The effects of balance training and ankle training on the gait of elderly people who have fallen

Jung-Hyun Choi, PT, PhD1), Nyeon-Jun Kim, PT, PhD2)*

1) Department of Physical Therapy, Namseoul University, Republic of Korea
2) Department of Physical Therapy, Faculty of Medical and Health, Pohang College: Pohang-si, Gyeongsangbuk-do, Republic of Korea

Abstract. [Purpose] The aim of this study was to examine the effects of balance training and muscle training around the ankle joints on the gait of elderly people who have experienced a fall. [Subjects] Twenty-six elderly people with a risk of falling and a Berg Balance Scale score of 37 to 50 points who had experienced a fall in the last year were randomly and equally assigned to either a balance training group or an ankle training group. The balance training group received training on a hard floor, training while maintaining balance on a cushion ball in a standing position, and training while maintaining balance on an unstable platform in a standing position; the ankle training group received training to strengthen the muscles around the ankle joints and conducted stretch exercise for the muscles around the ankle joints. [Results] There were significant changes in gait velocity, step length, and stride length in the balance training group after the intervention; there were significant changes in gait velocity, cadence, step time, cycle time, step length, and stride length in the ankle training group after the intervention. In a between-group comparison, the gait velocity of the balance training group showed a significant improvement compared with the ankle training group. [Conclusion] Both balance training and ankle joint training are effective in enhancing the gait ability of elderly people with a risk of falling; in particular, balance training is effective in improving the gait velocity of elderly people who have experienced a fall compared with ankle joint training.

Key words: Elderly people, Balance training, Ankle training

INTRODUCTION

When a person falls, they drop down to a position on the floor, a lower position than their original body position, because of an abrupt unintentional postural change, except for in the case of falling due to acute paralysis or external force1, 2). Factors that may trigger a fall include age, gender, changes in physical strength such as balance hypoesthesia, weakened lower limb muscles, reduced flexibility, reduced activities of daily living, visual deficits, peripheral nerve disorders, cognitive impairment, emotional problems like depression, residential environment, drug intake, drinking, urinary incontinence, past history of a fall, arthritis, and chronic diseases like cardiovascular disease3–6).

Falls are frequent among elderly people7). Elderly people who have experienced a fall may suffer from a series of severe complications including hip joint fractures, which increase their morbidity and mortality rates and waste medical resources5). Among the diverse methods of preventing falls, regular and appropriate exercise slows down decreases in physical strength such as balance ability, muscle strength, and flexibility5), and exercises that prevent falls are known to reduce their frequency5, 12).

Balance is a dynamic phenomenon that requires stability and mobility to be in good harmony, and in order to properly maintain body balance, the ability to integrate the neurological and musculoskeletal systems is important13). All the stimuli coming from various sensory receptors such as visual sensory, somatic sensory, proprioceptive, skin, joint, and vestibular sensory receptors are integrated in different levels of the central nervous system, affecting an individual’s ability to maintain balance through efficient muscle tone, muscle strength and endurance, and flexibility of the joints4, 14, 15).

Recovery of balance according to postural sway is achieved by an ankle strategy, a hip strategy, or both strategies in combination16). An ankle joint strategy is ordinarily used when there is a small amount of body sway on a solid base of support. It is the first postural adjustment strategy to be used and refers to primarily recovering upright standing balance through muscular contraction of the ankle joints13, 17, 18). Training programs to ameliorate balance include aerobic, muscle strengthening, and balance exercises. Balance exercise programs include aerobic exercise for the purpose of improving stability, exercise to enhance muscle strength, and a method to ameliorate balance using different sensory inputs19).

Research on gait stability is deeply related to research on
falls. In study of falls associated with age, the postural sway that appeared when maintaining postural balance became serious, and the stability limit significantly decreased\(^{(9)}\). As individuals age, the step width and gait speed in the gait process decrease, and the double-support stance phase during the gait cycle lengthens. Such growth in the double-support stance phase increases the step width, which is related to gait instability and is a factor for falls\(^{(20, 21)}\). In addition, a reduction in gait speed in elderly people means that their ability to perform movement in ordinary life decreases\(^{(22)}\). In order to enhance gait stability, lower limb muscle strength training and balance training are frequently used. Previous research in which elastic resistance exercises were applied to the lower extremities for 14 weeks showed that an elderly group that conducted such exercises saw greater improvements in gait speed and ankle flexor muscle strength than an elderly group that did not conduct such exercises\(^{(23)}\). In addition, resistance and balance exercises changed the gait patterns of elderly people who had experienced a fall\(^{(24, 25)}\). Most prior studies have concerned fall prevention or balance ability improvements. In this study, balance training and muscle training were applied around the ankle joints by changing the base of support to improve the balance ability of elderly people who have already experienced a fall, and the authors examined how such training affected their gait ability.

**SUBJECTS AND METHODS**

The Subjects for this research were selected from the patients of a retirement community located in Youngdeokgun, Gyeongbuk, South Korea during the period of January 4 to February 28, 2014. The criteria for inclusion were as follows: those who had not participated in any regular exercise program for the past six months, those who had no special disease that may affect the experiment, those who had normal cognitive function with a mini-mental state examination-Korean version score of 24 points or higher, and those with a Berg Balance Scale score of 37 to 50 points. Twenty-six elderly people who had experienced a fall in the past year were selected as the subjects for this study. All of the subjects were given an overview of the study and participated after providing consent. The Ethics Committee of Nameoul University, South Korea, also approved the study. The IRB approval number is Research-131104-2. The Ethics Committee of Nameoul University, South Korea, also approved the study. The IRB approval number is Research-131104-2.

A comparison of gait ability according to training indicated that the balance training group had statistically significant changes in gait velocity, step length, and stride length and no statistically significant changes in step time and cycle time \(p<0.05\) (Table 2). The ankle training group had statistically significant changes in gait velocity, cadence, step time, cycle time, step length, and stride length \(p<0.05\) (Table 2). According to a comparison of between-group differences, the balance training group showed a statistically significant improvement in gait velocity compared with the ankle training group.

### Table 1. General characteristics of the subjects

<table>
<thead>
<tr>
<th></th>
<th>BEG (n=13)</th>
<th>AEG (n=13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (male/female)</td>
<td>3/10</td>
<td>3/10</td>
</tr>
<tr>
<td>Age</td>
<td>73.0±3.9</td>
<td>73.4±3.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>56.0±4.3</td>
<td>57.6±4.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>159.2±3.4</td>
<td>159.1±4.3</td>
</tr>
<tr>
<td>MMSE-K</td>
<td>24.7±0.8</td>
<td>24.6±0.6</td>
</tr>
<tr>
<td>BBS</td>
<td>43.0±2.3</td>
<td>42.8±3.2</td>
</tr>
</tbody>
</table>

Values are means ±SD. \(p<0.05\).
BEG: balance exercise group, AEG: ankle exercise group.
DISCUSSION

Falls are a major cause of deaths in elderly people, and those who have experienced a fall once are afraid of falling again, which results in decreased activity\(^{28}\). Therefore, it is crucial to enhance the movement of elderly people who have experienced a fall through exercise. To improve their balance ability and basic gait, aerobic exercise and other diverse exercise methods aimed at increasing balance and muscle strength need to be applied\(^{29}\). Accordingly, this study examined the effects of balance and muscle exercises targeting the ankle joints on the gait of elderly people who have experienced a fall.

A comparison of gait ability according to training demonstrated that there were statistically significant differences in the gait velocity, step length, and stride length of the balance training group (\(p<0.05\)). In the ankle training group, there were statistically significant differences in gait velocity, cadence, step time, cycle time, step length, and stride length between before and after the training (\(p<0.05\)).

In general, gait speed may be affected by neurological control of such things as balance ability and physical and physiological characteristics like reciprocal coordination of the lower limb muscles and vital capacity\(^{30}\). Moreover, improving muscle functioning through regular exercise increases the number of steps and gait speed\(^{31, 32}\). Persch et al.\(^{33}\) reported that a 12-week lower limb muscle strength training program enhanced muscle strength, which resulted in gait speed being improved by 11.1% and gait ability being improved by 44%. In the present study, similar to previous research results, the gait velocity of the balance and ankle joint training groups increased after eight weeks of exercise. Steadman et al.\(^{34}\) noted that reduced balance ability in elderly people was related to reductions in gait velocity and balance ability. In the present study, the gait speeds of both the balance training group and the ankle joint training group increased, and the eight-week exercise programs had a positive effect on balance in the elderly subjects.

In the gait, increases in cadence, step length, and stride length affect the increase in gait speed\(^{35}\). Coa et al.\(^{36}\) observed that the reason elderly people's gait speed decreases is because their step width decreases. Ferrandez et al.\(^{37}\) reported that reductions in step width negatively influenced other aspects of gait—decreases in arm swing and rotation of the hip, knees, and ankles—and lengthened double-limb support time, triggering reduced gait speed. According to the present findings, the balance training group had increases in step length and stride length, and the ankle joint training group experienced improvements in cadence, step length, and stride length. In both groups, gait velocity increased, consistent with previous research results.

According to the between-group comparison, there were statistically significant changes in the gait velocity of the balance exercise group relative to the ankle joint exercise group (\(p<0.05\)). Balance ability and gait ability are known to have a high correlation\(^{38}\). Continuous postural adjustment is necessary between one lower limb and the other and between the lower extremities and the upper extremities on a base of support that is unstable and changes during gait\(^{39}\). Among the activities of daily living, gait is one that is performed at different speeds and in diverse directions, not just in one direction. A change in gait direction slows forward motion and triggers movement in a new direction, and balance should be well controlled to prevent falling and to maintain a stable gait in the new direction and speed\(^{40}\). Balance during gait is an important element, and therefore the balance exercise group's gait speed increased significantly more than that of the ankle joint exercise group.

This study has several limitations. The number of subjects was small, and various physical traits of the subjects were not sufficiently taken into account; therefore, it will be difficult to generalize the results to all elderly people. Besides, the variety of chronic diseases was not considered, and the effects of chronic degenerative physical traits cannot be excluded. The subjects of this study were elderly people who were able to independently walk without aid. However, physical capabilities such as visual perception ability or space perception ability that may have affected the results were not taken into consideration. Accordingly, future research that reflects individual traits should be carried out on the association between physical characteristics and functional levels and should utilize a larger number of subjects over a longer time period.

| Table 2. Comparison of the gait performance of the postural strategy and ankle joint exercise groups |
|---------------------------------------------|-------------------|-------------------|-------------------|-------------------|
|                                          | BEG Before | BEG After | AEG Before | AEG After |
| Gait velocity (cm/sec) **                  | 76.5±1.4    | 93.8±1.9*       | 81.4±2.3       | 88.8±2.6*       |
| Cadence (steps/min)                       | 103.8±2.3   | 99.0±1.3*       | 107.7±2.1      | 96.9±1.0*       |
| Step time Lt (sec)                         | 0.5±0.0     | 0.6±0.0         | 0.5±0.0        | 0.6±0.0*        |
| Step time Rt (sec)                         | 0.5±0.0     | 0.6±0.0         | 0.5±0.0        | 0.6±0.0*        |
| Cycle time Lt (sec)                        | 1.1±0.0     | 1.2±0.0         | 1.1±0.0        | 1.2±0.0*        |
| Cycle time Rt (sec)                        | 1.1±0.0     | 1.2±0.0         | 1.1±0.0        | 1.2±0.0*        |
| Step length Lt (cm)                        | 44.2±1.0    | 57.0±1.2*       | 45.6±0.9       | 55.1±1.1*       |
| Step length Rt (cm)                        | 44.5±1.1    | 56.6±1.2*       | 44.9±0.8       | 54.4±1.2*       |
| Stride length Lt (cm)                      | 89.1±2.0    | 113.9±2.3*      | 90.8±1.7       | 110.0±2.3*      |
| Stride length Rt (cm)                      | 88.3±2.1    | 113.2±2.4*      | 90.4±1.8       | 109.3±2.3*      |

Values are means±SD, *p<0.05, significant difference between before and after training, BEG: balance exercise group, AEG: ankle exercise group
ACKNOWLEDGEMENT

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REFERENCES