

The effect of resistance exercise direction for hip joint stabilization on lateral abdominal muscle thickness

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The aim of this study was to determine the effects of resistance direction in hip joint stabilization exercise on change in lateral abdominal muscle thickness in healthy adults. Twenty-six healthy adults were randomly allocated to either a hip stabilization exercise by hip straight resistance group (n = 12) or a hip diagonal resistance group (n = 14). The outcome measures included contraction thickness ratio in transversus abdominis (TrA), internal oblique (IO) and external oblique, and TrA lateral slide were assessed during the abdominal drawing-in maneuver by b-mode ultrasound. The researcher measured the abdominal muscle thickness of each participant before the therapist began the intervention and at the moment intervention was applied. There was a signifi-

cant difference in lateral abdominal muscle thickness between the straight resistance exercise of hip joint group and the diagonal resistance exercise of hip joint group. Significant differences were found between the two groups in the percentage of change of muscle thickness of the TrA ($P=0.018$) and in the thickness ratio of the TrA ($P=0.018$). Stability exercise accompanied by diagonal resistance on the hip joint that was applied in this study can induce automatic contraction of the IO and TrA, which provides stability to the lumbar spine.

Keywords: Stabilization exercise, Hip stabilization, Resistance direction, Lateral abdominal muscle thickness

INTRODUCTION


Spine stability starts from the point at which the nervous system receives movement and position information from the proprioceptors located in joints, muscles, and ligaments. The nervous system determines location control, movement, and the activation of the muscle system and executes spine balance by harmonizing and integrating nerves, skeletal structure, ligaments, and muscle structure (Panjabi, 1992). There exist two muscle systems in the human body that maintain spine stability. The global muscle system includes the rectus abdominis, external obliques (EOs), and iliocostalis, which are not directly attached to the spine but execute large force by acting on the body trunk. These muscles provide stability to the trunk but cannot directly affect spine segments. The local muscle system includes the transversus abdominis (TrA), internal obliques (IOs), posterior fiber, and multifidus and directly controls the spinal segments, to which it is directly

attached and provides stability (Bergmark, 1989).

Stevens et al. (2006) argued that overall harmony and coordination of the trunk muscles, rather than activation of a specific muscle, are important for spine stability. Their study reported that adjusted co-operation between global muscles and local muscles maintains a stabilized spinal state (Marshall and Murphy, 2005; Stevens et al., 2007).

Recently, a number of studies have attempted to increase trunk stability and reduce pain through activation of local muscles by inducing exact co-contraction of the deep trunk muscles the TrA and multifidus and reducing usage of the global muscle system using exercise programs focused on spine segment stability (Park, 2010; Rackwitz et al., 2006; van Middelkoop et al., 2011).

Meanwhile, suboptimal pelvic joint stability can cause lumbopelvic pain and hamstring pain (Arumugam et al., 2012). Poor endurance and delayed firing of the hip extensor and abductor muscles can cause low back pain and lower extremity instability

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(Nadler et al., 2002).

To address these problems, recent studies have applied interventions that provide stability to the hip joint (Park et al., 2010). The application of these intervention methods is based on a so-called “self-locking mechanism,” through which form closure, force closure, and neuromuscular control of the surrounding muscle structure are reinforced to assist the stability of the sacroiliac joint (Arumugam et al., 2012).

However, few studies verify the effect of intervention for hip joint stability on trunk stability according to the application method. Therefore, this study attempts to corroborate the impact on the change of lateral abdominal muscle thickness that contributes to lumbar stability according to the resistance direction when applying interventions for hip joint stability.

MATERIALS AND METHODS

Participants

The purpose and process of the study were explained to the participants, who voluntarily agreed to participate in the study. With regard to selecting healthy participants for this study, only those who had not experienced low back pain in the previous 6 months, did not have a neurologic disease, and had not received surgical intervention were selected (Yang and Park, 2014).

Design

Twenty-six healthy adults were randomly assigned to one of two groups: (a) The straight resistance exercise of hip joint (SR) group received hip stabilization exercise by hip straight resistance, and (b) the diagonal resistance exercise of hip joint (DR) group received hip stabilization exercise by hip diagonal resistance.

The researcher measured the abdominal muscle thickness of each participant before the therapist began the intervention and at the moment intervention was applied. A therapist with more than 10 years of professional experience implemented the hip stability

exercise with the subjects.

Exercise program

Hip stabilization exercise by hip straight resistance

While the subjects were in the supine position with the hip joint and knee joint in 90° of flexion, the therapist put pressure straight from the lower femur and upper leg right above the knee joint in both legs toward the femur head. Pressure resistance of a magnitude at which minute abdomen tension could be felt was permitted. The therapist kept his hand, which provided resistance, at a constant location during the intervention, and the subjects sustained resistance to the therapist’s resistance when motion was observed (Ishida et al., 2012) (Fig. 1).

Hip stabilization exercise by hip diagonal resistance

The subjects maintained the same posture as that during the previous hip stabilization exercise. The therapist applied pressure diagonally from the lower femur and upper leg right above the knee joint in both legs toward the femur head of the hip joint at the opposite side to the therapist. Pressure resistance of a magnitude at which minute abdomen tension could be felt was permitted. The therapist kept his hand, which provided resistance, at a constant location during the dynamic exercise, and the subjects sustained resistance against the therapist’s resistance when motion was observed (Ishida et al., 2012) (Fig. 2).

Measurements

Ultrasound measurement of lateral abdominal muscle thickness

An ultrasound device (Esaote Benelux B.V., Maastricht, The Netherlands) was used to measure the abdominal muscle thickness. The tester located the linear probe (7.5 MHz) at the middle of the eleventh costal cartilage and iliac crest to obtain a standardized ultrasonography image and measured the abdominal muscle on the dominant side of the subjects, as was checked in advance (Park, 2010; Teyhen et al., 2007). The space where the TrA and



Fig. 1. Hip stabilization exercise by hip straight resistance.



Fig. 2. Hip stabilization exercise by hip diagonal resistance.

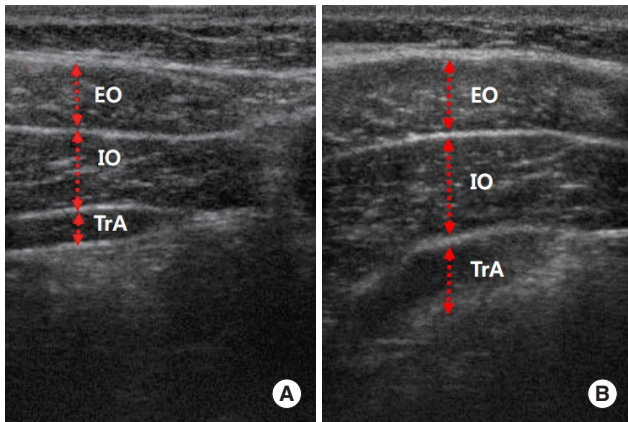


Fig. 3. Ultrasound measurement of the abdominal muscles thickness. Thickness measurement were obtained at rest (A) and full contraction (B) during intervention. EO, external oblique; IO, internal oblique; TrA, transversus abdominis.

thoracolumbar fascia meet was displayed on the right side of the ultrasonography image (Springer et al., 2006; Teyhen et al., 2007). To minimize error in the change in thickness of the abdominal muscle, which can be caused by respiration, all ultrasonography images was collected at the end point of expiration (Fig. 3). The thickness of each abdominal muscle was measured 3 times to compute the average. The percentage of changes from resting expiration were calculated as [(maximum expiration–resting expiration)/resting expiration × 100] (%) for the measurement of TrA and IO muscle thickness during both interventions (Ishida et al., 2012), Contraction thickness ratio (TR) was calculated by dividing muscle thickness at maximal contraction by muscle thickness at rest (Vasseljen and Fladmark, 2010).

Statistical analysis

Data obtained from the two groups of subjects were analyzed using IBM SPSS ver. 18.0 (IBM Co., Armonk, NY, USA). Between-group comparisons were performed using the Mann–Whitney *U*-test. The level of statistical significance was set to 0.05.

RESULTS

The mean values and standard deviation (SD) of physical characteristics (age, height, weight) of all 26 participants in the SR group and DR group are shown in Table 1. Statistically significant differences were not found between the two groups, as shown in Table 1.

Measurement of lateral abdominal muscle thickness

The mean values, SD, percentage of change of muscle thickness

Table 1. Characteristics of study participants (n = 26)

Characteristic	SR Group (n = 12)	DR Group (n = 14)
Gender, male:female	6:6	8:6
Age (yr)	24.16 ± 3.06	24.14 ± 2.82
Height (cm)	168.50 ± 9.59	169.42 ± 9.14
Weight (kg)	61.25 ± 11.91	61.71 ± 11.23

Values are presented as mean ± standard deviation.

SR, straight resistance exercise of hip joint; DR, diagonal resistance exercise of hip joint.

Table 2. Comparison of pulmonary function and PCMT, TR of the SR and DR groups

Variable	SR group	DR group	Z	P-value
PCMT				
EO (%)	-4.68 ± 14.00	-10.59 ± 20.16	-1.132	0.258
IO (%)	21.67 ± 13.71	28.42 ± 32.19	-1.234	0.217
TrA (%)	21.89 ± 16.78	43.20 ± 26.97	-2.366	0.018
TR				
EO (%)	0.95 ± 0.14	0.89 ± 0.20	-1.132	0.258
IO (%)	1.21 ± 0.13	1.28 ± 0.32	-1.234	0.217
TrA (%)	1.21 ± 0.16	1.43 ± 0.26	-2.366	0.018

Values are presented as mean ± standard deviation.

PCMT, percentage of change of muscle thickness; TR, thickness ratio of lateral abdominal muscles; SR, straight resistance exercise of hip joint; DR, diagonal resistance exercise of hip joint; EO, external oblique; IO, internal oblique; TrA, transversus abdominis.

(PCMT), and TR of the lateral abdominal muscles during intervention for both groups are shown in Table 2. Significant differences were found between the two groups in the PCMT of the TrA (*P* = 0.018) and in the TR of the TrA (*P* = 0.018).

DISCUSSION

The enhancement of the dynamic stability of the deep core muscles is critical during functional movements for the stability of the sacroiliac joint, through which load is appropriately delivered to the lower limbs (Park et al., 2010).

Contraction of the TrA significantly decreases the laxity of the sacroiliac joint. This decrease in laxity is larger than that caused by a bracing action using all the lateral abdominal muscles (Hoek van Dijke et al., 1999). These results support the argument that TrA contractions should be used to treat low back pain (Neumann, 2013). It also implies close correlation among the lateral abdominal muscles, sacroiliac joint, and hip joint. This study examined the impact of hip joint pressure resistance during hip joint stabilization exercises used in clinics on the lateral abdominal muscles. For this purpose, the study investigated the anatomical

cal structure and mechanism pressure resistance direction that affect the change of abdominal muscle thickness.

The study results proved that hip joint stabilization exercise increased PCMT and TR value, which represents the contractile force of the TrA and IO among the lateral abdominal muscles. The study confirmed that resistance in a diagonal direction can contract TrA thickness more efficiently. These results can be contributed to the simultaneous action of the ligaments of the sacroiliac joint, TrA, and IO as the therapist applied approximation resistance of the hip joint to allow the ilium to put pressure on the sacrum.

Previous studies reported that the proper participation of the overall spinal muscles, rather than when one trunk muscle makes the largest contribution under different loading conditions, is important for spine stability. It has been reported that motor control training based on the participation of all spinal muscles under diverse spine-loading conditions is required for rehabilitation exercises to enhance spine stability (Teyhen et al., 2007).

The hip joint stabilization exercise applied in this study induced the cocontraction of the trunk muscles by contracting muscles located in the pelvic region, and this could increase lumbar spine stability.

Meanwhile, Adler et al. (2008) argued that applying pressure in a diagonal direction can indirectly activate more muscles in a broad part and that the contribution of muscles involved in spine stability changes according to the loading magnitude and direction (Teyhen et al., 2007). The results of this study were consistent with those of previous studies as resistance of the hip joint in a diagonal direction caused significant contraction of the TrA. Here, pressure on the iliac crest was created along with the cocontraction of muscles surrounding the femur when applying hip joint pressure resistance diagonally. As a result, the subject made an isometric contraction by using the hip extensor muscle to overcome resistance when the therapist applied pressure, which resulted in a phenomenon in which the femur head was fixated on the acetabular fossa of the ilium. Moreover, the gluteus maximus and medius muscles of the hip joint that were closer to the therapist were further activated when applying diagonal resistance, and the femur head was firmly fixated inward to the acetabular fossa (Neumann, 2013). As for the hip joint at the opposite side to the therapist, the ilium was pulled toward the spine along with the contraction of the TrA, which was suspended at the iliac crest by contracting the adductor muscle. Activation of the TrA was confirmed based on the theoretical background, according to which the neighboring ligaments of the TrA and sacroiliac (SI) joint act together to lower SI joint laxity and provide spine stability (Hoek

van Dijke et al., 1999; Neumann, 2013).

Kwon et al. (2011) argued that inducing selective contraction of the TrA under the condition of removing the activity of the EO muscle is very difficult. Arguing that there are still difficulties in applying intervention based on selectively contracting the TrA, such as abdominal hollowing exercise, the study applied visual feedback. However, intervention using visual feedback is restrictively applied to patients in clinics due to problems in the therapy room environment and therapists' technical limitations. Moreover, the focus of interest has recently been moving to the automatic activity of muscles during different actions, while previous studies conventionally focused on the voluntary activation of the deep abdominal muscles (Rasouli et al., 2011). Therefore, stability exercise accompanied by diagonal resistance on the hip joint that was applied in this study can induce automatic contraction of the IO and TrA, which provides stability to the lumbar spine. We believe that this is a more efficient intervention method than the existing stability exercise programs that require special and precise technology.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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