



Original Article

Change in trunk muscle activities with prone bridge exercise in patients with chronic low back pain

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Abstract. [Purpose] The aim of this study was to determine the effect of three different bridge exercises on internal oblique, external oblique, transverse abdominis, and erector spinae activities. [Subjects and Methods] Forty-five subjects with chronic low back pain participated in this study. The training outcome was evaluated with three different testing methods: supine bridge exercise, supine bridge on Swiss ball exercise, and prone bridge exercise. The activities of the transverse abdominis, internal oblique, external oblique, and erector spinae were measured using surface electromyography. [Results] There were significant differences in the internal oblique, external oblique, and erector spinae according to the three kinds of bridging exercises. The internal oblique, external oblique and transverse abdominis activities were highest in the prone bridge exercise, followed by those in the supine bridge on Swiss ball exercise, and supine bridge exercises. The activity of erector spine was highest in the supine bridge on Swiss ball exercise followed by the supine bridge exercise and prone bridge exercise. [Conclusion] These results suggest that prone bridge exercise is more effective than conventional supine bridge exercise and supine bridge on Swiss ball in increasing trunk muscle activity of chronic low back pain patients.

Key words: Muscle activity, Bridge exercise, Electromyography

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INTRODUCTION

Low back pain is one of the most common and costly diseases in society today¹⁾. Nearly 60–80% of the world's population experiences low back pain at least once during their lives. Although most of these people recover, 5–15% continue to have pain and do not respond to treatment²⁾. Low back pain was the second leading reason for seeking treatment, and about 20% of patients with such pain developed chronic low back pain (CLBP)³⁾. Due to the pain, structural damage, and suppressed reflexive muscular contraction associated with CLBP, patients experience a decline in physical activity. Long-term physical inactivity can cause muscle atrophy and a decrease in muscle strength because the muscles remain unused, exacerbating low back pain, and resulting in secondary injury to the spine and further physical dysfunction⁴⁾.

Based on epidemiological findings, spinal instability is one of the leading causes of low back pain⁵⁾, and CLBP patients consider their spinal instability to be a serious problem¹⁾. An unstable spine reduces endurance, flexibility, and the range of motion of the lower back, in addition to causing pain⁶⁾. If the pain intensifies, patients are limited in the types of physical activity they can perform, and the spinal muscle fiber cross-sectional area is reduced, leading to disuse atrophy of the muscles⁷⁾. CLBP is characterized by a range of conditions and symptoms, which can have physical and psychological causes. The physical causes include muscle weakness and imbalance, repetition of bad posture, delayed recovery of deep abdominal muscles, inadequate motor control of trunk stabilization muscles, and neuromuscular disorders³⁾.

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In many cases, the reduced mobility of CLBP patients decreases flexibility in the lumbar area, muscular strength, and endurance. Because the decline in lumbar strength can result in increased pain and lumbar muscle fatigue in CLBP patients, strengthening the muscles of the lumbar spine is considered an essential part of treatment for low back pain⁸. The persistent pain and reduced mobility result in disuse muscle atrophy and changes in the structure of the lumbar spine and its surrounding tissues because of decreases in the cross-sectional area of spinal muscle fibers⁷. The resulting deterioration in the strength of the trunk and abdominal muscles further increases pain and functional limitations⁹. Moreover, the joint position sense of the lumbar spine in CLBP was reported to be degraded¹⁰. In a previous electromyogram (EMG) study¹¹, the activation of the transverse abdominis (TrA) and multifidus muscle (MM) was more delayed in those with CLBP than in those without CLBP, and these muscles showed a slower response and more severe atrophy in CLBP patients compared to those without CLBP^{12–14}.

Appropriate exercise programs are an essential component of physical therapy for CLBP patients after their symptoms have been evaluated and diagnosed¹⁵. In particular, the importance of lumbar stabilization exercise (LSE) has been stressed recently because of its role in preventing repetitive injuries to the intervertebral disc, small joints, and surrounding tissues and minimizing compressive stress in the spine during activities by strengthening core muscles^{16, 17}. Regular LSE in patients with low back pain strengthens ligaments, bones, tendons, and muscles and supplies sufficient nutrition to several joints and cartilages, including the spinal disc, thereby improving motor control¹⁸. In addition, it restores muscle strength, functional mobility, and balance and improves the muscle activity of the lower trunk and core, enhancing health and making LSE effective not only for patients with low back pain but also for athletes¹⁹.

In LSE, the TrA and MM are the most important muscles that contribute to trunk stabilization^{20, 21}. Stevens et al.²² reported that the TrA, internal oblique (IO), and other core muscles played significant roles in improving lumbar stability, whereas the MM was more important in controlling small movements of the spine. According to Bergmark²³, deep muscles, such as the TrA and IO, are directly attached to the spine and are involved in providing fine control of movements throughout the spine and stability between spinal segments, superficial muscles, such as the rectus abdominis (RA) and external oblique (EO), produce torque and provide general trunk stability by controlling gross movements of the trunk and pelvis. Among LSEs, pelvic tilt exercises, quadrupedal exercises, abdominal hollowing, and bridge exercises are generally practiced²⁴. The bridge exercise relieves pain in patients with low back pain and improves physical functioning by training large and small muscles to work together in proper combinations and by stabilizing the trunk. Due to their strengthening effects on the gluteal muscle and lower limbs, bridge exercises are widely prescribed in clinical practices²⁵. In a clinical treatment requiring low-intensity training of trunk muscles, a bridge exercise was effective in achieving trunk stability²⁶.

Previous studies reported various modifications of bridge exercises. One study aimed at improving trunk stability employed various unstable platform devices and exercises, with the participants adopting different postures on these devices^{27, 28}. Another study emphasized the importance of a range of postures in lumbar strengthening exercises²⁹. In a study that employed variations of the bridge in healthy individuals, the authors suggested that the prone bridge exercise (PBE) was more effective than the conventional bridge exercise in increasing the muscle activity of the trunk³⁰.

The aim of this study was to investigate and compare the effect of conventional bridge exercises and PBE on the trunk muscle activity of CLBP patients and to suggest the most effective variation of the bridge exercise.

SUBJECTS AND METHODS

This study was conducted with 45 CLBP patients who underwent physical therapy at a hospital in Donghae, South Korea. The subjects were divided into three groups to evaluate three different variations of the bridge exercise. Of the 45 subjects, seven dropped out of the study, one relocated to another area, and the remaining 38 completed the study. Prior to participation, all subjects were required to provide informed consent, in accordance with the ethical principles of the Declaration of Helsinki. The protocol for this study was approved by the local ethics committee of the Catholic University of Daegu.

The subjects were selected based on the following inclusion criteria: CLBP patients in their 20s–50s with a disease duration of 6 months or more and a diagnosis of CLBP based on an X-ray, computed tomography (CT), or magnetic resonance imaging (MRI). Patients were excluded if they had a vestibular abnormality or nerve damage, if they were taking medication due to a balance problem, if they had undergone orthopedic surgery due to a spine-related problem, or if they could not perform the exercise. The 38 subjects were randomly classified into three bridge exercise groups: a supine bridge exercise group (SBE, $n=11$), a supine bridge with a Swiss ball exercise group (SBSE, $n=14$), and a PBE group ($n=13$). There were 13 (34.2%) male and 25 (65.8%) female. The mean ages, weights, and heights were 39.4 years, 60 kg, and 163.5 cm, respectively, in the SBE group; 41.9 years, 59.5 kg, and 163.7 cm, in the SBSE group, and 42.6 years, 63.9 kg, and 165.1 cm, in the PBE group.

Three kinds of bridging exercise were conducted in the experiment. Supine bridge exercise (SBE): In the starting position of the bridging exercise in the supine position, subjects bent their knees at 90° and spread both arms at about 30°, with both hands on the ground. They kept the head and neck in a straight position, with eyes looking at the ceiling. Supine bridge on Swiss ball exercise (SBSE): The subjects adopted the same position as that of the supine bridge exercise, but placed their legs on the Swiss ball. Prone bridge exercise (PBE): In a prone position, the subjects bent their elbows at 90° and supported their bodies with forearms and toes, with the neck slightly extended and eyes looking to the front.

The subjects performed one set of 5 repetitions for each exercise, which consisted of 30-second work and 30-second rest periods, 3 times a day, 3 days a week. The training sessions were conducted for 8 weeks at a designated training facility under the supervision of an experienced physical therapist who ensured that each subject performed the exercises correctly.

Changes in the trunk muscle activity were examined by a surface EMG system (Telemyo 2400T-G2, Noraxon, USA), and Ag/Ag-Cl (Biopac, diameter 2 cm) measurement electrodes were used. The surface EMG signals were digitized by a surface EMG system and processed using the MR-XP (Noraxon, USA) program on a personal computer. The surface EMG signals were sampled at 1024 Hz and then filtered by band pass (20–500 Hz) and notch filters (60 Hz). The collected EMG data were full-wave rectified and smoothed using a root mean square (RMS) analysis.

The surface of the skin was gently scuffed with sandpaper three or four times to reduce any resistive barriers, and the scuffed area was wiped clean with an alcohol pad to attach the electrodes. The electrodes were aligned parallel to the muscle fibers, and ground electrodes were placed over the anterior superior iliac spine.

Each position was held for 10 seconds, and the activity of the muscles was measured for 5 seconds during the analysis, excluding the first 3 seconds and the last 2 seconds. All the positions were repeated three times for the EMG measurements, and the mean of three measured values was calculated.

The data collected from the participants who took part in the different exercise interventions were analyzed using PASW Statistics 18 (SPSS Inc). The Shapiro-Wilk test was used to verify the normal distribution of the variables. A paired t-test was used to determine the changes in the trunk muscle activity before and after the exercises, and a one-way analysis of variance (ANOVA) was used to determine the influence of the various bridge exercises on the trunk muscle activity. A Bonferroni post-hoc test was also performed to identify differences in the activities of the trunk muscles among the various exercises, and a p value of less than 0.5 was considered statistically significant.

RESULTS

The results and standard deviations the trunk muscles (TrA, IO, EO, and erector spinae; ES) are summarized in Table 1. The activity of the TrA, IO, and EO muscles significantly increased in the PBE group, whereas that of the ES significantly increased in the SBSE group. Interestingly, only the PBE group showed significant changes in the TrA muscle, while the SBE and SBSE groups did not show significant differences. The change in the muscle activities of the TrA, IO, and EO depended on the type of bridge exercise performed ($p < 0.001$), with the activities of the TrA, IO, and EO muscles greatest in the PBE group, followed by those in the SBSE and SBE groups. The greatest ES muscle activity was observed in the SBSE group, followed by the SBE and PBE groups. The results of the Bonferroni post-hoc test showed a significant difference in the activities of the TrA, IO, and EO muscles ($p < 0.001$) between the SBE and PBE groups and between the SBSE and PBE groups.

DISCUSSION

In this study, conventional and prone bridge exercises were performed to improve the stability of the trunk, and changes in the activity of the trunk muscles were measured to identify the effectiveness of the different types of bridge exercises.

After the 8-week training period, greater activity was observed in the TrA, IO, and EO muscles of the PBE group, followed by the SBSE and SBE groups. The ES muscle activity was greater in the SBE group, followed by the SBSE and PBE groups. These findings are due to the prone bridge using a greater muscle volume than the supine bridge and supine bridge with a Swiss ball to maintain the stability of the trunk, leading to a higher muscle activity level. In particular, the activity of the TrA muscle increased significantly in the PBE, whereas it did not in the SBE and SBSE groups. Moreover, Kong et al.³¹⁾ reported that muscle thicknesses of the TrA, IO, and EO after prone bridge exercise increased significantly more than after conventional bridge exercise.

To achieve spinal stability, the contraction of superficial muscles, such as the RA and ES, should be minimized, and the activities of core muscles, such as the TrA and MM, should be improved through exercises³²⁾. In this study, the participants performed the prone bridge to improve their core muscles, and this bridge variation effectively activated the core TrA and IO muscles while decreasing the activity of the ES muscle. This finding supports the effectiveness of the prone bridge for CLBP,

Table 1. A comparison of the trunk muscle activities during the bridge exercises (Unit: %MVIC)

	IO	TrA	EO	ES
SBE (A)	2.22±3.02*	-0.06±7.01†	3.32±6.38	6.87±10.83
SBSE (B)	7.30±6.86*	2.72±5.63	6.91±7.37*	10.23±12.93*
PBE (C)	27.68±17.26**	20.31±13.60**	16.84±13.91**	3.01±4.64*
post-hoc	AB/C**	AB/C**	AB/C*	

†pre-post mean±standard deviation, * $p < 0.05$, ** $p < 0.001$

SBE: supine bridge exercise, SBSE: supine bridge on swiss ball exercise, PBE: prone bridge exercise. IO: internal oblique, TrA: transverse abdominis, EO: external oblique, ES: erector spinae

which is characterized by weak abdominal muscles and severely contracted ES muscles.

A previous study of the bridge exercise claimed that it was more effective in preventing spinal cord injury when unstable platform devices were used, stating that the exercise induced greater muscle activity and mobility and improved balance functions compared with the bridge exercise on a stable platform³³). Another study reported that combining bridges with abdominal exercises for core muscles increased muscle activity³⁴). Thus, exercise balls, unstable surfaces, and abdominal exercises for deep muscles have been incorporated into bridge exercises to improve the stability of the trunk.

In this study, the prone bridge activated the TrA muscle, in addition to the IO and EO muscles, illustrating that the prone bridge is capable of boosting the activity of the EO muscle, in addition to deep muscles such as the TrA and IO. In functional stability training for the trunk, mutual coordination between large and small muscles, together with adequate activation of small muscles, is essential³⁵). In the present study, the prone bridge increased the activity of the core TrA and IO muscles, as well as that of the EO muscle. This finding indicates that proper co-contraction and coordination of large and small muscles can further improve the stability of the trunk.

The change in the muscle activities of the TrA, IO, and EO depended on the type of bridge exercise performed. Conventional bridge exercises are used to evaluate the influence of trunk flexion postures on spinal stability, whereas the PBE is used to evaluate the influence of trunk extension postures on spinal stability. According to a previous study, conventional bridge exercises selectively activated spinal extensors, whereas the prone bridge selectively activated spinal flexors³⁶). Another study noted that the PBE primarily used anterior stabilizer muscles, whereas the conventional bridge exercises mainly employed posterior stabilizer muscles³⁷). This means that the prone bridge induces greater activities of anterior muscles, such as the TrA, IO, and EO, and that it reduces the activity of posterior muscles, such as the ES. The increased activity of the TrA, IO, and EO muscles and the decreased activity of the ES are related to the resistance to gravity while the trunk is moving in a flexion pattern in the prone exercise. In this exercise, when the elbows and feet touch the ground, the trunk muscles use co-contraction to overcome the resistance to gravity. This likely explains why the TrA is contracted first, followed by the IO and EO which create an internal rotation moment.

Kong et al.³⁰) suggested that the muscle activity increased in response to biomechanical demands in the prone bridge position to overcome the instability associated with this position in which the base of support is reduced and weight is borne by the elbows and feet. As the elbows support the body's weight, the load imposed on the upper arms is decreased, making the maintenance of the prone position feasible, even for patients in early stages of rehabilitation³⁸).

In conclusion, the activities of the trunk muscles of CLBP patients increased in the PBE compared to those in the conventional bridge exercises, which included an exercise with a Swiss ball. The prone bridge is more effective at activating trunk muscles.

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