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Research Article

# Comparison of Walking, Muscle Strength, Balance, and Fear of Falling Between Repeated Fall Group, One-time Fall Group, and Nonfall Group of the Elderly Receiving Home Care Service

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ABSTRACT

*Purpose:* The purpose of this study was to provide information to develop a program to prevent repeated falls by analyzing the difference in gait, muscle strength, balance, and fear of falling according to their fall experience.

*Methods:* The study subjects were 110 elderly individuals aged over 60 years who agreed to their participation in this research. The study participants were categorized into a repeated fall group ($n = 40$), a one-time fall group ($n = 15$), and a nonfall group ($n = 46$) of the elderly. Measurements of gait, muscle strength, balance, and fear of falling were taken in each group.

*Results:* With regard to gait, there were significant differences among three groups in gait cycle ($F = 3.50$, $p = .034$), speed ($F = 13.06$, $p < .001$), and cadence ($F = 5.59$, $p = .005$). Regarding muscle strength in the upper and lower limbs, statistically significant differences were shown among three groups in muscle strength of upper ($F = 16.98$, $p < .001$) and lower ($F = 10.55$, $p < .001$) limbs. With regard to balance, the nonfall group had significantly greater results than the one-time fall group and repeated fall group in dynamic balance ($F = 10.80$, $p < .001$) and static balance ($F = 8.20$, $p = .001$). In the case of the fear of falling, the repeated fall group had significantly higher score than other two groups ($F = 20.62$, $p < .001$).

*Conclusion:* This study suggests that intervention program should be tailored to fall risk factors to enhance gait and balance and lower body muscle strength and reduce the fear of falling to prevent repeated incidences of falls in this population.



## Introduction

A fall is an accident involving the individual dropping to the ground or to a lower level due to an unintentional postural change. Elderly people experience falls because of remarkable deterioration of their physical strength and sensory functions, and a weakening of the central nervous system function for postural maintenance decreases their balance ability [1]. Most falls do not lead to severe injuries, but the elderly experiencing falls develop pain or fractures and are more afraid of falling. As a result, they take part in fewer physical activities that lead to degeneration of their physical ability and trigger a vicious circle of repeated falls. Repeated falls impede elderly individual's capacity to maintain an independent life. Therefore, it is necessary to prevent accidents like falls.

With aging, older adults have a reduction in muscle mass. Under these circumstances, if they engage in fewer activities because of their fear of falling, their muscle strength and muscle endurance sharply deteriorate and their physique changes greatly. Decreased overall motor skills of the elderly, such as muscle strength, power, flexibility, agility, and endurance, cause walking difficulty [1,2].

Walking is referred to as an individual's body movement from one place to another. When all parts of the musculoskeletal system are controlled in harmony, normal walking can occur [2]. Older adults experience a change in their musculoskeletal system with age, and thus their muscle mass, muscle strength, and range of motion (ROM) decrease. Moreover, the support time is shortened during the stance phase, and therefore, during walking, their step length becomes narrowed, gait speed slows, and variability of step

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length increases. Such changes in walking increase the risk of falling.

According to a previous study, the young and elderly differ greatly in their gait patterns, including characteristics such as step length, cadence, ROM, angular speed, and equilibrium sense. As such, the changes in an elderly individual's walking ability are related to delayed reaction time, increased brain loss rate, declined cognitive function, and weakened equilibrium sense [3]. Although the walking rhythm of older adults aged above 65 years does not change much, their step length becomes short, their cadence increases, their ankle motion is limited, and their stride length becomes short, and therefore, the ground support time on two feet increases [4,5].

Falls often occur while walking. In females, as the elderly individual who experiences a fall ages, there is a larger ratio of stance phase, swing phase, and total stride time, a longer time of the support phase of the lower limbs, and a slower cadence. With regard to the position of the body center during pelvic movement, the sagittal plane protracts with posterior flexion, coronal plane in down, and the transverse plane with external rotation, and thus, internal rotation occurs [6,7]. Therefore, to reduce the fall recurrence rate of the elderly, it is necessary to improve their walking, muscle strength, and balance. To accomplish this, analysis of elderly individuals' walking patterns on the basis of their experience of falls is required. Currently, to analyze the relationship between walking patterns and falls, the study on correlation between age and gait speed and the balance and equilibrium difference obtained depending on aging and weakened muscle strength from a perspective of postural maintenance was conducted [2,8].

However, most previous studies focused on adults in their 20s, adults, and older adults. As a result, there is a little research on the physical characteristics of the elderly who experienced falls and their remarkable kinematic differences. In particular, previous studies categorized elderly people into a fall and nonfall group according to their fall experience. The difference between elderly individuals with one-time fall and those with repeated falls has not been compared. Accordingly, previous studies fail to provide fundamental scientific data for this difference in variables.

Therefore, to lay the foundation for the information used to develop a program to prevent repeated falls in individuals with recurrent falls, this study attempts to categorize the elderly subjects into a repeated fall group, one-time fall group, and nonfall group according to their fall experience and to compare and analyze their walking, muscle strength, balance, and fear of falling.

## Methods

### *Study design*

This was a cross-sectional descriptive study aimed at identifying the walking, muscle strength, balance, and fear of falling according to the fall experience in the elderly receiving home care service.

### *Setting and samples*

The study subjects were 110 elderly individuals aged over 60 years living in N-gun of an island area, who agreed to their participation in this research. They were under health-care service at the health center in the Namhae-gun. The study participants were categorized into a repeated fall group (those who had more than two falls over the last year), a one-time fall group (those who had one fall over the last year), and a nonfall group of the elderly (those who had never experienced any fall). G*Power 3.1 was used to conduct analysis of variance on the differences in gait, muscle strength, balance, and fear of falling between the three groups. Given the two-sided test, a significance level of .05, a statistical power of 95%, an effect size of .40, and 102 participants were needed. However, in consideration of a withdrawal rate of 10%, 110 study participants were chosen. The final number of subjects to analyze was 101. The inclusion criteria of the study subjects were age over 60 years, the ability to walk in accordance with a tester's instructions, and to walk 10 m without any assistive device. Exclusion criteria were those whose activities were forbidden by medical doctor's criteria and who failed to walk because of body paralysis.

### *Ethical considerations*

The institutional review board of Sahmyook University approved the study (Approval no. SYUIRB2015-107). The participants' agreement and consent to participate in the study were also secured prior to the survey. Participants were informed that they could withdraw from the study at any time.

### *Measurements*

#### *Gait*

For accurate gait analysis with precise equipment, the subjects' walking was measured by GaitRite (CIR systems Inc., Franklin, NJ, 2008). GaitRite is an electronic matrix of 5 m in length, 0.6 m in width, and 0.6 cm in height. Pressure sensors 3 mm in diameter were arrayed vertically at an interval of 1.27 cm. When the study subjects walked over the matrix, the data collected by activated pressure sensors were extracted at 80 Hz. The two-dimensional walking data were transmitted to GaitRite, version 4.55 (CIR systems Inc., Franklin, NJ, 2011). Step length, stride, step time, gait cycle, speed, and cadence were measured by GaitRite. In a previous study, interrater reliability was r = .90, and the intraclass correlation coefficient (ICC = .99) was over .96 [9].

#### *Muscle strength*

##### *Muscle strength in upper limbs: grip strength*

Grip strength is a representative measure of muscle strength in the upper limbs. A dynamometer (Takei Scientific Instruments Co., Akiha, Niigata, 2005) was used to measure grip strength. Each study participant was asked to stand with an erect posture, extend the dominant arm to be tested away from the body at 15°, hold the dynamometer to make the second joint of the fingers right-angled, and grip the dynamometer as strong as possible.

##### *Muscle strength in lower limbs: 30-second chair-stand test*

The study subjects were asked to sit on a 40 cm tall chair without armrests on flat ground and were instructed to indicate if any pain in the joints occurred over the course of measurement. A research assistant stood next to them while the participants repeatedly sat on and stood up from the chair for 30 seconds in accordance with the tester's instructions, while the tester measured the number of times the participant sat down and stood up. In a previous study, interrater reliability was r = .95, and the intraclass correlation coefficient (ICC = .99) was over .98 [10].

#### *Balance*

##### *Single leg stance test (static balance test)*

Single leg stance test was used to measure static balance. For the safety of the participants, a research assistant stood next to them. The participants were asked to place their hands naturally on the waist with the eyes open while standing on their feet, and lift one leg 10 cm away from the ground according to a tester's instructions.