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Original Article

Effects of gait velocity and center of mass acceleration during turning gait in old-old elderly women

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Abstract. [Purpose] This study investigated gait velocity and center of mass acceleration in three directions during square and semicircular turning gait tasks in old-old elderly women. [Subjects] Fifteen community-dwelling, old-old elderly women (≥75 years old) who could walk independently were recruited. [Methods] We measured gait velocity and center of mass acceleration in three directions using an accelerometer during two different turning gait tasks. [Results] The velocity during square turning was significantly slower than that during semicircular turning gait. There were no significant differences between gait tasks with respect to normalized antero-posterior, medo-lateral, or vertical center of mass acceleration. [Conclusion] Changing the direction of travel while walking regardless of turning angle is one of the greatest challenges for balance in old-old elderly people. Furthermore, gait velocity is a useful clinical marker for predicting falls in old-old elderly populations.
Key words: Center of mass acceleration, Old-old elderly, Turning gait

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INTRODUCTION

Gait velocity and center of mass (COM) acceleration are essential clinical measurements, particularly for older adults, as they can potentially indicate the ability to safely ambulate in age groups with a higher risk of falls[1)]. Very elderly people, defined as age those 75 years older (old-old elderly) exhibit rapidly diminishing in functional activities of daily living compared to elderly persons aged between 60 to 74 years. Drastic muscle weakness in the lower extremities in particular leads to poor postural stability and falls[2)]. Changing the direction of travel during walking is a common activity, accounting for many of the steps taken when performing activities of daily living. However, turning gait is a complex and risky maneuver for older adult, that demands changes in both antero-posterior (AP) and medo-lateral (ML) impulses in order to slow the locomotion velocity and move the COM towards the new direction of travel[3)]. Indeed, slower walking in elderly people is associated with an increased risk of falls and controlling ML balance is critical for preventing falls during walking[4, 5)]. However, few studies have investigated the effects of gait velocity and COM acceleration at very slow velocities such as during square and semicircular turning gait, in old-old elderly people. Therefore, the present study compared to gait velocity and COM acceleration in three directions during different two turning gait tasks in old-old elderly people.

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SUBJECTS AND METHODS

A total of 15 community-dwelling, old-old elderly women ([mean ± SD] age, 80.20 ± 3.67; height, 148.81 ± 3.74 cm; and body weight, 49.76 ± 4.68 kg) who could walk independently were recruited. All participants were older than 75 years, were able to walk independently without assistive devices, and scored more than 24 points on the Korean Version of the Mini-Mental State Exam. No participants had a neurological disease; a major orthopedic diagnosis (i.e., bone fracture, joint fusion or replacement, or limb amputation) in the lower back, pelvis, or lower extremities; or significant visual, auditory, or vestibular impairments. Ethical approval was obtained from the Inje University Ethics Committee for Human Investigations, and written informed consent was obtained from all participants prior to participation. Gait velocity and COM acceleration during square and semicircular turning gait were measured by a tri-axial accelerometer (Fit Dot Life, Suwon, Korea) 35 × 35 × 13 mm in size and weighing 13.7 g; the detection range of the sensors is −8 G to +8 G, which can be selected in the acquisition software (Fitmeter manager 2, ver. 1.2.0.14, Korea). Raw data were obtained using the x, y, and z dimensions of acceleration. The data were automatically transferred to a computer via USB. The present study used an acceleration range of ±2 G. Data were sampled at 32 Hz. Walking velocity was calculated by dividing distance by the time required to complete the locomotor tasks. COM acceleration in the AP, ML, and vertical (VT) directions was calculated using the root mean squares (RMSs) of the different directions. The RMS values of the different directions were normalized to direction RMS/RMS, expressed as % RMS (RMS ratio)[6].

The investigator explained the tests beforehand. The participants walked along pathways marked by colored tape on the floor to indicate inner leg placement. The square turning task consisted of walking 3 m in a straight line, turning 90° over 1.5 m, and walking another 3-m in a straight line. The semicircular turning task consisted of walking 3 m in a straight line, following a 2.355-m semicircular curve with a 0.75 m radius, and walking another 3-m in a straight line. Colored tape was placed on the floor for the control condition. The tape was 5 cm wide and unnoticeably thick. An accelerometer was fixed over the L3 spinous process with double-sided adhesive tape. The participants were asked to walk barefoot on the two pathways at a self-selected speed. Participants also walked an additional 2 m before and after the pathways, to avoid the effects of acceleration and deceleration[7]. After two practice trials, the participants performed three measurement trials in random order with a one minute break between trials. The data were analyzed using SPSS statistical package (version 18.0 for Windows, SPSS Inc., Chicago, IL, USA). Differences in gait velocity and COM acceleration between tasks were analyzed using paired t-test. The level of significance was set at $p<0.05$.

RESULTS

The velocity during the square turning task was significantly slower than that during the semicircular turning task (55.77 ± 8.97 vs. 60.63 ± 8.31 cm/s, respectively; $p<0.05$). There were no significant differences between tasks with respect to normalized AP, ML, or VT COM acceleration between the square turning task (53.66 ± 8.08, 46.53 ± 6.51, and 43.77 ± 5.51%RMS, respectively) and semicircular turning task (53.30 ± 7.25, 44.23 ± 6.42, and 46.49 ± 6.68%RMS, respectively) (all $p >0.05$).

DISCUSSION

This study assessed gait velocity and AL, ML, and VT COM acceleration during square and semicircular turning gait tasks in old-old elderly women. The results indicate that although the velocity during semicircular turning was faster than that during square turning, old-old elderly women walked very slowly and frequently changed COM velocity during both gait tasks. Old-old elderly people require dynamic balance during sharp turning and semicircular turning. The magnitude of turning generally affects turning gait velocity. Akram et al.[3] demonstrate the gait velocity during a large turning angle is slower than that during a small turning angle (i.e., straight > 45°> 90°) at a self-selected walking speed. Walking straight ahead exerts equivalent force on the body from both limbs, whereas turning gait necessitates asymmetric limb kinematics and kinetics. Glaister et al.[8] report that square turning gait demands not only ML spanning impulses, but also a greater degree of braking and propulsive impulses. Thus, AP and ML COM acceleration require more balance control than walking straight. In addition, continuous limb asymmetry occurs during semicircular turning in contrast to square turning. The outer leg uses stronger plantar-flexion forces to propel the body, because it must move farther during the turn. In addition, the peak ankle dorsiflexion angle of the outer limb is less than that of the inner limb as well as that during straight walking. Thus, an insufficient ankle dorsiflexion angle of the outer limb results in insufficient shock absorption and increases in VT COM acceleration[9] compared to that during square turning. Hence, complex tasks such as changing the direction of travel while walking regardless of turning angle is one of the biggest challenges in balance faced by old-old elderly people. Furthermore, gait velocity is a useful clinical marker for predicting falls in old-old elderly populations. Further studies should investigate the kinematics and kinetics of the ankle, as well as their correlations with VT COM acceleration during turning gait in old-old elderly people.

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