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Original Article

Effects of trunk stabilization exercise on the local muscle activity and balance ability of normal subjects

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Abstract. [Purpose] The purpose of this study was to investigate the effects of trunk stabilization exercise on the transvers abdominalis (TA) and internal oblique (IO) muscle activity and balance ability of normal subjects. [Subjects and Methods] Forty healthy male subjects without orthopedic history of the lower extremity were selected for the present study. The experimental group received a hollowing exercise, curl-up and bridging exercise. The control group received a pelvic tilting exercise in the sitting position for the same period of time. [Results] Significant differences in the post-training gains in Balance index, TA, IO were observed between the experimental group and the control group. [Conclusion] The trunk stabilization exercise improved the balance ability and increased the activity of the TA and IO muscle.

Key words: Hollowing exercise, Curl-up exercise, Bridging exercise

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INTRODUCTION

Trunk stabilization refers to the control of muscles necessary to maintain stability around the trunk, and refers to the ability to consciously or unconsciously control gross or fine movements in the joints[1)]. If there is instability in the trunk, excessive load on the spinal structure and soft tissues may cause disturbance in balance and postural control. Therefore, the stability of the trunk is the basis of all functional movements[2)]. In recent, trunk stabilization training to maintain body balance is an important part of therapy and strengthening of trunk muscle is important to maintain body functional stability[3)]. The structure that stabilizes the trunk consists of the abdomen and the muscles around the lumbar-pelvis. It depends on the coordination of the box-shaped muscles, abdominal muscles on the front, paraspinal and gluteal muscles on the back, diaphragm on the upper side, pelvic floor muscles and hip girdle muscles on the lower side[4)]. These trunk muscles are places where all the strength and mobility of the human body occurs, and play an important role in improving balance and function. It is because it keeps the center whenever we move the body, adjust the posture through maintaining of balance against the gravity, and prepare the movement of our limbs for daily living activities[5, 6)]. Balance is the ability to maintain the body's center of gravity within the base of support with minimal sway[7)]. Interaction of central and peripheral factors is essential to maintain balance. The peripheral component consists of a somatosensory that provides information on joints, muscles, ligament tensions, pain, and joint location, and a vestibular system that provides information on environmental changes[8)]. The purpose of this study was to investigate the effects of trunk stabilization exercise on the transvers abdominalis (TA) and internal oblique (IO) muscle activity and balance ability of normal subjects.

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SUBJECTS AND METHODS

Forty subjects (experiment group=20, control group=20) completed the experiment. Subjects without orthopedic history of the lower extremity were selected for the present study. Their average age, height, and weight in experimental and control group were 22.26 ± 2.21, 23.54 ± 1.24 years old, 173.21 ± 6.54, 174.32 ± 5.53 cm and 68.72 ± 6.51, 70.14 ± 5.53 kg, respectively. Sufficient explanation of this study's intent and the overall purpose was given, and voluntary consent to participation in this study was obtained from all of the subjects. This study complied with the ethical standards of the Declaration of Helsinki. This exercise program consisted of 3 steps of hollowing exercise, curl-up and bridging exercise[9–11]. The exercise time for each step was 5 minutes, the rest time was 2 minutes. Exercise was performed 5 times a week for 4 weeks, for a total of 20 sessions.

The Hollowing exercise is to tilt the pelvis backward while lifting the navel up in the hooklying position. The curl-up is to allow the subject to cross the arms in a hooklying position, to lift the head and upper trunk from the floor in front of the chest, then slowly lower again. The bridging exercise is to lift the pelvis until the subject's hip joint angle at 0 ° in the hooklying position and then slowly down. The control group received a pelvic tilting (anterior, posterior, lateral tilting) exercise in the sitting position for the same period of time.

MP150 (Biopac Ststems Inc., USA) surface electromyography system was used to measure the activity of the trunk muscle, and the converted digital signal was analyzed using Acquisition software Ver. 4.2. Sampling rate of the signal was set to 1,000 Hz, band pass filter was used at 30–500 Hz, and the collected signal was processed by RMS (Root Mean Square)[12]. In order to standardize the activity potential of each muscle, the muscle activity at maximal voluntary isometric contraction (MVIC) was measured in the manual muscle-strength test posture. The TA muscle was measured while performing a straight-line sit-up, and the IO muscle was measured while performing a sit-up with rotation. After 3 measurements for 5 seconds, the mean EMG signal for 3 seconds except for the first and last 1 second was used as% MVIC. To reduce skin resistance to surface EMG signals, the hairs on the attachment site were removed and the skin was cleaned with sterilized alcohol. The surface electrode was attached to the TA (ASIS 2 cm from the inside bottom) and the IO (Umbilicus and ASIS in middle region), and the ground electrode was attached to the wrist.

Balance measuring equipment (Good Balance, Metitur, Finland) was used to quantitatively measure each subject's balance ability[13]. To measure balance function, the subject was instructed to stand on a triangle platform and maintain a symmetrical posture with the feet shoulder width apart. A visual fixed point was located in front of the subject to minimize head movements. The subject's arms were placed comfortably at the hip joints and the center of pressure (COP) was measured for 30 seconds in the standing posture with the eyes open. COP was measured three times and average values were calculated.

Data analysis was performed using SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). Mean and SD were calculated for each variable. Before the intervention, differences in the general characteristics of the experimental and control groups were compared using independent t-tests and χ^2 tests. Comparisons of variables before and after training within each group were made using paired sample t-tests. Comparisons of pre- and post-test differences in variables between the experimental and control groups were performed using the independent t-test.

RESULTS

No significant differences in the baseline characteristics were observed between the two groups ($p>0.05$). Forty subjects (experimental group=20, control group=20) completed this experiment. The experimental group showed significant increments in variable of Balance index, TA, IO compared to the pre-test results ($p<0.05$). In addition, the control group showed significant increments in the Balance index, IO compared to the pre-test results ($p<0.05$). Significant differences in the post-test gains in Balance index, TA, IO were observed between the experimental group and the control group ($p<0.05$). The effect size for gains in the experimental and control groups was very strong in Balance index, TA, IO (effect size=0.96, 1.34, 0.92 respectively) (Table 1).

Table 1. Comparison of change in characteristics of the experimental group and control group

	Experimental group (n=20)		Control group (n=20)	
	Pre-test	Post-test	Pre-test	Post-test
Balance index (scores)[a,b]	58.6 ± 13.3	65.3 ± 11.2*	56.1 ± 10.2	60.7 ± 12.4*
Transvers abdominalis (% MVIC)[a,b]	30.3 ± 5.6	35.2 ± 5.2*	32.4 ± 6.72	33.9 ± 4.7
Internal oblique (% MVIC)[a,b]	41.6 ± 4.7	45.4 ± 7.2*	40.5 ± 5.8	42.64 ± 5.3*

MVIC: maximal voluntary isometric contraction.
[a]Significant difference in gains between two groups, p<0.05.
*Significant difference in gains between pre-post test, p<0.05.
[b]Effect size greater than 0.80.
Mean ± SD.

DISCUSSION

Trunk muscles act as agonists or synergists in spontaneous trunk movements, and are automatically involved in unexpected sudden limb movements or trunk motions, and are involved in anticipatory postural control in the limbs or trunk[14]. The purpose of the trunk stabilization exercise is to change the aspect of the trunk muscles to increase the ability to regulate movement, to maintain proper coordination between muscles, and to create stability of the trunk against external resistance. The purpose of this study was to investigate the effect of trunk stabilization exercise on the balance, TA and IO muscles in 20 normal male subjects for 4 weeks. As a result, the trunk stabilization exercise improved the balance ability and increased the activity of the TA and IO. IO muscle is responsible for the stability of the trunk extension and lateral flexion. These muscles are mainly red muscles and are classified as stable synergist muscles. Of these, the IO muscle is the largest of the TA and is located in the most superficial layer[14]. This muscle acts on the anterior tilting of the pelvis, and stabilizes the trunk by fixing the pelvis[17]. In the previous study, the trunk stabilization exercise in adults in the 20s who were diagnosed with chronic low back pain decreased the fluctuation distance after exercise, which means that it is effective in improving balance ability[15]. In football players, the trunk stabilization exercise during 4 weeks resulted in a significant increase in the muscle activity of the TA and IO muscles[16]. In addition, there was a significant increase in the muscle activity of the TA and IO muscles as a result of trunk stabilization exercise in combination with neuro-development treatment in stroke patients[17]. The limitations of this study were that the intervention period was short, the general population was the target, and the number of subjects was small. Future research should be made more generalized by increasing the number of subjects and the intervention period.

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Conflict of interest

None.

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