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Original Article

Comparison of trunk acceleration ratios during stair negotiation in old-old females

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Abstract. [Purpose] This study compared trunk acceleration ratios in old-old adult females during stair negotiation. [Subjects and Methods] Twelve old-old adult females who could walk independently volunteered for this study. This study measured gait time and trunk acceleration ratios using an accelerometer during ascending and descending stairs [Results] The trunk acceleration ratio when descending stairs was significantly higher than that when ascending stairs. [Conclusion] These findings suggest that old-old females have greater deterioration of upper trunk control function for descending than for ascending stairs, regardless of task time. In addition, the trunk acceleration ratio during stair negotiation is a useful clinical marker to predict function and balance control ability in old-old females.

Key words: Trunk acceleration ratio, Old-old females, Stair negotiation

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INTRODUCTION

Previous studies have demonstrated the biomechanical strategies used to negotiate stairs in older adults by concentrating on lower extremity joint kinematics and kinetics[1)]. Larsen at al. reported that older adults have a relatively greater lower extremity extensor muscle load than young adults do during stair negotiation[1)]. Thus, older adults are deficient in the muscle reserve needed to manage unanticipated challenges, and muscle strength substantially affects the ability to successfully negotiate stairs[1, 2)]. However, trunk movements also are important in terms of postural control. The role of the trunk is to stably support the head and lower extremities by adjusting both the amplitude and structure of gait-related oscillations and contributes to visual and vestibular sensory input. In addition, the trunk acceleration ratio has been widely used to assess an index of trunk oscillations and predict falls[2)]. Therefore, the purpose of this study was to compare the trunk acceleration ratios during stair ascending and descending in old-old females.

SUBJECTS AND METHODS

Twelve old-old females, aged 82.1 ± 5.6 years, with a mean height of 149.3 ± 3.4 cm and a mean weight of 48.1 ± 6.0 kg participated in this study. All participants could walk independently without assistive devices and had a score of more than 24 on the Korean Version of the Mini-Mental State Exam. No participant had a neurological disease, a major orthopedic diagnosis (bone fracture, joint fusion or replacement, or limb amputation) in the lower back, pelvis, or lower extremities, or significant visual, auditory, or vestibular impairments. Approval was obtained from the Inje University Ethics Committee for Human Investigations, and written informed consent was obtained from all participants. The gait time and trunk acceleration ratio during ascending and descending stairs were measured with tri-axial accelerometer (Fit Dot Life, Suwon, Korea). The accelerometer measured 35 × 35 × 13 mm and weighed 13.7 g. The recording range of the sensors is between −8 g and

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+8 g, which can be selected in the acquisition software (Fitmeter Manager 2, ver. 1.2.0.14, Korea). This study measured raw data using x, y, and z variables of acceleration[3]. The data can be automatically transferred to a computer via a USB cable connection. The present study used a range of ± 2 g. Data were collected at a sampling rate of 128 Hz. Gait time was calculated by reference to the accelerometer data[4].Trunk accelerations were calculated by obtaining the vector sums of the anterior-posterior, medial-lateral, and vertical acceleration amplitudes. Then, the trunk acceleration ratio was calculated by obtaining the T2 trunk acceleration / L3 trunk acceleration value[2].This study used three three-step staircases (rise=17 cm, tread=28 cm, width=50 cm). Before the test, the ascending stair test was explained to all participants. Accelerometers were placed over the T2 and L3 spinous processes. Each participant was asked to ascend and descend the three stairs at her own pace and to progress in a "step-over" manner. After two practice trials, each participant randomly ascended the stairs three times. Participants rested for 10 s between trials and 1 minute between tasks. All data were analyzed using the SPSS statistical package (version 18.0 for Windows; SPSS, Chicago, IL, USA).The significance of the differences in gait times and trunk acceleration were explored using paired t-tests. The significance level was set at $p<0.05$.

RESULTS

There were no differences in gait time between tasks ($p>0.05$). The trunk acceleration ratios when climbing stairs (3.4 ± 1.6) were significantly higher than those when descending stairs (2.3 ± 0.7) ($p<0.05$).

DISCUSSION

The findings indicated that although gait times were not different between tasksin old-old females, trunk balance control ability, especially the upper trunk, deteriorates when descending compared to ascending stairs. Trunk acceleration is the rate of change of trunk velocity, and a higher trunk acceleration ratio means that upper trunk velocity changes frequently during a stair task. According to Hamel and Cavanagh, older adults demonstrate an exaggerated frontal plane movement of the upper trunk during stair descent when compared to ascent[5]. In addition, Samuel et al. reported that stair negotiation showed a high requirement of knee extensors, with the demand for ascending stairs attaining maximal isometric capacity, and that for descending stairs exceeding maximal isometric capacity[6]. Therefore, this study suggested that a stair descending task challenges balance more, especially for upper trunk control, than a stair ascending task, and that trunk acceleration ratios are useful clinical markers to predict falls in an old-old population.

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