

# Differences in Trunk Muscle Activities and Ratios between Unstable Supine and Prone Bridging Exercises in Individuals with Low Back Pain

JINHWA JUNG, PhD, OT<sup>1)</sup>, JAEHO YU, PhD, PT<sup>2)</sup>, HYUNGKYU KANG, MSc, PT<sup>3)</sup>

<sup>1)</sup> Department of Occupational Therapy, Semyung University

<sup>2)</sup> Department of Physical Therapy, Kangwon National University

<sup>3)</sup> Department of Physical Therapy, Graduate School, Sahmyook University: 26-21, Gongneung 2-dong, Nowon-gu, Seoul 130-650, Republic of Korea.

TEL: +82 2-3399-3010, FAX: +82 2-3399-3009, E-mail: hggang131@gmail.com

**Abstract.** [Purpose] This study aimed to investigate the differences in activities and ratios of the muscles internal oblique (IO), rectus abdominis (RA), multifidus (MF), and the thoracic part of the iliocostalis lumborum (ICLT) muscle between unstable supine and prone bridging exercises in individuals with low back pain (LBP). [Methods] A convenience sample of 14 individuals with LBP (7 men and 7 women) performed supine and prone bridging exercises. Surface electromyography signal amplitudes of the dominant trunk muscles during the 2 types of exercises were measured of all subjects. [Results] During the supine bridging exercise, the activity of the MF and ICLT and the IO/RA ratio were significantly higher than those during the prone bridging exercise. In contrast, the activities of IO and RA were significantly higher during the prone bridging exercise than that during the supine bridging exercise. [Conclusion] This study showed the differences in trunk muscle activities and ratios between unstable supine and prone bridging exercises in individuals with LBP. The information presented here is important for investigators who use lumbar stabilization exercises as an evaluation tool or a rehabilitation exercise for individuals with LBP.

**Key words:** Lumbar stabilization, Bridging exercise, Low back pain

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## INTRODUCTION

Approximately 50% of the general population experience low back pain (LBP)<sup>1)</sup>. Despite the high occurrence rate and the negative effect of LBP on the activities of affected individuals, the cause of nonspecific LBP is still open to debate. However, some approaches have been reported to be effective for LBP diagnosis and intervention<sup>2)</sup>.

Core stabilization exercises are being used to minimize the severity and frequency of LBP<sup>3)</sup>. The muscles involved in core stabilization are classified into global and local stabilization systems. The global and local muscles of the trunk are the main contributors to these stabilization systems<sup>4)</sup>.

Supine and prone bridging exercises are widely used for improving core stability<sup>5–7)</sup>. Core stabilization exercises are maximized when an exercise is performed under dynamic conditions (e.g., by using a therapeutic Swiss ball) rather than under static conditions (e.g., overground exercises), because proprioception and the motor area of the cerebrum are stimulated and balance ability is improved under dynamic conditions<sup>8)</sup>. Saliba et al. investigated individuals with LBP using supine bridging exercises on unstable and stable surfaces and reported that greater trunk muscle activity was required for the unstable supine bridging exercise<sup>5)</sup>.

The trunk muscles divide the global stabilization system (GSS) or that of the local stabilization system (LSS). The

function of LSS is control segments, and GSS is forceful movements<sup>9)</sup>. Coordination between the local and global muscles is a prerequisite for stabilization exercises<sup>10)</sup>. Ratios of local to global muscle activity have previously been measured using methods of independent contraction in local muscles<sup>11)</sup>, such as the abdominal drawing-in maneuver or isometric contraction exercises<sup>12)</sup>. A recent study reported that the ratio of the activity of the internal abdominal oblique (IO) relative to that of the rectus abdominis (RA) is improved by core stability exercises on an unstable surface, e.g., by using a Swiss ball<sup>13)</sup>.

As mentioned above, bridging exercises on stable and unstable surfaces improve trunk muscle activities and ratios. However, most studies on unstable bridging exercises have been conducted in the supine and other positions, and comparisons of trunk muscle ratios are scarce.

For these reasons, our study examined the differences in trunk muscle activities and ratios during unstable supine and prone bridging exercises in individuals with LBP, to determine the effective of the training methods on lumbar stabilization rehabilitation of LBP patients.

## SUBJECTS AND METHODS

Fourteen adults (7 men and 7 women) aged 27–51 years with a current episode of LBP were recruited at B Hospital

**Table 1.** General characteristics of the subjects

	Gender (male/female)	Age (years)	Height (cm)	Weight (kg)
Subjects (n=14)	7 / 7	39.4 ± 12.4	166.7 ± 13.4	63.3 ± 15.9

Note. All variables are mean ± standard deviation (SD).

through a leaflet explaining the details of the study. The general characteristics of the subjects are given in Table 1. The inclusion criteria were persistent LBP with or without referred pain (of a nonradical nature) of at least 3 months, and pain requiring medical attention or absence from work. The exclusion criteria included persistent severe pain, neurological symptoms, structural deformity, uncontrolled alcohol and/or drug use, recent abdominal surgery, or any other corresponding disorders preventing active rehabilitation.

In this study, two types of exercises were performed.

1. Supine bridging exercise: The subject lay in the supine position in a lumbar neutral position with the legs fully extended on the ball, palms facing the ground, hips flexed, and knees, elbows, and neck at an approximate angle of 0° to the ground and in a lumbar neutral position (Fig. 1).

2. Prone bridging exercise: The subject lay on the ground in a lumbar neutral position with only the lower leg and feet in contact with the surface of the ball. The hands were positioned directly underneath the shoulders, with the fingers facing forward. The surface test height (55 or 65 cm) was chosen so that the angle of the shoulder joint and the trunk was approximately 90° (as manually measured using a flexible goniometer).

The same surface height was used for both test conditions<sup>10)</sup>(Fig. 2).

The exercises were executed in a random sequence. Participants were given an orientation before the training to familiarize themselves with the exercise method. Each 5-second exercise was performed 3 times, and EMG signals of the middle 3 seconds the first and the last 1 second, was used for the analysis. A 3-minute break was given after each exercise to minimize muscle fatigue.

To measure the electrical activity of the muscle groups, the internal oblique (IO), rectus abdominis (RA), multifidus (MF), and the thoracic part of the iliocostalis lumborum (ICLT), during the unstable supine and prone bridging exercises, a surface electromyography (sEMG) system (Telemyo 2400T-G2 Telemetry EMG system; Noraxon, USA, 2007) with disposable bipolar surface EMG electrodes was used. The skin was prepared by shaving excess hair and rubbing with alcohol to reduce impedance (typically ≤10 kOhm). Disposable Ag/AgCl surface electrodes were attached parallel to the muscle fiber orientation and bilaterally over the following “local trunk muscles”: the inferior fibers of the IO (midway between the anterior iliac spine and symphysis pubis and above the inguinal ligament) and the lumbar MF (lateral to the midline of the body and above and below the line connecting both the posterior superior iliac spines). The electrode placement on the “global trunk muscles” was as follows: RA, 3 cm lateral to the umbilicus;

**Fig. 1.** Unstable supine bridging exercise**Fig. 2.** Unstable prone bridging exercise

ICLT, above and below the L1 level and midway between the midline and the lateral aspect of the body. The maximum spacing between the recording electrodes was 2.5 cm, as recommended, and each electrode had an approximately 1.0-cm<sup>2</sup> pick-up area. The reference electrode was placed over the superior aspect of the left iliac crest<sup>10)</sup>.

All EMG signals were amplified 1000 times with an amplifier (MyoResearch XP Master Edition; Noraxon Inc., USA). The sampling frequency was 1000 Hz. The raw data were band-pass filtered between 20 and 500 Hz and full-wave rectified using the analysis software. The root mean square was calculated for the 3 seconds during which the posture was stable during each exercise. For normalization, maximum EMG signals were acquired in maximum voluntary contraction (MVC) maneuvers of each muscle. The root mean square during the exercise was normalized as a percentage of the greatest root mean square obtained over the 3-second period during the MVC test (%MVC) using Noraxon MyoResearch software 2.10. The relative muscle activities of the different trunk muscles and the ratios of the local abdominal muscle activity to the global abdominal muscle activity (IO/RA) were calculated<sup>14)</sup>.

The SPSS 12.0 program was used for data analysis. The

paired *t*-test was used to compare the differences in trunk muscle activities and ratios during each bridging exercise. Significance was accepted for values of  $p < 0.05$ .

## RESULTS

The mean EMG amplitudes of the different abdominal and back muscles during the two bridging exercises are presented in Table 2. Because the contribution of local muscle activity was the main concern of this study, abdominal muscle activity and back muscle activity were analyzed separately. The IO/RA ratio is presented in Table 3.

During the supine bridging exercise, the muscle activity of the MF and ICLT and the IO/RA ratio were significantly higher than their respective values during the prone bridging exercise (all  $p < 0.01$ ). In contrast, the muscle activities of the IO and RA during the prone bridging exercise were significantly higher than that during the supine bridging exercise ( $p < 0.001$ ).

## DISCUSSION

The differences in trunk muscle activity and ratio during unstable supine and prone bridging exercises in individuals with LBP were examined in this study.

The muscle activities of the trunk are higher when performing exercises on a Swiss ball than using a stable surface because the increased need for spinal and whole-body stability in order to maintain balance and to reduce the threat of falling off the unstable surface<sup>15</sup>). Some researchers have suggested that the Swiss ball exercise, which offers an unstable surface, is the most effective core stabilization exercise<sup>10, 13–14, 16</sup>). Behm et al. reported that trunk region exercises with a Swiss ball significantly increase muscle activities in the lower abdominal region<sup>16</sup>). Stevens et al. studied 30 healthy adults who performed supine bridging exercises on a stable overground surface and on an unstable Swiss ball and compared their trunk muscle activities. They reported that exercise on the unstable Swiss ball, as compared to that on a stable overground, resulted in higher activities in both the trunk abdominal muscles and lower back muscles, such as IO, MF, ICLT, RA, and the external oblique. Especially, the lower back muscles, MF and ICLT, showed significantly higher activities. This study, in agreement with previous studies, verified that the lower back muscles, MF and ICLT, have higher activities than the abdominal muscles during an unstable supine bridging exercise<sup>14</sup>).

Schellenberg et al. studied 43 healthy adults who performed supine and prone bridging exercises on a stable surface and compared their muscle activities. During the supine bridging exercise, global muscles in the lumbar region, such as the lumbar extensor and hamstring, showed higher activities than global muscles in the abdominal region, such as RA and the external oblique. In contrast, during the prone bridging exercise, global muscles in the abdominal region showed a higher activity than global muscles in the lumbar region<sup>17</sup>). This study, like the preceding study, also verified that lower back muscles show higher activities than abdominal muscles during supine bridging exercises.

**Table 2.** Comparison of trunk muscle activities between the bridging each exercises

	Supine bridging exercise (M ± SD)	Prone bridging exercise (M ± SD)
IO***	9.81 ± 6.68	30.10 ± 6.22
RA***	2.10 ± 1.54	42.10 ± 18.59
MUL**	34.05 ± 11.64	12.05 ± 11.02
ICLT**	25.23 ± 11.05	11.16 ± 7.40

Note. All variables are mean ± standard deviation. IO: internal oblique. RA: rectus abdominis. MUL: multifidus. ICLT: the thoracic part of the iliocostalis lumborum. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

**Table 3.** Comparison of IO/RA ratios between the bridging exercises

	Supine bridging exercise (M ± SD)	prone bridging exercise (M ± SD)
IO/RA**	5.65 ± 4.04	1.11 ± 1.33

Note. All variables are mean ± standard deviation. IO/RA: the ratio of the activity of the relative internal abdominal oblique to that of the rectus abdominis. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

In contrast, abdominal muscles showed higher activities than lower back muscles during prone bridging exercises. Therefore, the trunk muscle activities of healthy adults and individuals with LBP are the same during supine and prone bridging exercises. Supine bridging exercises enhance lower back muscle activity, whereas prone bridging exercises enhance abdominal muscle activity.

In this study, the IO/RA ratio was higher in the supine bridging exercise than in the prone bridging exercise, and the ratio was  $>1$  in both exercises. The local stabilization system plays a role in the control and coordination of segmental movement, and the muscles of the global stabilization system generate large movements owing to their long moment arm of power and thick muscle belly. Moreover, the muscles of the local stabilization system are located near the vertebral column and can delicately regulate segmental movements<sup>18</sup>). The increased tension in these muscles promotes a compression force between each lumbar muscle and enhances stabilization<sup>19–22</sup>). Stevens et al. reported that the IO/RA ratio was very high because of the relatively small activity of RA during unstable supine bridging exercises<sup>14</sup>). In this study, the high activity ratio of local muscles was influenced by the lumbar neutral position, which reduces the activity of the global muscles and increases local muscle activity.

Our study was limited by the relatively small sample size and the use of only two exercises among the numerous available methods. Thus, these findings cannot be generalized to all patients with LBP. Therefore, additional research is necessary to determine the contribution of other exercises as well as the supine and prone bridging exercises on muscle activation and ratios.

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