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EMG Activities of Core Muscles During Bridging Exercises With and Without a Pilates Resistive Device

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Abstract

The purposes of this study were to compare core muscle activities with and without the use of Pilates resistive equipment during bridging exercises and to investigate the efficacy of a Pilates device. Fourteen healthy individuals (6 males, 8 females) between 20 to 26 years of age were examined. They were engaged in a bridging exercise with and without a magic circle. Three consecutive repetitions of each exercise were performed. Surface electromyography (sEMG) was used to measure the electrical activities of the right side internal oblique, the adductor longus, the multifidus, and the gluteus maximus muscles. Normalized EMG activities were compared using a paired t-test and the level of significance was set at =.05. The results showed that the EMG activities of the internal oblique (p=.0078), the adductor longus (p=.0007), and the gluteus maximus (p=.0001) muscles were significantly higher when using the magic circle during the Pilates bridging exercise. Also, statistically significant change existed in the multifidus muscle (p=.0106). The bridging exercise, combined with hip adduction using the magic circle, may enhance core stabilization. Therefore, using a magic circle during hip adduction combined with bridging exercise may be recommended usefully for individuals wanting to strength the core muscles. Further research is needed to access the nature of motor control of the Pilates mat exercises and to deliver exercise intervention for lower back pain patients.

Key Words: Core muscles; Electromyogram; Lumbar stabilization; Pilates exercise; Resistive device.

Introduction

Along with the development of technology, the numbers of people suffering from lower back pain have increased due to sedentary indoor living and a general failure to exercise (Gallagher and kryzanowska, 2000; O'Sullivan, 2000). Instability of the spine over the normal range is reported when it occurs in lower back pain from many reasons (Hodges and Richardson, 1996). Panjabi (1992) theorized regarding spinal instability in terms of laxity around the neutral position of a spinal segment developed by significant decreasing in the capacity of the stabilizing system. This system consists of three systems interacting to maintain the spine in a neutral position. The passive system contains the vertebra and intervertebral discs and ligaments, the active system involves muscles and tendon surrounding the spine, and the neural system includes the nerves and central nervous system. The active system is the

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only system capable of voluntary movement so lumbar stability under deficit of these stabilizing systemsis maintained in vivo by reinforcing the activity of the muscles around the lumbar segment (Cholewicki and McGill, 1996). To protect the spine from trauma, stabilization exercises devised to improve function of the trunk muscles activity are encouraged and are often used in clinical practice (Cholewici and VanVliet, 2002).

The Pilates system of body conditioning contains over 500 stretching and strengthening exercises and these exercises may be classified into mat and apparatus exercises. The method provides core strengthening in both the direct and indirect ways people move their body parts by using the core muscles (Muscolino and Cipriani, 2004; Lange et al, 2000). Siler (2000) insisted that the areas of the body that are in motion during exercises are the areas in which the mind should be focused. This concept is important in that core muscles have an opportunity to focus on the spinal stability when other areas of the body are not in motion.

In the Pilates mat exercises, exercise has been tried alone and in combination with equipment such as gymball, foam roll, thera-band, and magic circle. These are often used to enhance the efficiency of the exercises by giving resistance or a modification. Petrofsky et al (2005) reported muscle activities using the thera-band were higher in efficiency than muscle activities without the thera-band. Also, muscle use was gauged during exercise using conventional weight lifting and was compared to exercise during Pilates with resistive devices. However, there is not any research about measuring activities of the core muscles or the effects of exercises made in comparison with and without magic circle during the Pilates mat exercise. Although Pilates is increasingly popular and demand for this exercise is increasing in clinical practice, there has been little research on the effectiveness of Pilates exercise and related devices (Herrington, 2005). Therefore, the aims of these study were to compare activities of core muscles with and without a resistive device during Pilates mat exercise and to examine the utility of resistive devices.

Methods

Subjects

Fourteen health young subjects (6 male, 8 female) were recruited from university students. The exclusion criteria required that subjects not have past or present neurologic musculoskeletal, cardiopulmonary disease and not have pain in the lumbar spine region during the mat exercises. All the subjects provided informed consent after being explained the purpose and method of the study. The subjects had a mean age 23.50±1.65 years, a mean height of 166.94±5.03 ㎝, a mean weight of 57.86±10.17 ㎏. The age, height, and weight of the subjects are summarized in Table 1.

Table 1. Characteristics of the subjects (N=14)

Variable	Mean±SD	Range
Age (yrs)	23.50±1.65	20～25
Height (㎝)	166.94±5.03	160～180
Weight (㎏)	57.86±10.17	45～80

Instruments

Surface Electromyographic Recording

We collected and amplified electromyographic data using a Noraxon TeleMyo 2400T[1)] and analyzed the data using MyoResearch Master Edition 1.06 XP software (Noraxon Inc., Scottsdale, AZ, U.S.A.). The skin was prepared by shaving hair and rubbing the skin with an alcohol-water solution to decrease impedance. Surface electrode pairs were placed in a bipolar configuration over the fourmuscle sites and distance between two electrodes were 2 ㎝. The four sites on the right side were as follows: 1) the internal oblique abdominal (IO) muscle, approximately

1) Noraxon Inc., Scottsdale, AZ, U.S.A.

2 ㎝ medial and inferior to the right anterior superior iliac spine, 2) adductor longus (AL) muscle placed on the medial aspect of the thigh in an oblique direction 4 ㎝ from the pubis, 3) multifidus (MF) muscle located in 2 ㎝ part from the L5 vertebra, 4) the gluteus maximus (GM) muscles placed half the distance between the greater trochanter and the sacral vertebrae in the middle of the muscle on an obelize angle at the level of the trochanter or slightly above (Cram et al, 1998; Marshall and Murphy, 2003). The raw signal was full wave rectified and filtered using a Lancosh FIR digital filter. The band-pass between 80 ㎐ and 250 ㎐ were used for pre-amplitude and converted to digital date at a sampling rate of 1000 ㎐. The EMG data was processed into the root mean square (RMS) and RMS values from windows of 300 ㎳ data points. For a normalized state, the peak RMS values among the three trials of maximal voluntary contraction (MVC) were calculated for each muscle.

Magic Circle

The resistive device used during Pilates was a round-shaped ring 14 inches in diameter. It consisted of soft rubber material to which handles were attached on the inside and the outside of the ring to support or to give resistance on the body part such as thigh and chest (Figure 1).

Figure 1. Pilates magic circle.

Procedures

Before starting the study exercises, subjects performed four different contractions to obtain a maximal activity for normalization purposes. Each contraction was repeated three times, and subjects were given a one-minute rest to prepare for the real study. Two series of experiments were performed. In the first, bridging exercises of the Pilates method were accomplished on the mat. The subjects were taught to perform the bridging exercise by practicing them under the guidance of a Pilates instructor. Subjects lay supine on an exercise mat, knees flexed and feet flat, hip flexed to 70 as measured by a standard goniometer. The positions were aligned as a tuberosity of ischium, posterior part of the heel and second metatarsal head were placed in the lineal line. Arms were rested at the sides and buttocks lifted slowly while vertebra moved each segment separately until the hips were fully extended and the position was held for five seconds. The EMG signal was recorded during these five seconds. A verbal cue was given to correct the posture. In the second experiment, the same subjects performed the same bridging exercise with a magic circle known for resistive device in the Pilates. The magic circle was placed in the inner sites of both thighs and was available for bridging exercises with hip adduction. All of the exercises had three consecutive repetitions, and a short rest of generally one minute was given between each exercise to prevent muscle fatigue.

Statistical Analysis

All data were expressed as the mean and standard deviation. Paired t-test was used to test for differences in EMG activities of subjects with and without the magic circle. The analysis of data was performed using SPSS version 12.0 program and significant level set at a=.05.

Results

The electromyographic activity of the core muscles during bridging with use of the magic circles was increased. The increase in normalized EMG amplitude of the internal oblique abdominal, adductor longus, and gluteus maximus muscles was 66.72 (p=.0078), 15.67 (p=.0007), 40.73 (p=.0001), and was significant in bridging posture with hip adduction. Also, the multifidus muscle activity was significantly higher with magic circle than without magic circle during bridging exercises (p=.0106). A change from without using the resistive device was significant in the same posture and is shown in Table 2 and Figure 2.

Discussion

This study was performed to investigate the changes of the core muscles activities during the Pilates bridging exercise with and without a magic circle. The results showed that hip adduction with resistive device in the bridging position increased internal oblique abdominal muscle, gluteus maximus muscle, and multifidus muscle activities. These results are consistent with previous research that investigated the influence of resistive band on the muscles while leg adduction was obtained in a variety of positions (Petrofsky et al, 2005). It is believed that increasing the muscles activities may be possible not only using a specially designed apparatus, but also a resistive device used during the mat exercises.

In recent years, Pilates exercise has been introduced in physical therapy to promote rehabilitation programs which are focusing on lumbar stabilization. The Pilates method established by Joseph Pilates refers to a comprehensive body-conditioning method developing both the body and the mind of the individual into strength (Muscolino and Cipriani, 2004). The most basic principle of this training is core strengthening. The "core" has been described as a box with the abdominals in the anterior part, paraspinals and gluteals in posterior part, diaphragm as the roof and the pelvic floor and hip muscles as the bottoms. These are the center of the human body and are referred to the as the "power house" (Richardson et al, 1999). The increased muscle strength of the "power house" may predispose one to prevent injury of the spine and it serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement (Akuthota and Nadler, 2004; Willson et al, 2005). Blum (2002) reported that the addition of Pilates therapy during eight weeks was useful as a rehabilitation intervention to care for patients with chronic low back pain and deconditioning after spinal fusion surgery.

Pilates developed mat exercises which, as the name implies, are done on a mat on the floor, and apparatus exercises that require one to exercise against resistance being provided by the use of springs and a pulley (Anderson and Spector, 2000; Muscolino and Cipriani, 2004 Petrofsky et al, 2005). The apparatus work oriented from Pilates's original mat work, and offered assistance to injured individual to be able to complete movements successfully or increase the challenge of gravity so that an

Table 2. Comparison of the normalized EMG data of the muscles with and without magic circle during bridging exercises (Unit: %)

Muscles	Without magic circle	With magic circle	p
Internal oblique	44.45±36.14[a]	66.72±45.89	.0078
Adductor longus	23.50±15.67	48.80±24.64	.0007
Mutifidus	37.33±14.61	43.48±12.74	.0106
Gluteus maximus	22.47±11.29	40.73±13.99	.0001

[a]Mean±SD.

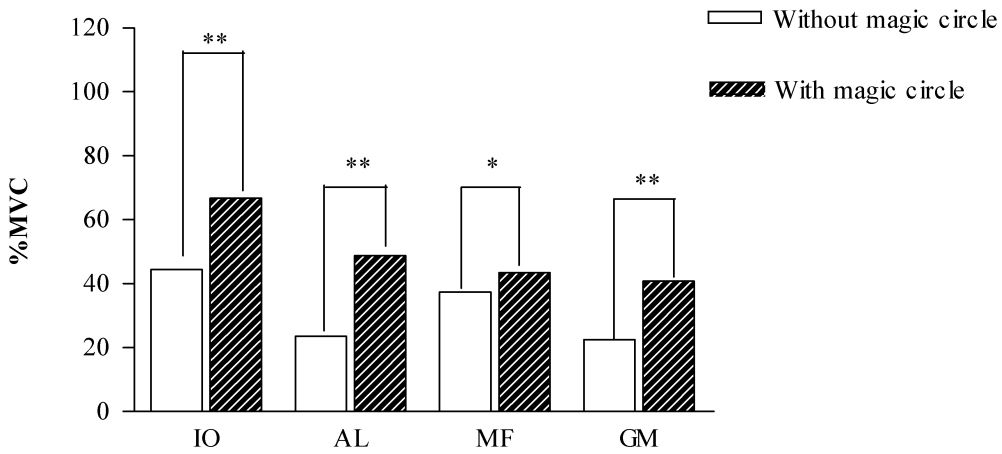

Figure 2. The %MVC data of the core muscles between with and without magic circle. IO: internal oblique abdominalis, AL: adductor longus, MF: mutifidus, GM: gluteus maximus (*p<.05, **p<.01).

individual may be progressed toward achieving functional movement (Anderson and Spector, 2000).

An interesting finding in the current study is that bridging exercise with magic circle concentrated more force to the adductor muscle and generated growing activities of all core muscles. Table 2 and Figure 2 show the increased core muscle activities. The hip adductor muscle contraction synergistically facilitated pelvic floor muscle and pelvic floor muscle occurred with contraction of the abdominal muscle (Bo and Stein, 1994; Hemborg et al, 1983). This co-activation of the hip adductor muscle, pelvic floor muscle, and internal abdominal muscle is necessary for occurrence of intra-abdominal pressure (IAP), and it reinforces the multifidus powerfully and contributes to spinal stability (Cholewicki et al, 1999; Hemborg et al, 1983). Of the abdominal muscles, especially internal abdominal muscle and transverse abdominal muscle have been identified as the muscles most closely associated with the increment of IAP, and the combined action of these core muscles may be related with increment of IAP (Cresswell et al, 1992). Moreover, increased activities of the internal oblique muscle and multifidus muscles enveloped with lumbar segment are responsible for providing segmental stability and control (Crisco and Panjabi, 1991). Therefore, both raising IAP and increasing core muscle contraction are thought to be able to effectively strengthen the spine to achieve a sufficient stability level. For this possible reason, we suggest that a resistive device or a magic circle combined with the Pilates bridging exercise should increase muscle activities more effectively than without a magic circle, and it is useful in management protocols designed to improve the strength of the core muscles.

The limitations of this study were that a small sample size was recruited, and all the subjects participating in the study were young, thereby our results were not able to be generalized to other populations. In clinical practice, we should investigate the effects of Pilates and related resistive devices toward the patients and conduct more research concerning the intervention period of management of the patients with lower back pain

Conclusion

This study compared EMG activities of core muscles with and without a resistive device during

Pilates mat exercise. We found that the by use of the Pilates bridging exercise with the magic circle, the muscle activities of the internal oblique abdominal muscle, adductor longus muscle, gluteus maximus muscle, and multifidus muscle were significantly increased. Therefore, using a magic circle during hip adduction combined with bridging exercise may be recommended usefully for individuals wantingto strength the core muscles. Further studies are needed to determine the scientific evidence and foundation for the use of Pilates exercises with resistive equipment.

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