

# The Effects of Modified Wall Squat Exercises on Average Adults' Deep Abdominal Muscle Thickness and Lumbar Stability

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**Abstract.** [Purpose] The purpose of this study was to compare the effects of bridge exercises applying the abdominal drawing-in method and modified wall squat exercises on deep abdominal muscle thickness and lumbar stability. [Subjects] A total of 30 subjects were equally divided into an experimental group and a control group. [Methods] The experimental group completed modified wall squat exercises, and the control group performed bridge exercises. Both did so for 30 minutes three times per week over a six-week period. Both groups' transversus abdominis (Tra), internal oblique (IO), and multifidus muscle thickness were measured using ultrasonography, while their static lumbar stability and dynamic lumbar stability were measured using a pressure biofeedback unit. [Results] A comparison of the pre-intervention and post-intervention measures of the experimental group and the control group was made; the Tra and IO thicknesses were significantly different in both groups. [Conclusion] The modified wall squat exercise and bridge exercise affected the thicknesses of the Tra and the IO muscles. While the bridge exercise requires space and a mattress to lie on, the modified wall squat exercise can be conveniently performed anytime.

**Key words:** Modified wall squat exercise, Bridge exercise, Abdominal drawing-in

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## INTRODUCTION

Lumbar stability is an important point that enables movement of the limbs while maintaining of the spine upright under postural change and load<sup>1)</sup>. Muscles that contribute to lumbar stability include the transversus abdominis, internal oblique, external oblique, quadratus lumborum, the multifidus of the posterior trunk, and the pelvic floor muscles<sup>2)</sup>. In particular, the multifidus and the transversus abdominis are activated earlier than the other muscles when the human body moves and adjusts the balance of the trunk. Similarly, the bilateral internal oblique muscles are important for maintaining lateral stability and the bending ability of the spine. Prior research on lumbar stability has been conducted with the aim of understanding how to strengthen the spine through the deep muscles such as the transversus abdominis and multifidus and different exercise tools including mattresses, balls, dumbbells, balance pads, and diverse postures such as the supine or prone positions that are used at the beginning of the lumbar flexion exercise have been used<sup>3)</sup>.

Squat exercises evenly develop upper body as well as lower body muscles<sup>4)</sup> and may be done anywhere and at anytime. This type of exercise is used for improving physical performance in many sports and may be effectively used in rehabilitation programs after an operation<sup>5)</sup>. Squat

exercises have great merit, but an unstable posture when this type of exercise is performed damage the lower back and exert pressure on the knees<sup>6)</sup>. However, wall squat exercises are safe, without any possibility of doing harm to the lumbar vertebrae or knees because the squats are performed with the body weight on the wall, making it easy for beginners to conduct this exercise. As a result, modified wall squat exercises were used in this study with the aim of improving lumbar stability rather than strengthening the lower body muscles, and this exercise included motions to strengthen the neck and improve shoulder stability. The aim of this study was to compare modified wall squat exercises that may be simply conducted without the help of tools or equipment and without any limitation in space, with bridge exercise an ordinary lumbar stability exercise, for lumbar stability improvement.

## SUBJECTS AND METHODS

Thirty normal adults were randomly allocated either to a bridge exercise group (BEG: 1 male, 14 female; the experimental group) or to a modified wall squat exercise group (MWSEG: 1 male, 14 female; the control group). Those with muscle, skeletal, or neurological problems, those who felt pain in the lumbar or pelvic areas, and those who could not perform the bridge exercise or wall squat due to pain in the knees or ankles were excluded. Sufficient explanation of this study's intent and the overall purpose was given, and

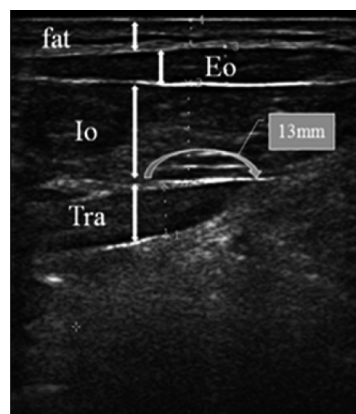


**Fig. 1.** Modified wall squat exercise

voluntary consent to participate in this study was obtained from all of the subjects. The mean $\pm$ SD age, height, and weight of BEG were 20.8 $\pm$ 0.3 years old, 161.8 $\pm$ 6.6 cm, and 55.3 $\pm$ 9.3 kg, respectively; and the mean $\pm$ SD age, height, and weight of MWSEG were 20.7 $\pm$ 0.3 years old, 162.9 $\pm$ 4.5 cm, and 56.3 $\pm$ 9.7 kg, respectively. Analysis of group difference in gender was made using the  $\chi^2$  test, and analyses of group difference in age, height, and weight were made using the independent t-test. The above factors were not significantly different ( $p>0.05$ ), therefore the two groups were considered homogenous.

The subjects conducted bridge exercises using the abdominal drawing-in method and modified wall squat exercises on stable ground. The abdominal drawing-in method aims to contract the transversus abdominis and internal oblique, thereby inducing concurrent contraction of the muscles and reducing excessive lumbar lordosis or anteversion of the pelvis that may occur during bridge exercises or modified wall squat exercise<sup>1)</sup>. For the bridge exercise, subjects flexed their knee joints to 90 degrees, spread both arms by about 30 degrees, and placed both hands on the chest. The subjects placed both feet at shoulder-width apart and placed both feet parallel on the ground. The head and the neck were maintained straight, and the eyes looked at the ceiling. The subjects raised the pelvis according to the instruction "raise the hips," maintained the posture for 15 seconds according to the instruction "maintain," then lowered the pelvis, and took a rest for 5 seconds according to the instruction "lower the hips." Ten repetitions of this process were considered one set, and the subjects performed a total of 10 sets<sup>7)</sup>.

For the modified wall squat exercises, the subjects stood against a wall, spread both legs shoulder-width apart, and stood at a distance of about a foot from the wall. With fingers spread out, one hand was held with the palm end upward from the chest, while the finger ends of the other hand around the belly were held downward, and pulled the chin was pulled in pushing the head toward the wall. The pelvis and the lumbar spine were in the neutral position (Fig. 1). During the squat motion, the soles of the feet did not leave the ground, the knees were flexed up to a 90 degree angle where they remained for 5 seconds, and then the knees were extended back to a 10 degree angle which was maintained for 3 seconds. This was counted as one motion was a process, and 10 motions were considered one set. The subjects took a rest for 15 seconds and conducted this process again for a total of 10 sets. The subjects conducted bridge exercises and modified wall squat exercises three times per week,



**Fig. 2.** Measurement of Tra & Io

30 minutes per day, for a total of 6 weeks.

In order to examine changes in muscle thickness of the trunk and the abdomen of the participants, this study used ultrasonography (MysonoU5, Samsung medison, Korea) with a 12 MHz linear probe. In order to ensure measurement at the same location each time, the measurement point was marked during the first measurement. Ultrasonography was performed by one well-qualified tester. First, the subject comfortably lay in the supine position. The probe was placed transversely on the top of the iliac crest, moved toward the center of the abdomen, and the screening was stopped when the external oblique, internal oblique, and transversus abdominis were all shown. The thicknesses of the internal oblique and transversus abdominis were measured at a point 13 mm distal from the point where the fascias of the internal oblique and the transversus abdominis met<sup>8)</sup>. For the measurement of the multifidus, the subjects lay in the prone position, and the probe was perpendicularly placed on the fourth lumbar vertebra on the left transverse process. The thickness from the transverse process to the superficial muscle was measured<sup>9)</sup> (Fig. 2). In order to evaluate static lumbar stability (SLS), the contractibility of TrA was evaluated using a pressure biofeedback unit (PBU, Chattanooga Group, Australia). The PBU is an inelastic sack that can be inflated and is connected to a pressure gauge. It is a simple device that monitors and records changes in pressure during the movement of the lumbar pelvis. The size of the sack is 16.7 $\times$ 24.0 cm, and it has a measurement range of 0–200 mmHg. Excessive changes in pressure signify that movement of the lumbar pelvic area is not regulated. For SLS measurement, the subjects lay in the prone position, and the PBU was placed on the midpoint of the bilateral anterior superior iliac spines; and the baseline pressure was set to 70 mmHg. The subjects pulled in their lower abdomens to the maximum level without moving the lumbar vertebrae or hips, lowering the pressure, and maintained this position for 10 seconds. The change in pressure was recorded. In order to measure dynamic lumbar stability (DLS), the subjects performed the bent knee fall out (BKFO), as described by Comerford and Mottram<sup>10)</sup>. For the measurement of BKFO, the subjects lay in the supine position, and the PBU was placed vertically below the

**Table 1.** Comparison of Tra, IO, multifidus, SLS and DLS between pre- and post-intervention in each group (mean±SD) (unit: Tra, IO, Multifidus-mm, SLS, DLS-mmHg)

Category	Group	Pre-intervention	Post-intervention
Tra	BEG*	0.3±0.1	0.4±0.1
	MWSEG*	0.3±0.0	0.4±0.1
IO	BEG*	0.5±0.1	0.6±0.1
	MWSEG*	0.5±0.1	0.7±0.1
Multifidus	BEG	2.4±0.6	2.5±0.1
	MWSEG	2.5±0.4	2.5±0.2
SLS	BEG	2.5±1.9	3.2±1.6
	MWSEG	2.5±2.6	3.2±2.6
DLS	BEG	2.3±0.4	1.7±1.2
	MWSEG	2.3±1.1	1.8±0.8

\* p<0.05; BEG, bridge exercise group; MWSEG, modified wall squat exercise group; Tra, transversus abdominis; IO, internal obliquus abdominis; SLS, static lumbar stability; DLS, dynamic lumbar stability

**Table 2.** Comparison of Tra, IO, multifidus, SLS and DLS between BEG and MWSEG (mean±SD)

	Category	BEG	MWSEG
Pre-intervention	Tra	0.3±0.1	0.3±0.0
	IO	0.5±0.1	0.5±0.1
	Multifidus	2.4±0.6	2.5±0.4
	SLS	2.5±1.9	2.5±2.6
	DLS	2.3±0.4	2.3±1.1
	Tra	0.4±0.1	0.4±0.1
post-intervention	IO	0.6±0.3	0.7±0.1
	Multifidus	2.5±0.1	2.5±0.2
	SLS	3.2±1.6	3.2±2.6
	DLS	1.7±1.2	1.8±0.8
Change between pre- and post-intervention	Tra	0.1±0.0	0.1±0.1
	IO	0.1±0.1	0.1±0.0
	Multifidus	0.0±0.7	-0.0±0.4
	SLS	0.6±1.6	0.6±1.3
	DLS	0.5±1.3	0.5±1.0

\* p<0.05

lumbar spine 2 cm from the posterior superior iliac spines. In order to minimize the sway of the trunk, folded towels of the same height were placed on both sides of the PBU. The baseline pressure was set to 40 mmHg. The hip and the knee of one leg were bent, and the feet were attached to the ground abducted by about 45 degrees, then moved back to the original posture. The change in pressure was recorded.

The data were analyzed using SPSS 12.0 KO (SPSS, Chicago, IL, USA), and are presented as average and standard deviations. The paired t-test was used to test the significance of changes in each group, and the independent t-test was used to test the significance of differences between the two groups. The significance level was chosen as  $\alpha = 0.05$ .

## RESULTS

The comparison of the pre-intervention and post-intervention measures of BEG and MWSEG revealed statistically significant differences in Tra and IO of both groups ( $p < 0.05$ ) (Table 1). Regarding the changes between pre- and post-intervention, there were no statistically significant differences between the two groups ( $p > 0.05$ ) (Table 2).

## DISCUSSION

This study compared the effects of bridge exercises and modified wall squat exercises using an abdominal drawing-in method on deep abdominal muscle thickness and lumbar stability. Prior research has shown that the abdominal drawing-in method is effective at activating the abdominal mus-

cles, in particular, the transversus abdominis<sup>2)</sup>. Stevens et al. reported that when subjects conducted bridge exercises in the neutral position, abdominal muscle activity increased but multifidus activity was not significantly different<sup>1)</sup>. Gorbet et al. in a study in which 30 lumbar pain patients and 30 average subjects completed abdominal drawing-in exercises that contracted the transversus abdominis, observed that the thickness of the transversus abdominis increased in normal subjects and lumbar pain patients who conducted abdominal drawing-in exercise contracting the transversus abdominis<sup>12)</sup>. In their study, the subjects in a quadruped position alternately stretched the upper and lower limbs in a quadruped position and ultrasonography was used to measure the thickness of the transversus abdominis. The result of the present study was similar to Bridge exercises and modified wall squat exercises increased the thicknesses of the transversus abdominis (Tra) and internal oblique (IO) of the normal subjects but did not increase that of the multifidus. This is probably because bridge exercises and modified wall squat exercises using an abdominal drawing-in method increase abdominal muscle activity and minimize compensation actions such as lumbar lordosis, by relatively reducing the actions of the erector spinae and the multifidus.

According to the comparison of the pre- and post-intervention measures of BEG and MWSEG, there were statistically significant differences in only Tra and IO in both groups. Regarding changes between pre- and post-intervention, there were no statistically significant differences between the two groups. These results show that the bridge exercise and modified wall squat exercise on stable ground affected the development of the Tra and IO muscles, but did not have an effect on the other muscles. In particular, although bridge exercises and modified wall squat exercises have the same effect on the development of the Tra and IO muscles, the bridge exercise requires a space to lie and a mattress. However, the modified wall squat exercises enable lumbar stability exercise against a wall and may be con-

veniently performed anytime, anywhere. Accordingly, the researcher hopes that the modified wall squat exercise will be utilized together with bridge exercises in home training for patients who need lumbar stabilization exercises.

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