

# Comparison of gait velocity and center of mass during square and semicircular turning gaits between groups of elderly people with differing visual acuity

SUN-SHIL SHIN<sup>1)</sup>, DUK-HYUN AN<sup>2)</sup>, WON-GYU YOO<sup>2)\*</sup>

<sup>1)</sup> Department of Rehabilitation Science, The Graduate School, Inje University, Republic of Korea

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

**Abstract.** [Purpose] The purpose of this study was to investigate gait velocity and center of mass (COM) during square and semicircular turning gaits between two groups of elderly people with differing visual acuity. [Subjects] Twenty elderly Korean women who could walk independently and who lived in the community were recruited. [Methods] We measured gait velocity and COM using an accelerometer during two different turning gaits. [Results] The velocity during square and semicircular turning gaits of participants with good binocular visual acuity (GBVA) was significantly higher than that of participants with poor binocular visual acuity (PBVA). The COM during square and semicircular turning gaits of the GBVA group was significantly decreased compared with that of the PBVA group. [Conclusion] These findings suggest that visual acuity affects velocity and COM during square and semicircular turning gaits of elderly people.

**Key words:** Center of mass, Turning gait, Visual acuity

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## INTRODUCTION

Square turning is frequently used for corners, and semicircular turning is often used to avoid obstacles during activities of daily living<sup>1)</sup>. Balance is challenged during turning gaits, and this is one of the most common reasons for falls by older adults<sup>1, 2)</sup>. Many older adults have decreased postural stability and have considerable visual through, for example, cataracts, glaucoma, or macular degeneration, the leading cause of visual impairment<sup>3)</sup>. Vision plays a key role in stabilizing balance in a number of ways. Visual cues before and during gait help us determine our speed of locomotion, and vision also allows us to influence the alignment of the body with reference to gravity and the environment during walking. Previous biomechanical studies have indicated that head stabilization and motion coordination between the head and trunk enhance postural control to balance the moving body and visual acuity for navigational control through a cluttered environment<sup>4, 5)</sup>. However, few studies have investigated the effects of gait velocity and COM during square and semicircular turning gaits of older people with PBVA. Therefore,

the purpose of this study was to investigate gait velocity and center of mass (COM) during square and semicircular turning gaits of elderly women with good and poor visual acuity.

## SUBJECTS AND METHODS

A total of 20 elderly women who could walk independently were recruited from among community dwellers. Visual acuity was measured with Hahn's vision test chart (KOR). The participants' binocular visual acuity (BVA) was evaluated separately with and without participants' own spectacles before they performed the tasks. The participants were categorized into two groups: those with poor vision (PBVA; corrected BVA  $\leq 0.5$ ) and those with good vision (GBVA; corrected BVA  $\geq 0.7$ ). The PBVA group consisted of subjects aged 75.00 (mean)  $\pm$  6.14 (standard deviation) years, with average height and weight of 149.26  $\pm$  4.68 cm and 50.06  $\pm$  5.85 kg, respectively, and left side VA and right side VA of 0.34  $\pm$  0.11 and 0.31  $\pm$  0.17, respectively. The GBVA group consisted of subjects aged 77.45  $\pm$  6.15 years, with average height and weight of 149.43  $\pm$  3.89 cm and 50.42  $\pm$  6.24 kg, respectively, and left side VA and right side VA of 0.72  $\pm$  0.13 and 0.73  $\pm$  0.15, respectively. The inclusion criteria were as follows: older than age 65 years with BVA of 5/10 or worse for the PBVA group, older than age 65 years with BVA of 7/10 or better for the GBVA group, the ability to walk independently without any assistive device, and a score  $>24$  on the Korean Version of the Mini-Mental State Exam. Each subject provided her informed

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

consent before participating in this study, which was approved by the Inje University Faculty of Health Sciences Human Ethics Committee. Gait velocity and COM during square and semicircular turning gaits were measured with a tri-axial accelerometer (Fit Dot Life, Suwon, Korea). The accelerometer was  $35 \times 35 \times 13$  mm in size and weighed 13.7 grams. The range of the sensor is  $-8$  g and  $+8$  g, and it can be adjusted using the data acquisition software (Fitmeter manager 2, ver. 1.2.0.14, Korea). We recorded the raw data using the  $x$ -,  $y$ -, and  $z$ -axes of acceleration. The data were automatically transferred to a computer via a USB cable connection. In the present study, we selected a range of  $\pm 2$  g. Data were collected at a sampling rate of 32 Hz. The COM trajectory was calculated using a two-point finite difference method<sup>6</sup>). The investigator explained the procedure of the tests before the participants walked along pathways which were marked with colored tape on the floor to indicate inner leg placement. The square turning pathway consisted of a 3-m straight path, a 1.5-m 90° turn, and a 3-m straight return path. The semicircular turning pathway consisted of a 3-m straight path, a 2.35-m semicircular curved path with a radius of 0.75 m, and a 3-m straight return path. Colored tape was placed on the floor for the control condition. The tape was 5 cm wide and almost 0 cm in thickness. The accelerometer was fixed with double-sided adhesive tape over participants' L3 spinous process. The participants were asked to walk on the pathway with bare feet at a self-determined speed for the two tasks: walking along the square turning gait pathway with a left turn and, walking along the semicircular turning gait pathway with a left turn. Participants started and finished walking 2 m before and after the start and end of the pathways, respectively, to avoid the effects of acceleration and deceleration on measurements<sup>7</sup>). After two practice trials, participants randomly performed three measurement trials. Participants rested for 1 minute between trials.

## RESULTS

The velocities of square and semicircular turning ( $64.60 \pm 6.80$  and  $69.87 \pm 6.48$  [cm/sec], respectively) in the GBVA group were significantly higher than those of the PBVA group ( $49.78 \pm 4.87$  and  $53.58 \pm 6.86$  [cm/sec], respectively;  $p < 0.05$ ). The COM of square and semicircular turning ( $1147.45 \pm 121.36$  and  $1289.71 \pm 199.35$  [cm/s<sup>2</sup>], respectively) of the GBVA group was significantly lower than that of the PBVA group ( $1355.32 \pm 224.76$  and  $1542.48 \pm 289.03$  [cm/s<sup>2</sup>], respectively;  $p < 0.05$ ).

## DISCUSSION

In the present study, we found that the velocity of the GBVA group during square and semicircular turning gaits was significantly higher than those of the PBVA group, and

the COM of the GBVA group during square and semicircular turning gaits was significantly less than that of the PBVA group. These findings indicate that visual acuity affects gait velocity and balance during square and semicircular turning gaits. Turning gaits require reorientation of the body in a new direction without stopping. Rhea and Rietdyk<sup>8</sup>) investigated the roles of visual exproprioception in navigating obstacles during walking under four visual conditions. They occluded that visual exproprioceptive information is used to finely regulate the lower limb trajectory during obstacle avoidance. Thus, the gait velocity and balance control ability of older adults with GBVA during square and semicircular turning are higher than those of older adults with PBVA performing the same conditions. In this study, although the gait velocity of the PBVA group was slower, their COM movements were significantly greater than those of the GBVA group. Walking directly forward demands that equal forces be imparted to the body from by limbs, whereas turning requires limb kinetic asymmetry. Furthermore, a greater threat to balance emerges because the COM leans toward the inner side of the turning path<sup>9</sup>). Our findings suggest that older adults with PBVA use more cautious gait strategies to perform changes in the direction of travel, decreasing gait velocity to prevent falls. However, gait velocity frequently changed during turning gaits. Therefore, we suggest that complex tasks such as changing the direction of travel while walking are among the biggest challenges for elderly people with PBVA. Thus, elderly people with PBVA require balance and gait training in a diverse environment to prevent falls.

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