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Original Article

The comparison of abdominal muscle activation on unstable surface according to the different trunk stability exercises

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Abstract. [Purpose] This study aimed to determine the effect of abdominal muscle activities and the activation ratio related to trunk stabilization to compare the effects between the abdominal drawing-in maneuver and lumbar stabilization exercises on an unstable base of support. [Subjects and Methods] Study subjects were 20 male and 10 female adults in their 20s without lumbar pain, who were equally and randomly assigned to either the abdominal drawing-in maneuver group and the lumbar stabilization exercise group. Abdominal muscle activation and ratio was measured using a wireless TeleMyo DTS during right leg raise exercises while sitting on a Swiss ball. [Results] Differences in rectus abdominis, external oblique abdominis, and internal oblique abdominis muscle activation were observed before and after treatment. Significant differences were observed between the groups in the muscle activation of the external oblique abdominis and internal oblique abdominis, and the muscle activation ratio of external oblique abdominis/rectus abdominis and internal oblique abdominis/rectus abdominis. [Conclusion] Consequently trunk stability exercise enhances internal oblique abdominis activity and increases trunk stabilization. In addition, the abdominal drawing-in maneuver facilitates the deep muscle more than LSE in abdominal muscle. Therefore, abdominal drawing-in maneuver is more effective than lumbar stabilization exercises in facilitating trunk stabilization.
Key words: Muscle activation, Abdominal drawing-in maneuver, Lumbar stabilization exercise

INTRODUCTION

Trunk stabilization regulates body alignment while the proximal part is moving and causes co-contraction of trunk muscles for the maintenance of posture. That is, it provides the overall body stability and the foundation for functional movement in the normal range. Therefore, changing trunk activation with stabilizing exercise may increase motor control ability and trunk stability[1]. These exercises are important exercises for increasing the deep abdominal muscles and improving stability[2, 3].

Among the many exercises for trunk stabilization, clinicians commonly apply drawing-in and lumbar stabilization exercises. The abdominal drawing-in maneuver (ADIM) is introduced to increase separated activation of the deep muscles. It is a voluntary exercise without movement of the pelvis and vertebra. It is more efficient for improving the cross-section of the deep muscles than general lumbar stabilization exercises[4].

Lumbar stabilization exercises (LSE) can cause thickening of the vertebra including a combination of muscle activation while performing a functional task. Highlighting superficial muscles as well as deep ones is a potential factor in the production of the longer moment arm and greater power, and increases perseverance against a pressure force[5].

Suni et al.[6] obtained a better result in reducing back pain and improving the capacity for work when the vertebra moved on a neutral line during LSE.

Koumantakis et al.[7] attempted to evaluate the clinical effect of three different types of training, which were similar to bridge exercises. This study applied specific techniques for the activation of deep muscles such as the transverse abdominis and multifidus compared to a third group who performed a similar type of exercise. In the result, subjects recovered slowly, and deep muscle training did not provide adequate efficiency, indicating that subjects should perform not only selective exercises to strengthen deep muscles but multiple ones. Thus selective deep muscle exercise is not always efficient to patients who suffer from back pain.

There are many studies describing exercises that isolate certain muscles, such as the transverse abdominis (TA) and multifidus. However, research on muscle activation and the muscle activation ratio of ADIM to facilitate deep muscles and LSE to induce co-contraction of the trunk muscles is lacking.

Accordingly, the purpose of this study was to indicate muscle activities related to trunk stabilization for comparison of the effects between the ADIM and the LSE.

SUBJECTS AND METHODS

Subjects

Informed consent was provided by the subjects before participating in this study. This study was approved by the Institutional Review Board of Daegu University, following the ethical principles of the Declaration of Helsinki. The subjects of this study were 30 healthy adults in their 20s (males: 20, females: 10) from B University, located in Daegu Metropolitan City. The criteria for exclusion were a history of lumbar pain in the past six months, congenital malformation of the limbs, or orthopedic or neurological disease. The subjects were equally and randomly assigned to either the ADIM group (mean age, 23.4±3.3 years; mean height, 169.8±5.9 cm; mean weight, 63.5±9.3 kg; mean BMI, 22.0±2.5 cm/kg) or the LSE group (mean age, 24.5±3.4 years; mean height, 169.5±8.1 cm; mean weight, 63.2±10.0 cm/kg; mean BMI, 21.9±1.90 cm/kg), and they performed their respective exercises in 30 minute sessions four times per week for five weeks.

Methods

Electromyographic (EMG) data were collected using a wireless TeleMyo DTS (Noraxon Inc., Scottsdale, AZ, USA) and Myo-Research Master Edition 1.06 XP software was used for analysis of the EMG data. Disposable Ag/AgCl surface electrodes were attached 2 cm apart to each muscle, based on the 'Surface EMG for Non-Invasive Assessment of Muscles (SENIAM)' guidelines[8]. The EMG signals were sampled at 1,500 Hz and band pass filter was used between 40 and 400 Hz with the notch filter preset to reject 60 Hz. The raw data were processed into the root mean square (RMS). Normalization of EMG data collected from each muscle was determined by calculating the RMS of a 5-s maximal voluntary isometric contraction (MVIC) for the muscles at manual muscle-test-position suggested by Kendall et al[9].

The preparation of EMG attachment sites was performed using the method suggested by Stevens et al[10]. The electrode sites were shaved and cleaned with scrubbing gel and alcohol to reduce skin resistance. For EMG data collection subjects were instructed to maintain a sitting position on a Swiss ball with no support and trunk muscle activation was measured while he/she performed a single-leg-lift for ten seconds. Except both initial and last 2 seconds signals were collected for 6 seconds and analyzed. A randomized-control study was conducted to exclude the cross-over effect and subjects were informed of the specific contents regarding exercises, with each exercise repeated three times. To minimize muscle fatigue which can be caused by repetition subjects rested for one minute after each exercise.

The ADIM was performed lying down with the knee joints flexed at 90°. The pressure biofeedback device was located under the lumbar vertebrae of the subjects during the ADIM. The subjects watched the pressure gauge connected to the pressure biofeedback device and were trained to increase the pressure from 40 mmHg to 50 mmHg and then maintain the pressure at 50 mmHg. Then, the examiner instructed the subjects to maintain the position by pulling the navel upward and posteriorly (in the direction of the lumbar vertebrae) so that the abdominal area was slightly hollow during expiration. They were instructed to maintain the abdominal drawing-in for ten seconds, and they rested for five seconds after each rep. One set consisted of ten repetitions and 5–7 sets were performed in each session.

The LSE consisted of a curl-up (raising the head and the thorax), side bridge (raising the trunk in a side-lying position), and bird-dog (alternately raising one hand and one leg in a quadruped position) exercise.

For the curl-up, the subjects lay in a supine position with their left knee joints flexed at 90°, and placed both hands behind their head. Then they raised their head and shoulders from the mat, maintained the position for ten seconds, and then rested for five seconds. They repeated this motion five times.

For the side bridge, the subjects adopted a side-lying position on their left side on the mat, supporting their weight with their left elbow and leg and then raising the hips. They maintained this posture for 12 seconds and rested for five seconds. They repeated this motion five times. They were then instructed to repeat the motion in a side-lying position on their right side.

For the bird-dog, the subjects adopted a quadruped position, and maintained a drawing-in position. Then they raised the left arm and the right leg until they were parallel with the floor and held this position for 12 seconds. After the task, they rested

for five seconds. They repeated this task five times. Then they repeated the task, raising the right arm and the left leg. The subjects performed all exercises on both sides, with three to four sets in ten minutes performed on each side

SPSS 20.0 was used for statistical processing. The differences in abdominal muscle activation between pre and post treatment were analyzed using the paired t-test. Differences in the abdominal muscle activation, the activation ratio of EO/RA and IO/RA between the two groups were analyzed using the independent t-test, and the Kolmogorov-Smirnov test was performed as a normality test for the measured values. The significance level was chosen as $\alpha=0.05$.

RESULTS

There were significant differences in the muscle activation of RA, EO, and IO in both groups in pre and post treatment ($p<0.05$) (Table 1). There were also significant differences in the muscle activation of EO and IO between the two groups ($p<0.05$) (Table 1). There were a significant difference in the EO/RA and the IO/RA ratio in pre and post treatment between the two groups ($p<0.05$) (Table 2).

DISCUSSION

Both groups showed a significant difference after the intervention. Muscle activation increased on the RA and EO but decreased on the IO. An accurate exercise with deep muscle contraction causes selective contractions of deep muscles such as IO and TA during soft contraction of superficial muscles such as RA and EO[11, 12].

Both groups showed a significant difference in the EO and IO but not on the RA. ADIM group did not show a significant difference in RA. These differences may be because this exercise is a specific stabilization training technique designed to make selective contractions for the IO and TA, and the RA and EO contract together during this exercise. This result is the same as that of Drysdale et al[13].

The muscle activation ratio is an important index used to check the change of recruitment pattern, making it easy to understand the phases of trunk muscle performance during various movements in daily activities[14].

Both groups showed a significant difference in the EO/RA ratio and the IO/RA ratio; particularly during the ADIM, the IO/RA ratio showed a higher ratio than EO/RA. To increase trunk stability superficial muscle activation should be decreased in contrast to activation of the deep muscles to make a proper activation ratio by co-contraction[15]. The contraction of superficial muscles should be reduced to a minimum while the IO and TA are activated[11].

The limitations of this study are as follows. The training was inadequate. In addition, the changes in the TA, multifidus, and pelvic floor muscles that participate in trunk stabilization were not checked. Thus another study should be conducted to accurately assess the performance of maintaining a neutral position with longer duration and to determine a method for directly assessing changes in deep muscles. This study compared the differences between the ADIM and the LSE in the RA,

Table 1. The comparison of muscle activation for the ADIM and the LSE in the pre and post treatment between groups (Unit: %MVIC)

		ADIM*	LSE*
RA	Pre Tx	3.1±2.4	4.0±2.6
	Post Tx	2.6±2.1	3.6±2.5
EO*	Pre Tx	38.1±11.1	26.4±7.8
	Post Tx	34.8±10.0	25.4±7.6
IO*	Pre Tx	33.6±11.1	26.0±7.6
	Post Tx	36.9±11.9	27.7±7.8

ADIM: abdominal drawing-in maneuver, LSE: lumbar stabilization exercises
*p<0.05

Table 2. The comparison of EO/RA and IO/RA ration for the ADIM and the LSE in the pre and post treatment between groups (Unit: %)

		ADIM	LSE
Pre Tx	EO/RA*	22.51±17.85	9.18±5.65
	IO/RA*	20.51±17.76	8.75±4.73
Post TX	EO/RA*	25.35±20.14	10.08±6.31
	IO/RA*	28.29±25.20	10.55±5.66

ADIM: abdominal drawing-in maneuver, LSE: lumbar stabilization exercises
*p<0.05

EO, and IO muscle activation and the EO/RA and IO/RA ratios. Between the two groups, EO muscle activity decreased significantly, and IO activation increased significantly, and the EO/RA and the IO/RA ratios increased significantly. These findings indicate that both exercises decrease the RA and EO, and increase IO activation. These changes enhance IO activity and increases trunk stabilization. In addition, the ADIM facilitates the deep muscle more than the LSE in abdominal muscles. Therefore, the ADIM is more effective than the LSE in facilitating trunk stabilization.

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