

Comparison of the Tibialis Anterior and Soleus Muscles Activities during the Sit-to-stand Movement with Hip Adduction and Hip Abduction in Elderly Females

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Abstract. [Purpose] The purpose of this study was to compare the activation of the tibialis anterior (TA) and soleus (SOL) muscles during the sit-to-stand (STS) task with hip adduction and hip abduction in elderly females. [Subjects] We recruited 16 healthy elderly females with no pain in the knee joint and no other orthopedic problems of the lower limbs. [Methods] The activities of the dominant lower extremity muscles were measured using a wireless electromyography (EMG) system. Subjects then performed a total of nine STS trials, including three trials each for hip adduction, hip abduction, and natural STS tasks. [Results] In the pre-thigh-off (TO) phase, the normalized EMG data of the TA muscle increased significantly when the STS task was performed with hip adduction compared with hip abduction. In the post-TO phase, the normalized EMG data of the TA muscle showed a significant increase during the STS task with hip adduction compared with hip abduction. Additionally, the normalized EMG data of the SOL muscle increased significantly when the STS task was performed with hip adduction compared with hip abduction. [Conclusion] Therefore, the STS movement with hip adduction poses a greater challenge for balance control, indicating that certain elderly individuals would have difficulty in executing an abrupt adjustment in their dynamic postural stability during the STS movement.

Key words: Sit-to-stand, Hip adduction, Hip abduction

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INTRODUCTION

The sit-to-stand (STS) movement is a movement people frequently perform as they change from a sitting to standing position, and the ability of an individual to rise from a chair has been considered an important indicator of an elderly person's functional independence; if impaired, it increases the risk of falling¹⁾. Among community-dwelling older adults, one in three experience at least one fall each year, with more than 30% requiring medical treatment after falling²⁾. Compared with young adults, healthy people 65 years of age or older exhibit moderate to high age-associated reductions in strength and functional limitations for tasks such as the STS task³⁾. Additionally, particularly in the frontal plane, older adults have greater difficulty maintaining and recovering postural stability caused by weak lower extremity muscles⁴⁾. A previous study examined the functional role of hip adduction (ADD) and abduction

(ABD) during squat exercise. Coqueiro et al.⁵⁾ reported increased activity of the medial and lateral portions of the quadriceps during squats with isometric hip ADD. Felício et al.⁶⁾ reported the squat exercise was associated with hip ADD producing higher activation of the vastus medialis oblique muscle and an increase in the activity of the gluteus medius muscle. Hip ABD during the squat exercise stimulated activation of the gluteus medius and produced higher activity in the vastus lateralis longus muscle. Pereira et al.⁷⁾ showed that displacement from 60° to 90° knee flexion increased myoelectric activity during a squat with hip ABD. Although the STS movement is necessary for older adults to live independently, no study of the STS task with hip ADD and ABD has been performed. Furthermore, in contrast to hip and knee muscle activity, relatively few studies have documented ankle muscle activity, such as the activities of the tibialis anterior (TA) and soleus (SOL) muscles during the STS task. Therefore, in the present study we compared the activation of the ankle joint muscles during the STS movement with hip ADD and hip ABD in elderly females.

SUBJECTS AND METHODS

Sixteen healthy elderly subjects (67.75 ± 1.61 years of age, range, 65–70 years) participated in this study. The mean height and weight of the subjects were 153.5 ± 6.61 cm and

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54.46 ± 7.22 kg, respectively. The elderly subjects were volunteers recruited from the local community. Subjects were included in the study if they were able to follow directions, had no lower-extremity amputations, and had no restrictions on lower-extremity movement or weight bearing ordered by a physician. The study participants had no muscular pathology or gait or balance disorders, no chronic deficiencies associated with a neurological, rheumatologic or orthopedic affections; and no chronic or acute illness leading to an inflammatory syndrome. This study was approved by the Inje University Faculty of Health Science Human Ethics Committee, and all subjects provided written informed consent prior to participating in the study. The activities of the dominant lower extremity muscles were measured using a wireless electromyography (EMG) system (Delsys, Inc., Boston, MA, USA) with surface electrodes fixed at an interelectrode distance of 10 mm. EMG surface electrodes were placed over muscle bellies of the dominant side tibialis anterior (TA) and soleus (SOL) muscles. For normalization, maximal EMG signals were acquired during a maximum voluntary isometric contraction (MVIC) maneuver, which was performed for 5 s. The EMG data expressed the entire STS task as a percentage of the MVIC. The starting position for the subjects was standardized. Sitting posture and movement pattern during the STS task were explained to the subjects before measurement. In a sitting posture, the subjects were positioned on an adjustable height chair without armrests or a backrest. The subjects were barefoot, placed both their legs symmetrically with their feet shoulder-width apart, and stretched their trunk in a straight line. The seat height for each subject was 100% of the lower leg length (LLL) measured from the center of the knee joint to the floor with the subject standing barefoot. To minimize any influence of the upper extremities, subjects were instructed to cross their arms lightly against their chest to minimize movement during observation. Subjects were asked to rise from the chair when instructed verbally with the word "go." They then performed a total of nine STS trials, including three trials each for hip ADD, hip ABD and natural STS (N) tasks, with the ordering of the conditions randomized. Subjects were instructed to face forward and stand up from the seat at their own speed. The EMG data during the STS tasks were collected from frontal and transversal planes with the participants' feet apart and hips in a neutral position. The STS tasks with the MVIC of hip ADD were performed in the same position as for N, a supportive position with the legs bent at the medial femoral epicondyle level. The STS tasks with hip ABD were performed in the same position as for N but with the MVIC of hip ABD resisted by a nonelastic band, adjustable with Velcro®, positioned at the lateral femoral epicondyle level. Following the STS movement, the subjects were instructed to stand still for 5 s. Subjects were allowed to practice the STS movement before the actual data collection started. Due to the influence of fatigue, each subject rested for 1 min between trials. The system required the STS trial to be performed three times. The STS start and finish times were determined with a marker attached on the right acromion. For the purpose of analysis, the STS movement was divided into a pre-thigh-off (TO) phase and

a post-TO phase with respect to chair seat support. To assess differences in EMG activity in the STS testing, a paired t-test was applied. Standard descriptive statistics were performed, and the data are reported as means ± standard deviation. Statistical analysis was performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago IL, USA) with the level of statistical significance set at $p < 0.05$.

RESULTS

In the pre-TO phase, the normalized EMG data of the TA muscle increased significantly ($p < 0.05$) when the STS task was performed with hip ADD (17.20 ± 13.21%) compared with hip ABD (12.81 ± 9.22%), but the normalized EMG data of the SOL muscle were not significantly different ($p > 0.05$; ADD, 10.17 ± 8.06%, ABD, 8.98 ± 4.69%). In the post-TO phase, the normalized EMG data of the TA muscle showed a significant increase ($p < 0.05$) during the STS task with hip ADD (25.27 ± 19.48%) compared with hip ABD (20.58 ± 15.53%). Additionally, the normalized EMG data of the SOL muscle increased significantly ($p < 0.05$) when the STS task was performed with hip ADD (26.55 ± 9.14%) compared with hip ABD (23.50 ± 9.11%).

DISCUSSION

In the elderly, a postural control system deficit is caused by greatly decreasing muscle strength and power. This leads to deterioration of the ability to rise from a chair and can become a critical limiting factor for quality of life³. The purpose of this study was to compare the activation of the TA and SOL muscles during the STS movement with hip adduction and hip abduction in elderly females. In the pre-TO phase, the normalized EMG data of the TA muscle increased significantly when the STS task was performed with hip ADD compared with hip ABD. In the post-TO phase, the normalized EMG data of the TA muscle showed a significant increase during the STS task with hip ADD compared with hip ABD. Additionally, the normalized EMG data of the SOL muscle increased significantly when the STS task was performed with hip ADD compared with hip ABD. In the present study, we examined muscle activity during the STS task with hip ADD and ABD movement to create baseline data regarding ankle stability in healthy elderly subjects. STS motion requires optimal neuromuscular coordination and postural adjustments to control movement changes and to prevent loss of balance⁸. Postural adjustments necessary for task modification or in altered environmental conditions must be controlled appropriately to maintain postural balance⁹. In the present study, the muscle activities of the TA and SOL were investigated during STS tasks under hip ADD and ABD conditions. The EMG activities in the TA and SOL were greater during the STS task with hip ADD compared with hip ABD movement. The results showed that in the elderly performing the STS task with hip ADD, the TA and SOL muscles were recruited more to maintain body stability. Moreover, muscle co-contraction has been observed as a task-independent strategy used to stiffen the joint and enhance stability¹⁰. Our results suggest that older adults may employ greater coactivation of

the uniarticular TA and SOL muscles during the STS movement with hip ADD in the post-TO phase, which may increase ankle stiffness and improve balance. Therefore, the STS movement with hip ADD poses a greater challenge for balance control, indicating that certain elderly individuals have difficulty in executing an abrupt adjustment in their dynamic postural stability during the STS movement, resulting in an increased risk of falling.

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