



Original Article

The effects of Pilates breathing trainings on trunk muscle activation in healthy female subjects: a prospective study

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Abstract. [Purpose] To investigate the effects of Pilates breathing on trunk muscle activation. [Subjects and Methods] Twenty-eight healthy female adults were selected for this study. Participants' trunk muscle activations were measured while they performed curl-ups, chest-head lifts, and lifting tasks. Pilates breathing trainings were performed for 60 minutes per each session, 3 times per week for 2 weeks. Post-training muscle activations were measured by the same methods used for the pre-training muscle activations. [Results] All trunk muscles measured in this study had increased activities after Pilates breathing trainings. All activities of the transversus abdominis/internal abdominal oblique, and multifidus significantly increased. [Conclusion] Pilates breathing increased activities of the trunk stabilizer muscles. Activation of the trunk muscle indicates that practicing Pilates breathing while performing lifting tasks will reduce the risk of trunk injuries.

Key words: Pilates breathing, Core muscle, Lifting task

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INTRODUCTION

Stabilizer muscles of the trunk in the human body refer to the deep muscles that contribute to stabilization. Stabilizer muscles in the waist region include the diaphragm, pelvic floor muscles, transversus abdominis, internal abdominal oblique, and multifidus¹⁾. Among these stabilizer muscles, the transversus abdominis and multifidus are especially important²⁾. Trunk stabilizer muscles are activated before the body initiates motion to stabilize the vertebral column³⁻⁵⁾. When there is back pain, pain prevents some movements of the lumbar spine and pelvis, and such a phenomenon weakens the stabilizer muscles, which can lead to chronic back pain⁶⁾. It has been confirmed that the contraction of stabilizer muscles is reduced and the order of muscle recruitment is reversed in patients with back pain⁷⁾. Therefore, physical therapy in patients with back pain focuses on rehabilitation of the stabilizer muscles to reduce pain, and improve muscle endurance and muscle strength⁸⁻¹¹⁾. Pilates-based therapeutic exercises have become popular as stabilization exercises^{12, 13)}. These exercises are based on six principles: concentration, control, centering, flowing movement, precision, and breathing¹⁴⁾. Among these basic principles, breathing applies to all ranges of motion during all exercises, and breathing promotes activation of the trunk stabilizer muscles¹⁴⁾. Even though study of effects of Pilates breathing on trunk muscle activation during the trunk flex in a previous study was existed¹⁵⁾, there was not studied another movement of trunk (for example, extension) or function associated movement.

It is necessary to investigate the actual effects of breathing on the trunk stabilizer muscles in various trunk movements. Therefore, the purpose of the present study was to investigate the effects of Pilates breathing on trunk muscle activities during trunk flexion and extension exercise. Additionally, the relationship between Pilates breathing and lifting, which is associated with back pain, was evaluated.

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SUBJECTS AND METHODS

Twenty-eight healthy female adults in their 20s participated in this study. Participants did not have a history of trunk surgeries, existing back pain, or prior Pilates experience, and they did not have any problems performing exercises. This study was approved by Cheongju University's Research and Ethics Committee. All participants received verbal and written information about the study and signed a consent form. Surface electromyography (EMG) (TeleMyo DTS Telemetry, Noraxon, AZ, USA) was used to measure the trunk muscle activities. The sampling rate was set to 1,000 Hz, band pass filter was set to 20–450 Hz, and notch filter was set to 60 Hz. Activities of the trunk flexors such as the rectus abdominis and trunk deep stabilizers such as the transversus abdominis, internal abdominal oblique and trunk extensor such as erector spinae, multifidus were measured. Electrodes were placed on the muscles of the right side of the participants' body, and the locations of the electrodes were shaved and cleaned with alcohol before the measurements were taken to reduce impedance. The electrode for the rectus abdominis was placed on upper belly of the muscle below the xiphoid process, 3 cm to the right of the medial line¹⁶. The electrode for the erector spinae was placed on the muscle, 3 cm to the right of the third lumbar spinous process. The electrode for the transversus abdominis/internal abdominal oblique was placed 2 cm below and medial of the right anterior superior iliac spine¹⁷. The electrode for the multifidus was placed 2 cm to the right of the fifth lumbar spinous process¹⁸. EMG data were collected during 3 Pilates based therapeutic exercises at baseline and after the breathing training. Head and chest curl-ups and chest-head lifts were selected for this study, as they are representative motions for trunk flexion and extension. Head and chest curl-ups in supine hook-lying position with both hands behind the head and maintain the Chin-in position was performed flex the upper trunk in the sagittal plane until scapula inferior angle. Chest-head lifts in prone position with both hands behind the head and maintain the Chin-in position was performed extend the upper trunk in the sagittal plane until xiphoid process. Additionally, lifting tasks, which are daily activities directly related to back pain, were also performed. Lifting task was lifted 10-kg weight Dumbbell placed in the middle of both knee with Knee flexed approximately 30° in 30 cm apart stance (indicated by floor markings) and keep straight arms and maintain neutral pelvic position that extend the only hip and trunk in the sagittal plane until upright the trunk. Sufficient exercise training without breathing control was provided to participants by Pilates instructor before the test so that the three exercises could be performed accurately. Participants were allowed 30 minutes of rest after the training before proceeding to the experiment. Each exercise was performed five times, and EMG data were recorded middle three times. To prevent muscle fatigue, 2 minutes of rest were allowed in between each exercise. Using a metronome, each exercise was performed for 6 seconds (3 seconds of contraction and 3 seconds of relaxation). The MVIC method was used to normalize the EMG data¹⁹. Five seconds of maximum isometric contraction was performed three times. After discarding 1 second from both the beginning and end, EMG data from the 3 seconds in between each recording were collected. Participants were allowed to rest for more than 5 minutes after the measurement was obtained. During the pre-measurement, participants were instructed to perform the exercises without restricting their breathing and by using their usual breathing methods. After the pre-measurement, participants underwent Pilates breathing training, which was guided by a Pilates instructor. A 60-minute Pilates breathing training session was performed three times per week for 2 weeks. Pilates breathing training session was consists of only breathing control in the supine position.

Changes in the muscle activities after the experiment (%MVIC) were investigated by performing the paired t-test. SPSS 22, version (IBM Corp., Armonk, NY, USA) was used to perform statistical analysis. The significance level was set to <0.05, and the Kolmogorov-Smirnov test was performed to test for normality.

RESULTS

As shown in [Table 1](#), all muscle activities increased after Pilates breathing. Statistically significant improvements were observed in the stabilizer muscles transversus abdominis/internal abdominal oblique and multifidus.

DISCUSSION

Appropriate breathing is very important during exercise. All different types of exercises have their own applicable breathing methods. There are several reasons why the importance of appropriate breathing is encouraged. The recovery of spinal stability can be achieved through breath training alone^{20, 21}. Pilates exercise also emphasizes the importance of appropriate breathing for stabilizing the trunk²². Besides stabilizing the trunk, stabilizer muscles such as the transversus abdominis, internal abdominal oblique, and multifidus also contribute to voluntary respiration. The transversus abdominis, especially, along with the diaphragm, is activated during exhalation, and it experiences the largest change in thickness during maximal exhalation²³. Additionally, the transversus abdominis, along with diaphragm movement, can induce isometric contraction of the trunk stabilizer muscles and activation of the pelvic floor muscles by increasing abdominal pressure. Therefore, incorporating abdominal respiration during trunk stabilization exercises can produce better results^{24, 25}. Since activities of the trunk stabilizer muscles can be regulated by one's breath, breathing should always be considered during stabilization exercises. Our study's results showed that performing Pilates breathing during curl-ups, chest-head lifts, and lifting tasks significantly increased activities of the transversus abdominis/internal abdominal oblique and multifidus. Barbosa et al. re-

Table 1. Comparison of muscle activities (MVIC%)

Exercise	Muscles	Pre-rest	Post-test
Curl-up	RA	38.84 ± 21.17	46.83 ± 18.62
	TrA/IO	45.07 ± 35.15	68.34 ± 40.64**
	ES	5.52 ± 4.84	5.84 ± 3.48
	MF	6.34 ± 4.77	8.95 ± 4.48**
Chest-Head lift	RA	13.17 ± 19.19	22.64 ± 31.46*
	TrA/IO	12.84 ± 12.97	40.36 ± 25.20***
	ES	39.72 ± 20.79	54.49 ± 15.59**
	MF	45.69 ± 14.26	54.40 ± 15.27**
Lifting task	RA	6.13 ± 4.1	6.61 ± 4.59
	TrA/IO	24.21 ± 22.72	39.22 ± 25.75***
	ES	47.69 ± 17.28	53.86 ± 15.31
	MF	50.17 ± 12.64	62.59 ± 18.22**

Values are expressed as mean ± SD.

Asterisks indicate a significant difference between Pre-Post test (*p<0.05, **p<0.01, ***p<0.001).

RA: rectus abdominis, TrA/IO: transversus abdominis/internal oblique, ES: erector spinae, MF: multifidus

ported that activities of the transversus abdominis or internal abdominal oblique significantly increase when Pilates breathing is incorporated, which coincides with our study's results¹⁵). Yoon et al. also reported that slow exhalations during curl-ups selectively increase activities of the transversus abdominis and internal abdominal oblique²⁶). The present study differs from previous studies since an intervention period was allocated for breathing training. In addition, previous studies were limited to curl-ups and trunk flexions, whereas our study measured activities of all the flexion, extension, and stabilizer muscles of the trunk. The effects of Pilates breathing on trunk muscles during lifting tasks were also investigated. Several studies have suggested that lifting tasks and back pain are related^{27–29}). Isometric contraction of the trunk muscles can reduce the risk of back pain during lifting tasks³⁰). Increased activities of the trunk muscles with Pilates breathing indicate that Pilates breath training during lifting tasks can reduce the risk of back injuries. Patients with acute back pain cannot easily move their spine due to severe pain. Trunk movements are also restricted in patients immediately after surgery due to severe pain and possible side effects. Pilates breathing can induce muscle activation even without actual body movements. Therefore, effectiveness of Pilates breathing trainings in patients with acute back pain or in those whose trunk movements are restricted due to a recent back surgery or surgical procedure is suggest future studies. The current study's findings show immediate results after the breath training intervention. Therefore, a further study in which participants are followed up for a specific period is necessary to determine the long-term effects of breath training.

Our study's results show that Pilates breathing increases activities of the transversus abdominis/internal abdominal oblique and multifidus. Therefore, the use of Pilates breathing can more effectively increase activities of the muscles during trunk-stabilizing exercises. Moreover, performing Pilates breathing during lifting tasks can prevent potential injuries by increasing muscle activities. Lastly, Pilates breathing can be an effective method for patients with acute back pain or those who have undergone back surgery and have restricted trunk movement.

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