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Original article

Modifying the hip abduction angle during bridging exercise can facilitate gluteus maximus activity

Sun-Young Kang [a], Sung-Dae Choung [b], Hye-Seon Jeon [c, *]

[a] Department of Physical Therapy, The Graduate School, Yonsei University, 1 Yonseidae-gil, Wonju, Kangwon-do, Republic of Korea
[b] Department of Physical Therapy, Baekseok University, Anseo-dong, Dongnam-gu, Cheonan-si, Chungcheongnam-do, Republic of Korea
[c] Department of Physical Therapy, College of Health Science, Yonsei University, 1 Yonseidae-gil, Wonju, Kangwon-do, Republic of Korea

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ABSTRACT

Purpose: To investigate how the erector spinae (ES) and gluteus maximus (GM) muscle activity and the anterior pelvic tilt angle change with different hip abduction angles during a bridging exercise.
Methods: Twenty healthy participants (10 males and 10 females, aged 21.6 ± 1.6) voluntarily participated in this study. Surface electromyography (EMG) signals were recorded from the ES and GM during bridging at three hip abduction angles: 0°, 15°, and 30°. Simultaneously, the anterior pelvic tilt angle was measured using Image J software.
Results: The EMG amplitude of the GM muscle and the GM/ES EMG ratio were greatest at 30° hip abduction, followed by 15° and then 0° hip abduction during the bridging exercise. In contrast, the ES EMG amplitude at 30° hip abduction was significantly lesser than that at 0° and 15° abduction. Additionally, the anterior pelvic tilt angle was significantly lower at 30° hip abduction than at 0° or 15°.
Conclusions: Bridging with 30° hip abduction can be recommended as an effective method to selectively facilitate GM muscle activity, minimize compensatory ES muscle activity, and decrease the anterior pelvic tilt angle.

1. Introduction

Bridging exercises are commonly included in physical therapy programs to facilitate pelvic motions and reinforce back and hip extensors in individuals with back and hip pathologies (Stevens et al., 2006). Bridging allows weight bearing through the feet and is an important precursor to assuming the kneeling position and in developing sit-to-stand control. In addition, performing bridging exercises in rehabilitation programs has several important functional implications, including bed mobility, use of a bedpan, pressure relief, movement from sit-to-stand, and stair climbing (O'Sullivan et al., 2013).

However, uncontrolled excessive lumbar lordosis, dominant erector spinae (ES) activity, and anterior pelvic tilts frequently are observed in patients performing bridging exercises, and the repetitive motion of this activity induces increased compression stress on the lumbar and pelvic areas (Sahrmann, 2002; Massoud Arab et al., 2011). Furthermore, repeating the bridging exercise without correcting any unwanted lumbopelvic motions may cause secondary lumbopelvic dysfunction (McConnell, 2002). Therefore, many recent studies have investigated how to control unwanted lumbar and pelvic movement during bridging. Kim et al. (2009) suggested that bridging with an abdominal drawing-in maneuver (ADIM) is an effective method to prevent excessive contraction of ES activity. Clark and Scott (2010) recommended maintaining the shoulders, hips and knee in a straight line during bridging in order to prevent excessive anterior pelvic tilt with dominant ES. In addition, Choi et al. (2015) applied isometric hip abduction using a Thera-band during bridging and showed increased GM muscle activity and reduced anterior pelvic tilt.

One of the essential factors considered during exercise is fiber arrangement within the muscles and joint positions (Soderberg, 1983). When the line of action of the muscle matches the line of fiber of the muscle, the effect of muscle contraction is augmented (Smidt and Rogers, 1982). In terms of the downward and outward

This work should be attributed to the Department of Physical Therapy, Yonsei University.

* Corresponding author. Department of Physical Therapy, Graduate School, Yonsei University, 1 Yonseidae-gil, Wonju, Republic of Korea. Tel.: +82 33 760 2498; fax: +82 33 760 2496.
E-mail address: hyeseonj@yonsei.ac.kr (H.-S. Jeon).

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fiber direction within the GM muscle, Kang et al. (2013) examined the effects of different hip abduction angles during prone hip extension with knee flexion. The results of their study showed that 30° hip abduction was the best way to maximize the GM amplitude and advance the firing time of the GM muscle relative to the hamstring. However, regardless of lumbar and pelvic compensation related to back and hip extension movement, their study did not measure ES muscle activity or the pelvic anterior tilt angle (Kang et al., 2013). In addition, lifting the leg in the prone position is considered an open kinetic exercise, and no study has reported on the effects of the hip abduction angle during closed kinetic exercise, such as bridging in the supine position.

Therefore, as an alternative method to prevent unwanted lumbar and pelvic compensation, this study aimed to examine the influence of various hip abduction angles during bridging on back and hip extensor muscle activity and anterior pelvic tilt angle. We hypothesized the following: GM muscle activity would increase, ES muscle activity would decrease, and the anterior pelvic tilt angle would be reduced as the hip abduction angle increased.

2. Methods

2.1. Participants

A power analysis was performed with G*Power software ver. 3.1.5 (Franz Faul, University of Kiel, Kiel, Germany) using the results of a pilot study involving 6 participants (Faul et al., 2007). The calculation of the sample size was carried out with a power of 0.80, an alpha level of 0.05 and an effect size of 0.79. The provided sample size was 16. Therefore, we recruited participants from Yonsei University in Korea, and 20 asymptomatic subject (10 males and 10 females) volunteered for the study (Table 1). Prior to testing, the principal investigator explained the entire procedure, and all participants voluntarily gave informed consent.

The exclusion criteria were as follows: (1) a history of lumbar, sacroiliac or lower limb injury within the past year, (2) past or present neurological, musculoskeletal and cardiopulmonary diseases, (3) hip flexor shortness by the Thomas Test (Magee, 2002), (4) adductor muscle shortness according to the Adduction Contracture Test (Magee, 2002), or (5) lumbar or hip pain when performing bridging exercises. These musculoskeletal examinations of the lower extremities were performed to avoid compensations related to muscle shortness by a principal investigator who is certified orthopedic physical therapist. The study protocol was approved by the Yonsei University Wonju Institutional Review Board.

2.2. Instrumentation

Surface electromyography (EMG) was used to record the ES and GM muscle activity during the bridging exercise. EMG data were collected using a wireless TeleMyo DTS (Noraxon Inc., Scottsdale, AZ, US) with a sampling rate of 1000 Hz. The raw signal was filtered using a 60-Hz notch filter and a digital band-pass filter (Lancosh FIR) between 20 and 450 Hz. The collected EMG data were analyzed using Noraxon MyoResearch Master Edition 1.08 XP software (Noraxon Inc., Scottsdale, AZ, US).

In addition, two reflective markers, a digital camera and Image J software (National Institutes of Health, Bethesda, MD, US), were used to measure the anterior pelvic tilt angle using the same method as that described by a previous study (Choi et al., 2015). The main investigator attached two markers to the anterior superior iliac spine (ASIS) and the posterior superior iliac spine (PSIS) of the testing dominant kicking leg. The digital camera was consistently placed at a 1.2-m distance from the participant, and it recorded the participant's pelvic position during the bridging exercise. After completion, the video files were transferred to the Image J software program, and the anterior pelvic tilt angle was calculated. In this study, the anterior pelvic tilt angle was defined as the angle between the line connecting the ASIS and PSIS and the vertical line from the ASIS.

Table 1
General characteristics of participants (N = 20).

	Mean ± SD[b]
Age (year)	21.6 ± 1.6
Height (cm)	169.3 ± 7.7
Weight (kg)	62.4 ± 10.6
BMI[a] (kg/m^2)	21.5 ± 3.2

[a] Body mass index.
[b] Mean ± standard deviation.

2.3. Bridging exercise procedure

Each participant began in the supine hook-lying position with 90° knee flexion. Their feet were a hip's width apart, and their arms were crossed over the chest. In the preparation stage, the examiner attached stickers to the midpoints of the patella and the ASISs bilaterally. The 0° hip abduction position was defined as when the stickers on the ASISs and mid-patellae were aligned in a straight line. The 15° and 30° of hip abduction angles were determined using a goniometer. Once the desired hip abduction position was achieved, two plastic poles were placed vertically along the lateral aspect of the bilateral knee joint to prevent any compensative hip movement. Also, a wooden target bar was placed at the mid-point of line between ASIS and mid-patella to maintain a consistent height of pelvic lifting for each trial. The height of the target bar was set as the height of the thigh when the shoulders, hips and knees were aligned in a straight line during bridging.

The participants were asked to lift their pelvis off the table at a self-selected speed, slightly touch the wooden target bar and then hold the end bridging position for 5 s. At the same time, the participant was instructed to maintain the lateral aspects of the knee joint in slight contact with the vertical plastic poles. Data from attempts where the participant failed to maintain the standardized position were discarded. Before data acquisition, all participants had practiced the bridging exercise for 5 min to familiarize themselves with the procedure. Then, for data acquisition, the participants performed the bridging exercise three times for each hip abduction angle with a 30-s inter-trial period. The order of the hip abduction angles was randomized using a computer-based randomization program, and a 2-min break was given between the conditions. This randomization was done to minimize threats to the study's internal validity (Youdas et al., 2008).

2.4. Data collection and processing

EMG data of ES and GM were collected from the dominant kicking leg with a pair of Ag–AgCl surface electrodes 2 cm in diameter. Prior to electrode placement, the electrode sites were shaved and rubbing alcohol was used to reduce skin impedance. The EMG electrode for the ES was placed over the muscle mass approximately 2 cm away from the spine at the level of the iliac crest. The electrode for the GM was placed half the distance from the greater trochanter to the second sacral vertebra at an oblique angle (Criswell, 2011).

The raw EMG signals were processed into the root mean square (RMS) moving window for 300 ms. The maximal voluntary isometric contraction (MVIC) was used to normalize EMG data for