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An Electromyographic Analysis of Trunk and Hip Extensor Muscles during Bridging Exercises –Effect of Voluntary Control of the Pelvic Tilt

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Abstract. [Purpose] A bridging exercise is most commonly used for people with weakness of the back and hip extensor muscles. However, little is known about the effect of voluntary control of the pelvic tilt on electromyographic (EMG) activities of the trunk and hip extensor muscles during bridging exercises. [Subjects] Sixteen healthy male volunteers participated in this study. [Methods] Bipolar electrodes were attached to the lumbar extensor muscle (L3), gluteus maximus, and medial hamstring. Subjects performed 3 bridging exercises with: discretionary control of the pelvis (position D), backward tilt of the pelvis (position B), and forward tilt of the pelvis (position F). While the subjects performed each bridging exercise, EMG signals were measured. [Results] The gluteus maximus showed significantly higher muscle activity in position B than in the other positions. We observed significantly increased activity of the lumbar extensor muscle (L3) in position F compared to the other positions. [Conclusion] The findings of this study should be considered when prescribing variations of the bridging exercise, as part of a lumbopelvic rehabilitation program.

Key words: Bridging exercise, Pelvic tilt, Electromyography

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INTRODUCTION

Exercises designed to increase strength or stabilization should target specific muscle groups that are weak or are important for the individual's activities. To this end, a clinician establishes a specific exercise program that includes optimal exercise positions to target specific, identified muscular performance deficits[1)]. A bridging exercise is most commonly used for people with weakness of the back and hip extensor muscles. Bridging exercises support the body weight at 2 points, namely, at the shoulders and legs. To support body weight against gravity, the back and hip extensor muscles must act more strongly than the abdominal muscles[1–5)]. Researchers recently reported that bridging exercises produce higher electromyographic (EMG) activities of the trunk extensor muscle and the hamstring than that of the gluteus maximus[2,6)]. In the classification of muscles, the trunk extensor muscle and the hamstring are classified as postural type muscles, and have a tendency to act more strongly than the gluteus maximus, which is classified as a phasic muscle type[7)]. We believe that there are various ways in which bridging exercises could be made more specific for recruiting the gluteus maximus. Most previous studies have focused on investigating the influences of different positions of the lower extremities on the EMG activities of the trunk and hip muscles during bridging exercises[1–3,6)], and Akimoto et al.[2)] showed that at knee angles of 130° flexion EMG activity of the gluteus maximus was more than that of the hamstring. We also think that there are various ways by which the specificity of the bridging exercises for recruitment of the trunk extensor muscle could be inproved. Ekstrom et al.[4)] suggested that prone trunk extension requires high levels of lumbar muscle activity, but bridging exercises activate these muscles at lower levels. Tsuzuki et al.[8)] reported on the effects of 2 styles of bridging exercises. They showed that a forward pelvic tilt increases the EMG activity of the trunk extensor muscle during bridging exercises, and that a backward pelvic tilt increases those of the gluteus maximus and hamstring. However, they only graded their results according to the amplitude of the raw EMG of the muscles, and did not perform a quantitative analysis. Normalization of EMG data is required to choose appropriate bridging exercises. Therefore, the purpose of this study was to analyze the effect of voluntary control of the pelvic tilt on the EMG activity levels of the trunk and hip extensor muscles during bridging exercises.

Table 1. The mean ± standard deviation values of the %IEMG (the recruitment change) of each position (%)

	position D	position B	position F	
L3	47.9 ± 16.7 (100)	45.2 ± 22.4 (94.2 ± 28.5)	58.6 ± 20.7 [ab] (123.1 ± 17.1)	*
GM	14.5 ± 13.4 (100)	25.5 ± 18.1 [a] (193.1 ± 138.8)	14.7 ± 15.3 [b] (99.4 ± 57.3)	*
MH	24.1 ± 31.7 (100)	27.5 ± 31.8 [a] (127.1 ± 38.5)	26.8 ± 32.1 [a] (122.5 ± 39.4)	*

position D: discretionary control of the pelvis. position B: backward tilt of the pelvis with maximal voluntary exertion. position F: forward tilt of the pelvis with maximal voluntary exertion. L3: lumbar extensor muscle (L3). GM: gluteus maximus. MH: medial hamstring. *: interactions with ANOVA ($p<0.05$). [a]: significant by Bonferroni's test compared to position D ($p<0.05$). [b]: significant by Bonferroni's test compared to position B ($p<0.05$).

SUBJECTS AND METHODS

Sixteen healthy male volunteers participated in this study. Their mean ± standard deviation values of age, height, and weight were 24.1 ± 5.1 years, 170.9 ± 7.5 cm, and 65.0 ± 11.3 kg, respectively. All experiments were carried out in an air-conditioned laboratory maintained at approximately 24 °C. The protocol for this study was approved by the Ethics Committee at the Kawasaki University of Medical Welfare (#228). Subjects provided their written informed consent prior to participation.

Disposable silver/silver chloride surface electrodes with a recording diameter of 1 cm (Blue Sensor P-00S; Ambu, Denmark) were used. EMG signals were recorded from the lumbar extensor muscle (L3), the gluteus maximus, and the medial hamstring of the right side. Electrode placement was based on a previous work that noted the position of the following muscles: the lumbar extensor muscle (3 cm lateral to the L3 spinal process), the gluteus maximus (midway between the sacrum and trochanter major), and the medial hamstring (midway between the tuber ischiadicum and epicondylus medialis of the tibiae)[9–11]. Bipolar electrode pairs were placed longitudinally over the muscle belly at an inter-electrode distance of 3 cm. A grounded electrode was placed over the spina iliaca anterior superior of the right side. Before the electrodes were placed, the skin was abraded with skin preparation gel (Skin Pure; Nihon Koden, Japan) and then cleaned with alcohol to reduce skin surface impedance.

The subjects wore only underpants and had bare feet. To monitor the elevation of their pelvises, square markers (2 cm × 2 cm) were attached to the right side of the subjects at the acromion, the greater trochanter, and the epicondylus lateralis of the femoris. They lay with their knees at 90° flexion, their feet approximately shoulder-distance apart, and their arms loosely resting beside their trunks. Then, they were asked to elevate their pelvises until the greater trochanter was in line with the acromion and the epicondylus lateralis of the femoris with the following 3 different pelvis positions: discretionary control of the pelvis (position D), backward tilt of the pelvis with maximal voluntary exertion (position B), and forward tilt of the pelvis with maximal voluntary exertion (position F). The order of performance of the 3 positions was position D first, followed by, the other 2 positions at random. Subjects were allowed to practice until they could consistently perform the movement. Data collection in each position was performed once. The EMG signals were recorded for 5 s while holding each position of the bridging exercise. They were amplified, band-pass filtered (10–500 Hz), digitized and stored using a data acquisition system (Myosystem 1200; Noraxon, USA) at a sample frequency of 1000 Hz. The integrated EMG (IEMG) of the 5-s sample for each exercise were normalized to isometric maximal exertion tasks, by using a standard manual muscle test (%IEMG)[12]. Each isometric maximal exertion task was held for 5 s. To investigate the recruitment changes in each position, the %IEMG in positions B and F were normalized to the %IEMG in position D.

SPSS 16.0J for Windows was used for the statistical analysis. One-way repeated-measures analysis of variance (ANOVA) was used to assess differences. Post-hoc analysis was performed using Bonferroni's test. The level of significance was chosen as $p<0.05$.

RESULTS

Significant differences (ANOVA results) were observed in the %MVC of the 3 muscles (Table 1).

The mean ± standard deviation values of the %IEMG (recruitment change) are shown in Table 1. The gluteus maximus showed significantly higher muscle activity in position B than in the other positions. We observed significantly increased activity of the lumbar extensor muscle (L3) in position F compared to the other positions. The activity of the medial hamstring was significantly higher in positions B and F than in position D.

DISCUSSION

The purpose of our study was to examine the effect of voluntary control of the pelvic tilt on the activity levels of the trunk and hip extensor muscles during bridging exercises which are commonly used in strengthening and stabilization exercise programs. Based on the amplitude of the EMG signal, a conclusion can be made about the types of exercises that may be beneficial for strengthening and those that may be beneficial for endurance or stabilization training[13,14].

Previous studies have shown that bridging exercises activate the lumbar extensor muscle at a low level of approximately 30–40%MVC (maximal voluntary contraction)[1,3,4]. Bridging exercises may be of low to moderate intensity for the lumbar extensor muscle during discretionary control of the pelvis. In our study, the lumbar extensor muscle showed significantly higher EMG activity during forward tilt of the pelvis with maximal voluntary exertion than in discretionary control of the pelvis during the bridging exercise. The intensity of the lumbar extensor muscle activity may be more suitable for providing strengthening during forward tilt of the pelvis than in discretionary control of the pelvis during bridging exercises. Tsuzuki et al.[8] found similar results for the lumbar extensor muscle during bridging exercises with a forward pelvic tilt. The active anterior pelvic tilt is due to the contraction of the hip flexor and back extensor muscles[15]. In theory, strengthening and increasing the postural control of these muscles, would induce a more lordotic posture in the lumbar spine[15].

In the literature, bridging exercises have been shown to activate the gluteus maximus at an intensity level of approximately 25%MVC[1,4]. Therefore, bridging exercises may be a low intensity exercise for the gluteus maximus during discretionary control of the pelvis. In our study, the gluteus maximus showed significantly higher EMG activity, and the recruitment change was about 200% during a backward tilt of the pelvis with maximal voluntary exertion compared to unconscious control of the pelvis during bridging exercises. The intensity of the activity of the gluteus maximus may, therefore, be more suitable for providing stabilization during an active posterior pelvic tilt than during unconscious control of the pelvis. Tsuzuki et al.[8] found similar results for the gluteus maximus during bridging exercises with a backward pelvic tilt. Active posterior pelvic tilt is produced by the contraction of the hip extensor and abdominal muscles[15]. Strengthening and increasing the individual's conscious control over the muscles theoretically induces a reduction in lumbar lordosis[15].

There were several limitations to our study. First, the angle of the pelvic tilt was not measured. To the best of our knowledge, the angle of the pelvic tilt during bridging exercises has not yet been studied. Further investigation is necessary to elucidate the effect of the voluntary pelvic tilt on lumbopelvic alignment. In addition, it is possible that the subjects did not generate a true maximal exertion in each muscle. This could be due to lack of effort, or the muscle testing positions may not have been optimal for producing the maximum possible EMG. Interpretation of the absolute muscular effort expressed as %IEMG may be affected by the isometric maximal exertion task. Generally, there was a fairly wide variation in the muscle activity between the individuals during the different exercises. This was partially due to the variation in muscle strength among subjects, which was not measured, and an exercise not requiring maximum effort, such as lifting a body segment like the trunk, may be easier for 1 subject but more difficult for others. The large SD for the exercises simply reflects the difference in exercise intensity between subjects. Because data collection in each position was performed only once, the reliability of each measure could not be calculated in this study. In the future, several measurements should be taken in each position to increase the reliability of the data.

The findings of this study should be considered when prescribing variations of the bridging exercise as part of a lumbopelvic rehabilitation program. During the clinical training of some individuals with lumbar disorders, trunk performance is impaired, and voluntary control of the lumbopelvic alignment is difficult. Further investigation is required of individuals with lumbar disorders.

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