



Original Article

# The effects of performing a one-legged bridge with hip abduction and use of a sling on trunk and lower extremity muscle activation in healthy adults

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**Abstract.** [Purpose] This study investigated the changes in the muscle activities of the trunk and lower limbs of healthy adults during a one-legged bridge exercise using a sling, and with the addition of hip abduction. [Subjects and Methods] Twenty-seven healthy individuals participated in this study (14 males and 13 females). The participants were instructed to perform the bridge exercises under five different conditions. Trunk and lower limb muscle activation of the erector spinae (ES), external oblique (EO), gluteus maximus (GM), and biceps femoris (BF) was measured using surface electromyography. Data analysis was performed using the mean scores of three trials performed under each condition. [Results] There was a significant increase in bilateral EO and contralateral GM with the one-legged bridge compared with the one-legged bridge with sling exercise. Muscle activation of the ipsilateral GM and BF was significantly less during the one-legged bridge exercise compared to the one-legged bridge with sling exercise, and was significantly greater during the one-legged bridge with hip abduction compared to the one-legged bridge exercise. The muscle activation of the contralateral GM and BF was significantly greater with the one-legged bridge with hip abduction compared to the general bridge exercise. [Conclusion] With the one-legged bridge with hip abduction, the ipsilateral EO, GM and BF muscle activities were significantly greater than those of the one-legged bridge exercise. The muscle activation of all trunk and contralateral lower extremity muscles increased with the bridge with sling exercises compared with general bridge exercises.

**Key words:** Bridge exercise, Surface electromyography, Lower extremity

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## INTRODUCTION

Stabilization exercises are used to treat postural instability, as well as to consciously and unconsciously assist the maintenance of the spine in neutral position<sup>1)</sup>. The purpose of stabilization exercises is to enhance stability and increase muscle strength, and therefore, recover the ability to adjust for balance and movement<sup>2)</sup>. Bridge exercises are one type of spinal stabilization exercise, which help to prevent damage to the local muscles of the spine, joint, and ligaments during activities of daily living, and they are widely used to enhance stabilization of movement<sup>3)</sup>. Bridge exercises are the most basic type of exercise performed on a mat, and they provide trunk stabilization, reduce pressure on the buttocks, promote ease of performance of bed mobility, toileting needs, and lower body dressing, improve sit-to-stand ability, and facilitate pelvic movement. They also facilitate proper pelvic movement during gait and during activities of daily living<sup>4)</sup>.

Sling exercises are also used for stabilization. Sling exercises use a rope to elicit many effects, and they are considered

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**Table 1.** General characteristics of the subjects

	Experimental group
Gender (male/female)	27 (14/13)
Age (years)	27.8 ± 5.8
Height (cm)	166.4 ± 10.1
Weight (kg)	66.2 ± 13.4

Values are expressed as mean ± SD.

an important stabilization exercise method for the trunk<sup>5</sup>). The therapeutic advantage of using a sling is that, when pain is present, it can be used as an early stage exercise and treatment due to its anti-gravity properties<sup>6</sup>). The use of sling exercises is based on the latest concepts and theories of trunk stabilization exercise, and has been suggested as a new therapeutic exercise<sup>6</sup>). Although it has been reported by previous studies that slings are commonly used in clinical settings, studies that compare muscle activation with the use of slings are lacking<sup>3</sup>). It has been confirmed that many previous studies have focused on the trunk, and studies comparing the muscle activation of the gluteus maximus and hamstring are lacking. In addition, hip abductor strengthening exercises are commonly performed in the side-lying position in clinical settings<sup>7, 8</sup>), and recently the widespread use of slings for stabilization purposes has been reported<sup>9</sup>). Therefore, the purpose of this study was to investigate the effects of performing one-legged bridge exercises with a sling and hip abduction on the trunk and lower extremity muscle activities of healthy adults, in order to suggest which positions most efficiently activate the lower extremity muscles.

## SUBJECTS AND METHODS

This was a cross-sectional study. Twenty-seven healthy subjects between the ages of 20 and 30 years agreed to participate in this study after being informed of the study purpose and methods. Subjects who had experienced back pain, deformity of the limbs, severe surgical or neurological disease, trauma, or pain within the last 6 months were excluded from the study (Table 1).

All subjects signed a consent form approved by the Sahmyook University Institutional Review Board.

Muscle activation was measured using electromyography while the subjects maintained a general bridge, one-legged bridge, a one-legged bridge with hip abduction, one-legged bridge with use of a sling, and one-legged bridge with hip abduction. After attachment of the electrodes over the erector spinae (ES), external oblique (EO), gluteus maximus (GM), and biceps femoris (BF), the EMG value of the maximal voluntary isometric contraction (MVIC) of the each muscle measured. Prior to the measurements, the subjects were fully informed on how to perform the bridge exercises and were allowed to practice the exercises at least 3 times to learn how to perform the bridge methods. Each type of bridge exercise was performed three times, and the measurements were made repeatedly in a random order.

### 1) General bridge exercise

The general bridge is performed by starting in a hook-lying position with both knees at 90 degrees of flexion, and the hip in 0 degrees of flexion. Then the hip is lifted from the surface<sup>3, 8</sup>).

### 2) One-legged bridge

Beginning with the same starting position as the general bridge, the left knee (contralateral) is maintained at 90 degrees of flexion, while the right lower extremity (ipsilateral) is lifted, followed by raising of the hip while maintaining 0 degrees of hip flexion.

### 3) One-legged bridge with hip abduction

Beginning with the same starting position as the general bridge, the left knee (contralateral) is maintained at 90 degrees of flexion, while the right lower extremity (ipsilateral) is lifted and abducted to 30 degrees, followed by raising of the hip while maintaining 0 degrees of hip flexion.

### 4) One-legged bridge with sling

Beginning in the same starting position as the general bridge, the left knee (contralateral) is maintained at 90 degrees of flexion, and the heel of the right lower extremity is placed in a sling. Then, the hip was raised while maintaining 0 degrees of hip flexion.

### 5) One-legged bridge with hip abduction and sling

Subjects lifted the hip while maintaining 0 degrees of hip flexion and stayed aligned with the trunk position for 5 seconds.

Each type of bridge condition was performed and measured three times. The bridge conditions were randomly performed by the subjects, and a one-minute rest period was provided between each bridge condition.

To investigate the muscle activation patterns during the bridge conditions, a Telemetry 2400 G2 Telemetry EMG system (Noraxon, USA, 2011) was used. A sampling rate of 100 Hz and band-pass filter of 10–450 Hz were used.

The electrode placement sites for the erector spinae was the iliac crest and 2 cm inside the triangle that connects the lower ribs, 15cm above the umbilicus for the external oblique, between the sacrum and greater trochanter for the gluteus maximus,

**Table 2.** Comparison of the trunk and lower extremity activities during the bridge exercises (Unit: %MVIC)

	Erector spinae		External oblique		Gluteus maximus		Biceps femoris	
	Ipsilateral	Contralateral	Ipsilateral	Contralateral	Ipsilateral	Contralateral	Ipsilateral	Contralateral
GBR	41.5 ± 16.4 <sup>a</sup>	39.8 ± 18.6	6.7 ± 5.9	6.7 ± 4.4	13.7 ± 7.9	15.4 ± 9.5	14.1 ± 9.6	14.3 ± 9.1
OBR	47.3 ± 16.0	37.6 ± 14.7	12.6 ± 7.3	12.8 ± 7.1*	5.2 ± 3.6*	28.8 ± 14.7	4.1 ± 3.1	27.7 ± 14.7*
OABR	46.7 ± 12.0*†	35.6 ± 13.1	15.7 ± 9.3*†	17.5 ± 9.2*	5.8 ± 3.8†	30.1 ± 14.5*†	4.4 ± 2.8*†	26.2 ± 11.9*
SOBR	44.6 ± 13.8*	41.3 ± 17.3	7.7 ± 5.2*†	7.7 ± 4.5*†	8.5 ± 7.6*†‡	19.1 ± 12.9*†	19.2 ± 11.3*†	17.8 ± 9.8*†‡
SOABR	50.3 ± 15.0*‡	40.2 ± 14.0†‡§	10.6 ± 8.8*†‡§	10.0 ± 9.7*†‡§	13.0 ± 12.1*†‡§	25.6 ± 14.8*†‡	5.0 ± 5.2*†	18.9 ± 8.3*†‡

GBR: General bridging exercise; OBR: One leg bridging exercise; OABR: One leg bridging exercise with hip abduction; SOBR: One leg bridging with sling; SOABR: One leg bridging with sling and hip abduction.

<sup>a</sup>Mean ± SD.

\*Statistically significant difference from GBR (p<0.05)

†Statistically significant difference from OBR (p<0.05)

‡Statistically significant difference from OABR (p<0.05)

§Statistically significant difference from SOBR (p<0.05)

and on the thigh between the knee and buttocks for the biceps femoris<sup>9</sup>).

Myoresearch XP Master edition software (Noraxon Inc., Arizona, USA, 2011) was used to process EMG measurements. After the EMG measurements had undergone full-wave rectification, the RMS (root mean square) values were divided by the MVIC, to convert the values to percentages of MVIC. Although the bridge condition was measured for 5 seconds once the hip was fully lifted off the mat<sup>4, 8</sup>), only the middle three seconds of data were used in the analysis; the measurements of the first and last second were excluded.

The PASW version 18.0 (SPSS Inc., Chicago, USA) was used for the statistical analysis. The general characteristics of subjects were analyzed using descriptive statistics, and one-way repeated measures ANOVA was used to investigate the effects of the different bridge conditions on the trunk and leg muscle activation. To investigate the differences in muscle activation between the trunk and lower extremity among the different bridge conditions, the least significant difference (LSD) test was used. Values of p<0.05 were accepted as significant.

## RESULTS

There was a significant increase in bilateral EO and contralateral GM with the one-legged bridge compared with the one-legged bridge with sling exercise (p<0.05). The muscle activation of the ipsilateral ES was significantly greater during the one-legged bridge with hip abduction and sling compared with the one-legged abduction bridge exercise (p<0.05). Muscle activation of the ipsilateral GM and BF was significantly less during the one-legged bridge exercise compared to the one-legged bridge with sling exercise, and it was significantly greater during the one-legged bridge with hip abduction compared with the one-legged bridge exercise (p<0.05). The muscle activation of the contralateral GM and BF was significantly greater with the one-legged bridge with hip abduction compared with the general bridge exercise (p<0.05) (Table 2).

## DISCUSSION

In order to investigate the effects of performing the one-legged bridge with sling, and the one-legged bridge with hip abduction condition on the trunk and lower extremity, surface EMG was used to compare the muscle activation of the ES, EO, GM, and BF in healthy adults.

With one lower extremity raised, a significant increase in muscle activation was observed in the ES and EO, as well as the GM and BF. It has been reported that raising one lower extremity reduces the base of support, and therefore, there is an increase in trunk muscle activation to compensate for the instability<sup>10</sup>. When the ipsilateral lower extremity is raised from the ground, an equivalent amount of force used to maintain the lower extremity off the ground is applied to the contralateral side, which leads to an increase in muscle activation on the contralateral side<sup>11</sup>. Due to the instability that occurs while performing a one-legged bridge exercise, muscular co-contraction is induced to maintain balance<sup>12</sup>.

This study confirmed that there was a significant increase in muscle activation during the one-legged bridge with sling and the one-legged bridge with hip abduction conditions compared with the general bridge condition. Bogla<sup>12</sup>) compared three closed chain exercises with three open chain exercises, and reported there was a greater amount of muscle activation during closed chain exercises performed in a side-lying hip abduction position (p<0.05). Thus, the length of the lever arm is important in optimizing the muscle activation. If the length of the lever arm increases, the mechanical and power demands on the related muscles increase. In this study, it is considered that the increase in muscle activation that occurred during the bridge with hip abduction condition compared to the general bridge condition was due to an increase in the lever arm.

In this study, an increase in ES and EO muscle activation was observed during the one-legged bridge with sling and one-

legged bridge with hip abduction condition compared to the general bridge condition, and an increase in the contralateral GM and BF muscle activation compared to the ipsilateral side. This is agreement with previous studies. Guthie et al.<sup>13)</sup> studied subjects in their twenties and with low back pain. They observed an increase in rectus abdominis muscle activation when the subjects performed a bridge with a sling compared to a conventional bridge ( $p < 0.05$ ). Also, the intensity of the sling exercises can be varied by the location of the suspension points, length of the sling, use of additional weights, the intensity level chosen by the therapist, and the use of a theraband in open or closed-chain exercises<sup>14)</sup>.

A significant decrease in muscle activation was observed with the one-legged bridge with sling condition compared with the one-legged bridge condition, due to the emergence of the co-contraction of the GM and hamstrings, as well as hip extension<sup>13, 15)</sup>. As a result, the use of a sling with bridge exercises may serve as a more efficient exercise for the activation of the trunk and lower limb muscles.

This study, provided evidence that performing bridge exercises with a sling and hip abduction has an effect on the trunk and lower extremity muscle activation in healthy subjects. It is presumed that these exercises may be a clinically effective method for providing treatment for one side or for treating patients with hemiplegia. However, due to the use of healthy subjects and the small sample size, the results of this study cannot be generalized. Also, only four muscles were analyzed, and the possibility of a learning effect cannot be excluded, since each subject had performed each of the five bridge conditions.

Therefore, further studies should consider these limitations and focus on patients who may need training on one side, or those with hemiplegia, and studies that assess the changes in muscle strength, cross-sectional area, and evaluate fatigue are also warranted.

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