



Original Article

Comparison of the tibialis anterior and soleus muscles isolation ratios during the sit-to-stand movement in elderly people

SANG-HOON LEE¹⁾, WON-GYU YOO^{2)*}

¹⁾ Department of Physical Therapy, The Graduate School, Inje University, Republic of Korea

²⁾ Department of Physical Therapy, College of Biomedical Science and Engineering, Inje University: 607 Obangdong, Gimhae, Gyeongsangnam-do 621-749, Republic of Korea

Abstract. [Purpose] To compared activation of the tibialis anterior and soleus muscles during the sit-to-stand movement in elderly people. [Subjects and Methods] Ten elderly women were enrolled. The activities of the dominant lower extremity muscles were measured using a wireless electromyography system. Subjects performed natural sit-to-stand tasks. [Results] In the pre-thigh off phase, the tibialis anterior isolation ratio was significantly higher than the soleus isolation ratio. In the post-thigh off phase, the tibialis and soleus isolation ratios did not significantly differ. [Conclusion] This result suggests that selective soleus exercises might help to reduce the risk of falling in the elderly.

Key words: Sit-to-stand, Elderly people, Soleus

(This article was submitted Feb. 2, 2017, and was accepted Mar. 11, 2017)

INTRODUCTION

The sit-to-stand (STS) movement is common in daily life and performance of this motion for measurement does not increase the risk of accidents¹⁾. The STS is a dynamic motion that requires extensive joint movement in the lower extremities and trunk and subjects the lower extremity joints to heavy loads that accompany the posture change from sitting to standing²⁾. The STS test is used as a test of physical function. It is a whole-body movement without support, employs a motor pattern that is commonly used in daily living, and requires the performer to continuously adjust body balance¹⁾. Thus, the test can reveal functional limitations of the neuro-musculoskeletal system²⁾. For the elderly, although various factors such as sensation, speed, balance, and psychological status in addition to strength influence the time required to perform a given number of repetitions in the STS task, knee extensor strength is the most important variable that explains the variance³⁾. However, previous studies have not examined the tibialis anterior (TA) and soleus (SOL) activity. Therefore, this study compared activation of the TA and SOL muscles during the STS movement in elderly people.

SUBJECTS AND METHODS

The study enrolled 10 elderly women (61.2 ± 1.6 years, 150.5 ± 6.2 cm, 55.4 ± 7.2 kg) who were recruited from the local community. No subject had any muscular pathology and all of them could stand up and walk independently. None had any restrictions placed on lower-extremity movement or weight bearing by a physician. The study purpose and methods were explained to the subjects, who provided informed consent according to the principles of the Declaration of Helsinki before participating. 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

*Corresponding author. Won-gyu Yoo (E-mail: won7y@inje.ac.kr)

©2017 The Society of Physical Therapy Science. Published by IPEC Inc.

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial No Derivatives (by-nc-nd) License <<https://creativecommons.org/licenses/by-nc-nd/4.0/>>.

no muscular pathology or gait or balance disorders; no chronic deficiencies associated with neurological, rheumatological, or orthopedic affections, and no chronic or acute illness leading to an inflammatory syndrome. The activities of the dominant lower extremity muscles were measured using a wireless electromyography (EMG) system (Delsys, Boston, MA, USA) with surface electrodes fixed at an interelectrode distance of 10 mm. EMG surface electrodes were placed over the bellies of the dominant side TA and 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. The 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 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 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,” after which they performed a total of three STS trials. For the purpose of the analysis, the STS movement was divided into a pre-thigh-off (TO) phase and a post-TO phase with respect to chair seat support. The isolated contraction ratio was calculated using the following formula: Isolation ratio (%) = (TA or SOL muscle activity / (TA muscle activity + SOL muscle activity)) × 100%. The isolated contraction ratio indicates the proportional contribution of muscles to the STS movement. To assess differences in the EMG activity in the STS movement, a paired t-test was applied.

RESULTS

In the pre-TO phase, the TA isolation ratio ($62.4 \pm 8.5\%$) was significantly ($p < 0.05$) higher than the SOL isolation ratio ($37.5 \pm 8.5\%$). In the post-TO phase, the TA and SOL isolation ratios did not significantly differ (49.8 ± 15.5 and $50.1 \pm 15.1\%$; $p > 0.05$).

DISCUSSION

In the elderly, greatly decreasing muscle strength and power cause a postural control system deficit. Such changes in the properties of the quadriceps femoris muscle with age can lead to strength deficits in the quadriceps femoris of elderly adults⁴. A previous study showed that the TA and SOL were co-activated during STS movement⁵. However, the SOL muscle isolation ratio was significantly lower in the pre-TO phase of the STS task. STS movement requires optimal neuromuscular coordination and postural adaptation to control motion changes and to prevent loss of balance². In the elderly, the muscle strength of the lower extremity and the ability to control balance also become major physical components of successfully performing STS^{2, 3}. Compared to young adults, elderly individuals have moderate to high age-associated reductions in strength and functional limitations for tasks such as the STS^{1, 3}. Muscle activity isolation ratios of the TA and SOL are important factors in the STS movement. In this study, the muscle activity isolation ratio in elderly people was different from the previous study. Many researchers have focused on strengthening the quadriceps muscles to reduce the risk of falls. However, elderly people should also engage in selective SOL strengthening exercises. This result suggests that selective SOL exercises might help to reduce the risk of falling in the elderly.

REFERENCES

- 1) Kanai A, Kiyama S, Goto H, et al.: Use of the sit-to-stand task to evaluate motor function of older adults using telemetry. *BMC Geriatr*, 2016, 16: 121. [[Medline](#)] [[CrossRef](#)]
- 2) Smith WN, Del Rossi G, Adams JB, et al.: Simple equations to predict concentric lower-body muscle power in older adults using the 30-second chair-rise test: a pilot study. *Clin Interv Aging*, 2010, 5: 173–180. [[Medline](#)]
- 3) Lord SR, Murray SM, Chapman K, et al.: Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. *J Gerontol A Biol Sci Med Sci*, 2002, 57: M539–M543. [[Medline](#)] [[CrossRef](#)]
- 4) Landers KA, Hunter GR, Wetzstein CJ, et al.: The interrelationship among muscle mass, strength, and the ability to perform physical tasks of daily living in younger and older women. *J Gerontol A Biol Sci Med Sci*, 2001, 56: B443–B448. [[Medline](#)] [[CrossRef](#)]
- 5) Matjacic Z, Zadavec M, Oblak J: Sit-to-stand trainer: an apparatus for training “normal-like” sit to stand movement. *IEEE Trans Neural Syst Rehabil Eng*, 2016, 24: 639–649. [[Medline](#)] [[CrossRef](#)]