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Original Article

Comparison of the gluteus medius and rectus femoris muscle activities during natural sit-to-stand and sit-to-stand with hip abduction in young and older adults

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Abstract. [Purpose] The purpose of this study was to compare the relative levels of activation of the gluteus medius (Gmed) and rectus femoris (RF) muscles during natural (N) sit-to-stand (STS) and STS with hip abduction (ABD) in young and elderly females. [Subjects] We recruited 15 healthy young females and 15 healthy elderly females. [Methods] The activities of the dominant lower extremity gluteus medius (Gmed) and rectus femoris (RF) muscles were measured using a wireless electromyography (EMG) system for natural STS and STS with hip abduction. [Result] In the elderly subjects, the Gmed increased significantly and RF decreased significantly when STS was performed with hip ABD compared with when it was performed naturally. The Gmed in the elderly subjects was significantly increased during natural STS compared with in the young subjects. [Conclusion] These results indicate that the Gmed was recruited to compensate for weakened RF muscle function in the elderly adults.
Key words: Gluteus medius, Sit-to-stand, Hip abduction

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INTRODUCTION

The inability to perform sit-to-stand (STS) can lead to institutionalization, impaired functioning and mobility in activities of daily living (ADL), increased risk of falls, and even death[1)]. Large moments are usually produced in both the hip and knee during STS. At the beginning of STS, the base of support (BOS) is large, consisting of three points including both feet and the chair. After that, it transitions to a smaller, two-point BOS consisting of the two feet[2)]. Compared with younger adults, older adults have greater difficulty maintaining and recovering postural stability, particularly in the frontal plane, and hip abduction strength is required for hip stability[3)]. Because lower electromyographic activity in the Gmed relative to the thigh muscles seems to affect knee function, the influence of the hip stabilizer muscles on knee function, such as the Gmed, has recently been evaluated[4, 5)]. Additionally, Dawson reported differences between male and female rates of hip and knee pain in the 65–74 age group, with the rates being higher for females[6)]. The present study aimed to develop a better understanding of electromyographic analysis of the STS movement in the elderly female and ultimately help clinicians in designing programs to improve quality of life. The purpose of this study was to compare the activation of the gluteus medius (Gmed) and rectus femoris (RF) muscles during natural (N) STS and STS with hip abduction (ABD) in young and elderly females.

SUBJECTS AND METHODS

Fifteen healthy young subjects (27.13 ± 5.26 years, 163.93 ± 6.2 cm, 57.2 ± 5.75 kg) and 15 healthy elderly subjects (67.75 ± 1.61 years, 153.5 ± 6.61 cm, 54.46 ± 7.22 kg) participated in this study. The young females who participated were university student volunteers, and the elderly were recruited from a local community dwelling. All subjects were devoid of muscular pathologies and could stand up and walk independently. They also had no restrictions on lower-extremity movement or weight bearing ordered by a physician. 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 muscles activities were measured using a wireless electromyography (EMG) system (Delsys, Inc., Boston, MA, USA). EMG surface electrodes were placed over muscle bellies of the gluteus medius (Gmed) and rectus femoris (RF) muscles. The EMG data expressed the entire STS task as a percentage of a maximum voluntary isometric contraction. In a sitting posture, the subjects were positioned on an adjustable height chair (100% of lower leg length)

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without armrests and backrest. In a barefoot state, the subjects symmetrically placed both legs at shoulder width and stretched the trunk in a straight line. They were instructed to cross their arms lightly against their chest; and asked to rise from the chair at their natural speed for N STS and STS with hip ABD in random order. The STS with hip ABD was performed in the same position as the N STS with the addition of maximum isometric voluntary contraction (MIVC) of hip ABD resisted by a nonelastic band, adjustable with Velcro®, positioned at the height of the lateral femoral epicondyle. Statistical analysis was performed using SPSS for Windows version 18.0 (SPSS Inc., Chicago IL, USA) with the level of statistical significance set at $p < 0.05$. To assess differences in EMG activity in the STS testing, a paired t-test and an independent t-test were applied.

RESULTS

In the young subjects, the Gmed muscle increased significantly ($p < 0.05$) when STS was performed with hip ABD (29.42 ± 11.91%) compared with when it was performed naturally (22.59 ± 9.88%). The normalized RF muscle activity was not significantly different ($p > 0.05$) when STS was performed with hip ABD (34.09 ± 14.06%) compared with when it was performed naturally (34.11 ± 14.61%). In the elderly subjects, the normalized activity of the Gmed muscle increased significantly ($p < 0.05$) when STS was performed with hip ABD (58.03 ± 20.78%) compared with when it was performed naturally (50.89 ± 19.60%). The RF muscle decreased significantly ($p < 0.05$) when STS was performed with hip ABD (32.46 ± 14.11%) compared with when it was performed naturally (38.56 ± 18.21%). Regarding the differences between groups, the Gmed muscle activities during N STS were significantly increased in the elderly subjects when compared with the young subjects ($p < 0.05$).

DISCUSSION

Hahn et al.[7] reported in a study specifically for the Gmed muscle that older adults displayed normalized EMG activation percentages that were approximately twice those of younger adults for level walking and for obstacle negotiation at most obstacle heights tested. Because of the important role of the Gmed in controlling the hip in the frontal plane, it is possible that elderly subjects showed greater activation of the Gmed to compensate for reduced hip muscle strength[8]. This indicates that while healthy elderly adults perform the STS with hip ABD, they may show the effects of increased challenge in the task of balance control, as indicated by a higher demand on the neuromuscular capacity of the hip abductors. In addition, the RF muscle activity was significantly decreased for STS with hip ABD by 15.82% compared with that for the N STS in the elderly subjects. Anderson and Herrington suggested that reduction of EMG activity of the quadriceps would be a strategy to better distribute forces over a greater surface area in the joint and thus reduce stress during increasing knee flexion tasks, thus reducing the perception of pain[9]. In the subjects in the present study, the Gmed muscle was activated to maintain STS with hip abduction by increasing recruitment of Gmed activity, so the decrease in RF activity would decrease the patellofemoral joint stress. Frontera et al. investigated the effects of age on skeletal muscle. In the quadriceps femoris muscle, older adults were found to exhibit a reduction in cross-sectional area compared with younger adults[10]. This change in the properties of the quadriceps femoris muscle according to increasing age can lead to strength deficits in the quadriceps femoris in elderly adults. For this reason, they have difficulty in performing independent STS[3]. In the results of the present study, the Gmed muscle activity during N STS was significantly increased in the elderly subjects compared with that in the young subjects, and the Gmed muscle activity was increased and RF muscle activity was decreased in the elderly subjects when STS was performed with hip ABD. The results indicated that the Gmed muscle activity was more often recruited to compensate for weakened RF muscle function in the elderly adults. Therefore, these results possibly indicate alternative muscle strategies of elderly females for STS compared with those of young adults. Therefore, we thought that the Gmed muscle could be strengthened to support or replace weakened RF muscle function in elderly people.

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