The Influence of an Unstable Surface on Trunk and Lower Extremity Muscle Activities during Variable Bridging Exercises

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Abstract. [Purpose] The aim of this study was to investigate the influence of an unstable surface on trunk and lower extremity muscle activities during various types of bridging exercises. [Subjects] Thirty healthy female adults voluntarily participated in this study. [Methods] All subjects were asked to perform 3 different bridging exercises (bridging exercise, single leg lift bridging exercise, single leg cross bridging exercise) with and without an unstable surface. The trunk and lower extremity muscle activities were measured by using surface electromyography during bridging exercise. [Results] During the bridging exercise (BE), single leg lift bridging exercise (LBE), and single leg cross bridging exercise (CBE), the muscle activities of the external oblique muscle (EO), erector spine (ES), and biceps femoris (BF) were significantly higher on an unstable surface than on a stable surface. The muscle activities of the EO on both sides, contralateral BF, and ipsilateral ES were significantly higher during LBE than during BE and CBE. [Conclusion] Use of an unstable surface increases muscle activity of the trunk and lower extremities, and single leg lift bridging exercise increases the muscle activity of the EO on both sides, ipsilateral ES, and contralateral BF.

Key words: Bridging exercise, Electromyography, Unstable surface

INTRODUCTION

Bridging exercise is a representative method of enhancing trunk muscle stabilization and is known to strengthen the muscle coordination patterns for generating overall torque of the trunk global muscle and stability of the local muscles3). Bridging exercise also enables the exerciser to prepare for the stance phase of gait by enhancing the strength of the gluteus maximus and hamstrings through closed-chain weight bearing exercises of the lower extremities and enhances postural control in sit to stand by conducting the important kneeling movement with weight bearing on the feet2). In particular, single leg lift bridging exercise contributes to stability of the trunk and pelvis by inducing co-contraction of the transverse abdominal muscle and the oblique abdominal muscle along with contraction of the rectus abdominal muscle3). Methods to enhance trunk muscle stabilization in bridging exercise include increasing the intensity of resistance, the repetitions of exercise, and the instability of the vestibular balance pad, therapeutic ball, and form roll5). Dynamic environments such as that when using a therapeutic ball for core stability exercise were reported to reinforce the ability to maintain balance better than a static floor, since the proprioceptors and cerebellum are stimulated5). Haynes6) conducted bridging exercise using a variety of unstable platform devices, and Akithota and Nadler7) emphasized core strengthening in various postures.

Although there have been some studies that used unstable surfaces to investigate the differences in trunk muscle activities during performance of one type of bridging exercise in healthy adults and lower back pain patients, the studies that have investigated the difference in muscle activities of the trunk and lower extremities during performance on an unstable surface of various bridging postures often used in the clinic are insufficient. Therefore, this study compared the difference in muscle activities of the trunk and lower extremities on both sides during performance on a stable surface and unstable surface of 3 types bridging exercises (bridging exercise, single leg lift bridging exercise, and single leg cross bridging exercise) in general clinical use. This study also compared the difference in muscle activities of the trunk and lower extremities on both sides according to the 3 types of bridging postures. Through this process, the present study presented a more effective posture and exercise methods during bridging exercise for the purpose of clinically reinforcing the trunk and lower extremities.
SUBJECTS AND METHODS

For this study, 30 females between the ages of 28 and 50 who had no low back pain were recruited. Those who had low back pain, an orthopedic or neurologic disease in the lower extremities for 6 months, or limited range of motion in the lower extremity joints were excluded from the study. Height and body weight were measured to determine body mass index, and those with a normal body weight (25 kg/m² or lower) were selected as the subjects for the study. All subjects signed an informed consent form that was approved by the Sahmyook University Institutional Review Board.

In this study, six types of bridging exercise were executed. Bridging exercise was conducted with the knees shoulder length apart and the eyes looking up. The detailed method of each exercise is as follows:

1) Bridging exercise (BE): subjects were instructed to touch the floor with their palms while slightly abducting both upper extremities from the trunk, to elevate their pelvis until the hip flexion angle was 0, and to maintain the knee angle at 90 degrees.

2) Bridging exercise on an unstable surface (BEU): The same posture as that for BE was maintained with an air cushion placed under each foot.

3) Single leg lift bridging exercise (LBE): The same posture as that for BE was maintained with the right leg extended and the left pelvis elevated until the hip flexion angle was 0 degrees.

4) Single leg lift bridging exercise on an unstable surface (LBEU): The same posture as that for LBE was maintained with an air cushion under the left foot.

5) Single leg cross bridging exercise (CBE): The same posture as that for BE was maintained with the right knee flexed and placed on top of the left thigh, and then the left hip was elevated until its flexion angle was 0 degrees.

6) Single leg cross bridging exercise on an unstable surface (CBEU): The same posture as that for CBE was maintained with an air cushion under the left foot.

Subjects were allowed to take a 2-minute break between each experiment to prevent muscle fatigue in the trunk and lower extremities. A 5-minute break was allowed after the bridging exercise on an unstable surface because it requires higher activity in the muscles due to constant postural and stability changes. The measurement tool used in this study was a Telemyo EMG system (TelemyoDTS, Noraxon USA Inc., Scottsdale, AZ, USA) with disposable bipolar surface electrodes of 1 cm in diameter that were placed 2 cm apart from each other. To reduce skin resistance before attaching the electrodes, hair was removed and the skin was sterilized with alcohol after rubbing the skin with fine sandpaper. EMG electrodes were attached on 3 muscles of the trunk and lower extremities at the midpoints between the navel and anterior superior iliac spine (ASIS) for the external oblique (EO), 2 cm lateral from the second lumbar (L2) spinous process for the erector spinae (ES), at the midpoint between the ischial tuberosity of the posterior thigh and the median board of tibia for the biceps femoris (BF). For EMG analysis, the analogue signals of surface EMG were converted into digital signals, and MyoResearch XP Master Edition 1.07 (Noraxon USA Inc., Scottsdale, AZ, USA) was used. The signal sampling rate was set at 1,000 Hz and the frequency band-pass and band-stop filters were set at 80–250 Hz and 60 Hz. Collected signals were processed by root-mean-square (RMS) after being full-wave rectified. The maximal voluntary isometric contraction (MVIC) was measured, and the MVIC value of each muscle was averaged from 3 repeated measurements. Bridging exercise was measured and analyzed by collecting signals for 5 seconds, excluding the first and last 1 second.

SPSS 12.0 was used for statistical analysis, and one-way ANOVA with repeated measures was used to compare the differences in the muscle activities of the trunk and lower extremities when the 6 types of bridging exercises were conducted. Significance verification was conducted by using Bonferroni’s correction as a post-hoc test, and the statistical level of significance was set to 0.05 or lower.

RESULTS

The subjects for this study were females with no low back pain, and their mean age was 37.13 ± 6.39, mean height was 159.43 ± 5.02 cm, mean body weight was 55.5 ± 5.23 kg, and mean BMI was 21.89 ± 2.44 kg/m².

During the BE, LBE, and CBE, the muscle activities of the EO on both sides, ES, and BF were significantly higher on an unstable surface than on a stable surface (p<0.05) (Table 1).

The muscle activities of the EO on both sides, contralateral BF, and ipsilateral ES were significantly higher during LBE than during BE and CBE (p<0.05) (Table 1).

The muscle activities of the EO on both sides, and contralateral BF were significantly higher during CBL than during BL (p<0.05) (Table 1).

DISCUSSION

This study compared the difference in muscle activity of the trunk and lower extremities during performance on a stable and unstable surface of 3 types of bridging exercise in general clinical use. The results showed that the muscle activities of the EO, ES, and BF were all significantly higher on an unstable surface than on a stable surface.

Shumway-Cook and Woollacott reported that the body generates co-contraction of the muscles in each body segment in order to maintain balance against an unstable surface. During a bridging exercise, the hip is lifted and the base of support (BOS) is reduced. The muscle activities of the lower extremities significantly increase in the process of overcoming the instability of the body caused by reduction of the BOS. In particular, the bridging exercise executed on an unstable surface in this study was a closed-kinematic chain and is considered to have facilitated movement of the hip and the knee simultaneously, which significantly increased the activity of the BF involved in knee flexion, hip extension, and stability and those of the EO and ES involved in trunk stability.

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In this study, the muscle activities of the EO on both sides, contralateral BF, and ipsilateral ES were significantly higher in LBE than in BE and CBE. The contralateral BF
showed significantly higher muscle activity in CBE than in BE. Kacviv et al.\textsuperscript{12} reported that stability is reduced in LBE compared with in BL, and for that reason, the muscle activities of the internal oblique muscle and EO increase. The motion of lifting the ipsilateral lower extremity is considered to increase instability due to decreased base of support and thus may have greatly increased the muscle activities of the BF on the contralateral side, which supports the body weight in order to maintain the balance of the body. Also, when the ipsilateral lower extremity is lifted, the force of gravity is converted into external resistance, increasing the muscle activities of the ipsilateral ES and EO on both sides to maintain trunk stability.

In this study, healthy female adults in their 20s performed 3 types of bridging exercises (BE, LBE, CBE) first to investigate how unstable surfaces can affect the muscle activations in the trunk and lower extremities and second to determine the effects of the 3 types of bridging exercise on the muscle activation in the trunk and lower extremities. When the bridging exercise was executed on an unstable surface, the muscle activities of the trunk and lower extremities increased for all three types of bridging exercises, and in particular, the muscle activities of the EO on both sides, ipsilateral ES, and contralateral BF were significantly increased during LBE in comparison with those of the other two types of bridging exercise (BE and CBE). As a result, unstable surfaces were found to increase the muscle activities of the trunk and lower extremities, and in particular, it was found that LBE increases the muscle activities of the EO on both sides, ipsilateral ES, and contralateral BF. Future studies will need to increase the sample size and investigate whether stroke patients with a lack of trunk stability and hemiparesis in the lower extremity would benefit from bridging exercises.

**REFERENCES**