The Effect of Lumbar Support on the Ultrasound Measurements of Trunk Muscles: A Single-Blinded Randomized Controlled Trial

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Objectives: To evaluate the effect of lumbopelvic belts on the thickness of lateral abdominal muscles and the cross-sectional area (CSA) of lumbar multifidus (LM) muscles.
Design: A single-blinded randomized controlled trial.
Setting: An academic and tertiary care referral spine and sports medicine center.
Participants: Sixty healthy volunteers with no history of low back pain in the previous year.
Methods: The subjects were allocated into belt and control groups. Lumbar belts were given to the subjects in the belt group, and they were asked to use the belts during the study period except during sleeping hours. The subjects were assessed at baseline and at 4 and 8 weeks.
Main Outcome Measures: The thickness of lateral abdominal muscles and the CSA of the LM muscles were measured by ultrasound with the patient in the hook-lying position on an examination table.
Results: The thickness of lateral abdominal muscles and the CSA of LM muscles on both sides decreased significantly among healthy subjects in the belt group after 8 weeks.
Conclusion: The results of this study show that lumbopelvic belts might influence the ultrasonographic measurements of lateral abdominal and LM muscles and thereby spine stability.

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INTRODUCTION

Worldwide, low back pain (LBP) is an extremely common and economically costly condition [1,2]. Although most symptoms subside by 3 months, chronic LBP (ie, pain lasting >3 months) is emotionally and economically taxing on patients and health care systems [3]. Evidence-based clinical guidelines have suggested various interventions for the prevention and treatment of LBP [4-6]. To this end, lumbar belts are commonly used for therapeutic and preventive purposes in clinical practice [7-11]. However, the mechanism of action of lumbar belts in the prevention and treatment of LBP is still uncertain. Although evidence indicates that lumbar belts are not effective in reducing muscle fatigue and low back injuries [12], Cholewicki et al [13] showed that wearing lumbar belts can increase lumbar stability and suggested that this outcome might explain the preventive and therapeutic role of lumbar belts for patients with LBP.

In the past decade, newer mechanical strategies such as core strengthening have been suggested as an effective treatment to stabilize the spine in patients with LBP [14,15]. The lateral abdominal muscles, including the transversus abdominis (TrA), internal obliques (IO), and external obliques (EO), as well as the lumbar multifidi (LM) muscles, have a prominent role in spinal stability. Independent feed-forward activation of TrA before limb movement has been identified in healthy subjects [16,17]. These hypotheses were further confirmed by studies in which investigators showed that TrA-strengthening exercises reduce the pain intensity in patients with LBP [18-20]. In addition, LM muscles have been identified as a spine stabilizer [21,22].

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To our knowledge, the impact of lumbar belts on the size of lateral abdominal and LM muscles has not previously been studied. Therefore, in the present study, we aimed to measure the effect of wearing a lumbar belt for 8 weeks on the thickness of lateral abdominal muscles and the cross-sectional area (CSA) of the LM muscles in healthy subjects. These findings might provide a platform for the recommendation of lumbar belts to a specific group of subjects with LBP who have impaired spinal stability.

METHODS

Study Design

The study was performed at an academic and tertiary care referral spine and sports medicine center. The 60 healthy male volunteers who participated in this study were chosen according to our inclusion and exclusion criteria (Table 1). Using a computer-generated sequence with a block size of 6, we randomly allocated subjects into 2 groups: a study group (belt group) that wore a lumbar belt and a control group (no intervention). The process and aim of the study, as well as possible adverse effects of wearing the lumbar belts, were described to the patients. All of the recruited patients signed a written informed consent. The study protocol was approved by the ethical committee of our university.

Interventions

A nonrigid lumbopelvic belt (Figure 1) was supplied to subjects in the belt group. They were instructed to wear the belt during waking hours and were allowed to remove the belt while sleeping. The belts were fitted for each subject in the following sizes: small, medium, large, extra large (X-large), XX-large, and XXX-large. The participants in control group were instructed to continue their previous pattern of life throughout the study.

Outcomes

General characteristics of each participant were recorded before the baseline evaluation. At baseline and at 4 and 8 weeks, the subjects were assessed at the authors' academic center. At these visits, the participants in the belt group were checked for any possible adverse effect of using the belt, and compliance with the study protocol was encouraged. Using diagnostic ultrasound, we measured the thickness of the lateral abdominal muscles and the CSA of the LM muscles at each visit.

According to the protocol described by Mannion et al [23], the diameters of the lateral abdominal muscles (TrA, IO, and EO) of both sides of the subjects were measured at rest and during an abdominal drawing-in maneuver (ADiM). The subjects were positioned supine on the bed with their hips flexed to 30° (ie, the hook-lying position). Measurement of the thickness of abdominal muscles was performed at a point 25 mm anteromedial to the midpoint between the inferior rib and the iliac crest on the midaxillary line. This point was selected on the basis of previous studies in which authors measured abdominal muscle thickness [24]. A linear transducer (6–13 MHz) was transversely positioned at the aforementioned anatomic point, and the thickness of abdominal muscles was recorded in B-mode format. To help the participants adapt to the protocol of the study, we used the biofeedback effect of the ultrasound to instruct them in how to perform the ADiM before the study began. To compensate for the effect of food consumption on lateral abdominal muscle thickness, we conducted ultrasound assessments for all participants 4 hours after their last meal [24].

Using the protocol developed by Hides et al [25], we also measured the CSA of the LM muscles on both sides of the subjects at rest and during contraction. To perform this measurement, the subjects were placed in a prone position and a small pillow was placed under their abdomen. An assessor palpated the lumbar vertebral levels and marked the location of the spinous process of the L4 vertebrae of the subjects. With a curve transducer (5 MHz), the LM muscle at

Table 1. Inclusion and exclusion criteria

Inclusion criteria
  Healthy male volunteers with no history of low back pain during the past 12 months
  Age 18-55 years
  No history of core-strengthening exercise or physiotherapy during the past 6 months
  No history of systemic and local diseases that might affect the lumbar multifidus and lateral abdominal muscles (eg, systemic scleroderma, muscular dystrophy, spinal deformities, or abdominal wall hernia)
  No history of laparotomy or lumbar surgery
  No history of use of any muscle relaxant medications (eg, methocarbamol or diazepam)
Exclusion criteria
  Having a hobby or job that requires extension of back or abdominal muscle training
  History of any dermatologic reaction as the result of wearing a belt
  Inability to attend the follow-up sessions of the study
  Depression
  A condition that requires prescription of muscle relaxant agents (eg, seizure)
  Current use of analgesic medications other than acetaminophen (especially nonsteroidal anti-inflammatory drugs)
  Systemic disease (eg, diabetes mellitus or collagen vascular disease)

Figure 1. The nonrigid lumbopelvic belt used in the study.

the mentioned level was demonstrated, the image was captured on the monitor, and the CSA was measured. In addition to the measurement of CSA at rest, the participants were asked to lift up their ipsilateral thigh and contralateral upper extremity so that we could record the CSA of the LM muscle in a contracted condition.

For all the ultrasound measurements, the image on the ultrasound monitor was frozen at the end of the patient's normal expiration and the ultrasound assessor was allowed to adjust the angle of the probe up to 10° until a clear image of muscles was achieved [26]. The assessor was not aware of the allocation of the subjects into belt and control groups.

Statistical Methods

Data analysis was performed with SPSS 16 (SPSS Inc, Chicago, IL). We determined 95% confidence intervals for differences between the belt and control groups at baseline. We also implemented analysis of covariance (while the baseline values were adjusted in the analyses) to analyze the outcome measures between the 2 groups during the study period. The level of significance was set at a *P* value of .05 or less.

RESULTS

Of 73 male volunteers who were assessed for eligibility, 60 subjects were randomly assigned to belt and control groups.

Eleven participants were lost to follow-up, and data for the remaining 49 subjects who successfully completed the 8-week study were included in the final analysis (Figure 2). The characteristics of the participants are provided in Table 2.

Ultrasound Measurements at Rest

At baseline, the thickness of lateral abdominal (TrA, IO, and EO) muscles at rest was similar in the belt and control groups. The thickness of all 3 muscle layers decreased significantly during follow-up in the belt group compared with the control group (Table 3). The CSA of resting LM muscles also was similar in both groups at the baseline. The CSA also decreased significantly during follow-up in the belt group compared with the control group (Table 3).

Ultrasound Measurements at Contraction

During ADiM, the mean thickness of lateral abdominal muscles was similar in the 2 groups at baseline. As with measurements at rest, the thickness of the TrA, IO, and EO muscles decreased significantly during follow-up in the belt group compared with the control group (Table 4). At baseline, no significant difference was found in the CSA of the LM muscles of the belt and control groups while the subjects were contracting their muscles. However, during follow-up, the CSA of the contracted LM muscles decreased significantly in the belt group compared with the control subjects (Table 4).
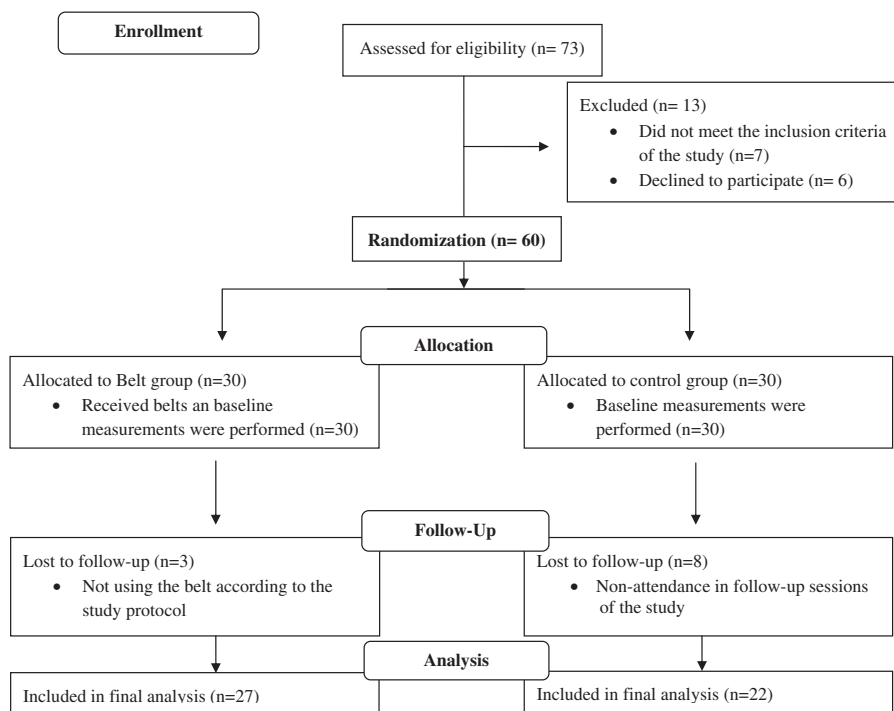
Figure 2. Flow of participants through the study.

DISCUSSION

Previous studies showed that TrA muscles have a significant role in the stability of the lumbopelvic complex by increasing the intra-abdominal pressure and thoracolumbar fascia tension [27,28]. Hodges et al [27,29] reported that activation of the TrA muscles in patients with LBP is delayed. On the basis of this finding, it was hypothesized that TrA motor control dysfunction might be related to persistent or recurrent LBP [30]. Although much of these findings were obtained from electromyographic (EMG) studies, ultrasound imaging was reported as an alternative method for the detection of variations in motor control and activation of the abdominal muscles [31-34]. In this regard, moderate to high associations between ultrasound studies and EMG functional assessment of TrA muscles were found [35]. In addition, Danneels et al [36] showed that patients with LBP had a smaller CSA of LM muscles. With use of ultrasound imaging techniques, it also was found that patients with chronic LBP had a localized pattern of LM atrophy [37,38]. This finding was further confirmed by studies in which authors showed

that lateral abdominal and LM strengthening exercises reduced the pain intensity in patients with LBP who had atrophied lateral abdominal and LM muscles [20].

The effect of different therapeutic and preventive interventions of LBP on the thickness of lateral abdominal muscles and the CSA of the LM muscles has been of interest for many researchers. A review of the literature reveals a few prospective studies that have targeted the clinical effects of lumbar belts on patients with LBP. In a prospective study, Calmels et al [7] showed that wearing a belt for 90 days led to lower levels of pain intensity and improvement of functional status of subjects with subacute LBP. Also, the role of lumbar belts in the reduction of direct and indirect costs of LBP among workers with recurrent LBP has been shown [8]. However, Oleske et al [39] reported no impact of back supports in conjunction with health education on self-reported recovery and lost work time during a 12-month follow-up. Because of controversial clinical results regarding the role of lumbopelvic belts in LBP, the long-term effects of lumbopelvic belts are not still clearly defined [10]. In the current study, we aimed to investigate the impact of lumbar belts on the size of lateral abdominal and LM muscles. Our results showed that the thickness of lateral abdominal muscles of both sides decreased significantly among healthy subjects after wearing a lumbopelvic belt for 8 weeks. The same was true for the CSA of the LM muscles.

Various studies suggest different mechanisms to explain the role of lumbopelvic belts in the treatment and prevention of LBP, including the limitation of back flexibility [40] and

Table 2. *Characteristics of 60 participants randomly assigned to the belt or control group*

Characteristic	Belt Group (n = 30)	Control Group (n = 30)
Age, year, mean (SD)	22.9 (1.47)	23.6 (1.95)
Right-hand dominants, no (%)	28 (93.3)	26 (86.7)
Left-hand dominants, no (%)	2 (6.7)	4 (13.3)

Table 3. The resting thickness of transabdominal muscles and cross-sectional area of lumbar multifidus muscles in belt and control groups

Muscle	Side	Time	Belt Group (n = 27)	Control Group (n = 22)	Mean Difference (95% CI)	P Value*
EO, cm	Right	Baseline	0.77 (0.24)	0.86 (0.12)	−0.09 (−0.20 to 0.02)	—
		Week 4	0.70 (0.18)	0.86 (0.12)	−0.09 (−0.14 to −0.05)	<.001
		Week 8	0.66 (0.17)	0.86 (0.12)	−0.15 (−0.19 to −0.09)	<.001
	Left	Baseline	0.72 (0.14)	0.78 (0.11)	−0.06 (−0.13 to 0.02)	—
		Week 4	0.67 (0.14)	0.78 (0.11)	−0.07 (−0.09 to −0.04)	<.001
		Week 8	0.64 (0.13)	0.78 (0.10)	−0.09 (−0.13 to −0.07)	<.001
IO, cm	Right	Baseline	0.88 (0.25)	0.90 (0.18)	−0.02 (−0.15 to 0.11)	—
		Week 4	0.82 (0.24)	0.90 (0.18)	−0.07 (−0.11 to −0.04)	<.001
		Week 8	0.77 (0.18)	0.90 (0.17)	−0.12 (−0.16 to −0.07)	<.001
	Left	Baseline	0.79 (0.24)	0.86 (0.17)	−0.08 (−0.20 to 0.05)	—
		Week 4	0.72 (0.20)	0.87 (0.16)	−0.08 (−0.12 to −0.05)	<.001
		Week 8	0.70 (0.19)	0.87 (0.15)	−0.11 (−0.15 to −0.08)	<.001
TrA, cm	Right	Baseline	0.32 (0.07)	0.32 (0.06)	0.003 (−0.04 to 0.04)	—
		Week 4	0.28 (0.06)	0.32 (0.05)	−0.04 (−0.06 to −0.03)	<.001
		Week 8	0.27 (0.05)	0.32 (0.06)	−0.05 (−0.07 to −0.04)	<.001
	Left	Baseline	0.31 (0.07)	0.30 (0.06)	0.01 (−0.03 to 0.05)	—
		Week 4	0.28 (0.07)	0.31 (0.06)	−0.04 (−0.05 to −0.03)	<.001
		Week 8	0.26 (0.06)	0.31 (0.06)	−0.06 (−0.07 to −0.04)	<.001
LM, cm^2	Right	Baseline	9.92 (2.88)	8.40 (2.56)	1.52 (−0.06 to 3.11)	—
		Week 4	8.67 (2.57)	8.16 (2.42)	−0.79 (−1.33 to −0.26)	.005
		Week 8	8.02 (2.37)	8.21 (2.39)	−1.36 (−2.00 to −0.72)	<.001
	Left	Baseline	9.17 (2.29)	7.86 (2.27)	1.31 (−0.006 to 2.63)	—
		Week 4	8.40 (2.29)	7.73 (2.07)	−0.54 (−0.91 to −0.18)	.004
		Week 8	7.59 (1.94)	7.70 (2.09)	−1.19 (−1.62 to −0.77)	<.001

Data are presented as mean ± SD.
CI = confidence interval; EO = external oblique; IO = internal oblique; TrA = transversus abdominis; LM = lumbar multifidus.
*Statistically significant (P < .05).

Table 4. The contracted thickness of transabdominal muscles and cross-sectional area of lumbar multifidus muscles in belt and control groups

Muscle	Side	Time	Belt Group (n = 27)	Control Group (n = 22)	Mean Difference (95% CI)	P Value*
EO, cm	Right	Baseline	0.74 (0.17)	0.83 (0.13)	−0.08 (−0.17 to 0.01)	—
		Week 4	0.68 (0.15)	0.84 (0.13)	−0.09 (−0.12 to −0.06)	<.001
		Week 8	0.65 (0.13)	0.84 (0.13)	−0.12 (−0.16 to−0.08)	<.001
	Left	Baseline	0.72 (0.16)	0.76 (0.13)	−0.04 (−0.13 to 0.04)	—
		Week 4	0.68 (0.15)	0.77 (0.11)	−0.07 (−0.09 to −0.05)	<.001
		Week 8	0.65 (0.13)	0.77 (0.11)	−0.09 (−0.12 to −0.06)	<.001
IO, cm	Right	Baseline	0.96 (0.24)	1.02 (0.16)	−0.06 (−0.20 to 0.09)	—
		Week 4	0.89 (0.28)	1.04 (0.16)	−0.09 (−0.14 to −0.05)	<.001
		Week 8	0.84 (0.22)	1.02 (0.17)	−0.15 (−0.21 to −0.09)	<.001
	Left	Baseline	0.89 (0.27)	0.99 (0.21)	−0.10 (−0.24 to 0.04)	—
		Week 4	0.82 (0.23)	1.00 (0.20)	−0.09 (−0.12 to −0.05)	<.001
		Week 8	0.79 (0.22)	1.01 (0.20)	−0.13 (−0.16 to −0.09)	<.001
TrA, cm	Right	Baseline	0.48 (0.14)	0.52 (0.14)	−0.04 (−0.12 to 0.05)	—
		Week 4	0.43 (0.13)	0.53 (0.12)	−0.07 (−0.09 to −0.04)	<.001
		Week 8	0.42 (0.12)	0.53 (0.12)	−0.08 (−0.11 to −0.06)	<.001
	Left	Baseline	0.47 (0.11)	0.52 (0.12)	−0.06 (−0.12 to 0.01)	—
		Week 4	0.42 (0.10)	0.53 (0.12)	−0.06 (−0.08 to −0.04)	<.001
		Week 8	0.40 (0.09)	0.53 (0.12)	−0.09 (−0.11 to −0.07)	<.001
LM, cm^2	Right	Baseline	10.93 (3.34)	8.85 (2.70)	2.08 (0.31 to 3.86)	—
		Week 4	9.80 (3.18)	8.93 (2.67)	−1.08 (−1.49 to −0.68)	<.001
		Week 8	8.93 (2.56)	8.89 (2.70)	−1.57 (−2.22 to −0.93)	<.001
	Left	Baseline	10.23 (3.13)	8.21 (2.07)	2.02 (0.46 to 3.59)	—
		Week 4	9.38 (2.83)	8.22 (2.08)	−0.69 (−0.99 to −0.39)	<.001
		Week 8	8.53 (2.49)	8.24 (2.09)	−1.36 (−1.83 to −0.89)	<.001

Data are presented as mean ± SD.
CI = confidence interval; EO = external oblique; IO = internal oblique; TrA = transversus abdominis; LM = lumbar multifidus.
*Statistically significant (P < .05).

an increase in muscular strength [41] and postural control [42]. Cholewicki et al [13] showed that lumbar supports increase spine stability during trunk motions and suggested that this outcome is the mechanism of effect of back supports. In addition, Fayolle-Minon and Calmels [43] reported reduction in the trunk extensor endurance strength of healthy subjects who were asked to wear a soft lumbar orthosis for 21 days, whereas no significant changes in the isometric and isokinetic strength of the trunk flexor and extensor muscles were found. However, the flexor and extensor trunk muscles were evaluated as a whole, and separate results regarding each of the muscle layers could not be obtained from this design.

In the present study, we investigated the possible impact of lumbopelvic belts on lateral abdominal and LM muscles as 2 groups of muscles that are important for spinal stability. Our results showed that the thickness of all 3 lateral abdominal muscle layers and the CSA of the LM muscles decreased after wearing lumbar belts for 8 weeks. Hides et al [44] showed that after 60 days of bed rest, the CSA of LM muscles decreased. Similarly, inactivation of abdominal and trunk muscles as the result of wearing a belt might also lead to a decrease of the muscle size of the subjects, which might indirectly lead to a decrease in core stability, particularly in persons who use the lumbopelvic belt for a longer period. A neuromuscular self-regulatory transmission failure and atrophy of type I and II muscle fibers might be the reason for this reduction in the ultrasound measurement of lateral abdominal and LM muscles after a period of immobilization [45,46].

The findings of our study stimulate further discussion regarding the long-term effect of lumbopelvic belts on lateral abdominal and paraspinal muscles and thereby on spine stability. Although a greater endurance and strength of back muscles [47] attributable to belt wearing has been previously reported, the impact of lumbopelvic belts on core stability of the subjects after a long period of belt wearing has not yet been studied. Most published studies evaluate the immediate effect of belts on the EMG activity of the muscles. These studies have also reported controversial results regarding the effect of belts on the muscular function of either healthy subjects or subjects with LBP. The conflicting results have emerged for a variety of reasons, such as recruitment of heterogeneous subjects and use of different types of belts.

This study has several limitations. Only healthy male subjects were recruited, which may limit the generalization of the study results to the general population. Another limitation is that the ultrasound measurements were only performed while the subjects were positioned on the bed and at rest and during contractions. We measured the lateral abdominal and LM muscle thickness in commonly used positions. For future studies, we suggest measuring these muscles in other functional positions and during lifting positions. In addition, compliance of the subjects with the study protocols was not measured in this study.

CONCLUSION

Although lateral abdominal (TrA, IO, and EO) and LM muscles are only one facet of a multifactorial matrix in lumbopelvic stability, the results of our study showed that the thickness of lateral abdominal muscles and the CSA of LM muscles of both sides decreased significantly among healthy subjects after the use of lumbopelvic belts for 8 weeks. The value of belt as a routine preventive and therapeutic tool for LBP and its effect on core stability must be further confirmed by future studies.

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CME Question

Which of the following core muscles showed a decrease in thickness or cross-sectional area in the treatment group that was significant at the $P < .001$ level compared to the control group at 8 weeks but not at 4 weeks?

a. external oblique at rest
b. internal oblique when contracted
c. lumbar multifidus at rest
d. transverse abdominus when contracted

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