Trunk Muscle Activity in Two-Leg Standing to One-Leg Standing in Healthy Elderly Adults

SATORU KAI, PT, PhD1), RYUJI YOSHIMOTO, PT, MS2), MASAMI NAKAHARA, PT2), SHIGEO MURAKAMI, PT, MS2), KAZUO WATARI, PT, MS2), SEIICHIRO TAKAHASHI, PT, PhD1)

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. [Purpose] Postural control has been shown to decline with age. The purpose of this study was to clarify the muscular activities of the trunk and hip joint while moving from two-leg standing to one-leg standing in healthy elderly adults and compare them with healthy young subjects. [Subjects and Methods] For 5 elderly and 8 young men subjects, electromyography activities of the left obliquus internus abdominis, left multifidus, left gluteus medius, and right ilio-psoas muscles were recorded using a surface electromyograph. EMG data were analyzed from 500 ms before lift-off to lift-off (0 ms). [Results] In the results, the muscular activities were not statistically significant between elderly and young people. [Conclusion] The presence of a qualitative change in muscle activities of elderly people was not demonstrated.

Key words: Muscular activity, Obliquus internus abdominis, Anticipatory postural adjustments

INTRODUCTION

Postural stability has been well researched1–6), and age-related postural instability has been reported2, 3). Poor postural balance is one of the major risk factors of falling7). The one-leg stance has been shown to be an indicator of poor balance and is used to determine the risk of falling in elderly people8–10). It is known that the muscles involved in the stabilizing action become anticipatorily active in the case of action in the standing position prior to the muscular activity of the prime mover. The lower trunk muscle is involved in the stability of the action in the standing position. The activation of the muscles of the hip joint is generated by the activation of the trunk muscles. However, the effect of aging has not been well proven. The purpose of this study was to clarify the muscular activities of the trunk and hip joint while moving from two-leg standing to one-leg standing in healthy elderly adults and compare them with healthy young subjects.

METHODS

Subjects

Healthy elderly volunteers aged 68–82 years without any history of neurological or musculoskeletal disorders participated in this study. In addition, a group of healthy young volunteers aged 19–31 years were recruited. In all, 5 healthy elderly men, with mean age 73.0 (SD 5.7) years, weight 56.6 (SD 8.0) kg, height 163.4 (SD 4.3) cm and body mass index (BMI) 21.1 (SD 2.2), and 8
healthy young men with mean age 22.6 (SD 4.4) years, weight 61.4 (SD 9.2) kg, height 172.6 (SD 5.5) cm and BMI 20.6 (SD 2.8), were enrolled. They all gave their informed consent. All procedures were approved by the institutional ethics committee and conducted in accordance with the Declaration of Helsinki.

Procedure

Surface electrodes were placed over the right iliopsoas muscle (IP), left obliquus internus abdominis muscle (OI), left multifidus muscle (MF), and left gluteus medius muscle (GM). The electrodes for the IP were placed just above the iliacus fascia under the lateral inguinal ligament. For the OI, the electrodes were placed in the center of the triangle formed by the horizontal lines between the anterior superior iliac spine (ASIS) of the innominate and the umbilicus, the midline, and the inguinal ligament. Cross-talk between the psoas major muscle and OI at this location is likely to be small. For the MF, electrodes were placed at the L5 level and aligned parallel to the line between the posterior superior iliac spine (PSIS) and the L1-2 interspinous space. This electrode position for the MF has produced findings similar to those recorded with intramuscular electrodes. The GM electrodes were placed at mid distance between the ASIS and PSIS and inferior to the iliac crest. The electrode position at these locations probably reflects the majority of the activity of the underlying muscle. A ground electrode was positioned over the acromion.

Subjects performed 3 times right hip flexion to 90 degrees of flexion while standing. Electromyography (EMG) activity was recorded during motion from the initial sound cue to the final position. Right foot pressure was measured by a pressure sensor linked to the EMG. In order to normalize the EMG data, maximum voluntary isometric contractions were performed in sitting on a chair or standing against manual resistance for 5 seconds. The normalization tasks involved isometric hip flexion (right IP), trunk flexion and ipsilateral rotation (left OI) in sitting, pelvic tilting (left MF) and hip abduction (left GM) in standing. The peak activity for each muscle across these tasks was selected for normalization. EMG signals were full-wave rectified, smoothed and integrated. Recorded EMG data were divided into 50-millisecond (ms) intervals from 500 ms before lift-off of the foot to lift-off (0 ms), and the mean value of each interval was calculated. Values are presented as a multiple of the value of the first 50 ms interval from 500 ms before lift-off. The EMG data were sampled at 1 kHz by use of a EMG system (Noraxon, myosystem 1200) and analyzed by myoresearch (Noraxon, EM-123). The foot pressure data were measured using a foot switch (Noraxon, EM-434, EM-135). Multiple comparisons were performed to examine differences in interval data. The difference between the two groups was examined by the Mann-Whitney U test. The level of significance was set at 5%.

RESULTS

The muscular activities of GM rose about 4-fold in the period from 100 to 50 ms before lift-off compared with the period of 500 to 450 ms in both the elderly and young groups. The muscular activities of IP were activated in the final period (50 to 0 ms) of both groups. The muscular activities of OI and MF were almost static throughout the whole period, but activated in the final interval before lift-off in both groups. There was no difference in the activity of all muscles between the elderly and young groups. There were no significant differences in muscle activities of between the young and elderly groups at any of the time intervals. These results are shown in Table 1. Raw waves of EMG are shown in Fig. 1.
DISCUSSION

In this study, the IP of the right side active as a prime mover as the right foot was raised. The GM of the left side was active for stabilization of the pelvis during the raising of the right foot, after body weight had changed to the left side. OI and MF were always active not only in the young group but also in the elderly group. However, in both groups, there was no clear difference in the muscular activity for the anticipatory postural adjustments. Postural control is considered a complex motor skill derived from the interaction of multiple sensorimotor processes1. The postural control system has been shown to decline with age16. Deterioration of the postural control system with age slows the speed of voluntary movement by delaying the onset of the voluntary muscle response3. Age-related differences were found in the timing of postural muscles. In older subjects the contralateral erector spinae muscles were activated later than in young subjects in anticipatory postural adjustments associated with arm movements17. Age-related decline in the integrity of many postural regulating systems, including musculoskeletal and sensory systems, as well as neural processing and conduction of information is caused by the resolution of sensory conflicts2. In the elderly people of this study, OI and MF were related to the anticipatory postural adjustments, and the stability of the action was enhanced. In aged Japanese men without disorders, the muscular activity of the lower trunk may be maintained comparatively well.

OI has been reported to be active with ipsilateral trunk rotation18-23. Though the stronger activity is observed in research using a thin needle electromyograph in the lower region of the OI in the inside, there is no difference in the direction of rotation in the intermediate place. It has been established that the activity differs between regions of the muscle. In a study using fine-wire EMG, the lower region of OI was more active in the opposite direction of rotation, the middle fascicles of OI were not different between directions of rotation. OI (and mainly transversus abdominis) activity varies between muscle regions24. It has been clarified that the activity differs between regions of the muscle. The electrode position of the OI was in the lower region, when activity was recorded in this study, and OI is related to the stability of the pelvis. In addition, it is reported that the muscular activity of the adductor muscle of the thigh changes due to stabilization of the trunk by OI and MF.

It was reported that the stability of the postural change cannot be estimated in static stability measurements because the correlation is low between static and dynamic stability4. One-leg standing balance performance is an indicator of poor balance in clinical practice8, 9. It has been shown that maintenance of standing balance in the dynamic phase in changing to one-leg standing from two-leg standing is difficult for elderly people10. In fallers and non-fallers, a difference is shown in the control of the lateral stability, and it was indicated that lateral stability is the most necessary factor in fall prevention intervention5. In addition, elderly people who experienced recurrent falls had inferior balance ability on a narrow base, and the mediolateral sway in the narrow base stance increased9. However, irrespective of experience of falls, there is no difference in maximum muscular

| Table 1. Muscular activity during right hip flexion in standing |
|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
|                        | 500 ms~                | 450 ms~                | 400 ms~                | 350 ms~                | 300 ms~                | 250 ms~                | 200 ms~                | 150 ms~                | 100 ms~                | 50 ms~                |
| Elderly group          |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |
| GM                     | 1.0                    | 1.3                    | 1.4                    | 1.6                    | 2.0                    | 2.0                    | 2.2                    | 2.8                    | 4.2                    | 4.0                    |
| OI                     | 1.0                    | 1.1                    | 1.1                    | 1.1                    | 1.1                    | 1.1                    | 1.1                    | 1.2                    | 1.2                    | 1.3                    |
| MF                     | 1.0                    | 1.2                    | 1.1                    | 1.2                    | 1.2                    | 1.1                    | 1.2                    | 1.6                    | 1.8                    | 2.3                    |
| IP                     | 1.0                    | 1.1                    | 1.2                    | 1.3                    | 1.2                    | 1.4                    | 1.6                    | 1.8                    | 1.8                    | 2.3                    |
| Young group            |                        |                        |                        |                        |                        |                        |                        |                        |                        |                        |
| GM                     | 1.0                    | 1.1                    | 1.4                    | 1.5                    | 1.5                    | 2.0                    | 2.3                    | 2.7                    | 4.3                    | 5.2                    |
| OI                     | 1.0                    | 1.0                    | 1.1                    | 1.2                    | 1.1                    | 1.1                    | 1.1                    | 1.1                    | 1.2                    | 1.2                    |
| MF                     | 1.0                    | 1.0                    | 1.0                    | 1.0                    | 1.2                    | 1.3                    | 1.2                    | 1.4                    | 1.4                    | 1.6                    |
| IP                     | 1.0                    | 1.0                    | 1.0                    | 1.2                    | 1.0                    | 1.0                    | 1.1                    | 1.1                    | 1.3                    | 1.6                    |

Values are presented as a ratio of the first value from 500 to 450 ms before lift-off. GM: gluteus medius muscle; OI: obliquus internus abdominis muscle; MF: multifidus muscle; IP: ilio-psoas muscle.
strength of flexion or extension of the knee or ankle joint, and all the factors except for maximum muscular strength may be related to balance ability. Recently, it is clarified that postural stability has been correlated with cooperative muscular activity of lower trunk and hip joint, and physical therapy develops this fact. Based on this fact, we find it of considerable use in fall prevention to measure to what extent the trunk muscles are active during one-leg standing. We aim to examine the muscular activity in anticipatory postural adjustments in elderly persons and/or persons with disabilities in future.

ACKNOWLEDGEMENTS

This study was supported financially by The Japan Health Foundation for the Prevention of Chronic Diseases and the Improvement of QOL of Patients.

REFERENCES