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Effects of bridge exercise performed on an unstable surface on lumbar stabilizing muscles according to the knee angle

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Abstract. [Purpose] This study aimed to determine the effects of bridge exercise performed on an unstable surface on lumbar stabilizing muscles according to the knee angle. [Subjects] Fifteen healthy adult men were selected for this study. [Methods] The study subjects performed the bridge exercise on an unstable surface and a stable surface, with the knees at different angles (45°, 90°, and 120°). An aero-step device was used as the unstable surface, and the flat ground was used as the stable surface. External oblique, internal oblique, and rectus abdominis muscle activities were assessed and compared using electromyography. [Results] The study results demonstrated that performing the bridge exercise on an unstable surface with a knee angle of 120° led to a greater increase in the external oblique, internal oblique, and rectus abdominis muscle activities than when performed on a stable surface. [Conclusion] The bridge exercise with the knees at a 120° angle was found to be an effective intervention for increasing the external oblique, internal oblique, and rectus abdominis muscle activities.
Key words: Bridge exercise, Knee joint angle, Lumbar stabilization

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INTRODUCTION

Spinal muscles that are related to core stability can be divided into global and local muscles. Global muscles are multi-segmental muscles that help maintain balance against external loads such as lifting a heavy object or gravity exerted on the body. These include the external oblique (EO), rectus abdominis (RA), and paraspinalis muscles. Local muscles, which include the internal oblique (IO) muscles, maintain the spinal curvature and are called slow-twitch muscles; these play an important role in maintaining stability at the anterioposterior and lateral spine[1, 2)].

Lumbar stabilization exercises are aimed at control of forces that may cause postural instability and at maintenance of normal spinal posture for maximum conscious or unconscious adaptation in response to external loads. These exercises have received much attention for their role as a therapeutic and preventative measure[3)].

In recent years, several studies have been conducted on posture and motion control, with special focus on lumbar or core stability on an unstable surface (US)[1, 4)]. In a study by Page[4)], sensorimotor exercises for postural control and normal somatosensory sensations were proposed in the treatment of patients with chronic musculoskeletal diseases, and rehabilitation exercises using unstable equipment, which included a balance plate and foam pad, were emphasized. Cho[5)] compared lumbar muscle activities in relation to core stability exercises performed on fixed surfaces and on a therapeutic ball in patients with back pain and suggested that therapeutic ball exercises were more effective than those performed on a flat surface. Stevens et al.[6)] reported that exercises performed on an US generated more muscle activity than those on stable ground, thereby increasing dynamic balance ability and treating or preventing spinal damage.

The bridge exercise has been used widely for improving lumbar stabilization[7)]. Furthermore, the bridge posture has been reported to be useful in bed mobility, toilet activities alleviating pressure on the spine, donning of lower extremity clothing, sit-to-stand movement, and walking[8)]. Kim[9)] studied the effects of the bridge exercise on lumbar stabilizing muscles and reported that exercises performed on an US increased muscle activity in the lumbar muscles.

Although several studies have been conducted on the effects of the bridge exercise performed on an US and a stable surface (SS) on lumbar stabilization, only a few of these have been in relation to the patient's knee angle. Therefore, this study aimed to determine the effects of the bridge exercise performed on an US and a SS on lumbar stabilizing muscles according to various knee angles.

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SUBJECTS AND METHODS

Fifteen young and healthy men in their 20s, who were attending the Y University in Chungbuk, Korea, were selected for this study. The mean age of the subjects was 22.2±2.0 years; the mean height was 176.3±6.4 cm; and the mean weight was 64.3±8.7 kg. All subjects were educated regarding the purpose of this study and the exercise methods prior to the experiment. Voluntary written informed consent was obtained from all subjects, in accordance with the ethical principles defined in the Declaration of Helsinki. The selection criteria were as follows: no history of back pain or orthopedic or neurological diseases in the last six months; no history of congenital malformations in the extremities; no serious surgical or neurological diseases; and no history of trauma or pain.

The bridge exercise was initiated with the subject in the hook-lying position and the shoulders in abduction with the palms facing the ground. The subjects stood with their feet approximately shoulder-width apart, and their head and eyes were fixed on the ceiling without affecting the experimental posture. The subjects' legs were raised to create a hip bending angle of 0°, where the trunk and lower extremities were aligned. Moreover, the subjects had a posterior pelvic tilt and maintained a neutral lumbar stance to prevent excessive lumbar lordosis during the exercise. Both feet were placed on an aero-step device (Aero-step XL, TOGU, Germany) as the US, while the flat ground was used as a SS. The selected knee angles were 45°, 90°, and 120°, as assessed using a goniometer. The measurements in each position were repeated three times for all experiments, and the experiment order was selected based on a table of random numbers.

Each exercise was performed for 5 s, where the first and last 2 s were eliminated from the muscle activity data, and only the middle 3 s were used for the analysis. To prevent fatigue during exercise, a rest break of 1 min was provided after the 5 s exercise, and a rest break of 5 min was provided when changing to an US.

For the US in this study, two aero-step devices were used. The device was 51 cm wide, 37 cm long, and 8 cm high. The device was made from soft rubber and consisted of two air spaces in which air was filled. To measure muscle activities, the electromyography module of MP150 (BIOPAC System Inc. Santa Barbara, CA, USA) was used, and surface electrodes were placed on the EO, IO, and RA muscles on the dominant side. The average EMG value was represented by a percentage of the maximum voluntary isometric contraction (%MVIC).

The data collected in this study were analyzed using the SPSS version 12.0 statistical program for Windows. To determine the difference in muscle activities between the bridge exercise on an US and a SS, a paired sample t-test was performed, and repeated one-way ANOVA was used to compare the knee angles between the US and SS. The statistical significance level was set as α=0.05.

RESULTS

The study result showed that performing the bridge exercise with the knees at a 120° angle on an US increased muscle activities in the EO, IO, and RA more than that performed on a SS ($p<0.05$) (Table 1).

Table 1. Comparison of the EO, IO, and RA muscle activities during the bridge exercise on an US and a SS according to the knee angle Unit (%)

Muscle	Surface	45°	90°	120°
EO	SS	4.3±2.57	4.1±3.4	4.9±5.1
	US	7.8±4.9††	6.1±6.1†	10.0±1.9††
IO	SS*	2.7±1.0	3.0±1.6	4.0±2.1
	US**	4.5±2.0††	4.1±2.4††	7.7±4.6††
RA	SS**	0.4±0.5	0.8±0.6	0.8±0.6
	US**	0.5±0.6†	0.9±0.7††	1.1±0.8††

EO: external oblique, IO: internal oblique, RA: rectus abdominis, SS: stable surface, US: unstable surface, *: repeated ANOVA, †: paired t-test, *,†: $p<0.05$, **,††: $p<0.01$

DISCUSSION

Akuthota and Nadler[1] reported that muscle control around the waist area was needed to maintain functional stability and stressed on core strengthening for low back and skeletal muscle injury prevention and improvement in performance. Bergmark[2] reported that core strengthening begins with improvement in stability. The muscles associated with core stability are located at the surface in the abdominal and lower back regions, and they are involved in the control of small spinal movements and stability of spinal segments as they were directly connected to the global muscles, abdomen, and deep lumbar muscles, which contribute to overall torque generation and trunk stability.

Kim[9] explained that increase in trunk muscle activity during the bridge exercise performed by normal individuals on an US and the change from a stable floor to an unstable floor was correlated with lumbar stability and balance. Stevens et al.[6] reported that the bridge exercise performed on a Swiss ball activated the EO more than that performed on a stable surface. Stevens et al.[10] reported that the bridge exercise during which a neutral lumbar spine position was maintained increased muscle activity in the IO and RA more than the bridge exercise during which a neutral spine position was not maintained; however, there was no significant difference in the EO activity. Richardson and Jull[11] revealed that lumbar lordosis increased due to excessive compensation if deep muscle co-contraction occurred first during the bridge exercise. Part et al.[12] reported that the bridge exercise using vibration training on an US increased the IO and EO muscle activities in normal adults. Baek et al.[13] reported that the bridge exercise with an abdominal drawing-in maneuver increased transversus abdominis and IO activation ratios when the knee angle was 90°. Cho and Jeon[14] reported that the bridge exercise on an US increased the transversus abdominis thickness more than that on a SS.

The study results showed that performing the bridge exercise at a 120° knee angle increased the EO, IO, and RA muscle activities more on an US than on a SS. This result implied that normal primary somatosensory information can be inputted on a SS, but a soft or US such as an aero-step device reduced and distorted primary somatosensory information. Thus, with an increase in trunk instability, the EO, IO, and RA muscle activities increased, and this indicated that the lumbar stabilizing muscle activity increased to ensure stability for maintaining balance. Furthermore, the reason for greater EO, IO, and RA muscle activities at the 120° knee angle than the 45° and 90° angles was that increase in the knee angle led to deep muscle co-contraction for maintaining posture.

Future investigations will determine the effects of the bridge exercise performed on an US on trunk and lower extremity muscle activity according to the knee angle.

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