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A Study on the EMG Activity of Abdominal Muscles with Stable and Unstable Bridging Exercises in Individuals with Healthy Subjects

The purpose of this study was to investigate the effects of stable and unstable bridging exercises on the EMG activity of abdominal muscles. Twenty healthy women participated in this study and the muscle activities of left-right rectus abdominis (RA), external oblique (EO), and internal oblique (IO) muscles were recorded during 4 bridging exercises (unilateral/ bilateral, stable/unstable). The activity of the right EO muscle was the highest during unilateral exercise in unstable condition, and left EO muscle also produced the same result. The activity of the right IO muscle was the highest during unilateral exercise in an unstable condition, and left IO muscle also produced the same result. The activity of the right RA muscle was the highest during unilateral exercise in a stable condition, and left RA muscle produced the same result. Unstable/unilateral (USUL) represented the highest activity among the 4 exercises. EO/IO muscles represented the highest activity during the USUL exercise, and RA did so during the stable/unilateral exercise. These results suggest that specific posture (USUL) can be administered targeting a specific side of abdominal muscles.

Key words: *Stable Condition; Unstable Condition; Bridging Exercise; Abdominal Muscle; EMG Activity*

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INTRODUCTION

Low back pain is one of the most common diseases, and 5-10% of low back pain patients in Western society turn out to be a chronic patient. It is recognized as a money-consuming health issue, taking up 90% of the medical expenses [1]. The symptoms of low back pain, one of the musculoskeletal diseases, include paraesthesia, radiating pain in lower limbs, pain during the rest or exercise, the lowered muscular strength and range of motion, and left-right dissymmetry [2-3].

There are several causes, and the most common one is a non-specific disease caused by epidemiological factors of the lumbar structure and surrounding tissues and by degenerative changes. This results in imbalance in the recruitment order and muscle length between core and exertional muscles [4], which, in turn, causes imbalance in the lumbar spine. Instability is the most important epidemiological cause of low back pain [5].

Conservative physical therapies have been widely used to relieve low back pain, but more recently, direct therapies to train muscles surrounding the lumbar area start to gain attention. In particular, the importance of the relation between lumbarstabilization and low back pain has been scientifically proven [6], and recently it has been recognized as the most scientific therapeutic exercise for low back pain among any other exercise methods [7-9].

The purpose of trunk stabilization exercise is to increase the stability of the spine and pelvis in a functional posture and motion [10], to strengthen muscular strength, and to restore the ability to control muscles and motions and their balance. Low back pain can be relieved and its recurrence can be prevented through the corset-like role of muscles by properly correcting imbalance between abdominal and extensor muscles the main cause of low back pain through trunk stabilization [11].

To control symptoms in the spine, most clinicians highlight the importance of trunk stabilization exercise that can develop the ability to control muscles in the lumbar pelvis areas and in the abdomen [12]. Local muscles such as internal oblique and transversus abdominis (RA) muscles are closely connected to the spine, providing fine control and stability between spinal segments.

Global muscles such as RA and IO muscles mainly generate power and create large motions of the pelvis and trunk, maintaining overall trunk stability. The stability of the spine contributes to the optimal control of motions and the proper maintenance of spinal alignment during functional activities, and both can affect the treatment and protection of low back pain [13]. The stability of the trunk relies on the harmonized activities of numerous trunk muscles, and muscles in front of, behind and next to the spine should co-contract to generate stable and strong contraction force, and to secure stability in various changing conditions of posture, speed and load imposed on the spine [14].

Shortening or weakening in one side of muscles causes imbalance that can change the pelvic and spinal alignment. In particular, the weakening of abdominal muscles lengthens these muscles, which can increase anterior pelvic tilt and lumbar lordosis and thus cause low back pain [15]. Bridging exercise is used in clinical programs for trunk stabilization, and uses postures in which patients with low back pain feel comfortable and less pain. This enables patients to retrain their ability to coordinate global and local muscles in proper proportion [16].

Bridging exercise a mediation method widely used in clinical rehabilitation programs to stabilize the trunk and train muscular strength. Clinicians have often modified bridging exercises over time to allow the gradual increase in exercise intensity [13]. For instance, therapeutic ball exercise provides a heavy load on trunk muscles during exercise by creating un unstable surface, and also have significant stabilization effects [12, 17]. Several studies suggested that therapeutic ball exercise could be effective to increase the activities of trunk muscles for the stability of the lumbar spine during bridging exercise [12, 16]. Bridging exercise is suitable to enhance the stability of the trunk through proper coordination between global muscles, such as erector spinae muscle and RA muscle, and local muscles, such as transversus abdominis muscle, internal oblique (IO) muscle and multifidus muscle. Depending on purposes, bridging exercises have been modified and applied in various ways [16]. Since bridging exercises increase the activities of trunk muscles, it is used in clinical settings mostly to increase the stability of lumbar pelvis areas [12, 16].

In another study, it was found that lumbar stabilization exercise applied to patients with low back pain improved the level of functionality, relieved pain, and increased the range of motion in the lumbar area and the range of flexion of the entire spine [18]. Such exercises have been applied on the assumption that exercises on an unstable surface such as swiss ball and ball cushion create more activities than those in stable conditions, increase dynamic balance, and thus treat and prevent damage to the spine [12,13,16]. The methods focus on pelvic floor muscles or trunk muscles themselves, and are often used in clinical settings to stabilize the trunk and increase the muscular strength of the hip and lower limbs [18].

It was found that trunk stabilization exercise is important to rehabilitation exercises requiring low intensity trunk muscle activities, and the necessity of bridging exercise was highlighted [13]. To support the spine of patients with back pain, strengthening trunk muscles was highlighted as part of rehabilitation programs. Bridging exercise is an advanced one of a lying posture with knees bent and commonly used to train trunk muscles, [19]. It is an important posture to kneel with weight-loading on feet, and effective to develop the ability to stand from a sitting position and facilitate hip exercises [20].

As reviewed above, this study aimed to find out whether bridging exercises in various postures can cause specific left right trunk muscle activities. Using an electromyogram (EMG), four bridging exercises were performed in stable/unstable, and bilateral/unilateral (with the right foot off the ground) conditions, and the activities of left-right RA, external oblique (EO), and IO muscles were observed.

METHODS

Research Subject

A test was conducted among 20 female students of M university who voluntarily agreed to participate in this test. The participants were selected among those who had enough muscular strength, the range of motion, and balance to perform test exercises, and who had no orthopedic or neurological medical history related to trunk and lower limbs such as low back pain over the past 6 months, thus neither complaining of muscle weakening or pain in lower limbs and trunk during the test, nor having contracture.

Test Tool

Muscle movements were measured using an EMG(FREE EMG, BTS Bioengineering, Italy), and enough time was given ahead of the test to each participant to make themselves familiar enough with every exercise to perform them in accurate and safe manners during the test. Gymnastic mats were put over the previously marked and standardized location on the floor. Two ball cushions were used in exercises 3 and 4.

Test Method

Exercise

Four bridging exercises were performed on stable and unstable surfaces as symmetric and asymmetric exercises [1-3]. For all participants, every unilateral exercise was performed with the right leg off the floor. The knee was bent to 90 degrees for visual evaluation.

Exercise 1 (Bilateral bridging on a stable floor)

- Lie on the back with the feet on the floor and with the knees bent to 90 degrees, and lift the hip from the floor.

Exercise 2 (Unilateral bridging on a stable floor)

- Bend the left knee to 90 degrees with the right leg completely flat on the floor, and lift the right leg from the floor.

Exercise 3 (Bilateral bridging on an unstable floor)

- Put a ball cushion under each foot, and place the feet on the floor. Bend the knees to 90 degrees and lift the hip from the floor.

Exercise 4 (Unilateral bridging on an unstable floor)

- Put a ball cushion under the left foot. Bend the left knee to 90 degrees with the right leg completely flat on the floor, and lift the right leg from the floor.

EMG Measurement

To remove sweat, moisture and electric resistance, the sides of surface electrodes to be attached to the skin were cleansed with a gauze soaked in alcohol. The cleansed surface electrodes were attached to 2cm left of the navel (RA), the midpoint between the navel line and the branch of the upper front hip bone (IO), and 15cm from the navel (EO).

Data Analysis

The measured data were analyzed using SPSS-Win19.0 version. To compare EMG activities according to postures, one-way repeated ANOVA was conducted, and the significant level was $\alpha = 0.05$.

RESULTS

General Characteristics of Research Subjects

The general characteristics of research subjects were as follows: gender, female; age, 22.05±2.41; height, 161.45±4.84; and weight, 52.1±3.74 (Table 1).

Table 1. General characteristics of research objects

(M±SD)

General characteristic	Mean ± SD
sex	Female
Age(yr)	22.05±2.41
Weight(kg)	52.10±3.74
Height(cm)	161.45±4.84

Posture Analysis by Muscle

During the unilateral exercise in an unstable condition, the left and right EMG values of EO muscle were 0.11±0.09 and 0.14±0.05 respectively, showing the largest increase ($p < .05$). Those of IO muscle were 0.15±0.03 and 0.24±0.13 respectively, showing the largest increase ($p < .05$) during the unilateral exercise in an unstable condition like the results of EO muscle. Both of the left (0.11±0.02) and right (0.07±0.01) EMG values of RA showed the largest increase ($p < .05$) during the unilateral exercise in a stable condition (Table 2).

Table 2. Muscle Posture Analysis (M±SD) (N=20)

		Stable	Stable Bridge Raising	Unstable	Unstable Bridge Raising	F	p
EO	R	.07±.03	.12±.03	.06±.02	.14±.05	11.05	.000*
	L	.05±.01	.09±.05	.05±.01	.11±.09	11.05	.000*
IO	R	.14±.11	.22±.14	.14±.11	.24±.13	5.80	.000*
	L	.15±.03	.16±.03	.14±.03	.15±.03	5.80	.000*
RA	R	.04±.01	.11±.02	.04±.01	.10±.01	67.06	.000*
	L	.04±.01	.07±.01	.04±.01	.06±.01	67.06	.000*

EO: external oblique, IO: internal oblique, RA: rectus abdominis
*: $p<0.05$

Muscle Analysis by Posture

Muscle activities according to postures during the 4 exercises all showed statistically significant values, and among them, the EMG activity of the unilateral exercise in an unstable condition was the highest except RA muscle. EO muscle showed the highest muscle activity during the unilateral exercise in an unstable condition, and IO muscle also showed the highest muscle activity during the unilateral exercise in an unstable condition. RA muscle showed the highest muscle activity during the unilateral exercise in a stable condition ($p<.05$) (Table 3).

Table 3. Comparison of EO, IO, RA muscle activity according to Stable, Stable Unilateral, Unstable, Unstable Unilateral Bridge Exercises (M±SD) (N=20)

		EO	IO	RA	F	p
Stable	R	.07±.03	.14±.11	.04±.01	21.69	.000*
	L	.05±.01	.15±.03	.04±.01	21.69	.000*
Stable Unilateral	R	.12±.03	.22±.14	.11±.02	13.23	.000*
	L	.09±.05	.15±.03	.07±.01	13.23	.000*
Unstable	R	.06±.02	.14±.11	.04±.01	19.18	.000*
	L	.05±.01	.14±.03	.04±.01	19.18	.000*
Unstable Unilateral	R	.14±.05	.24±.13	.10±.01	14.25	.000*
	L	.11±.09	.15±.03	.06±.01	14.25	.000*

EO: external oblique, IO: internal oblique, RA: rectus abdominis
*: $p<0.05$

DISCUSSION

Bridging exercises is used in clinical programs for trunk stabilization, and patients with low back pain feel comfortable and less pain in the posture. This enables patients to retrain their ability to coordinate global and local muscles in proper proportion [16, 21].

Spinal instability can cause discomfort to patients with low back pain in moving and maintaining postures in daily life. Trunk stabilization exercises to prevent and treat low back pain are used to strengthen muscular strength, treat and prevent musculoskeletal diseases, and enhance motor ability [8, 22].

The purpose of stabilization exercise is to restore the ability to control muscles and motions, and recently it starts to be recognized as an essential exercise for prevention not just as therapeutic exercises [23, 24]. The main purpose of spine stabilization exercise is to protect spinal joints from repetitive micro-damage to muscles surrounding the spine, pain caused by instability, and degenerative changes in the spine [16].

Low back pain can be relieved and its recurrence can be prevented through the corset-like role of muscles by properly correcting imbalance between abdominal and extensor muscles—the main cause of low back pain through trunk stabilization [11].

Bridging exercise focuses on retraining muscular coordination patterns by maintaining the proper proportion between the stabilization of segments of local muscles and the overall power generation of global muscles. During bridging exercises performed in various postures, the activity of internal oblique muscle was measured high in the proportion between RA muscle and IO muscle, which is attributable to the very low activity of RA muscle [16].

Bridging exercise, as a close kinetic chain weight-loading exercise, enhances the extensor muscular strength of the hip joint, and increase trunk stabilization. Unless core muscles are co-contracted ahead of bridging exercises, excessive lumbar lordosis can be caused by compensation [25].

For this reason, many researchers recommended the inducement of the co-contraction of core muscles to prevent compensation in performing bridging exercises [16, 24, 25].

Bridging exercise can be easily applied to clinical settings, and being informed of the level of activities of trunk muscles during trunk stabilization exercises is important to change the intensity of exercises in developing and prescribing exercise programs [13]. It was reported that exercises in an unstable condition can generate more activities than those in a stable condition, increase dynamic balance, and thus treat and prevent damage to the spine [13, 26].

In a study on the influence of specific stabilization training on trunk muscle recruitment patterns in healthy subjects during bridging exercise, it was reported that the activities of internal oblique and RA muscles with the spine in the neutral posture during bridging exercise were higher than those without the spine in the neutral posture ($p < .05$), and that there was no statistically significant difference in the activity of EO muscle [16].

In studies on specific stabilization training on trunk muscle recruitment patterns during bridging exercise, the activity of internal oblique muscle, one of local muscles, increased, while there was no statistically significant difference in the activities of global muscles including multifidus muscle and the transversus abdominis muscle of EO muscle [16]. Rehabilitation exercises on an unstable floor have been often prescribed to patients with low back pain [26, 27].

When instability increases, overall muscle activities increase more to secure stability to maintain balance than under stable conditions [28]. Numerous studies have been conducted to compare trunk muscle activities on stable and unstable surfaces [17, 22, 24, 29]. Among them, unstable conditions were applied to increase muscle activities using balls [28, 29], but in several studies to compare the exercise surfaces of stabilization and trunk extensor muscle exercises, it was found that the application of balls did not increase stabilization, and even decreased trunk muscle activities [11, 30, 31].

There is a limitation in this study using EMG. Since this method recorded the activities of neighboring muscles, it is difficult to say that the results of the test showed the activities of target muscles only. In addition, it was tried to minimize movements in bridging postures and eliminate factors such as noise in collecting EMG signals, but it was impossible to completely eliminate them. It is also difficult to consider the collected data from healthy subjects the same with those of patients with low back pain. Measuring the angle of a knee joint with the naked eye might cause changes in knee positions, and this might consequently affect the patterns of muscle activities. For bridging exercises with one leg placing on a ball and lifting off the floor, the activity of compensation muscles will be provided to correct spinaldistortion. Preferred legs can also affect the results of this study, but since there is no record on this, the aspect leaves room for inference. Compared to the exercises with the feet on the floor, those using a ball cushion changed the position of the trunk, of which effect on muscle activities is not clear. It is necessary to further discuss core trunk muscles including transversus abdominis and multifidus muscles, dorsal muscles and patients with low back pain.

CONCLUSIONS

This study aimed to analyze the activities of abdominal muscles (left and right external oblique, internal oblique and rectus abdominis muscles) during unilateral and bilateral bridging exercises in stable and unstable conditions, and the test was conducted among healthy participants. Among the four exercises, unilateral bridging exercise in an unstable condition showed the highest level of EMG activity, and by muscle type, external and internal oblique muscles showed the highest EMG activity during unilateral exercise in an unstable condition, and rectus abdominis muscle did so during unilateral exercise in a stable condition.

Right rectus abdominis muscle showed the highest EMG activity during unilateral exercises in stable and unstable conditions, and left external oblique muscle showed the highest EMG activity during unilateral exercises in stable and unstable conditions. In addition, right internal oblique muscle showed the highest EMG activity during unilateral exercises in stable and unstable exercises.

Compared to the exercises performed on a stable supporting surface, those performed on an unstable supporting surface changed the position of the trunk, and the effect of the change on muscle activities was not clear. Therefore, it is necessary to conduct further studies on core trunk muscles including transversus abdominis and multifidus muscles, dorsal muscles and patients with low back pain.

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