

# Effects of Bridging Exercise on Different Support Surfaces on the Transverse Abdominis

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**Abstract.** [Purpose] The purpose of this study was to identify the effects of bridging exercise on different support surfaces on the thickness of the musculus transversus abdominis and lower extremity muscle activities. [Subjects] Thirty-five students of H University. [Methods] The experimental group (n=18) performed bridging exercise on the sling support surface, and the control group (n=17) performed bridging exercise on a general support surface. [Results] Thickness changes in the musculus transversus abdominis were 0.35 cm in the experimental group, and 0.17 cm in the control group, suggesting that the experimental group showed a more significant change. For the lower extremity muscular activity, there was a significant difference between the experimental group and the control group only in the biceps femoris muscle. [Conclusion] Based on these results, we consider that bridging exercise on a sling support surface would increase the thickness of the transversus abdominis and lower extremity muscle activities in rehabilitation programs for patients with back pain.

**Key words:** Bridging exercise, Sling exercise, Transversus abdominis

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## INTRODUCTION

Back pain, the most common of musculoskeletal disorders, is a pain occurring in the waist region between the second lumbar and the sacroiliac joint<sup>1)</sup>. It is known to be experienced by 50% of the population<sup>2)</sup>, and results in activity reduction because of the pain and difficulty in social life, as well as economic problems requiring a certain amount of time and cost<sup>3)</sup>.

The main causes of back pain include dynamic causes of waist structure and neighboring tissues and non-specific causes due to degeneration<sup>4)</sup>. Back pain patients often show weakness of the trunk muscles and lowering of proprioceptive sense<sup>5)</sup> and have problems with vertebral stability owing to weakness and injury of soft tissue<sup>6)</sup>.

Vertebral stability is provided by the spinal column, muscles and tendon units surrounding the vertebrae, and a control sub-system. The spinal column is composed of a passive system of the vertebral ligaments, vertebrae, and intervertebral discs, and an active system of muscle and tendon units that provide vertebral stability<sup>7)</sup>. When these systems and the control sub-system move cooperatively, vertebral stability is improved<sup>8)</sup>.

Muscles surrounding the vertebrae are divided into global muscles and local muscles according to their roles. The global muscles are involved in large motions, and the local muscles are responsible for stability in each spinal

segment<sup>9)</sup>. It has been reported that people with back pain have shortened contraction times and poorer recruitment of the transverse abdominis and multifidus, which are deep local muscles<sup>10)</sup>. The functions of these muscles are not automatically restored even after recovery of normal function<sup>11)</sup>. Functional damage and weakening of the transverse abdominis and multifidus cause back pain, and the transverse abdominis plays an important role in vertebral stability<sup>12)</sup>.

Trunk stability exercise is an intervention for vertebral stability, which is performed to protect the vertebrae from repetitive damage, mitigate pain, and reduce degenerative deformation that might have developed in the vertebrae<sup>13)</sup>. Special exercises for trunk stability help back pain patients retain normal structure of the lumbar segments, provide stability, reduce pain, and improve function<sup>14)</sup>.

Bridging exercise, a closed chain weight-bearing exercise, is an exercise which increases muscular strength of the hip extensor and promotes trunk stability. It is often prescribed for patients with back pain<sup>15)</sup>, and increases the activities of trunk stabilization muscles such as the internal oblique, external oblique, and erector spinae muscles<sup>16)</sup>.

Among the trunk stabilization exercises, a stabilization exercise under a dynamic condition using a sling is known to have greater effect than a stabilization exercise under a static condition. It improves sense of balance and balance maintenance ability by stimulating proprioceptors<sup>14)</sup>. Exercise on an unstable support surface elicits greater muscle activity than exercise on a stable support surface, and improves dynamic balance, promotes vertebral stability, and prevents vertebral injury<sup>17)</sup>. It has been reported that stabilization exercise on an unstable support surface increases

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activity and coordination of the ventral muscles, and that the bridging exercise on an unstable support surface causes alteration of the internal oblique and rectus abdominis muscles.

Although there have been many studies of stabilization exercises on unstable support surfaces, few have compared the effects of different support surfaces.

In this study, we investigated and compared the effects of bridging exercise on different support surfaces on the thickness of the transverse abdominis and on lower extremity muscle activity, to present empirical data for a therapeutic intervention for chronic low back pain (CLBP), an ailment of the musculoskeletal system. CLBP involves pain in the thoracic vertebra 10 to the lumbar region that continues for more than three days<sup>1</sup>. Its annual prevalence rate is 4 to 7%, and its lifetime prevalence rate is 59%. The prevalence rate for acute, subacute, and chronic patients is 50 to 53%, 21%, and 26%<sup>2</sup>, respectively. Although CLBP patients recover within six to twelve weeks<sup>3</sup>, 60 to 80% undergo recurrence<sup>4</sup>.

Major factors that trigger low back pain include obesity, decrease in spinal mobility, increase in lumbar lordosis, tension in the hamstring muscle, weakening of the abdominal muscles, imbalance in trunk muscle strength, and differences in the lengths of the legs<sup>5</sup>. Low back pain is characterized by instability of the lumbar vertebrae<sup>6</sup>, which triggers problems in postural maintenance and trunk stability, causing functional problems for the body<sup>7</sup>.

The instability of CLBP patients may be reduced by muscular adjustment through exercises<sup>4</sup>, and selective exercise of the transversus abdominis (TrA), lumbar multifidus muscle, pelvic floor muscle, and diaphragm muscle, which all engage in stabilization<sup>8</sup>. In particular, spinal stabilization exercises increase the contraction capacity of the TrA and lumbar multifidus muscles, alleviate pain, and improve function<sup>6</sup>. Stabilization exercises based on the abdominal drawing-in maneuver are widely used to contract the TrA<sup>9</sup>. This method retrains the deep muscles using isometric contractions<sup>10</sup>, minimal contractions of the large muscles, and selective contraction of the TrA<sup>11, 12</sup>. It increases tension in the lumbar and thoracic fasciae, stabilizing the lumbar spine and the pelvis<sup>13</sup>.

This study examined the effects of lumbar stabilization exercises for patients with CLBP on functional disability, activation capacity, as well as the thickness of TrA, a trunk stabilization muscle.

## SUBJECTS AND METHODS

### *Subjects*

The subjects were 35 students of H University located in Chuncheon. They were divided into an experimental group (9 males and 9 females) and a control group (8 males and 9 females). In the test group, the mean  $\pm$  SD age was 23.67  $\pm$  2.00, height was 167.78  $\pm$  8.43 cm, and weight was 60.78  $\pm$  13.96 kg. In the control group, the mean  $\pm$  SD age was 23.18  $\pm$  2.46, height was 168.77  $\pm$  9.26 cm, and weight was 66.59  $\pm$  12.39 kg. The experimental group conducted a bridging exercise on a sling support surface, and the control group con-

ducted a bridging exercise on a fixed support surface. Those who experienced any back pain within the last 6 months or had any musculoskeletal problem, spinal deformity, orthopedic or neurological disease, or functional limitations of the extremities were excluded. The subjects were provided with information about this study, and signed an informed consent form indicating their voluntary participation.

### *Methods*

Subjects widened their knees and both feet to shoulder width in the supine position, crossed their arms and placed both their hands on their chests, and flexed their knees to 60°. In the bridging exercise on the sling (Redcord Workstation, Redcord AS, Norway) support surface, subjects put both feet on the strap of the sling and raised their bottoms to a height where the shoulder, the pelvis, and the knee made a straight line, by pressing against the strap. In the bridging exercise on the fixed support surface, subjects raised their bottoms to a height where the shoulder, the pelvis, and the knee made a straight line, by pressing against the floor with both feet. These bridging exercise were performed while keeping the pelvis in the neutral position with the abdominal drawing-in maneuver, by drawing the navel upward and rearward, pulling the abdomen inward as in expiration, prior to the bridging exercise<sup>19</sup>. For the bridging exercise, 2–4 sets were measured and recorded, with one set defined as 5 repetitions with 5 seconds maintenance. Whenever a subject developed any pain, the test was stopped immediately.

An Ultrasound Scanner (SONOACE X4, Medison Corp., Korea) linear array probe was used to measure thickness changes in the transverse abdominis. In order to scan the same region of the subjects, the guide was placed in the transverse and vertical direction and adjusted until the lateral abdominis appeared, and the abdominal anterior lateral edge between the right iliac crest and the inferior angle of the 11th rib was marked<sup>20</sup>. The depth was adjusted until the muscle layers accounted for 40–50% of the ultrasound imaging screen, and radiologists measured the thickness at the end of expiration to minimize the effects of the respiration cycle on the thickness. The thickness was measured at a point 2.5 cm from the lateral edge of the medial edge of the V shape on the screen.

For measurement of muscle activity, surface EMG (LXM3204, Laxtha Inc., Korea) was used. Body hair and horny substances were removed, and the skin was rubbed with alcohol to reduce skin impedance. Ag/AgCl circular electrodes about 1 cm of diameter, were used with an inter-electrode distance of 2 cm. For the gluteus maximus (GM), (the electrodes were placed halfway between the sacrum and greater trochanter. For the gluteus medius (Gm), (the electrodes were placed halfway between the iliac crest and greater trochanter). For the biceps femoris (BF), (the electrodes were placed halfway between the ischial tuberosity and caput fibulae)<sup>21</sup>. The reference electrode was attached on the spinous process of 7th cervical vertebrae. Data were sampled at 1,024 Hz and bandpass filtered between 13–480 Hz (–3dB response). The muscle activities of GM, Gm and BF of each group were normalized to %MVIC.

SPSS for Windows (version 18.0) was used for statistical

**Table 1.** Comparison of TrA within groups and between groups (n=35)

		Experimental group (n=18)	Control group (n=17)
TrA (cm)	pre	0.35 ± 0.09	0.36 ± 0.13
	post	0.70 ± 0.24*	0.52 ± 0.16*
	change	0.35 ± 0.21†	0.17 ± 0.14

\* p<0.05, Mean ± SD. TrA: Transverse abdominis muscle

**Table 2.** Comparison of muscle activities between groups (n=35)

	Experimental group (n=18)	Control group (n=17)
Gluteus maximus	25.9 ± 13.7	25.4 ± 11.3
Gluteus medius	27.8 ± 13.5	30.1 ± 29.4
Biceps femoris	61.6 ± 21.9†	30.9 ± 17.4

(unit: %MVIC) \*p<0.05, Mean ± SD

analysis. Subjects' characteristics and homogeneity were tested using the independent t-test. Transverse abdominis thicknesses and muscle activities were compared between the experimental and control group, and between before and after the bridging exercise using the paired t-test. For comparison between the groups, the independent t-test was used. The statistical significance level was chosen as 0.05.

## RESULTS

The thickness of the transverse abdominis changed from 0.35 to 0.70 cm in the experimental group, and from 0.36 to 0.52 cm in the control group, both significant differences (p<0.05). The variation of transverse abdominis thickness was 0.35 cm in the experimental group and 0.17 cm in the control group, a significant difference (p<0.05) (Table 1). In the comparison of muscle activity, the muscle activity of BF was 61.6%MVIC in the experimental group and 30.9%MVIC in the control group, a significant difference between the two groups (p<0.05). However, the muscle activities of GM and Gm showed no significant difference (Table 2).

## DISCUSSION

The purpose of this study was to present reference data for developing an effective exercise for patients with back pain by identifying thickness changes and muscle activities induced by performing bridging exercise on different support surfaces.

The bridging exercise is an exercise which controls weight load by pressing the feet against a support surface, which plays a role in controlling body balance and power to maintain the position<sup>22</sup>. It is performed to promote coordinated contraction of global muscles and local muscles in a position in which patients with back pain feel comfortable and less painful<sup>23</sup>, and to increase the muscle power of hip extensor group, and it can restore trunk stabilization ability<sup>19</sup>. In trunk stabilization exercises, a dynamic stabilization exercise on an unstable support surface is more effective, because it stimulates the motor regions of the brain, sense of balance, and balance maintaining ability, by

stimulating proprioceptors more than a static stabilization exercise on a stable support surface<sup>14</sup>.

Teyhen et al.<sup>24</sup> reported that LBP patients had 20.9% reduced thickness of the transverse abdominis compared to healthy people, and that the drawing-in maneuver should be included as exercise for control of the transversus abdominis. However, Beazell et al.<sup>25</sup> reported that the thickness of the transverse abdominis of back pain patients was 0.58 cm on the symptomatic side in rest and 0.82 cm in contraction, and in healthy subjects it was 0.56 cm on the right and 0.59 cm on the left in rest and 0.79 cm on the right and 0.81 cm on the left in contraction, with no significant differences between the two groups of subjects.

Vera-Garcia et al.<sup>18</sup> demonstrated that exercise on an unstable support surface further enhanced changes in the motor control system, increased the muscle activity, contraction speed, and strength of spinal stabilization, and improved the harmony of neuromuscular reflexes reactions more than exercise on a stable support surface<sup>26</sup>. Guthrie et al.<sup>27</sup> measured the contraction ratio of the transverse abdominis in sling bridging exercise and general bridging exercise. The ratio in the sling bridging exercise group was 1.61 in rest and 1.58 in contraction, and in the general exercise group it was 1.55 in rest and 1.65 in contraction, indicating the general bridging exercise induced greater contraction of the transverse abdominis. Vasseljen et al.<sup>28</sup> measured the muscular thickness and ratio of the transverse abdominis after exercise with a sling for 8 weeks. The ratio of the experimental group which performed exercise with a sling was 1.76 before exercise and 2.00 after exercise, and the group performing general exercise had a ratio of 1.80 before exercise and 1.81 after exercise, indicating the ratio of the transverse abdominis was greater after intervention with the sling, and the sling exercise increased the thickness of the transverse abdominis more than the general exercise.

Saliba et al.<sup>29</sup> reported that a bridging exercise group using a sling as the support surface showed greater changes in the transversus abdominis thickness than a bridging exercise group using the floor as the support surface. In the present study, we found that the transversus abdominis thicknesses of the bridging exercise group using the sling as the support surface and the bridging exercise group using

the fixed support surface were, respectively, 0.35 cm and 0.36 cm in rest and 0.70 cm and 0.52 cm in contraction, indicating that the bridging exercise using the sling support surface increased the thickness of the transverse abdominis more. We consider that the thickness difference from those of previous studies was a result of differences in posture. We also consider that the reason for the difference in the thickness of transverse abdominis was that the unstable support surface, the sling, provided a dynamic environment, so the number of myofibrils involved in motor control increased, and the increase of contractibility resulted in an increase in the transverse abdominis thickness.

Kang et al.<sup>30</sup> reported in a study comparing trunk muscle activities of bridging exercises, that a bridging exercise with a sling induced higher %MVIC of the trunk muscles than bridging exercises with a ball and general bridging exercise. In the present study, we found that the gluteus maximus muscle showed 25.9%MVIC in the experimental group and 25.4%MVIC in the control group; the gluteus medius muscle showed 27.8%MVIC in the experimental group and 30.1%MVIC in the control group; and the biceps femoris muscle showed 61.6%MVIC in the experimental group and 30.9%MVIC in the control group. We consider that in the bridging exercise on the unstable support surface, the knee flexor and hip adductor muscle were used more to prevent hip abduction in order to maintain balance and alignment, so the activity of the hip abductors was lower and the activity of knee flexors was higher than in the general bridging exercise.

Accordingly, we consider that the bridging exercise on the support surface using a sling, as a part of stabilization exercise program for patients with back pain, would be more effective at improving activity of the transversus abdominis and lower extremity muscles, and should be recommended for muscle retraining and muscular function improvement. A future study will be needed to compare the effectiveness of long term exercise performance and the activities of several lower extremity muscles with more subjects.

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