J. Phys. Ther. Sci. 30: 400–404, 2018

The Journal of Physical Therapy Science

Original Article

# Effects of stabilization exercise using flexi-bar on functional disability and transverse abdominis thickness in patients with chronic low back pain

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**Abstract.** [Purpose] The purpose of this study is to examine the effects of lumbar stabilization exercises using flexi-bar (FB) on pain, functional disability, transverse abdominis muscle (TrA) activation capacity and thickness in patients with chronic low back pain (CLBP). [Subjects and Methods] Twenty-seven patients were randomly assigned to an experimental (14 patients performing stabilization exercises with flexi-bar (FB)) or control (13 patients performing stabilization exercises) group. The patients in both groups then underwent stabilization exercises with or without FB 30 min/day, 3 times a week, for 6 weeks. The main outcome measures were perceived disability based on the pain, Oswestry disability index (ODI), TrA activation capacity and thickness. [Results] Both groups showed improved ODI, VAS, and TrA activation capacity performed for 6 weeks in patients with CLBP, but all outcomes, except for TrA thickness, showed greater improvements in patients following stabilization exercises with FB than following stabilization exercises. [Conclusion] Based on the above results, lumbar stabilization exercises with FB could restoring pain, functional disability and improving TrA activation capacity in CLBP patients.
**Key words:** Flexi-bar, Chronic low back pain, Transverse abdominis

*(This article was submitted Oct. 31, 2017, and was accepted Dec. 12, 2017)*

## INTRODUCTION

Squatting Major factors that trigger low back pain include obesity, decrease in spinal mobility, increase in lumbar lordosis, tension in the hamstring muscle, weakening of the abdominal muscles, imbalance in trunk muscle strength, and differences in the lengths of the legs[1)]. Low back pain is characterized by instability in the lumbar vertebrae, which triggers problems in postural maintenance and trunk stability, thus causing functional problems in the body[2)]. Instability in chronic low back pain (CLBP) patients may be reduced by muscular adjustment through exercises[3)] and selective exercise of transverse abdominis muscle (TrA), lumbar multifidus muscle, pelvic floor muscle, and diaphragm muscle, which all engage in stabilization[4)]. In particular, spinal stabilization exercises that increase the contraction capacity of the TrA and lumbar multifidus muscles alleviate pain and improve function[2)].

Stabilization exercises based on the abdominal drawing-in maneuver are widely used to contract the TrA[5)]. This method retrains the deep muscles using isometric contractions[6)], minimal contractions of the large muscles, and selective contraction of the TrA[7)]. It increases tension in the lumbar and thoracic fasciae, providing stability to the lumbar spine and the pelvis[8)].

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The vibrations caused by the flex-bar (FB) are effective in the movement perception through the generation of proprioceptive stimulation[9]. The exercises with FB increases trunk muscle activity, and increases the activity of the abdominal muscles and the muscles around the spine[10]. But few studies implemented lumbar stabilization exercises using FB. Therefore, the purpose of this study intends to examine the effects of lumbar stabilization exercises using FB in patients with CLBP.

## SUBJECTS AND METHODS

The present study was conducted with 31 patients of B Hospital. Subjects were excluded for refusal to participate and one for not enough time to attend. Therefore, the sample consisted of 27 subjects with CLBP. Subjects were randomized into two exercise groups, lumbar stabilization exercises with or without FB. The exclusion criteria were: 1) unable to tolerate the training positions (standing, hook-lying, quadruped, and prone) 2) significant neurologic involvement (myotomal weakness, impaired sensation, or diminished reflexes) 3) history of surgery in the area of the lumbar spine, pelvis and lower extremities, 4) any sickness that could affect the training of the participants (uncontrolled hypertension and cardiomyopathy) 5) becoming pregnant during the study 6) had a rheumatoid disease.

All study subjects received explanations about the study procedures, voluntarily participated, and provided written informed consent. The experimental procedures were designed and conduced in accordance with the tenets of the Declaration of Helsinki.

Both groups will receive exercise intervention three times a week for 6 weeks, and each session will involve a warm up for 5 minutes and cool down for 5 minutes.

Prior to the exercise, the both group was instructed to pull the belly upward and backward so that the abdominal area was in a slightly concave position, and then maintain a neutral posture by conducting an abdominal drawing-in maneuver for 10 seconds[11].

In the lumbar stabilization exercise, the experimental group conducted the abdominal drawing-in maneuver in standing, hook-lying, quadruped, and prone positions by maintaining each motion for 10 seconds. It was used both hands holding the FB. In quadruped position were carried out with both hands alternately. Each motion was conducted 10 times in sets of three repetitions. The patients were instructed to rest in intervals of three minutes between each set[12].

The FB (Flexi-bar Inc., Germany) used in this study was 1,530 mm in length with a thickness 9 mm, with a weight 650 g. It was used to cause vibrations with a 270 times per minute (4.6 Hz).

A visual analog scale (VAS) was used to evaluate the severity of the pain and the effects of the exercise[13].

The Korean version of the Oswestry disability index (ODI) was used to evaluate functional disabilities that the subjects experienced because of lumbar pain during daily activities[14].

TrA activation capacity was assessed by using the pressure biofeedback unit (PBU, Chattanooga Group, Australia). The subject will be asked to lie in prone position over a rigid surface, then a PBU device was placed under the TrA (above the anterior superior iliac spines). Before subjects were asked to contract the muscle, the device was inflated to a pressure of 70 mmHg. The subjects are asked to contract the lower stomach for 10 seconds without moving the back or the hips[15].

Subjects were positioned supine hook-lying position (hips flexed up to 45° and knees flexed up to 90°) and the examiners on the right side of the subjects. The thickness of the TrA was evaluated using the ultrasound measurements (Terason T-3000, Teratech Corp., USA). The forward lateral margin of the abdomen, a middle area between the 11th costal cartilage and the iliac crest, was marked, and a 12.5 MHz linear transducer was located. For standardization, the area where the TrA and lumbar and thoracic fasciae met appeared at the right end of the ultrasound imaging[7]. The images were collected at the end of the exhalation.

Data were analysed with the SPSS statistical package (version 18.0; SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test demonstrated a normal distribution of quantitative data ($p>0.05$). Paired sample t-tests were conducted to determine if pain, functional disability, TrA activation capacity, and TrA thickness were significantly different pre to post for both groups and independent sample t-tests were conducted to compare group differences. Results were reported as mean and standard deviation. A value of $p<0.05$ was used as an indicator of statistical significance.

## RESULTS

The experimental group (5 males, 9 females) had a mean age of 32.47 ± 7.89 years, weight of 63.25 ± 12.81 kg height of 167.31 ± 9.63 cm, and duration of onset of 12.13 ± 3.84 months, while the control group (5 males, 8 females) values were 34.18 ± 6.59 years, 64.37 ± 9.74 kg, 166.95 ± 9.42 cm, and 13.45 ± 5.87 months, respectively. There were no baseline differences in demographic and clinical findings between the experimental and control groups.

Changes in pain, functional disability, and TrA activation capacity after the experiment were −5.26 in the experimental group and −3.21 in the control group, −11.14 in the experimental group and −8.78 in the control group, and −3.33 mmHg in the experimental group and −0.93 mmHg in the control group, respectively, which were all significantly different ($p<0.05$). Differences in pain, functional disability, and TrA activation capacity between the two groups were 2.05, 2.36, and 2.40 mmHg, respectively, which were all significantly different ($p<0.05$). Changes in the thickness of the TrA were 1.13 mm in the experimental group and 0.92 mm in the control group, which was not significantly different (Table 1).

**Table 1.** Comparison of pain, functional disability, activation capacity and thickness of TrA within groups and between groups

| | | Experimental group (n=14) | Control group (n=13) |
|---|---|---|---|
| VAS (scores) | pre | 6.63 ± 1.21 | 6.55 ± 1.09 |
| | post | 1.37 ± 0.46* | 3.33 ± 4.21* |
| | change | −5.26 ± 1.16† | −3.21 ± 4.33 |
| ODI (scores) | pre | 16.35 ± 3.46 | 16.02 ± 4.51 |
| | post | 5.21 ± 2.08* | 7.23 ± 4.06* |
| | change | −11.14 ± 2.15† | −8.78 ± 2.67 |
| TrA activation capacity (mm Hg) | pre | −3.08 ± 1.27 | −3.65 ± 1.43 |
| | post | −6.41 ± 2.48* | −4.58 ± 1.67* |
| | change | −3.33 ± 2.30† | −0.93 ± 0.85 |
| TrA thickness (mm) | pre | 3.43 ± 0.97 | 4.02 ± 1.21 |
| | post | 4.56 ± 1.04* | 4.94 ± 1.34* |
| | change | 1.13 ± 0.45 | 0.92 ± 0.81 |

Mean ± SD. VAS: Visual analog scale; ODI: Oswestry disability index; TrA: Transverse abdominis muscle. *p<0.05 by paired t-test. †p<0.05 by independent t-test.

## DISCUSSION

The result of the present study is that significant decrease in pain and ODI, a significant increase in muscle activity, and not significant change of TrA thickness were observed following lumbar stabilization exercise using FB for six weeks, when compared to stabilization exercise only.

The FB is a oscillating exercise device and is effective in the control of nerve roots, proprioceptive feedback, and muscle strengthening[16]. Another study noted that double oscillating exercise device generates higher levels of activation in the erector spinae muscle than that generated by a single oscillating device[17]. A previous study reported that bridging exercises with FB exercises increases activation of the trunk muscle[10]. Moreside, Vera-Garcia and McGill[18] commented to be careful for using FB for the purpose of spine stability in the subjects with lumbar spine pathology, while Kim et al.[10] showed high level of muscle activity with the exercise using FB as a result of tonic vibration reflex occurred by vibration stimulus.

Mayer, Mooney and Dagenais[19] observed that the activation patterns of the abdominal and multifidus muscles of CLBP patients were different from those of normal people and that stabilization exercise could improve these activation patterns[4]. Andrusaitis et al.[20] noted that trunk stabilization exercises triggered co-contraction of the abdominal and multifidus muscles and could be applied in different postures. Macedo et al.[21] noted that stabilization exercises were effective in alleviating pain and improving function. Andrusaitis et al.[20] asserted that stabilization exercises were more effective than strengthening exercises in a study where pain and functional disability. VAS decreased from 5.08 to 0.23, and ODI decreased from 11.8 to 3.4 after stabilization exercises. In the present study, VAS decreased from 6.63 to 1.37 and ODI decreased from 16.35 to 5.21 in the experimental group. VAS decreased from 6.55 to 3.33 and ODI decreased from 16.02 to 7.23 in the control group, which showed results similar to those of the previous research. As a result, the lumbar stabilization exercises with FB have been shown to be more effective in pain and functional disability.

Hides, Richardson and Jull[3] insisted that deep muscles did not recover after pain decreased in CLBP patients, and therefore exercise to recover these muscles was necessary. França et al.[22] asserted that training of the TrA should be included in rehabilitation protocols for CLBP patients. A representative method to measure muscle contraction is a PBU test, which was used in this study to measure the activation capacity of the TrA. The values ranged from −4 to −10 mmHg in contractions of normal TrA[23]. França et al.[22] compared the contraction capacity of TrA when stabilization exercises and stretching exercises and reported increased contraction capacity of TrA in stabilization exercises. Stabilization exercise using FB was more effective to show from −3.08 mmHg to −6.41 mmHg in the test group than from −3.65 mmHg to −4.58 mmHg in the control group in this study, whose exercise method was different from that of the previous study. This result is consistent with the previous study result that the exercise using FB with quadruped position developed the equilibrium reaction by continuous vibration stimuli in the unstable condition, and the muscle activation levels were increased in both superficial and deep muscles[10].

Mannion et al.[24] noted that measuring the thickness of the TrA to evaluate core stability was important. Their results showed that the thickness of the TrA of low back pain patients was 21% smaller than that in normal people[25]. Hides et al.[26] verified the relation between weight load and the thickness of the TrA, noting that the thickness of the TrA was 4.0 mm at rest and increased to 4.5 mm at 25% weight load and to 4.9 mm at 45% weight load. Teyhen et al.[25] observed that the thickness of the TrA increased from 3.8 mm at rest to 6.1 mm during lumbar stabilization in unilateral low back pain patients. The thickness of the TrA increased from 4.1 mm at rest to 6.8 mm during lumbar stabilization in normal subjects, with no difference between the two groups. However, in a study where abdominal resistance training was conducted for 12 weeks, Noormohammadpour et al.[27] asserted that special TrA training was necessary that showed TrA played an important role in the stabilization of the spine. They observed that the thickness of the TrA increased from 0.42 mm prior to the intervention to 0.48 mm after the intervention[26]. In the present study, the TrA increased from 3.43 mm to 4.56 mm in the experimental group and from 4.02 mm to 4.94 mm in the control group. This result increased the neuromuscular activities in both the experimental and the control groups, resulting in increased TrA thickness.

The main limitation of the present study was its inability to blind the subjects and the therapist with regard to training allocation. The small number of samples, the relatively short intervention period of six weeks, and the fact that TrA activation capacity and thickness in dynamic conditions was not measured. The present study sample is likely not representative of all CLBP patients. In addition, the changes in the thickness of muscles and the quality of muscles in relation to age and muscle power should be also studied. Since only the thickness of the TrA was measured in the present study, measuring and comparing the thickness of other muscles may different results. Finally, the effects of the exercises performed by large participants for long-term should be examined in future studies.

*Conflict of interest*

None.

## REFERENCES

1) Bayramoğlu M, Akman MN, Kilinç S, et al.: Isokinetic measurement of trunk muscle strength in women with chronic low-back pain. Am J Phys Med Rehabil, 2001, 80: 650–655. [Medline] [CrossRef]
2) O'Sullivan PB, Phyty GD, Twomey LT, et al.: Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. Spine, 1997, 22: 2959–2967. [Medline] [CrossRef]
3) Hides JA, Richardson CA, Jull GA: Multifidus muscle recovery is not automatic after resolution of acute, first-episode low back pain. Spine, 1996, 21: 2763–2769. [Medline] [CrossRef]
4) Goldby LJ, Moore AP, Doust J, et al.: A randomized controlled trial investigating the efficiency of musculoskeletal physiotherapy on chronic low back disorder. Spine, 2006, 31: 1083–1093. [Medline] [CrossRef]
5) Urquhart DM, Hodges PW, Allen TJ, et al.: Abdominal muscle recruitment during a range of voluntary exercises. Man Ther, 2005, 10: 144–153. [Medline] [CrossRef]
6) Souza GM, Baker LL, Powers CM: Electromyographic activity of selected trunk muscles during dynamic spine stabilization exercises. Arch Phys Med Rehabil, 2001, 82: 1551–1557. [Medline] [CrossRef]
7) Teyhen DS, Miltenberger CE, Deiters HM, et al.: The use of ultrasound imaging of the abdominal drawing-in maneuver in subjects with low back pain. J Orthop Sports Phys Ther, 2005, 35: 346–355. [Medline] [CrossRef]
8) Hodges PW, Richardson CA: Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. Arch Phys Med Rehabil, 1999, 80: 1005–1012. [Medline] [CrossRef]
9) Cohen LG, Starr A: Vibration and muscle contraction affect somatosensory evoked potentials. Neurology, 1985, 35: 691–698. [Medline] [CrossRef]
10) Kim JH, So KH, Bae YR, et al.: A comparison of flexi-bar and general lumbar stabilizing exercise effects on muscle activity and fatigue. J Phys Ther Sci, 2014, 26: 229–233. [Medline] [CrossRef]
11) Kisner C, Colby LA: Therapeutic exercise: foundations and techniques, 4th ed. Philadelphia: FA. Davis, 2002.
12) Richardson CA, Jull GA: Muscle control-pain control. What exercises would you prescribe? Man Ther, 1995, 1: 2–10. [Medline] [CrossRef]
13) Jensen MP, Chen C, Brugger AM: Interpretation of visual analog scale ratings and change scores: a reanalysis of two clinical trials of postoperative pain. J Pain, 2003, 4: 407–414. [Medline] [CrossRef]
14) Jeon CH, Kim DJ, Kim SK, et al.: Validation in the cross-cultural adaptation of the Korean version of the Oswestry Disability Index. J Korean Med Sci, 2006, 21: 1092–1097. [Medline] [CrossRef]
15) França FR, Burke TN, Hanada ES, et al.: Segmental stabilization and muscular strengthening in chronic low back pain: a comparative study. Clinics (Sao Paulo), 2010, 65: 1013–1017. [Medline] [CrossRef]
16) Schulte RA, Warner C: Put to the test: Oscillatory devices accelerate proprioception training. Clin Biomech (Bristol, Avon), 2001, 8: 85–90.
17) Arora S, Button DC, Basset FA, et al.: The effect of double versus single oscillating exercise devices on trunk and limb muscle activation. Int J Sports Phys Ther, 2013, 8: 370–380. [Medline]
18) Moreside JM, Vera-Garcia FJ, McGill SM: Trunk muscle activation patterns, lumbar compressive forces, and spine stability when using the bodyblade. Phys Ther, 2007, 87: 153–163. [Medline] [CrossRef]
19) Mayer J, Mooney V, Dagenais S: Evidence-informed management of chronic low back pain with lumbar extensor strengthening exercises. Spine J, 2008, 8: 96–113. [Medline] [CrossRef]
20) Andrusaitis SF, Brech GC, Vitale GF, et al.: Trunk stabilization among women with chronic lower back pain: a randomized, controlled, and blinded pilot study. Clinics (Sao Paulo), 2011, 66: 1645–1650. [Medline] [CrossRef]
21) Macedo LG, Maher CG, Latimer J, et al.: Motor control exercise for persistent, nonspecific low back pain: a systematic review. Phys Ther, 2009, 89: 9–25. [Medline] [CrossRef]
22) França FR, Burke TN, Caffaro RR, et al.: Effects of muscular stretching and segmental stabilization on functional disability and pain in patients with chronic low back pain: a randomized, controlled trial. J Manipulative Physiol Ther, 2012, 35: 279–285. [Medline] [CrossRef]
23) Richardson CA, Hodges P, Hides JA: Therapeutic exercise for lumbopelvic stabilization: a motor control approach for the treatment and prevention of low back pain, 2nd ed. Queensland: Churchill Livingstone, 2004.

24) Mannion AF, Pulkovski N, Toma V, et al.: Abdominal muscle size and symmetry at rest and during abdominal hollowing exercises in healthy control subjects. J Anat, 2008, 213: 173–182. [Medline] [CrossRef]
25) Teyhen DS, Bluemle LN, Dolbeer JA, et al.: Changes in lateral abdominal muscle thickness during the abdominal drawing-in maneuver in those with lumbopelvic pain. J Orthop Sports Phys Ther, 2009, 39: 791–798. [Medline] [CrossRef]
26) Hides JA, Belavý DL, Cassar L, et al.: Altered response of the anterolateral abdominal muscles to simulated weight-bearing in subjects with low back pain. Eur Spine J, 2009, 18: 410–418. [Medline] [CrossRef]
27) Noormohammadpour P, Kordi R, Dehghani S, et al.: The effect of abdominal resistance training and energy restricted diet on lateral abdominal muscles thickness of overweight and obese women. J Bodyw Mov Ther, 2012, 16: 344–350. [Medline] [CrossRef]