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Change of the Muscular Activity by Activation Training of the Lower Trunk Muscle in Two-Leg to One-Leg Standing Shift of an Elderly Man

SATORU KAI, PT, PhD[1)], RYUJI YOSHIMOTO, PT, MS[2)], MASAMI NAKAHARA, PT[2)], SHIGEO MURAKAMI, PT, MS[2)], KAZUO WATARI, PT, MS[2)], SEIICHIRO TAKAHASHI, PT, PhD[1)]

[1)]*The School of Fukuoka Rehabilitation Sciences, International University of Health and Welfare: 137–1 Enokizu, Okawa city, Fukuoka 831-8501, Japan. TEL +81 944-89-2000, FAX +81 944-89-2001, E-mail: kai@iuhw.ac.jp*
[2)]*Fukuoka International College of Health and Welfare*

Abstract. The lower trunk muscle is involved in stabilizing the action of the standing position, and activation of the muscles of the hip joint is generated by activation of the trunk muscle. The purpose of this study was to clarify whether activation training of the obliquus internus abdominis muscle affects activation of the lower trunk muscle and hip joint abductor muscle action in the standing position. The subject was an elderly healthy man. The muscular activity of the lower trunk muscle in changing from two-leg standing to one-leg standing was compared before and after the training which mainly activated the obliquus internus abdominis muscle. Both % integrated electromyography and coefficient of variation of the obliquus internus abdominis muscle decreased significantly after the training and so did % integrated electromyography of the multifidus muscle. In the gluteus medius muscle, there was no change in % integrated electromyography and the coefficient of variation before and after the training. These results suggest that the training method may prove useful in activating a series of smooth activities of the lower trunk muscle.
Key words: Trunk, Training, Muscular activity

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INTRODUCTION

Prevention of falls for old people has become an important measure for the maintenance of activities of daily living (ADL)[1)]. Physical therapy (PT) is performed in which the muscle force of the foot is improved, improving motion in dynamic balance[2, 3)]. Recently, recognition of the importance of the trunk muscle has been increasing[4–7)]. The relationship between the hip joint and the lower trunk was described by Lee[7)]. Studies of anticipatory postural adjustments by Hodges et al.[8–11)] are also well-known. In humans with low back pain, there are many reports that anticipatory postural adjustments do not work well[9, 10)]. Smooth muscular activities are necessary for stabilizing action. It is desirable that active muscle training shows an effect in ADL. Therefore, the purpose of this study was to clarify whether activation training of the obliquus internus abdominis muscle (OI) affects the activation of the lower trunk muscle and hip joint abductor muscle action in the standing position. We anticipated that this effect would be reflected in postural control resulting in prevention of falls.

Table 1. Average %iEMG and coefficient of variation of 10 intervals before and after the training

Muscle	OI		MF		GM	
	%iEMG	CV	%iEMG	CV	%iEMG	CV
Pre-training	19.08 ± 2.43	37.57 ± 10.06	5.14 ± 1.04	32.24 ± 16.20	6.99 ± 1.41	25.99 ± 15.01
Post-training	15.61 ± 2.42*	19.38 ± 10.16*	3.93 ± 0.55*	21.41 ± 12.73	6.33 ± 1.36	26.18 ± 11.13

*p<0.01: pre-training vs post-training.
Mean ± standard deviation.
Abbreviations, OI, obliquus internus abdominis; MF, multifidus; GM, gluteus medius; CV, coefficient of variation.

METHODS

An 82-year-old healthy man without neurological and musculoskeletal disorders (height 164 cm, body weight 55 kg) was asked to perform from two-leg standing to one-leg standing three times. PT intervention for activation of the OI on the left side was performed, and the same action as described above was repeated 3 times after a rest. The muscular activities of the left OI, left multifidus muscle (MF), left gluteus medius muscle (GM), and right ilio-psoas muscle (IP) were recorded during the two-leg to one-leg standing action. The distance between electrodes was 2 cm and disposable silver-silver chloride electrodes were used. The electrodes were affixed along the extended axis direction of muscle fiber of each muscle. The placement of the electrodes on each muscle followed Hungerford et al.[12].

For the two-leg to one-leg standing movement, the right leg was raised on hearing an auditory cue, and returned to the start position after a few seconds. For the right foot, the reaction time until the foot-off after the sound cue was measured by a pressure sensor linked to the sound cue in milliseconds. Care was taken to prevent the subject from falling and immediate assistance was ensured through approach monitoring (as a result, there were no falls).

The subject underwent the following PT intervention: he was instructed to flex and rotate his trunk to the left 10 times, in the sitting position, while a physical therapist applied manual resistance to the examinee’s left lower rib to help activate the ipsilateral OI. By observing the wave on the monitor of an electromyograph, the activation of the muscular activity during training was confirmed by another therapist. Recorded electromyographic waves were full-wave rectified, smoothed and integrated. The period of full foot-off was made to was of a set length. Time was divided into 50 ms intervals, and the integrated myograms were divided by muscular activity in the maximum isometric contraction for normalization (% integrated electromyography, %iEMG). The transition of each muscle activity and the variation in the 3 trials before and after the intervention were calculated in order to observe the change between pre- and post-PT intervention. The coefficient of variation was used; it is shown as a percentage. Average %iEMG and coefficient of variation were calculated from 10 intervals: 500 ms before foot-off. The EMG data were sampled at 1 kHz by an EMG system (Noraxon, Myosystem 1200) and analyzed by Myoresearch (Noraxon, EM-123).

For statistical analysis method, the Wilcoxon signed-rank coefficient test was carried out using SPSS software and the level of significance was chosen as less than 1%.

RESULTS

The reaction time, from the sound cue until the right foot-off, was 1.51 ± 0.21 seconds (average ± standard deviation) before training, and 1.36 ± 0.22 seconds after training. In the left OI, both average %iEMG and coefficients of variation of the 10 intervals significantly decreased after training (Table 1). In the left MF, only average %iEMG of the 10 intervals significantly decreased (Table 1). Significant decreases in the left GM were not seen in average %iEMG and coefficients of variation of the 10 intervals (Table 1). Table 2 shows the muscular activity of each muscle over the 10 intervals pre- and post-training.

DISCUSSION

Both average %iEMG and the coefficient of variation of OI and the average %iEMG of MF were

Table 2. Muscular activity at 10 intervals before and after the training

A. left obliquus internus abdominis muscle		before 500 ms~	before 450 ms~	before 400 ms~	before 350 ms~	before 300 ms~	before 250 ms~	before 200 ms~	before 150 ms~	before 100 ms~	before 50 ms~
Before training	1st	16.4	11.6	22.8	9.2	12.0	12.4	15.6	11.2	21.6	12.0
	2nd	18.8	25.2	14.8	24.0	12.8	12.0	17.2	22.4	11.2	15.6
	3rd	29.6	17.6	28.8	22.4	32.0	18.8	27.6	25.6	30.4	20.8
After training	1st	14.4	12.8	10.0	8.8	14.4	18.0	15.6	10.8	12.8	19.6
	2nd	20.4	19.2	17.2	15.6	12.8	17.6	14.8	14.4	13.6	15.2
	3rd	13.2	26.8	12.8	12.8	15.2	22.4	15.2	18.0	17.2	16.8

B. left multifidus muscle		before 500 ms~	before 450 ms~	before 400 ms~	before 350 ms~	before 300 ms~	before 250 ms~	before 200 ms~	before 150 ms~	before 100 ms~	before 50 ms~
Before training	1st	4.7	6.9	3.7	8.4	9.0	7.8	8.6	6.6	5.5	9.0
	2nd	5.4	7.7	9.4	5.3	8.4	4.3	4.2	7.0	12.0	7.2
	3rd	3.4	8.0	4.6	9.9	6.2	5.7	5.0	7.0	8.5	10.5
After training	1st	5.0	3.7	4.9	5.1	5.5	6.8	7.2	7.9	5.7	7.4
	2nd	2.4	6.2	5.5	6.7	7.1	8.3	5.5	4.2	9.8	5.8
	3rd	6.6	5.2	4.9	3.7	9.7	7.6	10.8	6.8	9.7	4.5

C. left gluteus medius muscle		before 500 ms~	before 450 ms~	before 400 ms~	before 350 ms~	before 300 ms~	before 250 ms~	before 200 ms~	before 150 ms~	before 100 ms~	before 50 ms~
Before training	1st	1.5	3.9	2.9	3.2	4.5	3.2	3.0	6.5	4.3	8.4
	2nd	5.5	5.1	4.0	4.8	6.7	4.3	5.2	5.7	6.3	4.6
	3rd	6.5	5.2	8.4	5.3	4.9	3.4	5.4	4.1	10.7	6.7
After training	1st	3.5	3.3	3.5	2.6	3.6	4.2	4.1	3.8	3.3	3.6
	2nd	3.3	3.6	2.7	7.8	2.6	4.2	3.5	3.2	3.4	4.7
	3rd	4.3	4.3	4.5	4.8	2.6	4.4	5.1	5.2	5.0	3.4

Values present %iEMG.

decreased during two-leg standing to left leg standing by activation training of the OI in healthy elderly male. The decrease was thought to be the effect of PT intervention to improve smooth contraction of the trunk muscle which works to maintain postural stability. In previous research, trunk stability decreased with reduced muscular strength of the trunk muscle[6, 13]. In these reports, it was considered that muscle activity was increased by activation of the trunk muscle. In the present study, because both average %iEMG and the coefficient of variation of OI decreased after PT intervention, it seems likely that muscle activity was maintained, while smooth contraction of the trunk muscle was improve. It was suggested that the smooth activity of the muscle is decreased by disuse of the muscle, because of superficial lumbopelvic muscle overactivity and decreased cocontraction after 8 weeks of bed rest[14].

There are intrinsic and extrinsic muscle stabilizers stabilizing the core of the trunk[6]. MF is included in the former, and OI and the obliquus externus abdominis muscles are included in the latter. For stability of the trunk, it is well known that the transverse abdominis muscle (TA) contracts before the deltoid muscle contracts in the shoulder joint action in the standing position for stabilization of the trunk[8]. It is also known that in cases of lower back pain the activity of TA is delayed[4]. OI in cooperation with adductor muscles of the thigh is related to the stabilization of the pelvis[7], and the stability of the pelvis increases with improvement of the smooth activity of the muscles. Hence the action from two-leg standing to left-leg standing was facilitated.

The muscular activity of adductor muscles of the thigh changes in stabilization of the trunk due to OI and MF[5]; the integrated muscle system[7] with GM is not known. A significant change in GM after the intervention in this study was not seen. This may be because there are in fact no integrated muscle systems with GM. Future clarification of these integrated muscle systems, as well as other long-term changes that might result from PT interventions is required. One of the limitations of analysis by EMG is the lack of the reproducibility due to disconnection of electrodes. Our future project will carry out a long-term intervention. Even if the muscular activity is normalized at muscular activity in maximum isometric contraction, and the active mass of the maximum isometric contraction may change. Real change may therefore be missed by % maximum voluntary contraction evaluation with variable evaluation times. The present study aimed at supplementing the defect in such analysis by focusing on an intervention effect in the same day.

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