J Int Acad Phys Ther Res 2013; 4(2): 595-599
ISSN 2092-8475
www.iaptr.org
http://dx.doi.org/10.5854/JIAPTR.2013.10.25.595

Comparison of Muscle Activity of Lower Limbs in Bridging Exercise according to Knee Joint Angle

The purpose of this study is to identify the bridge exercise posture for the efficient exercise by comparing the muscle activity of the lower limbs according to the changes in muscle length because of knee angle in bridge exercise. The subjects of this study were 9 randomly selected males in their 20s living in D city from those who satisfied inclusion criteria. The measured muscles were Vastus medialis oblique, Vastus lateralis, Semitendinosus, Biceps femoris, Gluteus maximus, Gluteus medius, Tensor faciae latae, and Adductor longus. Data were analyzed through paired comparison test. In the result, ST, BF, and TFL muscle activities were high when knee joint flexion angle was 90° Although in most cases higher muscle activity was shown at 90° than 60° there was no statistical significance. Interestingly, it was lower at 90° than 60° in VL. In ST, BF, and TFL, it was significantly higher at 90° han 60°($p<.05$). Conclusively, knee angles in bridge exercise may affect the muscle activity, and in particular when the activity of two joint muscles such as semimenbranosus muscle, biceps femoris muscle, and tensor fasciae latae muscle increase as the angle gets higher. Therefore, it is considered that this study will provide helpful tips to develop muscular strength enforcement program for the patients with damages in the lower limbs through bridge exercise in clinical situations.

Key words: *Bridging Exercise; Eletromyography; Muscle Activity*

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Received : 27 May 2013
Accepted : 8 October 2013

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INTRODUCTION

Bridge exercise which is a kind of Closed Kinetic Chain Exercise is mainly used for the stabilization of the lumbar and the trunk, and additionally for muscular strength improvement of gluteus maximus muscle and hamstring muscle(1). It can be used as a low intensity weight bearing exercise, as it is an important posture to perform getting to the knee with loading the weight and at the same time it develops coordination from sitting to standing position. It may be used as an effective method to enforce hip joint extensor for preparation stage for steps. It is well known that forward and backward rotation and lateral movement of the hip necessary for everyday life movements can be stimulated in bridge position(2).

The effects of bridge position have been studied in and reported by previous studies. In a study regarding the activity of trunk muscle according to knee joint angle in bridge exercise, difference among muscles was reported(3), and higher muscle activity was reported on the unstable supporting plane when bridge exercise was applied to various kinds of supporting planes(4). A study researched the ratio of large muscles and small muscles according to the task difficulty through instability of supporting plane in bridge exercise(5).

Factors affecting the tension of the muscle include length-tension relationship, and tension increases when muscle length increases by differing the angle of joints(6). With the changes in the posture, muscular strength is changed, and the posture change brings the change of tension by causing the change in muscle strength(7).

Accordingly, in this study, we tried to identify bridge exercise position for efficient exercise program by comparing muscle activity of lower limbs according to muscle strength change by knee angle in bridge exercise position.

METHODS

Subjects

The subjects of this study were 9 males in their 20s living in D city. They were randomly chosen from those who satisfied research criteria. Inclusion conditions were those who did not have neurosurgical diseases, severe musculoskeletal disorders, and musculoskeletal orthopedic issues in the trunk and the lower limbs. The physical characteristics of the subjects are shown in Table 1.

Table 1. General characteristics of the subjects

Group	Age (years)	Height (cm)	Weight (kg)
Subject (n=9)	26.33±0.86	175.55±3.57	73.00±6.44

Procedures

In this study, 8 channel surface electromyogram (EMG; MyoSystem 1400A, Noraxon, USA) was used to measure muscle activities of Vastus medialis oblique, Vastus lateralis, Semitendinosus, Biceps femoris, Gluteus maximus, Gluteus medius, Tensor faciae latae, and Adductor longus in bridge exercise. To reduce the resistance of skin against the electrode of EMG, we removed hairs and sterilized skin with alcohol.

Electrode 2237(3M, USA) surface electrode, a disposable electrode made of Ag-Agcl was used, and the distance from the electrode was within 3cm. Ground electrode was attached to the predominant side lower limb muscle of the subject.

When we measure surface electromyogram, sampling rate was 1024Hz, EMG signals were amplified by 1785 times, band-pass filter was 20~450Hz, and notch filter was 60Hz. The collected muscle activity signals were recorded in RMS(root mean square) after full-wave rectification.

To standardize action potential of each measured muscle, MVIC(maximal voluntary isometric contraction) was measured. For the measurement position, we followed the method that Kendal and et al. proposed(8). For MVIC of each muscle, contraction was performed for 5 seconds three times and mean signal amount for three seconds in the middle excluding a second in the beginning and at the end was converted to %MVIC and then standardized. Attachment positions are provided in Table 2.

Table 2. Attachment positions 0f muscles surface electromyogram

Group	Attachment position
VMO	At 80% on the line between the anterior spina iliaca superior and the joint space in front of the anterior border of the medial ligament
VL	At 2/3 on the line from the anterior spina iliaca superoir to the lateral side of the patella
ST	At 50% on the line between the ischial tuberosity and the medial epicondyle of the tibia
BF	At 50% on the line between the ischial tuberosity and the lateral epicondyle of the tibia
GMAX	At 50% on the between the sacral vertebrae and the greater trochanter
GMED	At 50% on the line from the crista iliaca to the trochanter
TFL	On the line from the anterior spina iliaca superoir to the lateral femoral condyle in the proximal 1/6
ADD	At 1/3 on the line from sympisis pubis to medial side of the patella

In this study, two types of bridge exercises were performed by setting knee joint flexion angle as 90¤nd 60¤ Flexion angles are shown in Figure 1 and 2, which is the knee angle at the beginning of the exercise. For bridge position, we asked them to cross hands, place them on the chest, spread the legs with the width of shoulders, place them on the floor, lift the hip to make a line with the lumbar by making hip joint flexion 0¤ and maintain the position for 5 seconds(3, 9).

Bridge exercise was performed while the lumbar neutral position is being maintained through the hip rear slant exercise. All experiments were repeated and measured three times. Each exercise was performed for 5 seconds, and data of three minutes in the middle were used for the analysis. To prevent tiredness during the exercise, a minute resting time was given after 5 seconds' exercise.

Fig. 1. knee 60°

Fig. 2. Knee 90°

Data Analysis

Collected materials were analyzed using SPSS WIN 18.0. General characteristics of subjects were analyzed with descriptive statistics such as Mean(M) and Standard Deviation(SD), and muscle activity according to knee angle after bridge exercise was compared and analyzed using paired t-test. Statistical significance was set as α =.05.

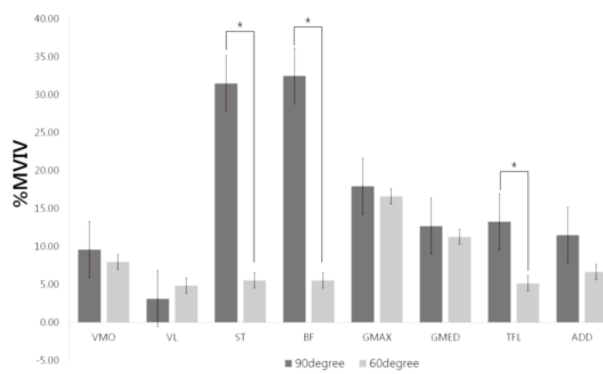
RESULTS

Muscle activity of lower limbs according to knee angle are shown in Table 3 and Fig 2. Regarding the changes of electromyogram signals according to knee angle, ST and BF muscle activity was high at 90° Although most muscles show higher activity at 90° than at 60°, there was no statistical significance. Rather, VL showed lower activity at 90° . ST, BF, and TFL showed significantly higher activity at 90° than at 60° (p<.05).

Table 3. Muscle activity of lower limbs according to knee angle

Knee angle	90°	60°	T-value
VMO	9.59±14.55	7.95±8.65	.617
VL	3.12±1.27	4.84±3.73	1.317
ST	31.39±22.62	8.60±7.03	3.781*
BF	32.45±26.25	5.52±3.53	3.098*
GMAX	17.92.±12.67	16.59±10.47	.625
GMED	12.69±5.31	11.25±7.94	.635
TFL	13.24±11.30	5.13±4.23	2.416*
ADD	11.48±3.41	6.64±4.01	2.343

※ Result=Mean ± SD, *: p<.05
VMO:vastus medialis oblique, VL:vastus lateralis, ST:semitendinosus, BF:biceps femoris, GMAX:gluteus maximus, GMED:gluteus medius, TFL:tensor faciae latae´ADD:adductor longus



※ Result=Mean ± SD, *: p<.05
VMO:vastus medialis oblique, VL:vastus lateralis, ST:semitendinosus, BF:biceps femoris, GMAX:gluteus maximus, GMED:gluteus medius, TFL:tensor faciae latae´ADD:adductor longus

Fig. 3. The different lower extremity %MVIC during bridging exercise

DISCUSSION

In bridge exercise which is a kind of closed chain exercise, centrifugal contraction is predominant for dynamic stability, reduces shearing force with pressure of joints and provides stability. Such bridge exercise is muscular strength exercise program and affects stability of damaged joints as antagonistic muscles act centrifugally each other(10)

Bridge exercise is widely used as an exercise for abdomen stabilization. However, many exercises using characteristics of bridge exercise emphasize stability of the trunk, and there are many studies regarding the relationship with lower limb muscles based on the stability(11). Bridge exercise which is a closed chain weight load exercise of lower limbs includes not only waist but also all muscles of lower joints. Such movement is made by two antagonistic joint muscles, and length-tension relationship(when a muscle length becomes long, the other muscle length becomes short) is maintained(1). Patients with damages on the lumbar and hips and lower limbstake bridge exercise to improve stability of lower limbs. However, they have specific muscles that should be enforced or inhibited selectively according to their diseases. Front knee paints are shown because of activity of musculum tensor fasciae latae(12), and the weakened hamstring muscle is related with injury to the anterior cruciate ligament(13). This study tried to find better bridge position through the comparison of muscle activity by differing knee angle.

When checking the changes in hamstringmuscle strength by changing hip joint and knee joints, it was found that the biggest muscle strength was shown at the angle where the muscle became the longest(7), which supports the result of this study. In this study, from the perspective of muscle length-tension relationship, there was not big changes in activity because muscle length of vastus medialis oblique and vastus lateralis gets short because of increased knee angle and Semitendinosus and Biceps femoris showed increased muscle activity because they got longer.

In the comparison of muscle activity through abdomen drawing-in in bridge exercise, it was found that muscle activity of hamstring muscle which is extension muscle was higher than hip joint flexion muscle(14), and that there was no significant difference in muscle activity in gluteus maximus muscle which is a one joint muscle. Although it reported similar results to this study, it showed some different interpretations on other factors; because of the presence of abdomen drawing-in, rear slant of the hip shorten the hamstring muscle but stimulate its activity because of length-tension relationship. However, with increase of activities of abdominal muscles through abdominal drawing-in, lumbar lordosis action became minimized, activities of erector spinae muscle decreased but internal and lateral head of hamstring muscle increased.

Additionally, in the changes in trunk muscle activities according to knee angle, activities of internal oblique abdominal muscle, musculus rectus abdominis, and external oblique abdominal muscle reduced but erector spinae muscle showed significant increase as knee angle increased in the four postures such as 120°, 90°, 60°, and 45°(3). Given these results, activities of abdomen muscles reduced according to the increase ofknee angle under the same condition of abdominal muscle drawn-in, and the increase of erector spinae muscle was caused by length-tension relationship of hamstring muscle and the difference of stability according to angle of lower limbs.

In the experiment through instability of supporting plane in bridge exercise, muscle activity of medial hamstring muscle increased significantly according to the increase of intensity(15).

Additionally, when bridge exercise was applied to various supporting planes, it was reported that higher muscle activities were found in bridge exercise on unstable supporting plane(4). It shows not only length-tension relationship through posture but also various factors such as supporting base, hip angle and exercise method may affect muscle activity of lower limbs.

Although there are various kinds of factors affecting muscle activity, adjustment of knee angle is an easy method to apply to clinical situation to make bridge exercise efficient by changing the length-tension relationship.

The limitation of this study is that signal noise can be made according to the movement of muscles in exercise because of the characteristics of surface electromyogram. Additionally, it may be not proper to generalize the study results as it has small number of subjects only. Therefore, multifaceted studies should be made because many different factors can affect muscle activity in bridge exercise.

CONCLUSION

In this study, it was tried to identify the right posture of bridge exercise for efficiency by comparing muscle activity of lower limbs according to changes in muscle length by knee angle in bridge exercise. Results show that knee angle may affect muscle activity in bridge exercise, and in particular when the activity of two-joint muscles such as semimenbranosus muscle, biceps femoris muscle, and tensor fasciae latae muscle increase as the angle gets higher. Therefore, it is considered that this study will provide helpful tips to develop muscular strength enforcement program for the patients with damages in the lower limbs through bridge exercise in clinical situations.

REFERENCES

1. Kisner C, Colby LA. Therpeutic exerise. foundations and techniques. 4th ed. Philadelphia, PA, FA. Davis 2002; 497–500, 657–659.
2. OSullivan SB, Schmitz TJ. Physical rehabilitation: assesment and treatment. 4th. Philadelpia FA. David company, 2001.
3. Kim KH, Park LJ, Jang JH et al. The effect of trunk muscle activity on bridging exercise according to the knee joint angle. J Korean Soc Phys Med 2010; 5(3): 405–312.
4. Hong YJ, Kyun OY, Lee CH et al. Effect of the support surface condition on muscle activity of abdominalis and erector spinae during bridging exercise. Korea Phys Ther 2010; 17(4): 16–25.
5. Song EJ, Choi JD. The Effects of task difficulty controlled by surface condition during bridging exercise on relative multifidus activation ratio. Korea Physical Therapy 2011; 18(3): 59–66.
6. lunnen J. Relationship between muscle length, muscle activity and torque of the hamstring muscle. Phys Ther 1981; 61: 190.
7. Choi JC. A study on the evaluation of the muscle strength according to the change of the hamstring muscle length. The J Korea Soci Phy Ther 1999; 11(2): 1–4.
8. Kendall FP, McCreary EK, Provance PG. Muscles: Testing and function with posture and pain. 5th ed. Baltimore. Williams & Wilkins. 2005.
9. Na SW, Oh DW, Park HJ. Effect of hip adductor co–contraction on trunk muscle activation during bridge exercise in healthy young Individuals. J Korean Soc Phys Med 2012; 7(3): 275–282.
10. Iwasaki T, Shiba N, Matsuse H et al. Improvement in knee extention strength training by means of combined electrical stimulationand voluntary muscle contraction. Tohoku J Exp Med 2006; 209(1): 33–34.
11. Youn HJ, Kim KH, Park SH et al. The effect of lower extremity muscle activity on bridging exercise and combined lifting pattern bridging exercise. J Korean Proprio neuromusc faci A 2012 10(4): 49–55.
12. Page P. Incidence of anterior knee pain in ACL reconstruction: A retrospective multi–case analysis. Abstract. J Athl Train Suppl no. 2001; 36(2): S13.
13. Buckley, B.D., and T.W. Kaminski. Hamstring and quadriceps strength ratios in healthy males and females: Implications for ACL injury. Abstract. J Athl Train 2003; 38(2): S14–15.
14. Kim EO, Kim TH, No JS et al. The influence of abdominal drawing–in maneuver on lumbar lordosis and trunk and lower extremity muscle activity during bridging exercise. Korea Phys Ther 2009; 16(1): 1–9.

Kim TH, Choi HS. EMG activities of trunk and lower extremity muscles induced by different intensity of whole body vibration during bridging exercise. Korea Phys Ther 2009; 16(4): 16–22.