

Original Article

Effect of trunk stabilization exercises on trunk muscle activation using different respiratory conditions

SANG-HUN LEE¹⁾, SEUNG-GEUN LEE¹⁾, BO-RAM CHOI, PhD, PT^{1)*}

¹⁾ Department of Physical Therapy, College of Health and Welfare, Silla University:
315 Euisaengmyung-gwan, 700 Bakyangdae-ro, Sasang-gu, Busan 46958, Republic of Korea

Abstract. [Purpose] The purpose of this study is to evaluate differences in trunk muscle activity after 4 weeks of trunk stabilization exercises performed under expiration and inspiration conditions. [Subjects and Methods] Thirty subjects were assigned randomly to an expiration group (n=15) or an inspiration group (n=15). The outcomes measured were magnitude of muscle activation (rectus abdominis, multifidus, internal oblique and external oblique) in the bridge position and performance on a trunk muscle endurance test. Paired t-tests were used to assess the statistical significance of the effects of the trunk stabilization exercise program within each group. [Results] Comparison of the electromyography activity of the trunk muscles revealed a significant increase in internal oblique activation in the inspiration group, and a significant increase in multifidus activation in the expiration group. Assessment of the endurance of the trunk muscles revealed a significant increase in both groups. [Conclusion] Our results showed that expiration during trunk stabilization exercises increased the activity of the multifidus muscle, while inspiration enhanced the activity of the internal oblique muscle. Different types of respiration seem to differentially affect trunk muscles during trunk stabilization exercises.

Key words: Expiration, Inspiration, Trunk stabilization exercise

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INTRODUCTION

Trunk-stabilizing exercises using a sling are considered useful for improving muscular strength and endurance around the abdomen and pelvis, and for increasing stability and maintaining proper posture of the spine and trunk. As well as being beneficial for healthy people and athletes, these exercises are also used for rehabilitation and to prevent damage from exercise in patients with lumbar pain^{1,2)}. In previous studies, the efficacy of trunk stabilization exercises varied according to breathing method. Lee et al. reported that internal oblique muscle activity was activated more during trunk stabilization exercises with expiration than with inspiration³⁾. However, Son's study reported that balance was improved, and back pain reduced, to a greater degree after trunk stabilization exercises with inspiration than with expiration⁴⁾. Many studies have highlighted the effects of expiration and inspiration on trunk muscle activity during trunk-stabilizing exercises, but few have compared differences in trunk muscle activity according to these two breathing methods. The purpose of this study was to assess the difference in trunk muscle activity between an expiration group and an inspiration group over a 4-week trunk-stabilizing exercise program.

SUBJECTS AND METHODS

In total, 30 women were recruited and assigned randomly to two groups (expiration group, n=15, mean age: 19.9 ±

*Corresponding author. Bo-ram Choi (E-mail: boram@silla.ac.kr)

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0.2 years, mean body mass index (BMI): $20.8 \pm 2.1 \text{ kg/m}^2$; inspiration group, $n=15$, mean age: 20.9 ± 0.2 years, mean BMI: $20.9 \pm 2.8 \text{ kg/m}^2$). Participants with respiratory and neuro-muscular skeletal diseases, or a history of spinal surgery were excluded. Subjects were provided informed consent according to the principles of the Declaration of Helsinki. All procedures were reviewed and approved by the ethics committee of Silla University (1041449-201511-HR-001). To measure activity of the rectus abdominis (RA), internal oblique (IO), erector spinae (ES), and multifidus (MF), surface electromyography (EMG) was used (Myotrace 400; Noraxon Inc., Scottsdale, AZ, USA) and an analog to digital conversion was performed on the data using the MyoResearch XP Master software (ver. 1.07; Noraxon). The sampling rate was set at 1,000 Hz. A band-pass filter of 20–450 Hz and notch filter of 60 Hz were used. To maintain the electrode distance of Ag/AgCl at 2 cm, the poles were attached parallel to the direction of the muscle fibers. For normalization of the EMG data, maximal voluntary isometric contraction (MVIC) was measured in the muscles in the manual testing position⁵). The MVIC was detected after 3 s of contraction, and then measured for 5 s. We used the highest 1-s value among three recordings. Participants practiced for 20 s to familiarize themselves with the procedure. The expiration group maintained expiration by relaxing the diaphragm and activating the abdominal muscles during the trunk stabilization exercise. The inspiration group maintained inspiration by activating the diaphragm and relaxing the abdominal muscles during the trunk stabilization exercise. The exercise program consisted of a revised expert's sling exercise⁶). Participants performed warm-up exercises (lumbar relaxation, lumbar extensor stretching, and traction), followed by the main exercises (sling exercise in supine and prone position), and cool-down exercises (lumbar relaxation, lumbar extensor stretching, and traction). The participants performed the exercises three times per week (30 min per day) for 4 weeks. Muscle activation when in the bridge posture was assessed, according to EMG measurements of trunk muscle activity changes, before versus after the trunk stabilization exercise program. The endurance test consisted of a trunk flexor and extensor endurance test⁷). The endurance test of trunk flexor was held trunk flexion in 60° in supine position. The endurance test of trunk extensor was held trunk extension in parallel to table in prone position. Each test was stopped when the subject gave up. Data were analyzed with SPSS software (ver. 20.0; SPSS Inc., Chicago, IL, USA). To determine changes in %MVIC of trunk muscle activity and endurance time before versus after the exercise program, paired t-tests were performed. To compare changes in trunk muscle activity and endurance between the groups, before versus after the exercise program, independent t-tests were used. Statistical significance was set at $\alpha=0.05$.

RESULTS

Regarding trunk muscle activity before versus after the trunk stabilization exercise program, the inspiration group showed significantly increased activity in the IO and the expiration group showed significantly increased activity in the MF (Table 1). Regarding the endurance test, both groups showed significant increases in endurance after the trunk stabilization exercise program (Table 2). No significant difference was seen in trunk muscle activity or endurance test performance between the expiration and inspiration groups.

Table 1. Comparison of trunk muscle activity before and after trunk stabilization exercise

Muscle activation (%)		Pre-test	Post-test	p
Inspiration group	RA	18.3 ± 15.9	16.7 ± 11.8	0.728
	IO	6.3 ± 5.1	10.8 ± 8.2	0.013
	ES	70.1 ± 31.0	66.3 ± 21.3	0.408
	MF	74.2 ± 34.8	87.3 ± 25.8	0.345
Expiration group	RA	19.1 ± 11.6	18.0 ± 19.6	0.356
	IO	11.9 ± 13.51	15.6 ± 14.3	0.102
	ES	98.0 ± 24.3	94.6 ± 22.3	0.596
	MF	95.4 ± 22.9	115.4 ± 21.8	0.001

RA: Rectus abdominals; IO: Internal oblique; ES: Erector spinae; MF: Multifidus.

Table 2. Comparison of trunk muscle endurance before and after trunk stabilization exercise

Endurance time (sec)		Pre-test	Post-test	p
Inspiration group	Trunk flexor	17.2 ± 15.5	39.9 ± 26.6	0.000
	Trunk extensor	25.7 ± 11.4	79.3 ± 26.2	0.000
Expiration group	Trunk flexor	17.9 ± 21.6	41.5 ± 33.1	0.000
	Trunk extensor	33.9 ± 23.2	85.5 ± 55.4	0.000

DISCUSSION

Trunk muscle activity before versus after the trunk stabilization exercise program was increased in the inspiration group for the IO, and in the expiration group for the MF.

In both groups, activity of the deep muscles, i.e., the IO and MF increased, while that of the superficial muscles, i.e., the RA and ES, decreased (non-significant), greater activity of these deep muscles will be helpful for patients who have low back pain. O'Sullivan et al. and Hides et al. reported that trunk stabilization exercises activated the MF and decreased low back pain^{8, 9}). However, Kim et al. reported that in their inspiration group, exercises performed in various positions increased the activation of the ES, had no effect on the activation of the RA, and increased the activation of the IO relative to a control group¹⁰). Additionally, when trunk muscle activity was measured during exercises done using a Swiss ball in the supine and prone postures, RA activity showed an up to 30% increase versus that of the other trunk muscles¹¹). Previous studies examined temporary muscle activity during trunk stabilization exercises, but the exercises involved control of the breathing⁵). Thus, when the trunk stabilization exercise was carried out in the inspiration group, the activity of the ES decreased (non-significant) and that of the IO increased. Accordingly, trunk stabilization exercises are considered to be more effective when done with controlled inspiration rather than with uncontrolled breathing. Additionally, endurance of flexor and extensor increased after the trunk stabilization exercises. It is thought that this endurance increase was due to increased activation of the deep muscles (IO and MF). Trunk-stabilizing exercises have been shown to increase the endurance of the trunk flexors and extensors, and to improve balance in the standing posture¹²). Thus, there is a close connection between deep muscle strengthening and increased trunk endurance. This study was limited by the participants all being healthy students, making the results difficult to generalize. If participants had a sign of spinal instability, the purpose of this study was more supported than healthy participants because the increased muscle activity would contribute in stabilizing the spine. Also, the 4-week intervention period was relatively short. The transverse abdominis muscles are the deepest abdomen muscles that affect trunk stabilization, but they could not be checked for activation in this study due to the limitations of surface EMG. Future studies should investigate diaphragm movement and activation of the transverse abdominis after trunk stabilization exercises performed under different breathing conditions. In conclusion, our trunk stabilization exercises increased deep muscle activity and endurance. Also, deep muscle activity increased endurance to a greater degree under the inspiration versus expiration condition. Thus, different types of respiration seem to differentially affect trunk muscles during trunk stabilization exercises.

Conflict of interest

None

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