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Effects of Fall Experience on the Balancing Ability and Ankle Flexibility in Elderly People

The purpose of this study was to investigate the effect of fall injuries on the balancing abilities and ankle flexibility. Fifteen of the voluntary participants had no experience of falling in the last two years (none falling group, NFG) and 15 others experienced at least one (falling group, FG). Static balance (sway length, sway area), dynamic balance (timed up and go (TUG), and functional to reach test (FRT) were measured in each group. In comparison of static balance, sway length was not significantly different between NFG and FG in both eyes open and eyes close, however the sway area of the FG was significantly wider than that of the NFG ($p<.05$). In dynamic balance comparisons, TUG of FG was significantly longer than that of NFG ($p<.05$), however FRT and STS were no significant difference between groups. Ankle flexibility was significantly higher in NFG than in FG. This study suggests that the fall prevention program should include methods for improving ankle stability and lower extremity function.

Key words: *Fall Experience, Balancing Ability, Ankle Flexibily*

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INTRODUCTION

The development of technical advancements in the industrial and medical sectors has increased the elderly population in Korea. The increase was so rapid that it is unrivaled among other countries and has also brought on a rise in the prevalence of geriatric diseases, which is echoed in the country's demographics. The percentage of elderly people (classified as ages 65 or older) was 3.1% in 1970, 7.2% in 2000, and 13.8% in 2017, indicating that we have an aging society [1]. By 2025, the percentage of elderly people is estimated to be 20%, and by 2037 it is estimated to be 30.5% [1]. Of the elderly people aged 65 or over, 88.5% have chronic geriatric diseases, and as their age increases, they continue to develop more diseases [2]. It was reported that 21% of the elderly population in Korea has experienced fall injuries and 47.4% of them have experienced an after effect due to the fall [2].

The ability to maintain balance can be classified into static balancing ability and dynamic balancing ability. Static balancing refers to the ability to hold the body in a standing position against gravity on a fixed surface, while dynamic balancing refers to the ability to adjust the posture without falling while the body is moving [3]. A loss of balance is when both of the lower limbs cannot support the body symmetrically, resulting in increased postural sway and frequent falls [4, 5].

The elderly are less able to maintain balance when the range of motion and vertebral flexibility are reduced [6]. In order to maintain a successful daily life, it is necessary for the elderly to have a balancing ability, so that a proper posture can be maintained [7]. However, with the increase in age, the balancing ability is reduced, and the muscle strength is weakened, along with a decrease in flexibility. The overall balancing ability is reduced, and the incidence of falls increases [8].

Therefore, this study aims to investigate the static and dynamic balancing ability, and ankle flexibility, based on the presence or the absence of past falling experience.

METHODS

Subjects

This study was conducted on 15 elderly women who have non experienced a fall(non fall group; NFG) and 15 elderly women who have experienced(fall group; FG) more than one fall in the past two years. All of the subjects are users of the Yeongwol-gun, Gangwon-do based community elderly center and are over 65 years of age. This study was conducted from October 7, 2017 to November 4, 2017, over the course of four weeks.

In order to gather general characteristics of the subjects before the experiment, a questionnaire was created to confirm whether or not the subject had experienced fall injuries and was able to have an independent life without an assistive device. The questionnaire also looked for any abnormality in their basic senses. The right leg was used as the dominant leg. Also, if a participant had received medical treatment to the patellar nervous system, central nervous system, or had a psychiatric problem, they were excluded from the study. All participants were informed of the study risks and protocol and signed an informed consent.

Table 1 shows the general characteristics of the participants.

Table 1. General characteristics of the subjects

(M±SD)

Equipment name		NFG (n=15)	FG (n=15)	p
Age (years)		75.93±5.85a	79.53±4.93	.079
Height (cm)		154.28±7.07	150.45±4.77	.093
Weight (kg)		59.59±9.38	55.31±7.73	.183
Gender (Female)		15	15	
Fall experience	0	15	0	
	1	0	8	
	2	0	4	
	3	0	3	

NFG; non fall group, FG; fall group, a; mean±SD

Measurements Method

Evaluation of static balancing ability

Static balancing ability was measured using the BioRescue (RM INGENIERIE, France). The BioRescue can evaluate balancing ability by measuring the area and distance of the movement. Romberg's test was performed separately in a standing position with the participant's eye closed and with their eyes open.

Before measuring the balancing ability, the measurement methods were explained to the subjects in detail. The default measurement posture sets the subject so that the centerline of their foot is aligned with the 30 degree indicator line drawn on the plate while in a standing position. Romberg's test was conducted by measuring the movement of the COG in a standing position on the force plate. Romberg's test was conducted by measuring the COG movement for 30 seconds with the participant's eye closed and with their eyes open. The subject was in a standing position with their two legs supporting their body on the force plates.

Evaluation of the dynamic balance ability

Timed Up & Go test (TUG)

The TUG is easy and straightforward to conduct without any special equipment or training, requiring only a small amount of space. This test evaluates a person's ability to balance the gaits movements over a period of time [9], and is also a balance test that can quickly measure balancing ability. The measuring starts with the subject sitting on a chair that has an armrest and a backrest capable of bending the knee joint at a 90 degree angle. After they hear the signal to start, the subject stands up from the chair and walks 3 m and back, ending with the subject sitting back down in the chair. The time is measured in seconds. The measurements were recorded by averaging two measurements with a three-minute rest period between the two measurements, in order to prevent fatigue between the measurements.

Sit-to-stand test (STS)

The STS was used in order to differentiate the effect of physical predisposition due to aging and the effect of impairment due to the onset of deterioration in balancing abilities [11]. The risk of falling is high when the elderly take more than 12 sec to complete the test [12]. The measuring starts when the subject moves from the back of the chair to the front of the chair and ends when the back of the subject comes in contact with the back of the chair. The default completion posture was defined as the fully extended state of the knee joint and the body. The measuring method of the STS is to measure the time required for the subject to repeatedly sit and stand up from a chair five times. Before the measurements, the subjects were given a onetime demonstration. The two measurements were averaged and a 3 minute break was given between the measurements in order to prevent fatigue.

Functional reach test (FRT)

The FRT is an economically sound testing method that can easily replace the balancing ability tests that require expensive equipment. FRT sets the subject's posture so that the shoulder joint is bent 90 degrees in an upright position, so that it extends forward in parallel and measures the difference in distance between the third fingertip of starting position and the third finger fingertip of the subject's arm, extended as far as it can go. The measurement is conducted after one initial practice. The measurements were conducted twice and the measurement was recorded as the mean of the two values. After each measurement, a short rest period was given to prevent fatigue. FRT is useful for detecting balance impairment for impaired older persons [10].

Evaluation of ankle flexibility

The measurement of the ankle flexibility was conducted with the knee to wall test (KTW) [13]. The leg is to be measured in first place on the wall so that the knee comes in contact with the wall, then the foot of the measured leg is moved away from the wall up to the point where the foot does not get lifted from the ground. After the foot is moved away from the wall, the distance between the wall and the big toe is measured in cm. The recorded value was an average of the two conducted measurements.

Data analysis

All of the collected data was analyzed using SPSS 23.0 (IBM Corp, USA) in the Windows Program. The mean and the standard deviation were calculated using descriptive statistics in order to determine the general characteristics of the subjects. The normality of the distribution was verified using the Kolmogorov-Smirnov test. In order to determine the effect of falling experience on the muscle strength, leg angle, walking ability, balancing ability, and ankle flexibility, an independent sample t was used. The significance level was set at $\alpha=0.05$.

RESULTS

Comparison of the balancing ability of each study group

Comparison of the static balancing ability in each group

In order to study the static balancing ability, the sway length has been compared among the groups. With the eyes open, the NFG showed 19.03±4.04 ㎜ and the FG showed 20.84±6.08 ㎜ resulting in no significant difference. With the eyes closed, the NFG showed 17.14±5.19 ㎜ and the FG showed 18.92±7.18 ㎜ giving no significant difference.

In order to study the static balancing ability, the sway area has been compared among the groups. With the eyes open the NFG showed 55.33±34.05 ㎟ while the FG showed 109.73±69.98 ㎟ giving a statistically significant different ($p<.05$). With the eyes closed the NFG showed 78.53±71.35 ㎟ while 111.93±87.32 ㎟ was shown by the FG, resulting in no significant difference.

Table 2. A comparison of static balance according to each groups (M±SD)

		NFG	FG	t	p
Sway length (㎜)	Eye open	19.03±4.04	20.84±6.08	-.958	.346
	Eye close	17.14±5.19	18.92±7.18	-.778	.443
Sway area (㎟)	Eye open	55.33±34.05	109.73±69.98	-2.707	.013*
	Eye close	78.53±71.35	111.93±87.32	-1.147	.261

NFG; non fall group, FG; fall group, * p<.05

Comparison of the dynamically balancing ability in each group

After conducting the TUG in according with the falling experience, the NFG showed 10.64±1.56 sec while the FG showed 11.86±1.59 sec resulting in a statistically significant difference ($p < .05$).

After conducting the STS in according with the falling experience, NFG showed 13.65±10.80 sec, while the FG showed 14.53±5.16 sec, resulting in no significant difference.

After conducting the FRT in according with the falling experience, the NFG showed 18.01±7.03 ㎝, while the FG showed 17.16±3.55 ㎝, resulting in no significant difference.

Table 3. A comparison of dynamically balancing ability according to each groups (M±SD)

	NFG	FG	t	p
TUG (sec)	10.64±1.56	11.86±1.59	−2.134	.042*
STS (sec)	13.65±10.80	14.53±5.16	−.285	.779
FRT (㎝)	18.01±7.03	17.16±3.55	.417	.681

NFG; non fall group, FG; fall group, TUG; timed up and go test, STS; sit to stand test, FRT; functional reach test, * $p < .05$

Comparison of the ankle flexibility of each group

For the comparison of the ankle flexibility(KTW) in according with the falling experience, the NFG showed 6.93±4.73 ㎝ while the FG has shown 3.00±3.31 ㎝, resulting in a statistically significant difference ($p < .05$).

Table 4. A comparison of ankle flexibility according to each groups (M±SD)

	NFG	FG	t	p
KTW (㎝)	6.93±4.73	3.00±3.31	2.639	.013*

NFG; non fall group, FG; fall group, KTW; knee to wall test, * $p < .05$

DISCUSSION

The purpose of this study was to compare the balancing ability, and ankle flexibility, all in relation to the experience of falling. By using the data, this study aimed to create a more effective elderly fall injury prevention program.

Balancing ability is an important part of the daily lives of elderly people, and the body maintains its balance through the posture control mechanisms that allow the center of gravity to be located in the support surface [14]. The group that had experienced falling is shown to have lower balancing ability than the group that had not experiences any fall injuries [15]. In a static stance posture, the size and frequency of the swaying was shown to be larger in the elderly [16, 17]. A healthy, middle-age adult was shown to have an increase in their swaying when measured for their static balancing ability, every 10 years. The largest increase was found at the age of 80 [18]. The FG has higher swaying distance and swaying time than the NFG [19]. Also, this study found that with the eyes open, the FG has a statistically significant increased amount of swaying area when maintaining a static stance than the NFG ($p < .05$). Proceeding studies state the difference found in the swaying distance of the balancing ability in terms of falling experiences. In contrast our study found only the swaying area to have a statistically significant difference. However, our study results show that both the swaying area and the swaying distance decreased the balancing ability for the FG when compared to the NFG. It can be observed that experiences of fall injuries decrease balancing abilities in the elderly.

Flexibility has been found to decrease with aging [20]. In particular, the decrease in the flexibility of the ankle occurs frequently in the elderly and has been found to lead to a decrease in balance and functional abilities [21]. Nam and Choe [22] stated that for the FG has lower movement range of the DF than the NFG. The FG has also been found to have less flexibility than the NFG [23]. Our study has also found that the

FG, compared to NFG, has statistically significant amount of decrease in flexibility ($p<.05$).

In the preceding studies, it can be stated that the programs to prevent fall in juries in the elderly should include contents that can improve the function of the lower limbs. However, our study was not able to observe the lower limb function at the time of the fall injury, therefore a further study will be required in the future.

The limitations of this study were that the number of subjects who participated in the study was not large and it did't check the individual factors for the fall, making it difficult to generalize the results of the study to people of different ages or fall characteristics. These limitations should be overcome in future research on various individual factors for the fall.

CONCLUSION

The purpose of this study was to investigate the effect of fall injuries on the balance abilities and ankle flexibility. It can be concluded that elderly women in Korea may fall dawn experience, which negatively affects the balancing ability, and ankle flexibility. Therefore, a program that prevents fall injuries in the elderly should also include a program that improves the ankle flexibilty, as well as a program to improve the overall lower limb functionalities

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