



Original Article

The effects of the continuous bridge exercise on the thickness of abdominal muscles in normal adults

WONTAE GONG, PhD, PT¹⁾

¹⁾ Department of Physical Therapy, Korea Nazarene University: 48 Wolbong-ro, Seobuk-gu, Cheonan-si, Chungcheongnam-do 31172, Republic of Korea

Abstract. [Purpose] The purpose of this study is to investigate the effects of continuous bridge exercises accompanied by an abdominal drawing-in maneuver on the thickness of abdominal muscles of normal adults. [Participants and Methods] The number of participants were 32, of which 16 people were assigned to the experimental group and 16 to the control group, respectively. Continuous bridge exercises were performed by the experimental group in 15 sets of 25 minutes each, 3 times a week for 6 weeks. The thickness of the abdominal muscles was measured using real-time ultrasonography. [Results] When the thicknesses of the abdominal muscles in the experimental and control groups before and after the experiment were compared, it could be seen that the internal obliques abdominis (IO) and transversus abdominis (TrA) of the experimental group had been increased. [Conclusion] This study confirmed that continuous bridge exercises effected a change in the thickness of deep abdominal muscles.

Key words: Continuous bridge exercises, Abdominal muscle thickness, Ultrasonography

(This article was submitted Feb. 21, 2018, and was accepted Apr. 21, 2018)

INTRODUCTION

In comparison to the past, the physical activity of people in modern society has decreased because of changes in industrial and economic activities and utilization of informational knowledge using computers. In particular, the biomechanical burden caused by sedentary lifestyles appears as chronic muscular weakness, such as the inability to contract abdominal muscles, other muscular weakness, and instability of spinal joints, thereby causing lumbar pain, reduced endurance, restricted flexibility, and restricted range of joint movement¹⁾. The deep muscles of a patient with backache are weaker than normal, and the absence of joint repositionability caused by proprioceptive sensory impairment becomes the reason for the problem of spinal instability and pain²⁾.

Lumbar stability is a preceding component in movement of the arms and legs when changing posture, imposing a load through the maintenance of the spine in the right position³⁾. Muscles such as the transverse abdominis (TrA); internal oblique abdominis (IO) and external oblique abdominis (EO) in the abdomen; quadratus lumborum and multifidus on the rear trunk; and pelvic floor muscles in the pelvis all contribute to lumbar stability⁴⁾. The deep muscles typically used for lumbar stability are the TrA and multifidus muscles. Various studies have demonstrated that the TrA contributes significantly to lumbar stability, and its importance has been magnified⁵⁾. In particular, Hodges and Richardson used EMG measurements to prove that the TrA contracts prior to limb movement⁶⁾.

To maintain a neutral position in opposition to trunk rotation caused by external resistance, it is efficient to minimize contraction of the rectus abdominis muscle and contract the TrA and IO/EO at the same time⁷⁾. Waist stability exercises are an important component in the rehabilitation of patients with backache, as well as in hobby or sports training⁸⁾. Lumbar stabilization exercises aimed at this component include mat exercises, sling exercises, Pilates exercises, and the bridge exercise.

Corresponding author. Wontae Gong (E-mail: owntae@hanmail.net)

©2018 The Society of Physical Therapy Science. Published by IPEC Inc.



This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License. (CC-BY-NC-ND 4.0: <https://creativecommons.org/licenses/by-nc-nd/4.0/>)

The bridge exercise is widely used in the clinic to train large muscles and local muscles to coordinate in an appropriate ratio⁹⁾. The bridge exercise, which is a closed kinetic chain exercise, increases the muscular strength of the hip joint extensor group and improves trunk stability¹⁰⁾.

In the prone bridge exercise, the face is toward the floor and balance is maintained on the elbows and tiptoes, while the posture from the heels to the knees, pelvis, spine, and head stays straight. The side bridge starts on one side of the trunk, lifting the hip off the floor, using the right or left arm to balance, while the posture from shoulders to feet stays straight. The prone bridge and the side bridge are the core stabilization exercises activating deep muscles such as the TrA, IO/EO, erector spine, and quadratus lumborum, thereby stabilizing the trunk¹¹⁾. During the continuous bridge exercise, excessive lumbar lordosis can occur without the pre-execution of deep muscle contraction, and therefore, the abdominal drawing-in maneuver (ADIM) should be executed prior to bridge exercises as a preventive measure⁹⁾.

Various studies have been conducted on different exercises and the use of deep abdominal muscles that are important for lumbar stability, including the effect of the prone bridge and supine bridge exercises on deep abdominal muscle thickness¹²⁾, the effect of the modified wall squat exercise on deep abdominal muscle thickness¹³⁾, the effect of dynamic exercises utilizing PNF patterns on deep abdominal muscle thickness¹⁴⁾, the effect of conducting the bridge exercise on an unstable surface on deep abdominal muscle thickness¹⁵⁾, and the effect of isometric hip abduction squats on deep abdominal muscle thickness¹⁶⁾. However, exercises conducted in a standing posture are not appropriate for patients with problems of the lower limbs or lumbar pain. The supine bridge exercise focuses too much on the hip extensor muscle and the lumbar back muscles, meaning that the prone bridge and side bridge exercises, which directly affect the deep abdominal muscles, should be studied. In particular, the continuous bridge exercise, which repeatedly executes the prone bridge and side bridge, is a mixed exercise of static and dynamic stability that can influence deep abdominal muscle thickness.

Therefore, this study examined the effect on deep abdominal muscle thickness of the continuous bridge exercise, which can be performed to improve lumbar stability without the restriction of place and support of facilities or experts.

PARTICIPANTS AND METHODS

This research targeted 32 students from the N University in Korea, who were normal adults with healthy bodies. Applicants with problems in the spine or pains such as backaches, applicants who regularly take medication, applicants with neurological disorders, applicants who consumed alcohol on the previous day, applicants who were overweight, and applicants who regularly exercised were all excluded. The training group (TG; male=1, female=15), who took part in the continuous bridge exercise, and the control group (CG; male=1, female=15), who did not conduct the exercise, were randomly assigned. The average age of the TG was 22.3 ± 2.1 (mean \pm SD), height was 162.2 ± 2.0 cm, and weight was 57.5 ± 5.3 kg. The average age of the CG was 21.6 ± 0.2 , height was 161.3 ± 2.2 cm, and weight was 58.6 ± 3.6 kg. The χ^2 test was applied for analysis of the variable of gender, and an independent sample t-test was applied for the analysis of the variables of age, height, and weight. Given that there were no statistically significant differences ($p > 0.05$), there was no problem of homogeneity in these two groups. This study was approved by Kyungpook National University's Institutional Review Board (2017-0012) and the participants were safely protected during all of the processes of the experiment. All of the participants understood the purpose of this study and provided written informed consent prior to their participation in the study in accordance with the ethical standards of the Declaration of Helsinki.

For the prone bridge exercise, the participant should be in the prone position, supporting the body with both forearms and the elbows on the floor. At this point, the shoulder line sets to be perpendicular to the upper arm. For efficient and continuous exercise, both forearms are folded with a 90° medial rotation of the shoulder. The knees are extended, gathering both feet, and the ankles conduct the dorsiflexion. The neck, waist, hip, and legs are set to be straight, and the pelvis and spine are in a neutral position. During the exercise, the cervical spine maintains the neutral position by pulling in the chin, and the TrA is contracted by abdominal drawing-in.

In the side bridge exercise, participants lie on their side, putting the elbow on the floor and supporting the body with the forearm. The opposite arm lies along the waist or hip naturally. The knees are extended, gathering both feet, and the ankles conduct the dorsiflexion. The neck, waist, hip, and legs are set straight, and the pelvis and spine are in a neutral position. Care should be taken not to lift the shoulders and hips while the trunk is lifted.

To apply the appropriate intensity of the exercise to participants, for the first and second weeks, a set consisted of the prone bridge for 3 seconds, the right-side bridge for 3 seconds, the prone bridge for 3 seconds, the left-side bridge for 3 seconds, and the prone bridge for 3 seconds. A break of 20 seconds was given after each set, and 10 sets were conducted in total. From the third to sixth weeks, a set consisted of the prone bridge for 5 seconds, the right-side bridge for 5 seconds, the prone bridge for 5 seconds, the left-side bridge for 5 seconds, and the prone bridge for 5 seconds. A break was given for 30 seconds after a set of exercise, and a total of 15 sets were conducted. A warm-up exercise was conducted for 5 minutes before the bridge exercise, and a cool-down exercise for 5 minutes after the bridge exercise. An execution of the exercise took about 20–25 minutes, and the frequency of the exercise was three times a week for six weeks. The CG did not conduct any exercises and only underwent muscle measurements.

Review of the changes in abdominal muscle thickness caused by the continuous execution of the prone bridge and side bridge exercises was completed using ultrasonography (Mysono U5, Samsung Medison, Korea) with a linear probe of

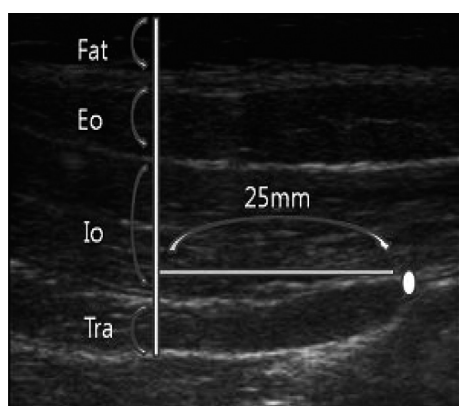


Fig. 1. Abdominal muscle thickness.

Table 1. Comparison of Eo, IO and TrA between pre-test and post-test in each group (mean \pm SD) (unit: cm)

Category	Group	Pre-test	Post-test
Eo	Training G	0.5 \pm 0.0	0.5 \pm 0.1
	Control G	0.5 \pm 0.1	0.5 \pm 0.0
IO	Training G*	0.7 \pm 0.2	1.0 \pm 0.2
	Control G	0.7 \pm 0.2	0.7 \pm 0.1
TrA	Training G*	0.5 \pm 0.1	0.7 \pm 0.1
	Control G	0.5 \pm 0.1	0.5 \pm 0.1

*p<0.05, G: group; Eo: external obliquus abdominis; IO: internal obliquus abdominis; TrA: transversus abdominis.

12 MHz. The person who conducted the measurements was an expert who was sufficiently trained to measure the thickness of abdominal muscles with ultrasonography. The group classification of each participant was hidden to the measurer. First, the participant lay down comfortably in a supine position, and a triangular pillow was put beneath the knees of the participant to relax the lower limbs. The probe was placed in a horizontal direction on top of the iliac crest and moved to the center of the abdomen. The screen was then held on the point where the EO, IO, and TrA could be seen, and the thickness of the EO, IO, and TrA muscles were measured to 25 mm outward from the point where the IO and TrA fascia meet. To maintain a constant contraction of the abdominal muscles during the measurement before and after the experiment, a pressure biofeedback unit (Chattanooga Group, Australia) was put beneath the waist of the participant, and the pressure gauge was maintained at 40 mmHg during the abdominal drawing-in (Fig. 1)¹⁴.

The measured data were analyzed using the Statistical Package for the Social Sciences (SPSS) 18.0 KO software (SPSS, Chicago, IL, USA), and the collected data were proposed with the average and standard deviation. A paired t-test was used to determine significance of each group before and after the experiment, and an independent t-test was used to test the significance of the difference between two groups. The statistical significance level, α , was set at 0.05.

RESULTS

Between the pre-test and post-test, the TG showed statistical significance in IO and the TrA ($p < 0.05$); no statistical significance was observed in the CG for any of the items ($p > 0.05$) (Table 1). When the pre-test, post-test and change between pre and post-test values were compared for the two groups, no statistical significance was found for the pre-test values ($p > 0.05$); in the post-test and change between pre and post-test evaluation, the IO and the TrA values were found to be statistically significant for both groups ($p < 0.05$) (Table 2).

DISCUSSION

Stability refers to the ability of the musculoskeletal system to maintain balance during soft exercises or when balance is disturbed¹⁷. The IO and TrA, which are dedicated to stabilizing the lumbar region, provide micro control of the spine and stability among spinal segments. To maintain the stability of the lumbar region, both the superficial muscles and, preferentially, the deep muscles must be mobilized¹⁸. In this research, the effect of the continuous bridge exercise, which repeats the prone bridge and side bridge exercises, on deep abdominal muscle thickness was studied to determine any strengthening effect on the abdominal muscles of a normal adult, helping to stabilize the lumbar region.

An advanced study on lumbar muscular strength where 30 participants conducted the sling bridge exercise for four weeks proved that it increased the endurance and flexibility of the waist muscles in the case of teenagers with lumbar pain¹⁹. In addition, a study of 33 normal men and women proved that utilizing the bridge exercise on an unstable surface using a Swiss ball enhanced the results of electromyography (EMG) of the abdominal muscles²⁰.

Among the studies about the influence of deep abdominal muscle thickness is one where 18 adult women and 8 adult men conducted intensive Pilates on their core areas for six months, and the thickness of the TrA and IO muscles were measured. According to the results, the TrA showed a significant difference. Therefore, training of the core area has been proved to positively affect the strength of the abdominal muscles and stabilization of the abdomen²¹. In the research about the effect of the prone and supine bridge exercises on deep abdominal muscle thickness, the prone bridge exercise and flank exercise have both been shown to improve TrA and IO thickness more than the supine bridge exercise¹². Also, the modified wall squat exercise has been reported to increase TrA and IO thickness¹³. Moreover, dynamic exercises utilizing PNF patterns has been

Table 2. Comparison of Eo, IO and TrA between training group and control group (mean \pm SD) (unit: cm)

	Category	Training G	Control G
Pre-test	Eo	0.53 \pm 0.08	0.56 \pm 0.13
	IO	0.73 \pm 0.24	0.77 \pm 0.21
	TrA	0.58 \pm 0.15	0.59 \pm 0.19
Post-test	Eo	0.58 \pm 0.11	0.53 \pm 0.08
	IO*	1.06 \pm 0.28	0.76 \pm 0.18
	TrA*	0.71 \pm 0.13	0.52 \pm 0.13
Change between pre and post-test	Eo	0.05 \pm 0.09	-0.03 \pm 0.13
	IO*	0.33 \pm 0.38	-0.01 \pm 0.31
	TrA*	0.12 \pm 0.17	-0.07 \pm 0.19

*p<0.05.

reported to be effective at improving deep abdominal muscle thickness¹⁴⁾, and the isometric hip abduction squat was reported to be more effective at improving TrA and IO thickness than the standard and isometric hip abduction squat exercises¹⁶⁾.

In this study, the thicknesses of the EO, IO, and TrA abdominal muscles were measured before and after continuous bridge exercises. According to the results, the differences in the TG before and after the experiment were statistically significant, with values for the IO of 0.3 \pm 0.3 cm and for the TrA, 0.1 \pm 0.1 cm. However, there was no statistically significant difference in the EO.

While there are a number of exercises meant to increase the thickness of the abdominal muscles, many of them require facilities and/or they have time and place restrictions. In particular, exercises done in a standing posture are difficult for patients with problems of the lower limbs or lumbar pain to apply. According to the result of this research, the continuous bridge exercise, which is not restricted by the need for particular facilities, nor by time or place, has been statistically shown to be effective for improving deep abdominal muscle thickness.

As an exercise that is a mix of static and dynamic stabilities, the continuous bridge exercise, which is repeated alternation between the prone bridge and the side bridge while maintaining ADIM, was effective at improving deep abdominal muscle thickness because the abdominal muscles are continuously activated. Therefore, the proposed continuous bridge exercise can be utilized to strengthen the deep abdominal muscles of patients with insufficient trunk stability or lumbar pain.

Funding

This research was supported by the Korea Nazarene University Research Grants in 2018.

Conflict of interest

None.

REFERENCES

- 1) Gill K, Krag MH, Johnson GB, et al.: Repeatability of four clinical methods for assessment of lumbar spinal motion. *Spine*, 1988, 13: 50–53. [Medline] [CrossRef]
- 2) O'Sullivan PB, Burnett A, Floyd AN, et al.: Lumbar repositioning deficit in a specific low back pain population. *Spine*, 2003, 28: 1074–1079. [Medline] [CrossRef]
- 3) Willson JD, Dougherty CP, Ireland ML, et al.: Core stability and its relationship to lower extremity function and injury. *J Am Acad Orthop Surg*, 2005, 13: 316–325. [Medline] [CrossRef]
- 4) O'Sullivan PB, Grahamslaw KM, Kendell M, et al.: The effect of different standing and sitting postures on trunk muscle activity in a pain-free population. *Spine*, 2002, 27: 1238–1244. [Medline] [CrossRef]
- 5) Hodges PW: Is there a role for transversus abdominis in lumbo-pelvic stability? *Man Ther*, 1999, 4: 74–86. [Medline] [CrossRef]
- 6) Hodges PW, Richardson CA: Inefficient muscular stabilization of the lumbar spine associated with low back pain. A motor control evaluation of transversus abdominis. *Spine*, 1996, 21: 2640–2650. [Medline] [CrossRef]
- 7) Richardson C, Toppenberg R, Jull G: An initial evaluation of eight abdominal exercises for their ability to provide stabilisation for the lumbar spine. *Aust J Physiother*, 1990, 36: 6–11. [Medline] [CrossRef]
- 8) Escamilla RF, Lewis C, Bell D, et al.: Core muscle activation during Swiss ball and traditional abdominal exercises. *J Orthop Sports Phys Ther*, 2010, 40: 265–276. [Medline] [CrossRef]
- 9) Stevens VK, Coorevits PL, Bouche KG, et al.: The influence of specific training on trunk muscle recruitment patterns in healthy subjects during stabilization exercises. *Man Ther*, 2007, 12: 271–279. [Medline] [CrossRef]
- 10) Richardson CA, Jull GA: Muscle control-pain control. What exercises would you prescribe? *Man Ther*, 1995, 1: 2–10. [Medline] [CrossRef]

- 11) Graham JF: Exercise technique: front bridge. *Strength Condit J*, 2009, 31: 79–80. [[CrossRef](#)]
- 12) Lee KB, Kim MK, Ha KG, et al.: Comparison of lateral abdominal muscle thickness during bridge exercises with different support surfaces in healthy individuals. *Isokinet Exerc Sci*, 2017, 25: 301–308. [[CrossRef](#)]
- 13) Cho M: The effects of modified wall squat exercises on average adults' deep abdominal muscle thickness and lumbar stability. *J Phys Ther Sci*, 2013, 25: 689–692. [[Medline](#)] [[CrossRef](#)]
- 14) Gong W: The effects of dynamic exercise utilizing PNF patterns on abdominal muscle thickness in healthy adults. *J Phys Ther Sci*, 2015, 27: 1933–1936. [[Medline](#)] [[CrossRef](#)]
- 15) Cho M: The effects of bridge exercise with the abdominal drawing-in maneuver on an unstable surface on the abdominal muscle thickness of healthy adults. *J Phys Ther Sci*, 2015, 27: 255–257. [[Medline](#)] [[CrossRef](#)]
- 16) Lee YJ, Lim OB, Cynn HS, et al.: Differential increase in the thickness of abdominal muscles during different squat exercises in college athletes. *Isokinet Exerc Sci*, 2017, 25: 193–200. [[CrossRef](#)]
- 17) Granata KP, Lee PE, Franklin TC: Co-contraction recruitment and spinal load during isometric trunk flexion and extension. *Clin Biomech (Bristol, Avon)*, 2005, 20: 1029–1037. [[Medline](#)] [[CrossRef](#)]
- 18) McGill SM, Grenier S, Kavcic N, et al.: Coordination of muscle activity to assure stability of the lumbar spine. *J Electromyogr Kinesiol*, 2003, 13: 353–359. [[Medline](#)] [[CrossRef](#)]
- 19) Kim KY, Sim KC, Kim TG, et al.: Effects of sling bridge exercise with rhythmic stabilization technique on trunk muscle endurance and flexibility in adolescents with low back pain. *International Journal of Contents*, 2013, 9: 72–77. [[CrossRef](#)]
- 20) Czaprowski D, Afeltowicz A, Gębicka A, et al.: Abdominal muscle EMG-activity during bridge exercises on stable and unstable surfaces. *Phys Ther Sport*, 2014, 15: 162–168. [[Medline](#)] [[CrossRef](#)]
- 21) Brill PW, Couzen GS: *The core program: fifteen minutes a day that can change your life*. New York: Buntam Books, 2008, pp 1–231.