

The effects of prone bridge exercise on the Oswestry disability index and proprioception of patients with chronic low back pain

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Abstract. [Purpose] The purpose of this study was to investigate the effect of bridge exercises on the Oswestry disability index (ODI) scores and proprioception among patients with chronic low back pain (CLBP). [Subjects and Methods] A total of 38 patients participated in this study. After eight weeks of bridge exercise, the joint position angle of the body trunk was measured and the ODI was used in survey form to investigate the intensity of the patients' low back pain. [Results] After eight weeks of exercise, the ODI showed significant differences in all three groups. Subjects' joint position sense of the trunk in both lumbar flexion and extension was also significantly different after completing the exercise program; this was true for all three groups. [Conclusion] Performing the prone bridge exercise for eight weeks improved proprioceptive function and reduced pain and impediment of activity, showing it a more effective exercise than other bridge exercises.

Key words: Bridge exercise, Proprioception, Chronic low back pain

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INTRODUCTION

Patients with chronic low back pain (CLBP) have weaker and unbalanced lumbar deep muscles compared to people without low back pain. Moreover, their proprioception is decreased, which eventually causes problems in spinal stability which result in recurring low back pain¹⁾. Pakhurst and Burnett²⁾ argued that diminished proprioception is highly correlated with the occurrence of low back pain. Luoto et al.³⁾ also reported that patients with lower back pain had less lumbar sense and motion control ability than those without low back pain. Lumbar instability induces pain, decreases endurance and flexibility, and limits the range of motion of the low back⁴⁾, distorting the normal signals coming from the muscles and sensory organs and impairing balance⁵⁾.

Proprioception plays an important role in maintaining joint stability. It is a neural signal that begins in the nerve terminals known as mechanoreceptors, and travels to the central nervous system⁶⁾. Proprioception is an important biofeedback for controlling nerve roots, balance, and mobility as well as securing and maintaining joint stability^{6, 7)}. Information from proprioceptive senses plays an important role in movement and balance as well as control of the neural muscles, as it transfers information regarding body

movement and the position of the joints to the central nervous system⁸⁾. When proprioception is impaired, the amount of movement, sensory information about the position of the joint where the movement takes place, and the amount and properties regarding muscle contraction, etc. are changed. As a result, the ability to respond to unexpected and destabilizing forces is diminished, potentially causing injury⁹⁾. Proprioceptive malfunction in patients with low back pain causes chronic pain and a limited range of joint motion⁵⁾. Hence, accurate stimulus input of proprioception is important for normal movement and articular damage prevention.

Measurement of kinesthesia and joint position sense are often used to evaluate proprioception. One method of evaluating kinesthesia involves measuring the cognition threshold of slow passive movement. Meanwhile, joint position sense can be evaluated by error determination of the active or passive reproduction of joint angles^{10, 11)}. In the case of the loss of joint position sense, movement ability diminishes and carrying out daily activities becomes difficult. Moreover, it hampers learning ability when acquiring new movements, potentially causing degeneration¹²⁾.

This study chose to use bridge exercises as a means of reinforcing weakened body trunk muscles among patients with CLBP. The bridge exercises used a comfortable posture that reduced the pain of the patients with low back pain. They are widely used in clinics, as they stabilize the trunk and enhance the muscle strength of the buttocks and lower limbs¹³⁾. Most previous studies of bridge exercises have focused on the muscle activity of the trunk and lower limbs^{14, 15)}; however, research on proprioception is scarce.

This study implemented bridge exercise programs for eight weeks and investigated their effect on the Oswestry

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Disability Index score and proprioception of the trunk by measuring the activity index and joint position sense, respectively, using a sample of patients with low back pain with the purpose of suggesting an effective method of using bridge exercises.

SUBJECTS AND METHODS

A total of 38 patients with CLBP undergoing physical therapy at Hospital P were selected. They were randomly allocated to the following three groups according to bridge exercise type: the supine bridge exercise (SBE) group, the supine bridge on Swiss ball exercise (SBSE) group, and the prone bridge exercise (PBE) group. Of the 38 participants, 13 (34.2%) were male and 25 (65.8%) were female. The average age, weight, and height of the SBE group was 39.4 years, 60.9 kg, and 163.5 cm, respectively; The average age, weight, and height of the SBSE group was 41.9 years, 59.5 kg, and 163.7 cm, respectively; and the average age, weight, and height of the PBE group was 42.6 years, 63.9 kg, and 165.1 cm, respectively.

Before the test, the researchers explained the purpose and methods of the research to all of the subjects; then, they were asked to complete the ODI. The research participants also signed written informed consent forms in accordance with the Declaration of Helsinki before beginning the experiment. The protocol for this study was approved by the local ethics committee of the Catholic University of Daegu. The patients were ages between 20 and 50 years old and had suffered from CLBP for a period of over six months. They had been diagnosed as having chronic low back pain via X-rays, CT scans, MRIs, etc. Those with problems in their vestibular organs or neural damage, those taking balance-related medicines, those with a history of spinal surgery due to orthopedic problems, and those who were unable to perform the exercise program were excluded from the sample.

The following is a description of the three types of bridge exercises. Exercise 1 (supine bridge exercise): Lying down, the arms are spread at approximately 30° and the knees are flexed at 90°; the palms are placed face down on the ground, and the head and neck are kept straight with the eyes looking at the ceiling. Exercise 2 (supine bridge on Swiss ball exercise): With an identical starting position to Exercise 1, the feet are placed on a Swiss ball. Exercise 3 (prone bridge exercise; the plank): In the prone position, the body weight is supported on the forearms and the toes, with the elbows flexed at 90°, the neck slightly extended, and the eyes looking forward.

For each group, one set of each exercise consisted of 30 seconds of exercise followed by 30 seconds of rest repeated five times. Each group performed three sets per day three times per week. In order to minimize error, an experienced physical therapist instructed and observed the subjects in a designated area to ensure that they correctly performed the exercises. The program lasted for a total of eight weeks.

A Zebris (Zebris Medical GmbH CMS100, Germany) was used to evaluate proprioception. Zebris is a device that measures the range of motion of the spine and has been proven to have high stability and reliability¹⁶. Two sensors are used to measure the joint angle of the spine using

ultrasound. Joint position sense was measured in order to gauge proprioception. The patients first stood in a neutral position, and the measurements were made in flexion, extension, right rotation, and right lateral flexion in the standing position. The patients received instruction while they were in the neutral position to keep their eyes open so that they could recognize the angle. Then, they were told to reproduce an arbitrary angle with their eyes closed. When the patients reached the arbitrary angle, they said “stop”. During the measurement, the patients were not allowed to receive visual feedback from the monitor. To prevent learning effects, each motion was repeated no more than three times. The difference between the actual angle and the arbitrary angle was measured three times, and the average value was used.

The data was processed using PASW 18 Statistics (SPSS Inc.). The paired t-test was conducted to examine differences in proprioception and the ODI before and after the exercise program. Analysis of covariance (ANCOVA) was performed by controlling the pre-test proprioception as a covariance. The Bonferroni test was conducted to examine post-test differences according to the exercise method. Statistical significance was accepted for values of $p < 0.05$.

RESULTS

In the case of lumbar flexion and extension, joint position sense showed a statistically significant difference after the exercise program in all three groups ($p < 0.05$). In the case of lumbar lateral flexion and lumbar rotation, joint position sense did not show a statistically significant difference after the exercise program (Table 1). The ODI showed a statistically significant difference after the exercise program in all three groups ($p < 0.05$). According to the Bonferroni post-test results after controlling the pre-test value as a covariance in order to verify the between-group effect, there was a difference in joint position sense in lumbar flexion between the SBE and PBE groups ($p < 0.05$). Moreover, there was a difference in joint position sense in lumbar extension and the ODI between the SBE and PBE groups and between the SBSE and PBE groups ($p < 0.05$) (Table 2). However, there were no between-group effects of lumbar rotation and lateral flexion.

DISCUSSION

This study conducted eight weeks of bridge exercises to investigate their effects on ODI scores and proprioception of patients with chronic low back pain. The biggest problem for patients with CLBP is lumbar instability¹. Hence, instability can be said to be the biggest factor inducing all kinds of lower back pain¹⁷.

The subjects of this study were patients with CLBP who had instability such as lumbar spondylolisthesis, lumbar herniated intervertebral disc, lumbar spinal stenosis, sacroiliac articulation syndrome, and lumbar sprain. Due to individual variation or pathological problems, their spines were out of the neutral position. Patients with CLBP have low lumbar flexibility due to decreased mobility, and their muscle strength and muscle endurance are often weaker than those of subjects without CLBP. The subsequent decrease in

Table 1. Comparison of joint position sense among groups (Unit: degree)

Category	Group	Pre	Post	Change
Flexion	Exercise 1**	4.99±1.27	3.22±1.10	1.77±1.27 ^{3*}
	Exercise 2**	4.57±1.69	2.59±1.05	1.97±1.55
	Exercise 3**	5.51±1.66	2.31±3.41	3.19±1.24 ^{1*}
Extension	Exercise 1*	2.96±0.67	1.95±0.72	1.01±0.80 ^{3*}
	Exercise 2*	2.45±0.83	1.78±0.70	0.67±0.67 ^{3*}
	Exercise 3**	2.78±0.88	1.26±0.51	1.51±0.94 ^{1,2*}
Lateral flexion	Exercise 1*	3.70±2.18	2.10±1.22	1.60±1.73
	Exercise 2	3.03±1.40	2.35±1.31	0.67±1.40
	Exercise 3*	3.33±1.18	2.17±1.14	1.16±1.50
Rotation	Exercise 1	2.13±0.71	1.86±0.79	0.27±0.79
	Exercise 2*	2.64±0.96	1.76±0.89	0.87±0.98
	Exercise 3*	2.19±0.86	1.38±0.58	0.80±0.91

*p<0.05, **p<0.001

¹ Significantly different compared with exercise 1² Significantly different compared with exercise 2³ Significantly different compared with exercise 3**Table 2.** Comparison of Oswestry disability index among groups (Unit: score)

Category	Group	Pre	Post	Change
ODI	Exercise 1*	39.65±14.5	27.58±6.8	12.06±10.1 ^{3*}
	Exercise 2**	38.30±10.1	27.21±8.1	11.08± 6.3 ^{3*}
	Exercise 3**	44.42±13.1	23.87±3.6	20.55±13.1 ^{1,2*}

*p<0.05, **p<0.001

ODI: Oswestry Disability Index

¹ Significantly different compared with exercise 1² Significantly different compared with exercise 2³ Significantly different compared with exercise 3

lumbar function is linked to pain and fatigue in the lumbar muscles; hence, it is known that strengthening the lumbar muscles is critical for ameliorating low back pain¹⁸⁾.

In order to verify the effect on the proprioception of chronic low back pain sufferers, this study measured the lumbar joint position error. According to our results, in the case of lumbar flexion, joint position error decreased by 1.77°, 1.98°, and 3.2° in the SBE group, the SBSE group, and the PBE group, respectively, after the eight weeks of exercise. All three groups showed a significant difference after the exercise program, and a significant difference was observed between the SBE and the PBE groups. In the case of lumbar extension, the SBE group showed a decrease of 1.01°, the SBSE group showed a decrease of 0.67°, and the PBE group showed a decrease of 1.52°. All three groups showed significant differences after the exercise program, and a significant difference was observed between the SBE and PBE groups and between the SBSE and PBE groups. In the case of lumbar lateral flexion and rotation, all three groups showed significant differences after the exercise program, but no between-group differences were found. One remarkable finding was that the bridge exercise type of the PBE group facilitated a more accurate joint repositioning sense than the exercises of the SBSE and SBE groups.

To improve proprioception, the Golgi tendon organ, lo-

cated at the muscle spindle and musculotendinous junction, needs to be stimulated to activate the receptors. Janwantanakul et al.¹⁹⁾ reported that the accuracy of joint position sense improved at the end point of the range of motion, when the resistance tension of muscle, tendon, and ligament against movement increased. The prone bridge exercise, joint position sense improved. Sensory function was enhanced by the interaction between the muscles surrounding the shoulder joint and the body trunk muscle, since the upper limbs supported body trunk. This is because the prone bridge exercise requires more muscle activity as well as a higher level of balance and exercise control than a conventional bridge exercise. Moreover, the muscle activity is surmised to have increased more since more muscles were mobilized in order to maintain the stability of the trunk. As increase in muscle activity stimulates muscle spindles and joint receptors in the muscles, the accuracy of the sensory integration process is enhanced, enabling correct joint repositioning. Kong et al.¹⁴⁾ reported that muscle activity in the trunk increased more when performing the prone bridge exercise (performed by a group of normal people) than other bridge exercises, and argued that the muscle activity increased to overcome the instability. Proprioception is essential for maintaining balance and controlling fine movement. Hence, for patients with CLBP who have spinal instability and

potential degenerative diseases, an exercise method that enhances proprioception impaired by decreased joint position sense should be considered.

Appropriate evaluation is required to select the best pain therapy method and determine its therapeutic effects. The ODI is an objective measurement tool that is used not only for evaluating subjects after surgery, but also the effects of the treatment, as it reveals the overall severity of impediments to daily living and physical activities. In the present study, the ODI scores significantly decreased after the eight-week exercise program in all three groups. There was a difference between the SBE and PBE groups and between the SBSE and PBE groups; the PBE group in particular showed a great deal of improvement. The results indicate that for patients with chronic low back pain, the prone bridge exercise was the most effective exercises at reducing low back pain and impediments to activity, in a comparison with the conventional bridge exercise and bridge exercise on a Swiss ball. This is consistent with the results of Marshall and Murphy²⁰ who reported a significant decrease in the ODI after the Swiss ball exercise. It is also consistent with the results of Hicks et al.²¹ who showed there were statistically significant decreases in the visual analog scale and the lumbar disability index after an eight-week lumbar stabilization exercise program.

In conclusion, the prone bridge exercise more effectively enhanced joint reposition sense impaired by diminished proprioception by securing the stability of the body trunk via activating the trunk muscles than the conventional bridge exercise. The ODI results suggest that the prone bridge exercise is effective at enhancing quality of life as it reduces pain and impediments to activity.

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