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# Effects of bridge exercise on trunk core muscle activity with respect to sling height and hip joint abduction and adduction

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**Abstract.** [Purpose] This study evaluated the effects of bridge exercise on trunk core muscle activity with respect to sling height and hip joint abduction and adduction. [Subjects] Fifteen healthy adult males participated. [Methods] In the bridge exercise, the height of the sling was set low or high during hip joint abduction and adduction. Electromyography was used to compare the differences between the muscle activities of the transverse abdominis, rectus abdominis, and erector spinae muscles. [Results] The muscle activities of the transverse abdominis, rectus abdominis, and erector spinae were significantly higher in the high sling position. Furthermore, the activities of the transverse abdominis and erector spinae were significantly higher during hip joint adduction than abduction regardless of sling height. [Conclusion] A high sling height is the most effective intervention for increasing the muscle activities of the transverse abdominis and erector spinae muscles during hip joint adduction in a bridge exercise.
**Key words:** Bridge exercise, Trunk core muscle, Sling

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## INTRODUCTION

Sling exercise therapy offers the major therapeutic advantage of underwater exercise, which is a reduced effect of gravity, on solid ground. It uses variable changes in axes to train the body, thereby improving joint mobility, stretching, muscle endurance, relaxation, and trunk stabilization[1)]. Kim and Kwon[2)] report exercising using a sling is highly effective for stabilization and stimulates proprioceptors by providing instability using sensory movements in contrast to exercising on stable mats.

The hip adductors account for approximately 25% of the volume of lower extremity muscles of healthy adults[3)]. As the ratio of muscle volume is closely associated with muscle strength, the proportion of muscle strength by the hip adductors by volume is high compared to that of other muscles around the lower extremities[4)]. Contractions of the hip adductors are responsible for adduction movements of the lower extremities; however, in cases in which the body weight is supported only by one lower extremity, they play a role in controlling pelvic movements. Moreover, contractions of the hip adductors can facilitate coordination between pelvic and abdominal muscles[5, 6)]. Lee[7)] determined the effects of isometric contractions of hip adductors and abductors on the activities of the abdominal and lower extremity muscles during three bridge exercises: (1) under adductor contraction, (2) under abductor contraction, and (3) a general bridge exercise. However, few studies have examined changes in the activities of trunk muscles with respect to sling height and hip joint movement. Therefore, this study examined the effects of a bridge exercise on the activities of trunk core muscles with respect to sling height and hip joint abduction and adduction.

## SUBJECTS AND METHODS

The subjects in this study were 15 healthy young male students in their 20s attending Youngdong University in Chungbuk, South Korea; all were right handed. Subjects were included if they had no musculoskeletal or neurological disorders affecting the upper or lower extremities, lesions, or history of surgery of the spine or upper extremities. The subjects were selected randomly among those who met the above criteria. The mean age, height, and weight of the subjects were 21.1 ± 2.3 years, 174.9 ± 6.0 cm, and 67.3 ± 9.8 kg, respectively. Ethical approval for the study was granted by the Institutional Review Board of Youngdong University. All subjects were fully informed of the objectives and methods of the study beforehand and gave informed consent to participate in the experiments.

At the start of the bridge exercise, the subjects adopted a supine position with their arms crossed on their chest. The subjects were directed to look at the ceiling so as not to affect the experimental posture. A sling band was wrapped around both ankles and feet as the subjects lifted their pelvis from the ground. The sling height was adjusted when the subjects

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were in an upright position as follows: the low position was set between the ground and middle of the fibular head, and the high position was set between the greater femoral trochanter and middle of the fibular head. Hip joint abduction was determined at the maximum abduction position, and adduction was recorded when the feet touched each other. Four motions were performed: hip joint abduction and adduction in the low and high positions, respectively. These motions were performed three times in succession in random order. The muscle activities under each condition were measured for 5 s; the measurements were obtained three times, and the mean value was calculated. Only the data from the middle 3 s were used in the analysis. To prevent fatigue during the exercises, the subjects rested for 1 min after each 5-s exercise.

Changes in muscle activity were measured by surface electromyography using an MP150 SYSTEM (BIOPAC System Inc., Santa Barbara, CA, USA). Surface electrodes were attached to the transversus abdominis (TrA), rectus abdominis (RA), and erector spinae (ES). The mean electromyography signal of the subjects was expressed as a percentage of the maximum voluntary isometric contraction.

Paired t-tests were used to determine differences in the muscle activities with respect to sling height and hip joint abduction and adduction. The level of significance was set at $p < 0.05$. Windows SPSS version 12.0 was used for statistical analysis.

## RESULTS

The activities of the TrA, RA, and ES muscles were significantly higher in the high sling position than the low sling position ($p < 0.05$). Furthermore, the activities of the TrA and ES muscles were significantly higher during hip joint adduction than abduction at both sling heights ($p < 0.05$) (Table 1).

**Table 1.** Activities of the trunk core muscles with respect to sling height and hip joint abduction and adduction

| Muscle | Motion | Low | High |
|---|---|---|---|
| Transversus abdominis | Adduction* | $16.2 \pm 3.3^{\dagger}$ | $48.2 \pm 14.1^{\dagger}$ |
| | Abduction** | $10.9 \pm 1.5$ | $21.3 \pm 3.4$ |
| Rectus abdominis | Adduction* | $6.3 \pm 1.0^{\dagger}$ | $12.4 \pm 3.4$ |
| | Abduction* | $3.9 \pm 0.4$ | $8.0 \pm 1.7$ |
| Erector spinae | Adduction* | $77.0 \pm 9.5^{\dagger\dagger}$ | $86.3 \pm 10.5^{\dagger\dagger}$ |
| | Abduction* | $50.6 \pm 10.0$ | $56.6 \pm 9.1$ |

Data are percentages of the maximum voluntary isometric contraction (mean ± SD). *, **$p < 0.05$, $p < 0.01$ within low and high sling position, respectively. $^{\dagger, \dagger\dagger}$ $p < 0.05$, $p < 0.01$ within adduction and abduction, respectively.

## DISCUSSION

Sling exercise therapy is an empirically proven exercise method that can maximize the effects of exercise by using a combination of pulleys, elastic bands, lengths of lines, suspension points, rubber bands, and exercise balls in addition to changing the height of therapeutic beds.

Moseley[8] compared the effects of lumbar stabilization exercise and sling exercise in patients with chronic back pain for 8 weeks and found dysfunction decreased significantly in both groups. Park et al.[9] report that a bridge exercise using vibration training under an unstable support using sling equipment significantly increases the muscle activities of the internal and external oblique muscles of healthy subjects. Lee[7] found that inducing adductor activity during a bridge exercise is more effective for stabilization than inducing the activity of abductors in a neutral position; in Lee's study of 45 healthy adults, adductor magnus activity was positively correlated with the activities of the TrA, RA, and gluteus medius. Furthermore, Park et al.[10] report simultaneous contraction of the hip joint adductors affects the activities of trunk muscles during a bridge exercise performed by healthy male and female adults in their 20s and 30s, and that this increases the activities of local muscles. Homborg et al.[6] found that simultaneous contraction of the hip joint muscles facilitates the contractions of the pelvic muscles and musculi abdominis, and that it strengthens the deep muscles of the trunk, thereby increasing lumbar stability by reducing the load on the hip joints. Clay and Pounds[11] also indicate hip joint adductors contribute not only to adduction of the lower extremity joints, but also to flexion, extension, rotation, and stabilization of the hip joints. Moon and Koo[12] report that a bridge exercise using isometric contraction of the adductors is strongly correlated with the activities of trunk muscles such as the TrA and RA compared to a general bridge exercise. Furthermore, Hodges and Richardson[13] propose deep muscles in the waist perform proactive postural adjustment during lower extremity movements; play a role in trunk stabilization; and facilitate a functional relationship among the hip joints, vertebrae, and lower extremities. They also report different activities of the deep musculi abdominis and upper extremity muscles with respect to the direction of movement of the lower extremities.

In the present study, the muscle activities of the TrA and ES were highest when the sling was in the high position and the hip joints were adducted. At the high sling height, the pelvis was farther from the ground than that at the low sling height, reducing the load on the subjects. The unstable support surface also increased the activities of more muscles in the trunk core. Muscle activity was higher during contraction of the adductors, because the adductor magnus is responsible not only for hip joint adduction, but also medial rotation, which reduces the intra-pelvic space; this reduction in intra-pelvic space adjusts the joint locations, providing an advantageous environment for abdominal muscle contraction.

The results of the present study cannot be generalized to all subjects, because the sample size was small and all subjects were healthy male adults in their 20s. Therefore, additional studies are required to clarify the effect of changes in sling height and hip joint adduction and abduction on the activities of lumbar core muscles of patients with lumbar dysfunction.

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