# Trunk Stabilizer Muscle Activity during Manual Lifting with and without Back Belt Use in Experienced Workers

Nopporn Kurustien MSc*,**, Keerin Mekhora PhD*,
Wattana Jalayondeja PhD*, Suebsak Nanthavanij PhD***

** Faculty of Physical Therapy, Mahidol University, Nakhon Pathom, Thailand*
*** Faculty of Physical Therapy, Huachiew Chalermprakiet University, Samutprakan, Thailand*
**** Engineering Management Program, Sirindhorn International Institute of Technology, Thammasat University, Pathumthani, Thailand*

***Objective:*** *The present study evaluated the changes in trunk-stabilizer electromyography (EMG) activities during manual lifting with and without a back belt in experienced back belt users.*
***Material and Method:*** *Eighteen participants from a warehouse and distribution center in Thailand, aged 22 to 44 years, were assessed for trunk stabilizer muscle EMG activity, including the rectus abdominis (RA), external abdominal oblique (EO), transversus abdominis (TrA), internal abdominal oblique (IO), erector spinae (ES), and multifidus (MF). The EMG data were recorded during (1) rest and (2) the initial phase of manual lifting in a dynamic semi-squat posture. For both conditions, the data were compared with and without wearing a back belt.*
***Results:*** *The results showed that wearing a back belt significantly decreased TrA/IO activity during rest ($p<0.01$) and significantly increased RA activity during the lifting period ($p<0.05$) as compared with the condition of no back belt.*
***Conclusion:*** *The present study does not recommend healthy workers wear a back belt as a protective device for lower back injury, particularly without any lifting activity. However, the back belt can be applied during lifting as it can enhance RA activity, which may help improve abdominal pressure and is less likely cause weakness of the TrA.*

***Keywords:*** *Abdominal support, Electromyography, Ergonomics, Material handling, Transversus abdominis muscle*

***J Med Assoc Thai 2014; 97 (Suppl. 7): S75-S79***
***Full text. e-Journal:*** *http://www.jmatonline.com*

Workers commonly apply a back belt during lifting to prevent lower back pain (LBP). It was previously believed that using a back belt can help to reduce back muscle activity, enabling a worker to improve stability and lifting capacity(1). Nonetheless, the reduction of muscle work may affect trunk-stabilizer, muscle performance in a way that subsequently increases the risk of back injury. The transversus abdominis (TrA) is an important trunk-stabilizer muscle that primarily attributes stability to the spinal column through the elevation of intra-abdominal pressure (IAP)(2) and a feed forward mechanism(3). Many studies have also found a decrease in or absence of TrA activity in patients with chronic LBP(4,5). Back belt users may change their lifting style to cope with the different weight of lift that may result in using different abdominal and back muscles recruitment pattern, and TrA may be the one of those changes. However, the target of previous research was to determine the effects of using a back belt reported by non-experienced back belt users(1,6-8), for which the data may differ from experienced back belt users. Therefore, the present study investigated the changes in trunk stabilizer EMG activities, especially the TrA muscle, during manual lifting and a resting period with and without back belt use among experienced back belt users.

***Correspondence to:***
*Mekhora K, Faculty of Physical Therapy, Mahidol University, 999 Phutthamonthon Sai 4 Road, Salaya, Nakhon Pathom 73170, Thailand.*
*Phone: 0-2441-5450 ext. 21603*
*E-mail: keerin.mek@mahidol.ac.th*

## Material and Method

The present study employed a quasi-experimental design. The subjects were all the workers from one section of a warehouse and distribution center in Thailand, where workers were involved only in repetitive manual lifting tasks and had been wearing back belts for at least six months. All subjects provided written informed consent before participating in the present study. The protocol for the present study was approved by the Mahidol University Institutional Review Board (COA. No. MU-IRB 2010/003.0501).

### *Materials and apparatus*

#### *Back belt*

The back belt used in this study was a typical industrial elastic belt with four semi-rigid bars aligned on the back with anterior fastening with Velcro. It had a posterior height of 20 cm and an anterior height of 12 cm (Fig. 1).

#### *Work simulator and EMG*

A Primus RS system (BTE Technologies, Inc. USA) was used to simulate lifting work tasks. A lifting box was made from wood, 25 x 32 x 29 cm$^3$ (W x L x H), and was placed on a wooden stand 24 cm high. The base of the box was attached with the cable system of Primus RS. The two parameters of the lifting task, torque (T), velocity (V) were synchronized with an EMG unit (Telemyo 2400 G2, Noraxon, USA, Inc) using the Noraxon Program on an EMG monitor (Fig. 1).

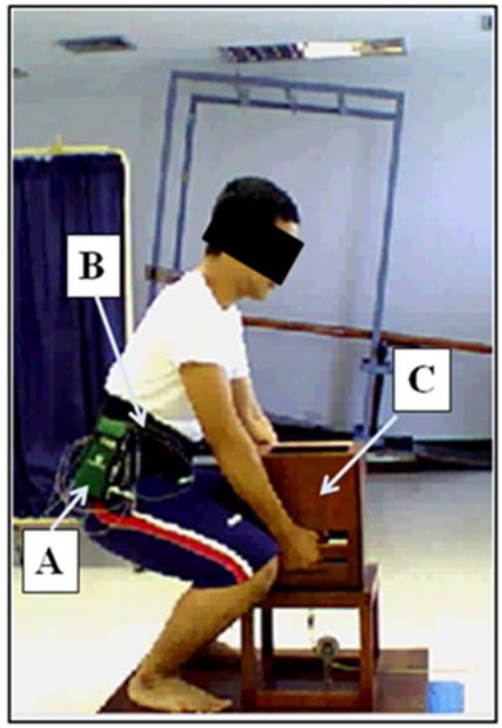


**Fig. 1** Starting position at the "lifting period". (A) EMG, (B) typical industrial elastic back belt, (C) wooden box.

### *Experimental procedure*

All participants were prepared to reduce skin impedance for EMG electrode placement on the right trunk muscles, including the transversus abdominis/ internal abdominal oblique (TrA/IO), rectus abdominis (RA), external abdominal oblique (EO), erector spinae (ES), and multifidus (MF)[9]. Each pair of electrodes was fixed with elastic tape to prevent them from sliding during trunk movement and because of direct pressure from the belt. Then, participants performed three sets of tasks, including the maximum voluntary contraction (MVC) test, maximum acceptable weight limited (MAWL) test, and lifting task test.

1) The MVC test was performed three times for abdominal and back muscles according to the guidelines from the Noraxon educational booklet[10].

2) The MAWL test was performed by using the Primus RS device, which already included the standardized protocol for testing in the squat lifting posture. The value of this test was used for setting the lifted weight for each participant but was limited to 20 kg to prevent overexertion.

3) The lifting task test involved dynamic semi-squat lifting from the mid shank to knuckle height with and without a back belt. Participants were instructed to lift three times with 20 s of rest between each lift. The lifting condition order was randomized with 5 min of rest between conditions. Lifting speed was controlled by a metronome preset at a frequency of 48 beats/min.

### *Data processing*

EMG signals were recorded at a sampling rate of 2 kHz and processed using MyoResearch XP EMG Application Protocols v. 1.06.54 (Noraxon Inc., USA) to reduce the electrocardiogram (ECG) signal and smooth data using the root mean square (RMS) while moving the processing window every 20 ms. All average RMS values of the 'resting' and 'lifting' periods from lifting task test (Fig. 2) were calculated to determine the percentage of the MVC (% MVC) in order to normalize all EMG values (NEMG).

### *Statistical analysis*

The SPSS program for Windows, version 17, was used to analyze all data. Descriptive statistics was applied to explain baseline demographics and the findings of the present study. The differences of the findings between with and without back belt condition of the quiet standing and squat lifting conditions were compared using the dependent samples t-test. An alpha level of less than 0.05 was established for statistical significance.

## Results

In all, 18 experienced manual lifting workers were included in the present study. They had no musculoskeletal disorders or other disorders that might affect participation in the present study. Their mean age, height, weight, and body mass index (BMI) were 30.17±6.15 yrs, 170.5±6.05 cm, 62.08±8.4 kg, and 21.29±2.02 $kg/m^2$, respectively. The most common amount of experience of back belt use was 6-12 months (70.6%), the highest frequency of back belt use was "every working day" (55.6%), the longest duration of back belt use in one day was "more than eight hours", and the most frequent lifting task was "lifting all day for six days per week" (94.4%).

Dependent t-test results revealed a significant difference of NEMG between without and with back belt wearing for the TrA/IO and RA muscles (Table 1). During resting, back belt use significantly decreased the NEMG of the TrA/IO as compared to lifting without a back belt ($p$<0.01). On the contrary, for the lifting period, back belt use significantly increased the NEMG of the RA when compared with lifting without a back belt ($p$<0.05).

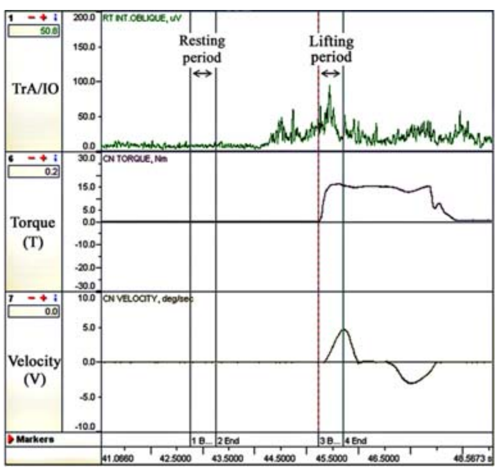


**Fig. 2** The EMG activity of transversus abdominis/ internal oblique (TrA/IO) at resting and lifting period in one lift condition.

## Discussion

The NEMG of the trunk muscles in the resting period was used to represent the work load of the trunk muscles in a real situation of industrial work that included a time of no lifting activity or merely performing a light job. The belt may have helped stabilize the spine, as the TrA did not have to work significantly, which explains the results showing that the TrA/IO muscles worked less when wearing a back belt. Thus, for long-term use of back belts, lifting workers, who do not engage in continuous lifting activity but still wear a belt all day, may tend to decrease TrA muscle performance. When the TrA muscle does not function properly, the feed forward mechanism to protect the spine from any injury also cannot occur, resulting in an increased back injury rate among back belt users when not wearing the back belt after use over a certain time. During lifting, RA muscle activity significantly increased while wearing a belt. The pressure from the belt pushing against the abdominal wall may facilitate a more superficial layer of the abdominal muscle. This increase in RA activity during lifting may help improve IAP to assist in the stability of the spinal column for back injury prevention. However, from this point of view, using the belt while lifting for some time may cause an imbalance in the trunk muscles. In addition, the increased RA activity during lifting with a belt may not provide a proper benefit for spinal control because the RA generates a greater flexor moment to counteract extensor moment from the IAP[2]. Thus, workers would

**Table 1.** Comparison of NEMG (%MVC) of trunk muscle activities during resting and lifting periods between without and with back belt wearing conditions (n=18), mean(SD)

| Trunk muscles | % MVC during resting | | p-value [a] | % MVC during lifting | | p-value [a] |
|---|---|---|---|---|---|---|
| | Without belt | With belt | | Without belt | With belt | |
| RA | 0.94 (0.48) | 0.81 (0.52) | 0.053 | 3.64 ( 2.22) | 4.09 (2.09) | 0.021* |
| TrA/IO | 4.55 (3.07) | 3.18 (2.49) | 0.006** | 13.92 (9.49) | 15.14 (13.81) | 0.412 |
| EO | 1.16 (0.57) | 0.92 (0.68) | 0.078 | 4.36 (2.48) | 3.91 (2.48) | 0.071 |
| ES | 3.87 (2.68) | 4.27 (2.55) | 0.395 | 56.69 (12.27) | 55.77 (15.43) | 0.583 |
| MF | 5.05 (5.96) | 5.86 (6.24) | 0.222 | 56.56 (15.98) | 56.63 (20.72) | 0.977 |

RA = rectus abdominis; TrA/IO = transversus abdominis/internal abdominal oblique; EO = external abdominal oblique; ES = erector spinae; MF = multifidus
* = significant difference at $p$-value <0.05, ** = significant difference at $p$-value <0.01, a = $p$-value from the dependent t-test

benefit if they could generate more activity in the TrA during lifting, as this muscle generates more stability because of the direction of the TrA fiber is in a transverse plane. However, the present study did not find any significant difference in TrA activity during lifting between with and without a back belt.

## Conclusion

The present study does not recommend healthy workers wear back belts as protective devices, particularly without any lifting activity. The back belt can be applied during lifting, as it can enhance RA activity, which may help improve abdominal pressure and is less likely to cause weakness in the TrA muscle. To confirm the findings of the present study, future studies should focus on trunk muscle performance, especially the endurance of experienced back belt users. However, back belt users should always exercise all trunk muscles to prevent an imbalance in the abdominal and back muscles, as suggested by the findings of the present study.

## What is already known on this topic?

The TrA is an important trunk stabilizer muscle that primarily attributes stability to the spinal column through the elevation of IAP and a feed forward mechanism. It was found that back injury rates increased among lifting workers who stopped using a back belt after wearing it for a certain period of time.

## What this study adds?

While wearing a back belt, TrA muscle activity decreases when there is no lifting activity. Therefore, for long-term use of back belts, TrA muscle performance tends to decrease in lifting workers who do not engage in continuous lifting activity with a belt on all day.

## Acknowledgment

The authors are thankful for support from the Faculty of Physical Therapy, Mahidol University and for all of the participants in the present study and gratefully acknowledge the research grant from Huachiew Chalermprakiet University Affairs.

## Potential conflicts of interest

None.

## References

1. Magnusson M, Pope MH, Hansson T. Does a back support have a positive biomechanical effect? Appl Ergon 1996; 27: 201-5.
2. Hodges P, Kaigle HA, Holm S, Ekstrom L, Cresswell A, Hansson T, et al. Intervertebral stiffness of the spine is increased by evoked contraction of transversus abdominis and the diaphragm: in vivo porcine studies. Spine (Phila Pa 1976) 2003; 28: 2594-601.
3. Hodges PW, Richardson CA. Feedforward contraction of transversus abdominis is not influenced by the direction of arm movement. Exp Brain Res 1997; 114: 362-70.
4. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. Spine (Phila Pa 1976) 1996; 21: 2640-50.
5. Hodges PW. Changes in motor planning of feedforward postural responses of the trunk muscles in low back pain. Exp Brain Res 2001; 141: 261-6.
6. Lavender SA, Shakeel K, Andersson GB, Thomas JS. Effects of a lifting belt on spine moments and muscle recruitments after unexpected sudden loading. Spine (Phila Pa 1976) 2000; 25: 1569-78.
7. Warren LP, Appling S, Oladehin A, Griffin J. Effect of soft lumbar support belt on abdominal oblique muscle activity in nonimpaired adults during squat lifting. J Orthop Sports Phys Ther 2001; 31: 316-23.
8. Kawaguchi Y, Gejo R, Kanamori M, Kimura T. Quantitative analysis of the effect of lumbar orthosis on trunk muscle strength and muscle activity in normal subjects. J Orthop Sci 2002; 7: 483-9.
9. Marshall P, Murphy B. The validity and reliability of surface EMG to assess the neuromuscular response of the abdominal muscles to rapid limb movement. J Electromyogr Kinesiol 2003; 13: 477-89.
10. Konrad P. The ABC of EMG: A practical introduction to kinesiological electromyography [Internet]. Arizona: Noraxon U.S.A.; 2005 [cited 2013 Apr 4]. Available from: http://demotu.org/aulas/controle/ABCofEMG.pdf

## *การทำงานของกล้ามเนื้อช่วยเสริมความมั่นคงของหลังส่วนล่างระหว่างการยกของที่สวมและไม่สวมเข็มขัดพยุงหลังในกลุ่มพนักงานที่มีประสบการณ์*

*นพพร คุรุเสถียร, คีรินท์ เมฆโหรา, วรรธนะ ชลายนเดชะ, สืบศักดิ์ นันทวาณิช*

***วัตถุประสงค์:*** *การศึกษานี้มีวัตถุประสงค์เพื่อประเมินการเปลี่ยนแปลงคลื่นไฟฟ้าของกล้ามเนื้อช่วยเสริมความมั่นคงของหลังส่วนล่างระหว่างการสวมและไม่สวมเข็มขัดพยุงหลัง ในกลุ่มพนักงานที่เคยมีประสบการณ์ในการสวมเข็มขัดพยุงหลัง*

***วัสดุและวิธีการ:*** *ผู้เข้าร่วมทดสอบเป็นพนักงานยกของเพศชาย จำนวน 18 ราย อายุ 22-44 ปี ทำงาน ณ คลังสินค้าและศูนย์กระจายสินค้าแห่งหนึ่ง ผู้นิพนธ์ทำการวัดคลื่นไฟฟ้าของกล้ามเนื้อช่วยเสริมความมั่นคงของหลังส่วนล่าง ได้แก่ กล้ามเนื้อ rectus abdominis (RA), กล้ามเนื้อ external abdominal oblique (EO), กล้ามเนื้อ transversus abdominis (TrA)/internal abdominal oblique (IO), กล้ามเนื้อ erector spinae (ES), และกล้ามเนื้อ multifidus (MF) โดยวัดคลื่นไฟฟ้าในช่วงขณะ (1) พัก และ (2) เริ่มต้นยกของแบบ dynamic semi-squat เปรียบเทียบคลื่นไฟฟ้าของกล้ามเนื้อระหว่างการสวมและไม่สวมเข็มขัดพยุงหลังทั้ง 2 ช่วง*

***ผลการศึกษา:*** *พบว่าขณะพักการทำงานของกล้ามเนื้อ TrA/IO ลดลงอย่างมีนัยสำคัญทางสถิติเมื่อสวมเข็มขัดพยุงหลัง ($p<0.01$) ส่วนขณะเริ่มยก การทำงานของกล้ามเนื้อ RA เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติเมื่อสวมเข็มขัดพยุงหลังเปรียบเทียบกับไม่ได้สวมเข็มขัด ($p<0.05$)*

***สรุป:*** *ผลการศึกษาครั้งนี้ไม่ได้แนะนำให้พนักงานสุขภาพดีสวมเข็มขัดพยุงหลังเพื่อป้องกันการบาดเจ็บบริเวณหลังส่วนล่าง โดยเฉพาะอย่างยิ่งไม่ควรสวมเข็มขัดในช่วงที่ไม่มีกิจกรรมการยกของ แต่พนักงานสามารถสวมเข็มขัดพยุงหลังในขณะที่ยกของได้ เนื่องจากแรงรัดเข็มขัดช่วยกระตุ้นการทำงานของกล้ามเนื้อ RA ซึ่งอาจมีส่วนช่วยให้แรงดันในช่องท้องเพิ่มขึ้นและไม่น่าจะส่งผลต่อภาวะอ่อนแรงของกล้ามเนื้อ TrA ได้*