift (MAWOL)[2].

Lumbar supports are frequently used in low back disorder clients to support their backs and to limit the back range of motions. Various workplaces have applied lumbar supports or back belts as equipment for prevention of low back disorders[3]. Kraus et al.[4] compared the low back injury rate of 36,000 retail workers before and after mandatory back belt policy periods (6 years). They reported that back belt wearing reduced the incidence of low back injuries by 34%. Wassel et al.[5] studied the incidence of low back injuries and self-report low back pain among 13,873 manual material handling workers and also found the positive results of back belt wearing. In contrast, when controlling for potential confounding factors, many researchers found the back belt implementation could not reduce the incidence of back injury claim[6]. A study by Cochrane Back and Neck Group revealed that back belts are not more effective than training or no intervention in preventing low back disorders[7]. However, many industries still use back belts and distribute them to MMH workers.

There are few studies related to psychophysical approach and back belt wearing during lifting and the results are still controversial[8-10]. Long term effects of back belt wearing on biomechanics and back muscle activities have been extensively studied. Previously, there have been no study related to long term effects or experience of back belt usage on MAWOL. Therefore, this study attempted to determine effects of these 2 factors, i.e., 1) back belt and non-back belt wearing and 2) experience in back belt usage on MAWOL determined by psychophysical methodology.

2. METHODS

2.1 Subjects

Thirty male workers aged from 18-30 years old from department stores around Bangkok area participated in this study. All subjects worked as manual material handling workers for at least 1 year. Fifteen subjects who usually wore back belts for at least 6 hours/day were classified into experience (E) in back belt usage group, while the rest (n=15) were categorized to non-experience (NE). Subjects who had heart diseases, hypertension, diabetes, and musculoskeletal diseases which could affect lifting capacity were excluded.

2.2 Instrumentation

A 31.5x 24x27.5 (cm) wooden box and 72.8 cm height shelf were used to determine maximum weight of lift (MAWOL) from psychophysical lifting tests[11]. This height of the shelf (approximately at knuckle height) was determined from the database of Thai male stature at 50 percentiles. A pulley system was attached to the wooden box in order to lowering the box back to the starting point on the floor (Fig. 1). Iron pieces at different weights were used for subjects to adjust the box's weight. A scale (Detecto®, USA) and a Polar interface plus® were used. Three different sizes (M, L and XL) of stretch back belts (Valeco, Thailand) were worn by subjects according to their waist sizes.

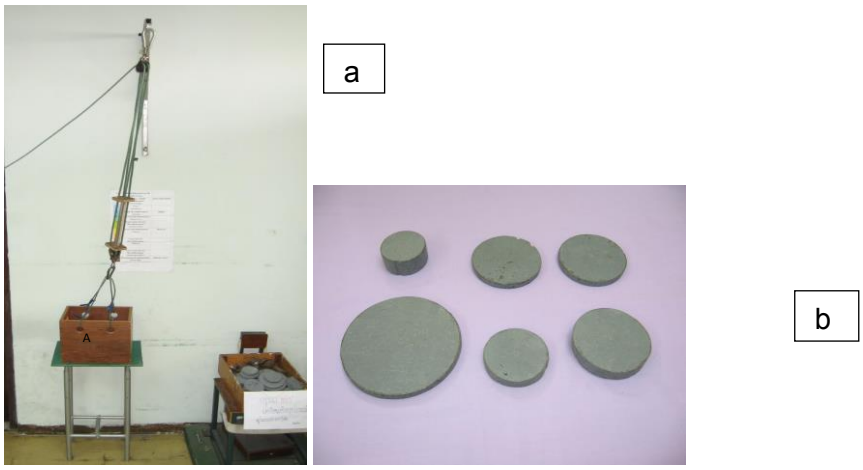

Fig. 1 Instruments for determining maximum acceptable weight of lift (MAWOL); a wooden box, a 72.8 cm height shelf, a pulley system (a) and iron pieces (b)

2.3 Procedure

Inform consents were signed. Height and body weight of the subjects were determined. Lifting tasks with or without back belts were randomized. Each task was separated by at least 1 day and not more than 6 days

Subjects were required to wear comfortable clothes and lifted in a room which its temperature was maintained between 25–28°C. The initial weight of lifts was randomized from light (5 kg) and heavy one (20 kg). The box weight was adjusted by different pieces of iron. Subjects wore a Polar® and a back belt or no back belt before lifting procedure. Subjects started lifting the box from the floor to the 72.8 cm height shelf (floor to knuckle height) with frequency of 4.3 lifts/min or every 14 seconds by following beep sounds from a tape recorder. After each lift, the box was brought back from the shelf to the floor for the next lifting by the wall pulley system.

Subjects were asked to determine their maximum acceptable weight of lift (MAWOL) by adding or took off iron pieces to adjust the box's weight. While the box's weight was adjusted, subjects was instructed to lift without "straining or becoming unusually tired, weakened, overheated, or out of breath". Each subject continued to lift and adjusted the box's weight to obtain the MAWOL within 20 minutes. After a ten minutes break, subjects started the second set. If the initial weight of the first set was the light one (5 kg), then the second set of the initial weight would be the heavy one (25 kg) and vice versa[2].

At the end of each period, weight of the box was measured by the scale (Detecto®, USA) and recorded. Weights from the two sets (light and heavy) was averaged to obtain the MAWOL. Rating of perceive exertion (RPE) at the scale of 6-20 each task was asked immediately after finishing the lifting task. RPE from the 1st and the 2nd sets of lifting tasks were averaged.

Each subject performed lifting for the 2 tasks (wearing and not wearing a back belt) in a random order within 6 days. In each day, MAWOL was collected for each subject. Subject's heart rate was continuously monitored and recorded throughout the time of the test.

2.4 Statistical analysis

Kolmogorov Smirnov Goodness of Fit Test was used to test for distribution of the data. Independent t-test was used to compare subjects' characteristics between non-experienced and experienced back belt usage groups. To test the effect of experience in wearing back belts and back belt wearing conditions on MAWOL, heart rate and RPE, two-way mix analysis of variance (ANOVA) was used. The significance level was set at 0.05.

3. RESULTS

Means and standard deviations of subjects' characteristics (age, body weight, height, and body mass index) of non-experience (NE) and experience (E) in back belt usage were shown in Table 1. An independent t-test showed no significant differences of these characteristics between the NE and E groups.

Table 1 Comparison of subjects' characteristics between non-experience (NE) and experience (E) in back belt wearing groups (mean ± SD)

Characteristics	Non-Experience (NE) (n=15)	Experience(E) (n=15)	*p*-value
Age (yr)	24 ± 2.33	24.07 ± 3.03	0.947
Height (cm)	171.6 ± 3.71	171 ± 5.24	0.720
Weight (kg)	63 ± 7.10	62.8 ± 5.57	0.932
BMI (kg/m^2)	21.38 ± 2.17	21.38 ± 1.45	0.897

Table 2 shows means and standard deviations of MAWOL, heart rate and RPE of NE and E groups separated by NB and WB conditions. It is noted that MAWOL of both NE and E groups increased by back belt wearing condition by 8.7% and 12.0%, respectively (NB vs. WB = 12.17 vs. 13.63 kg for NE group and NB vs. WB = 15.8 vs. 17.18 kg for E group). When compared between NE and E groups, it was found that E group had higher MAWOL than NE group, whereas HR was lower in the E group. There are no differences in heart rate and RPE between NB and BW conditions in both NE and E.

Two-way mixed repeated measured ANOVA were used to determine effects of back belt wearing conditions and experience in back belt usage on MAWOL, HR and RPE (Table 3). It was noted that both factors had significant effects MAWOL with no interaction. For HR, experience in back belt usage had a significant effect while no significant effect of back belt wearing was demonstrated. No significant effects of both factors on RPE.

Table 2 Mean and standard deviation of Maximum acceptable weight limit (MAWOL), heart rate and Rating Perceived Exertion (RPE) during lifting tests with Non-Back Belt (NB) and Back Belt Wearing (WB) conditions in Non-E (NE) and Experience (E) of back belt usage groups

Groups and conditions	MAWOL(kg)		Heart rate (beats/min)		RPE	
	mean	SD	mean	SD	mean	SD
Non-Experience (NE) (n=15)						
Non-back belt wearing (NB)	12.16	3.58	100.23	12.06	10.80	0.88
Back belt wearing (WB)	13.63	3.60	100.46	11.43	10.46	0.55
Total	12.89	3.55	100.35	11.35	10.63	0.73
Experience (E) (n=15)						
Non-back belt wearing (NB)	15.80	2.13	89.63	7.31	10.23	0.46
Back belt wearing (WB)	17.18	3.13	93.00	8.86	10.40	0.68
Total	16.49	2.68	91.31	8.02	10.31	0.56

Table 3 Two-way mixed repeated measured ANOVA results: effects and interaction of back belt wearing and experience in back belt usage on MAWOL and heart rate

Factors	Variables					
	MAWOL		Heart rate		RPE	
	F	p-value	F	p-value	F	p-value
Back belt wearing (NB vs. WB)	13.41	0.001*	2.73	0.109	0.26	0.608
Experience in back belt usage (NE vs. E)	10.81	0.003*	6.56	0.016*	0.04	0.092
Back belt wearing × Experience	0.12	0.915	2.07	0.161	2.42	0.131

4. DISCUSSION

The results of this study support the effects of back belt wearing and experience in back belt usage on MAWOL. For back belt wearing condition, it can increase maximum acceptable weight of lift (MAWOL) by 8 and 12% in both non-experience and experience back belt usage, respectively. The results are in accordance with the study by McCoy et al.[8]. They found that wearing back belts could increase the MAWOL by approximately 19 % when compared to the control (no belt). However, other two studies[9, 10] did not support our findings and reported no effects of back belt wearing on MAWOL. In this present study and McCoy et. al.[8], only male subjects participated to determine MAWOL, whereas studies by Reyna et al.[9] and Lavendar and Kenyari[10] included both male and female subjects. A study by Jackson and Sekula[12] examined the effects of strength, and gender on psychophysical lift capacity of 209 men and 181 women. They found that gender account for considerable variability in psychophysical lift capacity. Therefore, it is possible the combination of gender in Reyna and Lavendar studies would affect the determination MAWOL.

This would explain the differences between the present study results and their studies. Further studies in the issue are warranted.

This study discovered that subjects with experience in back belt usage had higher MAWOL than that of the in-experience group both with back belt and non-back belt conditions. This might be the effect of long-term training or usage of back belts. As stated earlier in the effects of back belt on MAWOL, it is possible that this experience group accustomed to heavy weights which they had to lift on daily basis when compared to lower loads in in-experience group. Adaptations to resistance or overload are commonly apparent after 8 to 12 weeks[13, 14]. According to the inclusion criteria the experience group had at least 6 months of back belt usage which was long enough for the adaptions.

This study also found that back belt wearing had no significant effects on heart rate and perceived exertion (RPE). Many studies also found no significant effects of belt wearing on heart rate[15-17]. For RPE, a study determined perceive exertion during lifting two different loads at 3 frequencies[16]. Subjects in their study did not perceive less exertion in lifting with back belts versus non-back belt wearing. Their findings are confirmed by the result of the present study.

This study found that experience in back belt usage group showed lower heart rate than the in-experience group during MAWOL. This means the experience group have higher cardiovascular fitness than that of the in-experience group. Higher MAWOL in experience group might explain the above result. At work, experience group can lift heavier weight than non-experience group. They may also lift at higher frequency than the frequency which was set at our experiment (4.3 lifts/min). Mital et.al.[18], measured physiological responses at MAWOL with high (up to 16 lifts/min) and very high frequency (> 16 lifts/min). They found that at these frequencies of lift, the metabolic costs were between 52-57% of their maximum aerobic capacity. It is possible that at work, experience workers lifted heavier workloads and higher frequencies than our experiment setting. Therefore, cardiovascular adaptation might be more prominent in experience group which load of lift were heavier than non-experience group. Their heart rate may become lower because of the day to day lifting of heavy loads. Further investigations to compare the cardiovascular fitness between experience and non-experience are needed.

Some limitations of this study should be concerned. Firstly, various characteristics of subjects including aerobic capacity, muscle strength and endurance were not measured. These variables might be used for further explanations of the differences in MAWOL and heart rate between NE and E group. Secondly, all subjects were volunteers. The study did not randomly select subjects from the MMH population. Considering the limitations of this study, these results must be interpreted with caution.

This study supports the hypothesis that wearing and long-term usage of back belts can increase acceptable weight of lift. Workers may have false feeling of security when wearing back belts. They may attempt to lift heavier load which may lead to injuries.

In conclusion, back belt wearing and experience of back belt usage increase maximum weight of lift. Experience users have lower heart rate when lifting compared to the non-experience users of back belts. No changes in RPE was found by this psychophysical methodology. Short and long term wearing of back belts can lead to injuries from heavy load lifting from this false feeling of security.

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