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The Effect of Abdominal Bracing in Combination with Low Extremity Movements on Changes in Thickness of Abdominal Muscles and Lumbar Strength for Low Back Pain

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Abstract. [Purpose] The purpose of this study was to investigate the effects of abdominal bracing with low extremity movement on changes in thickness of abdominal muscles and lumbar strength. [Subjects] Sixteen patients with chronic low back pain were randomly assigned to two groups: an abdominal bracing with active straight leg raise (ABSLR) group and abdominal bracing with ankle dorsiflexion (ABDF) group. [Methods] All subjects were evaluated for their abdominal muscle strength using a MedX Lumbar Extension Machine and thickness of external oblique (EO), internal oblique (IO), and transverse abdominis (TrA) muscles using rehabilitative ultrasound imaging. Subjects in both groups were instructed to perform Abdominal bracing (AB). Simultaneously, those in the ABSLR group performed active SLR, and those in the ABDF group performed ankle dorsiflexion. [Results] In comparison between the ABSLR and ABDF groups, significant differences in the thickness of the IO and TrA muscles were observed after the intervention in the ABSLR group. Also, lumbar strength was showed a significant increase in both groups after interventions. [Conclusion] The results of this study demonstrated that ABSLR is a more effective method than ABDF for improvement of abdominal stabilization by increasing the thicknesses of the TrA and IO.
Key words: Abdominal bracing, Transverse abdominis, Ultrasonography

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INTRODUCTION

Low back pain (LBP), one of the most widespread musculoskeletal disorders in many developed countries, frequently involves persons under the age of 45 years[1)]. LBP is also associated with significant financial costs[2)]. Numerous research studies have focused on the course and treatments of LBP. A variety of nonoperative methods are available for treatment of LBP, including medication, manual therapy, modalities, and exercise. Although it is difficult to define the most effective treatment for LBP, numerous research studies have suggested that lumbar stabilization exercise may be effective in improving functional mobility and reducing the impairments of patients with LBP[3)]. Lumbar spine stability is one of the most important factors in defining mechanisms of low back injury and in establishment of treatment goals in those with LBP[4)]. Some research studies on management of LBP have suggested that restoration of neuromuscular control in the TrA muscle, which forms the deepest musculature, with minimal contraction of internal and external abdominal muscles is essential for effective treatment to stabilize the lumbar spine during the early stages of rehabilitation[5–7)]. The TrA plays an important role in lumbar stability by creating tension in the thoracolumbar fascia, and compression of sacroiliac joints[5)]. The mechanism by which patients recruit their abdominal muscles in order to stabilize their back is changed. For example, the TrA is recruited later, after starting contraction of the IO and EO muscles, and this has resulted in an unhealthy or unstable spine[7)]. Therefore, some studies have proposed that lumbar stabilization exercises have a positive influence on those with LBP by changing the process for recruitment of abdominal muscles[4, 8)].

A number of recent studies have demonstrated that improvement of lumbar stability is possible by application of abdominal muscle contraction with movements of limbs, such as the abdominal hollowing technique[4, 9)]. Abdominal muscle contraction with functional movements of limbs has recently been shown to affect the process of abdominal muscle recruitment and the strength of the TrA[10)]. Manshadi et al. reported[11)] that the abdominal hollowing (AH) maneuver was helpful for increasing the thickness of the IO and TrA muscles. In addition, Chon et al.[6)] investigated the effect of the abdominal draw-in manoeuvre in combination with ankle dorsiflexion on strengthening the TrA, and

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showed that use of the combined exercise was more effective than use of the abdominal draw-in manoeuvre alone.

However, although numerous studies have reported on the efficacy of core stabilization exercises in LBP, there is little information on the efficacy of core exercise combined with lower limb activities. Therefore, this study investigated the effect of abdominal bracing exercise combined with SLR and ankle dorsiflexion on lumbar stability in patients with LBP by comparing the abdominal muscle strength and thickness of the TrA, IO, and EO.

SUBJECTS AND METHODS

This study was a single-blind, randomized clinical trial; 18 patients with chronic LBP (10 males and 8 females) at W hospital in Seoul, Korea, were recruited. None of the patients had any experience with abdominal bracing exercise. Those who had neurological, other orthopedic disorders not associated with LBP, or systemic diseases were excluded. We began the research only after providing adequate explanation of the method and purpose of the experiment to the participants and obtaining their full agreement regarding participation. Two participants were dropped from the test, as they could not maintain the interventions; therefore, the study was conducted with 16 subjects (7 males and 9 females). The participants were allocated randomly to an abdominal bracing with active straight leg raise (ABSLR) group (n=8) and abdominal bracing with ankle dorsiflexion (ABDF) group (n=8). General characteristics of the ABSLR group were: a mean age of 25.0 ± 2.8 years, a mean height of 170.3 ± 7.2 cm, and a mean weight of 63.1 ± 8.2 kg; subjects in the ABDF group were: a mean age of 23.5 ± 3.4 years, mean height of 165.8 ± 8.2 cm, mean weight of 61.1 ± 8.2 kg. No evident significant differences in terms of baseline values were observed between the groups.

Abdominis muscle activation of all groups was assessed using a Pressure Biofeedback Unit (PBU; HEALIENCE, Korea). The PBU consists of a gauge and an inflation bulb, which are connected to a pressure cell. The PBU determines the change in pressure in an air-filled pressure cell caused by spinal movements. The pressure cell measures from 0 to 200 mm Hg, with a precision of 2 mm Hg. According to changes in body position, the pressure is registered by a sphygmomanometer. The device was inflated to a pressure of 70 mm Hg before instructing individuals to contract the abdominal muscles. The device was placed on the lordotic curve of the lumbar spine. Depression of the abdominal muscles over the spinal cord typically decreases the pressure by 4 to 10 mm Hg[10]. The instructor allowed participants to draw the lower stomach gently off the pressure sensor without moving the back or the hip and to maintain it for 10 seconds by measuring with a stop watch[12]. Patients in the ABSLR group were instructed to raise one leg with abdominal bracing until the heel was 20 cm above the table, without bending the knees, and to keep the leg elevated for 10 s. After every active SLR, subjects were asked to relax for approximately 10 s[13]. Patients in the ABDF group were instructed to draw in their lower abdomen below the navel, maintain a neutral pelvic position, dorsiflex their ankle joint for approximately 10 s, and then relax for 10 s. Patients in both groups performed three sets of their own intervention for 30 minutes per day, 2–3 days per week over a four-week period.

Abdominal muscle thickness was assessed by rehabilitative ultrasound imaging (RUSI; Sequoia 512, Siemens, Erlangen, Germany)[14]. The RUSI unit set in B-mode with a 4 MHz linear transducer was used for assessment of the change in muscle thickness of the TrA, IO, and EO during the intervention based on the method explained by the instructor. Measurements were performed on the right side of the abdominal wall at the end of expiration. The participants were tested in the supine position, and the lumbar spine was in a neutral position. The RUSI transducer was transversely located across the abdominal wall over the anterior axillary line between the 12th rib and the iliac crest. To assure reliability, one examiner performed all measurements, and the entire procedure was performed twice in one day. First, the examiner completed the ultrasound measurements during abdominal maneuvers in a subject and then repeated the measurement randomly after 30 min[14, 15]. To ensure identical placement throughout the entire experiment, the scanning point at the pretest was marked for the posttest. The image data acquired were stored, and muscle thickness was assessed by drawing a vertical reference line on a screen caliper located 2.5 cm from the muscle–fascia junction[6].

Abdominal muscle strength was evaluated using a MedX Lumbar Extension Machine (MedX, Ocala, FL, USA); its interobserver reliability was demonstrated to be suitable for measurement of maximal isometric strength and for measurement of the ROM of the lumbar spine. Usage of abdominal muscles, especially the EO, is inclined to increase when participants flex their trunk using MedX training[16]. Therefore, this study assessed abdominal flexor strength at 48°, 60°, and 72°. The participants were seated in an upright position in the MedX and flexed their knees at 30°. Their thighs were positioned at 15° relative to the seat. Their feet were placed on a footboard, and a belt and thigh pads were used to fix the position of their lower limbs and pelvis. The participants were asked to cross their arms in order to avoid unnecessary movements. This study quantified the resistance of each participant by determining maximal voluntary isometric contractions (MVIC). The participants were instructed to perform the maximal contraction within the first two seconds and to maintain the contraction at that level for another one second before terminating the trial. These exercises were performed three times with a pause of 10 seconds[16].

Statistical analyses were performed using SPSS (v 15). The Shapiro-Wilks test was used to confirm the normality of the data. The paired t-test was used for comparison of the difference between pre- and post-test values within each group. The independent t-test was performed for comparison of the two groups. The level of significance was chosen as 5% for all statistical analyses.

RESULTS

Descriptive statistics for the thicknesses of the TrA, IO,

Table 1. The changes in abdominal muscle thickness (n=16)

Parameters	Values				Change values	
	ABSLR (n=8)		ABDF (n=8)		ABSLR (n=8)	ABDF (n=8)
	Pre	Post	Pre	Post	Post-pre	Post-pre
EO (cm)	0.49 (0.11)	0.53 (0.12)*	0.46 (0.10)	0.46 (0.10)	0.05 (0.05)	0.00 (0.05)
IO (cm)	0.97 (0.30)	1.16 (0.38)*	0.68 (0.160)	0.74 (0.16)**	0.18 (0.18)§	0.07 (0.03)
TrA (cm)	0.47 (0.10)	0.57 (0.12)*	0.42 (0.45)	0.45 (0.05)***	0.10 (0.05)§	0.03 (0.01)

Values are means (SD). ABSLR, abdominal bracing with active straight leg raise, ABDF, abdominal bracing with ankle dorsiflexion; EO, external oblique; IO, internal oblique, TrA, transverse abdominis, *$p<0.05$ compared with the pretest values; §$p<0.05$ in comparisons of post-pre values between the two groups.

Table 2. The changes of abdominal muscle strength (n=16)

Parameters	Values				Change values	
	ABSLR (n=8)		ABDF (n=8)		ABSLR (n=8)	ABDF (n=8)
	Pre	Post	Pre	Post	Post-pre	Post-pre
MedX 48 (Nm)	170.4 (66.9)	186.8 (64.8)*	131.7 (71.2)	144.7 (65.2)*	16.3 (16.9)	13.0 (9.8)
MedX 60 (Nm)	193.2 (80.0)	206.1 (73.9)	143.1 (72.6)	156.9 (67.9)*	13.0 (14.9) *	13.8 (14.4)
MedX 72 (Nm)	211.8 (81.4)	233.1 (82.4)*	152.9 (67.0)	169.9 (73.7)*	21.4 (16.8)	16.9 (14.0)

Values are means (SD). ABSLR, abdominal bracing with active straight leg raise; ABDF, abdominal bracing with ankle dorsiflexion; *$p<0.05$ compared with the pretest values.

and EO under different interventions are shown in Table 1. The muscle thicknesses of the TrA ($p<0.05$) and IO ($p<0.05$) were significantly higher in the ABSLR group, compared with the ABDF group. This result indicates that abdominal bracing with SLR is more effective than that with dorsiflexion in improving the TrA and IO muscle thickness. In the pre and post-test, the thickness of all abdominal muscles showed a significant increase in both groups after the intervention period, except for the EO in the ABDF group.

The changes in abdominal muscle strength are shown in Table 2. The abdominal strength of the ABSLR group showed a significant increase after the intervention period at 48° ($p<0.05$), 60° ($p<0.05$), and 72° ($p<0.05$). In the ABDF group, muscle strength also showed significant changes at 48° ($p<0.05$), 60° ($p<0.05$), and 72° ($p<0.05$). However, no significant difference in muscle strength was observed between the two groups after intervention.

DISCUSSION

The results of this study demonstrated the effect of abdominal bracing with low extremity activities on changes in the thickness of abdominal muscles and lumbar strength. They indicate that abdominal contraction combined with ASLR or ankle DF effectively increased TrA and IO muscle thickness and lumbar strength in subjects with chronic LBP. Our findings suggest that ASLR and DF followed by abdominal bracing stimulate lumbar stability.

In this study, ultrasound imaging was used for investigation of a participant's ability to contract three abdominal muscles by determining the muscle thickness. In our study, significantly increased thicknesses of the TrA and IO were observed in both groups. This result suggests that abdominal bracing combined with ASLR or with ankle DF has a positive effect on lumbar stability by increasing the thickness of deep abdominal muscles. Our ultrasound imaging data are consistent with the findings of Hu et al.[13)], who investigated the various mechanisms involved in performance of ASLR. They suggested that ASLR, which consists of ipsilateral hip flexion, a contralateral hip extension moment, has a lumbar stabilizing effect on the TrA and IO symmetrically. Previously, Chon et al.[6)], who studied co-contraction of ankle dorsiflexors and TrA function in 20 patients with LBP, reported that co-contraction of ankle dorsiflexors with abdominal draw-in manoeuvre (ADIM) training had a positive influence on a thickness change in the TrA muscle and associated pain management in patients with chronic LBP. In this study, independent samples t-tests showed significant differences in the thicknesses of the TrA and IO between the ABSLR group and the ABDF group after the intervention. The post-test differences in TrA and IO muscle thickness between groups implied that the factor of ASLR has more influence on deep abdominal muscle thickness than that of active DF. However, there is little related literature on the relationship between ASLR and lumbar stability. Some reports have addressed the strong association of ASLR with lumbar stability, and problems with ASLR may result from insufficient lumbar stability[17)]. Liebenson et al.[17)] determined the utility of ASLR in a screen of lumbar spine stability. According to their study, ASLR can assess control of lumbar rotational movements, and abdominal bracing during ASLR can measurably improve the stability of the lumbar spine. In our study, abdominal co-contraction with hip flexion during ASLR may have stimulated contraction of the TrA and IO, suggesting that co-contraction might be useful in contributing to pain reduction in people with LBP, since increases in TrA muscle thickness showed an association with improved lumbar stability. In measuring abdominal muscle strength, data from both the ABSLR group and the ABDF group showed a significant increase after the intervention period, however, no significant difference was observed between the two groups.

We demonstrated increased muscle thickness and strength after the intervention. Abdominal bracing with low extremity training could be integrated as a part of lumbar stabilization for treatment of patients with LBP, however, conduct of further studies with a larger sample size to investigate the long-term effects of abdominal bracing combined with low extremity activities on improvement of lumbar stability in patients with LBP is warranted.

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