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# Effects of back belt on vertical load transfer among adults with non-specific low back pain during asymmetrical manual load carrying

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ABSTRACT

The aim of this study was to examine the effects of a back belt on vertical load transfer in terms of carrying using a single dominant hand, lumbopelvic muscle strength, and perceived difficulty in performing an active straight lower limb raise (ASLR) test among adults with non-specific low back pain (NSLBP). A total of 20 adults with NSLBP and 20 matched individuals without low back pain (LBP) participated in this study. Vertical load transfer was measured via a Matscan pressure assessment system for both standing and walking scenarios while carrying incremental loads. Lumbopelvic muscle strength during prone hip extension (PHE) test was assessed using a handheld dynamometer. Perceived difficulty in performing the ASLR test was measured with a 6-point Likert scale. A three-way ANOVA was conducted to examine the effects of vertical load transfer. Lumbopelvic muscle strength and perceived difficulty were analyzed using a two-way ANOVA. The results demonstrated an increase in vertical load transfer, increased lumbopelvic muscle strength, and decreased perceived difficulty in performing ASLR test with use of a back belt. The findings suggest that the use of a back belt in adults with NSLBP may improve vertical load transfer during load-carrying tasks, maximize lumbopelvic muscle strength, and decrease perceived difficulty in performing a task. This is relevant to industry, as use of a back belt is an option for industrial workers with NSLBP during manual load carrying to optimize vertical load transfer and personal comfort.



## 1. Introduction

Manual material handling tasks such as carrying and lifting are known risk factors for low back pain (Arjmand et al., 2015; Chow et al., 2014; Jaap et al., 2003; Yang et al., 2002). Generally, the load from the body is transferred between the trunk and lower limbs, then dispersed to the feet during activities of daily living (Eichenseer et al., 2011; Snijders et al., 1993). Alterations in load transfer may result in overloading of lumbopelvic tissues and contribute to lumbopelvic instability and low back pain (Eichenseer et al., 2011; Snijders et al., 1993).

Asymmetrical manual load carrying of items such as shopping bags and briefcases is an ineffective method. Past studies have reported that carrying a load using a single hand causes the upper body to shift to the opposite side for compensation (Rohlmann et al., 2000). Alterations of vertical load transfer due to carrying or lifting loads have also been reported (Goffar et al., 2013; Pau et al., 2015). The opposing equal action of load transfer from the body is referred to as ground reaction force or vertical load transfer (Ledoux and Hillstrom, 2002). Increased loads will generate higher vertical load transfer due to the additional weight. For example, increased vertical load transfer has been reported during loaded gait (Castro et al., 2013). Similarly, an increase in vertical load transfer was demonstrated with an incremental increase of load (Birrell and Haslam 2009).

There is limited information regarding vertical load transfer during carrying loads using a single dominant hand, particularly in terms of changes in plantar pressure (PP), maximum force (MF) and contact area (CA). Force is described as the interaction between two bodies or the body and its environment whereas pressure is the measure that analyzes the distribution of the force across a surface

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area (pressure equals force divided by area) (Orlin and McPoil, 2000). Contact area refers to the level of surface contact between the plantar surface of the foot and a sensor (Orlin and McPoil, 2000). The association between vertical load transfer and lumbopelvic muscle strength remains unclear.

The lumbopelvic region is a potential source of LBP (Hodges and Richardson, 1997, 1999). For example, activities of daily living such as rotation and bending over requires movements of the lumbopelvic region in a range of environments with a complex interaction between internal and external forces (Harris-Hayes et al., 2009). Movement impairments in this region can lead to increased forces and stresses in the surrounding structures resulting in low back pain symptoms (Hodges and Moseley, 2003). Lumbopelvic muscle strength is attained through the self-locking mechanism of the pelvis through the anatomy of the pelvic bones and the muscles supporting the pelvis (Snijders et al., 1993; Vleeming et al., 1990). Based on the theory of motor control, behavior is a process of controlling the results of motor outputs or can be called as the 'perceptual control theory' which describes behavior as a process of controlling the perceived results of motor outputs. Optimal pelvic stability, mobility, and neuromuscular performance of the lumbopelvic segments may be achieved when self-locking mechanisms of the pelvis and motor control system works collectively (Arumugam et al., 2012). However, when internal stability is insufficient, external supports such as back belts can be used to achieve lumbopelvic stability (Oh et al., 2007).

A back belt is worn by adults with low back pain as a preventive measure to overcome the worsening of back pain (Chiou et al., 2000). Initially, back belts were used to provide additional back support during rehabilitation of injuries in order to give users a feeling of control over low back pain (Chiou et al., 2000; Joubert and London, 2007). The idea of bracing using a back belt is intended to reduce pain in adults with low back pain (Kawchuk et al., 2015). Short-term bracing for adults with low back pain have shown to improve function and reduce pain as weight transfer through the brace increases stability and aid ambulation (Kawchuk et al., 2015). Despite the increased in popularity of the back belt as a preventive measure, its effectiveness remains uncertain (Ammendolia et al., 2005).

Therefore, the purpose of our study was to investigate changes vertical load transfer in terms of plantar pressure (PP), maximum force (MF) and contact area (CA) during asymmetrical load carrying, on lumbopelvic muscle strength and perceived difficulty in performing active straight lower limb raise (ASLR) test while wearing a back belt among adults with non-specific low back pain (NSLBP) and matched adults without LBP (MAWLBP). It was hypothesized that vertical load transfer, lumbopelvic muscle strength, and perceived difficulty in performing an active straight lower limb raise (ASLR) test would be altered following the application of back belt among adults with non-specific low back pain (NSLBP).

## 2. Methods

### 2.1. Participants

Forty volunteers (20 NSLBP and 20 MAWLBP) aged between 30 and 55 years participated in this study. Prior to data collection, participants were screened for normal body mass index (BMI) ranging from 18.50 kg/m$^2$ to 24.99 kg/m$^2$ to standardize the BMI of participants. MAWLBP group were recruited with similar weight, height, gender, and BMI. Thus, 20 NSLBP adults with the following anthropometrical characteristics (mean $\pm$ standard deviation): age 52.10 $\pm$ 13.88 years, weight 64.76 $\pm$ 8.77 kg, height 163.45 $\pm$ 6.63 cm; and 20 MAWLBP with the following anthropometrical characteristics (mean $\pm$ standard deviation): age 43.55 $\pm$ 14.57 years, weight 62.59 $\pm$ 8.73 kg, height 162.68 $\pm$ 5.40 cm, were tested. Adults with NSLBP were recruited from the orthopedic clinic of a university hospital. All participants were right-handed and right lower limb dominant. The inclusion criteria for adults with low back pain were: (1) presenting with NSLBP for more than 3 months; and (2) being able to walk without any assisting aids. The exclusion criteria for adults with NSLBP were (1) pregnancy; (2) past history of low back surgery; (3) surgical interventions in the lower limbs; (4) presenting with a history of acute low back pain with duration less than 6 weeks; (5) lower limb pain due to degeneration and arthritic diseases; (6) traumatic neuromuscular problems requiring hospitalization over the past 6 months; (7) presenting with radiating pain below the gluteal fold; and (8) scoring $\geq$7 in the visual analogue scale (VAS). Written informed consent was obtained from all participants prior to data collection. Ethical approval was granted by Research and Ethics Committee of Universiti Kebangsaan Malaysia (Research code NN-067-2014).

### 2.2. Measurements

#### 2.2.1. Vertical load transfer

Changes in PP (kPa), MF (% of body weight, %BW), and CA (cm$^2$) were measured using the Tekscan Mat Scan Pressure Assessment Systems, Sensor Matscan Version 6.3 (TekScanInc, South Boston, USA). This system has a floor mat embedded with sensors made up of over 2000 individual pressure-sensing locations which detect PP, MF and CA. The system consists of a 5-mm thick floor mat (432 $\times$ 368 mm). Each mat was calibrated individually for all participants before recording the study data. PP is the pressure applied to the entire foot, whereas MF represents the highest force value acting on the force plate while participants stand and walk. CA is the amount of surface contact beneath the entire foot when standing and walking.

#### 2.2.2. Prone hip extension (PHE) test

Lumbopelvic muscle strength was measured using a PHE test and the outcome was recorded using a microFET2 (Hoggan Scientific LLC, United States) hand held dynamometer (kilogram-force, Kgf), positioned on the hamstring muscle. MicroFET2 is an accurate and portable force evaluating and testing dynamometer designed to record objective, reliable, and quantifiable muscle testing data (Murphy et al., 2006). The PHE test was adapted from an established procedure by Janda (1983). The PHE test has good reliability for measuring muscular activation patterns in the lumbopelvic region (Janda, 1983; Murphy et al., 2006).

#### 2.2.3. Active straight lower limb raise (ASLR) test

The ASLR test is known to have good reliability, sensitivity, and specificity in examining load transferred between the pelvis and lower limbs (Mens et al., 2001). The outcomes for the ASLR tests were scored for each participant on a 6-point Likert scale: 0: not difficult at all; 1: minimally difficult, 2: somewhat difficult; 3: fairly difficult; 4: very difficult; 5: unable to do (Mens et al., 2002). This ASLR test was adapted from the protocol by Mens et al. (2002).

### 2.3. Application of back belt

The THUASNE Lumbar belt (Levallois- Perret Cedex- France) was utilized in this study. The belt consists of 2 parts, a main body belt and 4 elastic bands. The belt was applied around the waist, where the main body belt was located just below the anterior superior iliac spine (ASIS) (Arumugam et al., 2012). The four elastic bands were fastened firmly to the body belt to provide stability. Participants tightened the belt as comfortably as possible using their own