

Effects of selective exercise for the deep abdominal muscles and lumbar stabilization exercise on the thickness of the transversus abdominis and postural maintenance

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Abstract. [Purpose] The purpose of this study was to examine the effects of selective exercise for the deep abdominal muscles (SEDA) and lumbar stabilization exercise (LSE) on the thickness of the transversus abdominis and postural maintenance on an unstable base of support. [Subjects and Methods] The subjects of this study were 20 male and 10 female adults in their 20s without lumbar pain. They were equally and randomly assigned to a SEDA group and a LSE group. The thickness of the transversus abdominis was measured using ultrasound imaging during rest and drawing-in. The thickness of the transversus abdominis was measured when subjects raised their right and left legs while lying on a Swiss ball. [Results] Initially, there were no differences between the two groups. After the intervention, significant differences were observed in all parameters. A significant interaction between group and period was not found for any parameters. [Conclusion] In conclusion, both SEDA and LSE thickened the transversus abdominis, which is a deep abdominal muscle, thereby adjusting posture, and stabilizing the trunk. These exercises increased the thickness of the deep abdominal muscles. They are important exercises for improving the stability of athletes or patients who need postural adjustment.

Key words: Transversus abdominis, Selective exercise, Lumbar stabilization

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INTRODUCTION

Training of trunk muscle control has been found to be effective at improving muscle activity. Although there are many training methods, they can largely be divided into two types of exercise: isolated voluntary contraction, and non-isolated voluntary contraction that also includes co-activation of all trunk muscles¹⁾. Selective exercise for the deep abdominal muscles (SEDA) is an isolated voluntary contraction exercise. It generates smooth voluntary contraction of the lower abdominal wall surface by pulling the muscle upward and medially without movements of the pelvis, thorax, or vertebrae²⁾.

The abdominal drawing-in exercise, a SEDA, thickens and voluntarily activates the transversus abdominis while leaving the externus obliquus abdominis and the internus

obliquus abdominis relatively unchanged³⁾. The abdominal drawing-in exercise is often used as a stabilization technique to recover the neuromuscular control of athletes whose trunk stability muscles have been damaged, and it is widely known to reduce the pain of low-back pain patients⁴⁾.

The Lumbar stabilization exercise (LSE) is a non-isolated voluntary contraction exercises. It elicits postural adjustment and production of optimal power, coordinated movement of the pelvis and trunk, and the ability to adjust the power and movement of the final phase of integrated task activities⁵⁾. All muscles, including the back muscles and abdominal muscles, contribute to trunk stability, and exercise programs aimed at trunk stability include co-activation of the trunk flexor and extensor muscles⁶⁾. Suni et al.⁷⁾ reported that LSE aligned the vertebrae the neutral position. According to the results of their study, lumbar pain decreased and task ability increased when the vertebrae were aligned in the neutral position as a result of LSE, that also elicits co-contraction of the muscles. There have been many studies of exercises that isolate certain muscles, but research on exercises using multiple muscles is lacking. Accordingly, this study was conducted to examine the effects of SEDA and LSE performed by adults on the thickness of the transversus abdominis and postural maintenance on an unstable base of support.

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SUBJECTS AND METHODS

Subjects

The subjects provided their informed consent before participating in this study. This study was approved by the Institutional Review Board of the Daegu University, following the ethical principles of the Declaration of Helsinki.

The subjects of this study were 30 healthy adults in their 20s (males: 20, females: 10) from B University, which is located in Daegu Metropolitan City. The criteria for the exclusion were: a history of lumbar pain in the past six months, 2) congenital malformation of the limbs, or orthopedic or neurological disease.

The subjects equally and randomly assigned to a SEDA group and a LSE groups, and they performed their respective exercises in 30 minute sessions four times per week for five weeks.

Methods

The SEDA group received training on abdominal drawing-in using a pressure biofeedback device. The abdominal drawing-in exercise was conducted lying down, and the knee joints were flexed at 90°. The pressure biofeedback device was located under the lumbar vertebrae of the subjects during the abdominal drawing-in exercise. The subjects watched the pressure gauge connected to the pressure biofeedback device and were trained to increase the pressure from 40 mmHg to 50 mmHg and then to maintain the pressure at 50 mmHg. Then, the examiner instructed the subjects to maintain the position by pulling the navel upward and posteriorly (in the direction of the lumbar vertebrae) so that the abdominal area was slightly hollow during expiration. They were instructed to maintain the abdominal drawing-in for 10 seconds. They rested for five seconds after each trunk. One set consisted of 10 repetitions and 5–7 set were performed in each session.

The LSE consisted of curl-up (raising the head and the thorax), side bridge (raising the trunk in a side-lying position), and bird-dog (alternately raising one hand and one leg in a quadruped position) exercise.

For the curl-up, the subjects lay in a supine position with their left knee joints flexed at 90°, and they placed both hands behind their head. Then they raised their head and their shoulders from the mat, maintained the position for 10 seconds, and then rested for five seconds. They repeated this motion five times¹⁰. They conducted this exercise for both sides performing three to four sets in 10 minutes on each side.

For the side bridge, the subjects adopted a side-lying position on their left side on the mat, supporting their weight with the left elbow and leg and then raising the hips. They maintained this posture for 12 seconds and rested for five seconds. They repeated this motion five times. They were then instructed to repeat the motion in a side-lying position on their right side. They conducted the exercise on both sides, performing two to three sets in 10 minutes for each side⁸.

For the bird-dog, the subjects adopted a quadruped position, and maintained a drawing-in position. Then they raised the left arm and the right leg until they were parallel with the floor and held this position for 12 seconds. After the task,

they rested for five seconds. They repeated this task five times. Then they repeated the task, raising the right arm and the left leg. They performed the alternately, performing two to three sets within 10 minutes¹⁰.

Ultrasound equipment (Achievo CST, KOASTRON Co., Singapore) with a 7.5 MHz ultrasound transducer were used for measurement. Ultrasound gel was applied between ultrasound probe and the skin. The abdominal muscles were identified using ultrasound imaging. The thickness of the transversus abdominis, internus obliquus abdominis, and externus obliquus abdominis were measured 1 cm from the boundary delineated by the fascia in the direction of the central area of the muscles⁹. The thickness of the transversus abdominis was measured during rest and drawing-in. Measurements were taken three times, and the average value was used in the analysis.

For the measurement of the posture maintenance time, the motionless time was measured while the subjects raised one leg in a supine position on a Swiss ball without support. In order to exclude a carry-over effect, the order was randomly determined. Prior to the experiment, the subjects were trained to sufficiently understand the content of the exercises. The subjects repeated each exercise three times, and the average value was used in the analysis. In order to minimize any muscle fatigue that might have occurred due to repeated measurement, the subjects rested for one minute after each exercise.

SPSS 17.0 was used for statistical processing. Differences in the general characteristics between the two groups were analyzed using the independent t-test, and the Kolmogorov-Smirnov test was performed as a normality test for the measured values. ICC_(3,1) was used to derive the intra-rater reliability of ultrasound measurements. Two-way analysis of variance was used to examine differences in the thickness of the transversus abdominis and the time taken to maintain the postures between the two groups and period. The significance level was chosen as $\alpha=0.05$

RESULTS

In the SEDA group, the subjects' average height was 169.8 cm, and their average weight was 63.5 kg (10 males and 5 females). In the LSE group, the subjects' average height was 169.5 cm, and their average weight 63.2 kg (10 males and 5 females) (Table 1). The general characteristics of the two groups were not significantly different. In this study, the intra-rater reliability for the measurement of the transversus abdominis thickness was high, ICC_(3,1) values from 0.88–0.99 (Table 2). Initially, there were no differences between the two groups. After the intervention, significant differences were observed for all parameters. A significant interaction between group and period was not found for any parameter (Table 3).

DISCUSSION

The deep abdominal muscles are used in postural adjustment. Accordingly, this study examined changes in the thickness of the transversus abdominis in order to verify changes in the deep abdominal muscles associated with postural

maintenance and adjustment, and how the thickness affects postural adjustment.

Drysdale et al.¹⁰⁾ reported that the muscle activity of the rectus abdominis and the obliquus externus abdominis decreased more when subjects performed an abdominal hollowing exercise than when they performed a pelvic tilt exercise. They indicated that the reason for this was that when the exercise was properly performed, inducing contraction of local deep muscles, the transversus abdominis was selectively contracted, while the global muscles of the surface, such as the rectus abdominis, obliquus internus abdominis, and obliquus externus abdominis, were contracted less¹¹⁾.

In this study, there were no differences in the two groups, characteristics and the thickness of the transversus abdominis during the drawing-in maneuver increased after the intervention. The transversus abdominis of the SEDA group became thicker than that of the LSE group, because SEDA selectively and more effectively contracts the transversus

abdominis. Both the SEDA and the LSE are considered to elicit contraction of the transversus abdominis and to thicken it. Kim et al.¹²⁾ reported that abdominal drawing-in exercise increased the thickness of the deep abdominal muscles, significantly increased the thickness of the deep abdominal muscles of patients with low back pain. Park et al.¹³⁾ reported that trunk stabilization exercise improved balance ability and postural adjustment.

Hides et al.¹⁴⁾ reported that the transversus abdominis, internus obliquus abdominis, and externus obliquus abdominis stabilize the trunk and also play important role in postural adjustment, and in particular, the transversus abdominis plays a major role, in stabilizing the lumbar region together with the multifidus.

Ainscough-Potts et al.¹⁵⁾ reported that when the subjects sat on a ball supported by both legs, there was no change in the transversus abdominis activity. However, when subjects sat on a ball supported by one leg, the activity of transverse abdominis increased.

In this study, the transversus abdominis became thicker, and the time which subjects could maintain posture on the ball increased significantly after both interventions. Postural adjustment was achieved and the trunk was stabilized by thickening of the transversus abdominis as assessed by the maintenance of posture on an unstable base of support. Moreover, it was reported that more co-contraction of the abdominal muscles occurred when the left leg was raised than when the right leg was raised, even though the base of support was the same. This indicates that it is more difficult to maintain posture when the left leg is raised¹⁶⁾. In the present

Table 1. General characteristics of the subjects (Mean±SD)

	SEDA	LSE
Age (years)	23.4±3.3	24.5±3.4
Height (cm)	169.8±5.9	169.5±8.1
Weight (kg)	63.5±9.3	63.2±10.0
BMI (cm/kg)	22.0±2.5	21.9±1.9

SEDA: selective exercise for the deep abdominal muscles, LSE: lumbar stabilization exercise

Table 2. Intra-rater reliabilities of transversus abdominis thickness measurements during resting and drawing-in

		SEDA			LSE		
		ICC	95% CI		ICC	95% CI	
			L/B	U/B		L/B	U/B
Resting	Before intervention	0.98	0.95	0.99	0.94	0.83	0.98
	After 5 weeks	0.98	0.93	0.99	0.96	0.89	0.99
Drawing-in	Before intervention	0.97	0.91	0.99	0.88	0.65	0.96
	After 5 weeks	0.98	0.93	0.99	0.99	0.98	0.99

ICC: intra-class correlation coefficient, CI: confidence interval, L/B: lower bound, U/B: upper bound

Table 3. Comparison within and between groups of the resting, drawing-in, and trunk holding times for raising the right and left legs on a Swiss ball (Mean±SD)

		Before intervention	After 5 weeks	Group (F)	Period (F)	GroupX-Period (F)
Resting (mm)	SEDA	2.69±0.26	2.73±0.27	3.47	0.82	0.06
	LSE	2.80±0.25	2.88±0.30			
Drawing-in (mm)	SEDA	2.96±0.31	4.31±0.44	2.60	104.91*	4.15
	LSE	3.01±0.21	3.91±0.62			
Rt raise time (sec)	SEDA	3.19±2.11	7.16±2.40	0.17	43.47*	0.09
	LSE	3.12±1.40	6.75±2.79			
Lt raise time (sec)	SEDA	2.55±0.59	6.10±3.10	0.84	44.82*	1.22
	LSE	2.64±0.59	5.18±1.45			

SEDA: selective exercise for the deep abdominal muscles, LSE: lumbar stabilization exercise

*p < 0.05

study, the subjects also reported that raising and maintaining their right leg was relatively more comfortable than raising and maintaining their left leg after the transversus abdominis has been thickened through exercise (when performing other exercises, they usually made the first step with their right leg and mostly used their right leg).

In conclusion, both the SEDA and the LSE exhibited thickening of the transversus abdominis, which is a deep abdominal muscle, thereby helping to adjust posture, and to stabilize the lumbar region. These exercises increased the thickness of the deep abdominal muscles. They are important exercises for improving the stability of athletes or patients who need postural adjustment.

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