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The Relationship between Near-Fall Experiences and Lower Limb Function and Balance Function

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Abstract

[Purpose] The purpose of this study was to clarify the relationship between near-fall experiences and lower limb function and balance function. [Method] For lower limb function, quadriceps muscle strength, CS-30, and walking time were measured. For static balance function testing, a stabilometer (ANIMA, GRAVICORDER, G-620) was used. One-leg stand time with eyes open was also measured. For dynamic balance function testing, TUG and 10 m obstacle walking time were used. [Results] There was a significant correlation between total trajectory length with eyes open and height and weight. There was also a significant correlation between total trajectory length with eyes closed and height, weight, standing on one leg with eyes open, and quadriceps strength for the 10 m obstacle walking time, CS-30, TUG, and 10 m walking time ($p < 0.05$). When examining the validity of balance function as a factor in near misses of falls (presence or absence), the highest F-value (11.4) was found for total trajectory length with eyes closed. [Conclusion] For static balance function testing, the total trajectory length with eyes closed was useful, and for dynamic balance function testing, the 10 m obstacle walking time was useful.

Keywords

Near-Fall Experiences, Lower Limb Function, Balance Function

1. Introduction

Japan's population is rapidly aging, and it is estimated that the number of bedridden elderly people will exceed 3 million by 2025. Furthermore, the main causes of bedriddenness are dementia (17%), stroke (16%), and fractures/falls (14%), with the latter increasing 1.5-fold. [1] In Japan, where the population is rapidly aging, it is highly significant to examine the decline in activities of daily living and the falls that lead to bedriddenness among the elderly.

Previous domestic and international studies [2]-[6] have mainly focused on physical functions such as the ability to maintain a standing posture, lower limb muscle strength, lower limb joint mobility, and sensory input in relation to falls.

When examining the causes of falls, it is important to note that elderly people often experience near-falls (near misses), even if they do not actually fall. These near-miss experiences may lead to falls. [7]

Balance function can be divided into static and dynamic balance functions. Typical static balance function tests include the center of gravity sway test and one-legged standing test, while dynamic balance function tests include the 10-m obstacle walk and the Timed Up and Go test (TUG). The purpose of this study was to clarify the relationship between the presence or absence of near-miss falls and lower limb function and balance function.

2. Subject and Methods

2.1. Participants

This study, part of a health survey for the elderly (hereafter referred to as the survey), is being conducted as part of a local knowledge hub development project. The subjects were 23 women aged 65 years or older (mean age 70.4 years) who participated in response to a call from K City, Saga Prefecture.

The survey was advertised in city and town newsletters, and residents who saw the advertisements participated. Subjects were verbally informed of the purpose of the survey, that participation was not mandatory, that data obtained through the survey would not be used for purposes other than research, and that the data would be anonymized. Informed consent was obtained from the subjects.

This study falls under the category of "observational research using existing data" under the "Ethical Guidelines for Epidemiological Research" (partially revised December 1, 2008) issued by the Ministry of Education, Culture, Sports, Science and Technology and the Ministry of Health, Labour and Welfare, and falls under the category of "not necessarily requiring informed consent from research subjects." [8] Furthermore, permission to use this survey data was obtained from K City, Saga Prefecture.

2.2. Methods

2.2.1. General Information Participants

General information (age, height, weight) and whether or not participants had experienced a near-fall during the past year (**Table 1**) were collected.

The operational definition of near-fall experience was assessed by asking subjects to respond with a yes or no answer to the question, "Have you had a near-fall experience in the past year?"

Table 1. General information participants.

	participants (n = 23)
age	70.4 ± 5.2
height (cm)	151.4 ± 4.5
weight (kg)	49.5 ± 7.3
total length of postural sway while standing in the open eyes (cm)	43.8 ± 11.6
total length of postural sway while standing in the closed eyes (cm)	67.6 ± 22.3
single leg standing in the open eyes (sec)	66.7 ± 41.8
quadriceps femoris strength (kg)	22.0 ± 8.3
CS-30 (times)	23.6 ± 5.3
10 m walking time (sec)	5.3 ± 0.38
TUG (sec)	6.5 ± 0.38
10 m obstacle walking (sec)	6.9 ± 0.6
	average e ± standard deviation

2.2.2. Lower Limb Function

Quadriceps muscle strength was measured using a handheld dynamometer (Anima μTasF-1 Isometric Muscle Strength Measurement System) according to the method described by Kato *et al.* [9]. The subject was seated with the knee flexed at 90°. The sensor of the handheld dynamometer was attached to the distal part of the lower leg and secured to the support post of the treatment bed with a belt. Maximum isometric muscle strength was measured twice on each side. The maximum value (kg) was used as the representative value.

The CS-30 measured the number of times the subject stood up from a position with both arms resting on the knees. Upon receiving the "start" signal, the subject began standing from the starting position, reached an upright position, and immediately sat down. The number of times (times) was measured over a 30-second period. A 40-cm-high, armless metal chair was used.

Walking time was measured as the time (seconds) spent walking at maximum effort along a 10-m straight section with 3-m walkways at both ends.

2.2.3. Static Balance Function Test

Static balance function was measured using a stabilometer (ANIMA, GRAVICORDER, G-620).

Subjects stood barefoot on the two insoles of the stabilometer, with their upper limbs in a natural, downward position. The measurement time was 30 seconds, the acquisition cycle was 50 ms, and the evaluation item was total trajectory length (cm). Subjects were measured once with their eyes open and once with their eyes closed.

For the eyes-open, single-leg stance, the time they could maintain the stance with their eyes open was measured twice on each side using a digital stopwatch, with a maximum of 120 seconds. The longest time was recorded. Subjects were required to be barefoot, with both upper limbs lightly resting at their sides, and gaze 2 m ahead at the same height as their line of sight. The time spent standing on one leg with eyes open (seconds) was recorded.

2.2.4. Dynamic Balance Function Test

The TUG was performed according to the method of Okamochi *et al.* [10] and measured the time (seconds) required to stand up from a chair, walk at a comfortable and safe speed to a target 3 m away, change direction, return to the chair, and sit down. Measurement began with the body planted on the backrest and seat, with weight bearing. The measurement was taken from the moment the subject said "yes" until the buttocks touched the chair. A digital stopwatch was used for measurement. Measurements were conducted once.

The 10-m obstacle walking time was measured as the fastest time (seconds) required to walk a 10-m straight line through six 20-cm-high sponge obstacles placed at 2-m intervals. Measurements were conducted once, using a digital stopwatch.

2.2.5. statistical Analysis

Pearson's correlation coefficient was calculated for the relationship between total trajectory length and measured values. Furthermore, the validity of balance function was examined by performing a one-way analysis of variance with near misses of falls (presence or absence) as a factor. Statistical analysis was performed using SPSS 26.0 for Windows, with a statistical significance level of 5%.

3. Results

There was a significant correlation between total trajectory length with eyes open and height and weight. There was also a significant correlation between total trajectory length with eyes closed and height, weight, standing on one leg with eyes open, and quadriceps strength, as well as 10m obstacle walking time, CS-30, TUG, and 10m walking time ($p < 0.05$) (**Table 2**).

The "total trajectory length" of a postural sway device refers to the cumulative length of the trajectory traced by the center of gravity during the measurement period. This serves as an indicator of how much the body swayed. Generally, a larger value indicates greater body sway, meaning unstable balance function.

The total open-eye trajectory length was associated with height and body build, while the total closed-eye trajectory length was associated with height, body build, single-leg stance, and lower limb muscle strength.

Table 2. Correlation coefficient static of static balance functions, dynamic balance functions and variables.

	static balance functions				dynamic balance functions
	total length of postural sway while standing in the open eyes		total length of postural sway while standing in the closed eyes		10 m obstacle walking
height	0.44	*	0.44	*	−0.03
weight	0.46	*	0.46	*	0.16

Continued

single leg standing in the open eyes	−0.19	−0.48	*	−0.04	
quadriceps femoris strength	0.19	0.46	*	−0.78	
CS-30	0.09	−0.05		−0.45	*
10ｍ walking time	−0.07	0.04		0.43	*
TUG		−0.05		−0.42	*

Notes: *$p < 0.05$ by correlation coefficient.

When examining the validity of balance function based on whether or not there was a near miss of a fall, the F value (11.4) was the largest for the total trajectory length with eyes closed (Table 3).

Table 3. Comparison of each balance function using one-way analysis of variance with the presence or absence of near-fall experiences (near misses) as a factor.

factor	total length of postural sway while standing in the closed eyes (cm)	single leg standing in the open eyes (sec)	10 m obstacle walking (sec)
near misses			
presence (15 person)	69.8 ± 20.7	67.8 ± 49.6	6.9 ± 0.7
absence (8 person)	63.4 ± 25.9	64.6 ± 37.0	7.0 ± 0.5
F value	11.4	9.1	9.3
p value	0.01	0.02	0.01
average ± standard deviation			

4. Discussion

Of the subjects in this study, 15 people (65%) answered that they had experienced a near-fall in the past year. In a previous study targeting elderly people living at home, Murata *et al.* [7] reported that 36 people (32%) had experienced a near-fall in the past year. The incidence rate in the group with a near-fall experience in this study was higher than in previous studies. It is expected that this includes people who have actually experienced a fall.

kai *et al.* [11] investigated the relationship between balance function, height, and 10-meter walking time in young people in their 20s (13 men, 12 women, mean age 24.3 years) and older people (12 men, 12 women, mean age 69.5 years). The results showed a significant correlation between height and 10-meter walking time and total trajectory length with eyes open in young people, but no correlation in older people. It is predicted that as young people grow taller, their stride length increases and they walk faster. In this study, a significant correlation was found between height and total trajectory length with eyes open and eyes closed. In elderly women aged 70 - 74, the mean times for one-legged standing with eyes open, 10-meter walking time, TUG, and 10-meter obstacle walking were 17 seconds, 6.5 seconds, 10.3 seconds, and 7.5 seconds, respectively [12], whereas in this study, the mean times were 67.6 seconds, 5.3 seconds, 6.5 seconds, and 6.9 seconds, respectively. From these findings, it can be inferred that the subjects in this study had better walking function than their age group, which correlated with height.

In this study, a significant correlation was found between total trajectory length with eyes closed, open-leg standing, and quadriceps muscle strength. It is thought that eye closure increases sway during static standing, resulting in muscle response and posture adjustment. [13]

Tanaka *et al.* [14] investigated the relationship between balance function and lower limb muscle strength in elderly subjects (32 men, 42 women, average age 68.6 years). They reported significant correlations between the 10-m obstacle walk and walking speed, TUG, and CS-30. In this study, significant correlations were found between the 10-m obstacle walk and CS-30, 10-m walking time, and TUG, which were consistent. The 10-m obstacle walk requires adjusting stride length and walking faster due to the presence of obstacles. Elderly people tend to respond by increasing their walking rate rather than stride length. [15]

When evaluating criterion-related validity, particularly predictive validity, multiple independent variables (predictors) are sometimes used in multiple regression analysis to predict a single dependent variable (criterion). In this case, an F-test is used to test the significance of the entire multiple regression model, yielding an F-value as a result.

A large F-value indicates that the regression model as a whole has a significant effect in predicting the dependent variable. In other words, it provides evidence that the group of predictors as a whole is associated with the criterion.

In this study, we examined the validity of using the presence or absence of near-falls as an external criterion. The total closed-eye trajectory length showed higher criterion-related validity (F value) compared to the open-eye one-leg stance or the 10-meter obstacle walk. That is, the longer the total closed-eye trajectory length, the more participants in the near-fall group were present.

This study suggests that total trajectory length with eyes closed is useful for static balance, and the 10-m obstacle walk is useful for dynamic balance.

Factors influencing the control of standing posture balance include the following reported findings: information from the support surface and muscles of the ankle joint is more closely involved in maintaining posture than vestibular sensation or kinesthetic information from areas other than the feet; and vision plays a role in maintaining the position of the head and trunk [16].

This study suggests that total closed-eye trajectory length is useful for static balance, while the 10-meter obstacle walk is useful for dynamic balance.

Moving forward, we will increase the sample size and calculate cutoff values for balance function tests to identify elderly individuals at an early stage of fall risk.

Limitations of this study include a small sample size and the fact that it was conducted exclusively with female participants. Moving forward, we aim to conduct verification studies involving larger, more diverse populations that include male participants.

5. Conclusions

The purpose of this study was to clarify the relationship between near-fall experiences and lower limb function and balance function.

The subjects were 23 women aged 65 years or older (mean age 70.4 years) who participated in response to a call from K City, Saga Prefecture.

There was a significant correlation between total trajectory length with eyes open and height and weight. There was also a significant correlation between total trajectory length with eyes closed and height, weight, standing on one leg with eyes open, and quadriceps strength for the 10m obstacle walking time, CS-30, TUG, and 10m walking time ($p < 0.05$). When examining the validity of balance function as a factor in near misses of falls (presence or absence), the highest F-value (11.4) was found for total trajectory length with eyes closed.

For static balance function testing, the total trajectory length with eyes closed was useful, and for dynamic balance function testing, the 10 m obstacle walking time was useful.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] National Health Trends (2024) Welfare Indicators.

[2] Kimura, M. (2000) Significance of Evaluation of The Balancing Ability in The Elderly, *Japan Society of Physiological Anthropology*, **5**, 65-71.

[3] Fujiwara, K., Toyama, H., Asai, H., Miyaguchi, A., Yamashina, T., Usui, S. and Kunita, K. (1993) Analysis of Dynamic Balance and Its Training Effect, Focusing on Fall Problem of Elder Persons. *Bulletin of the Physical Fitness Research Institute*, **83**, 123-134.

[4] Daubney, M.E. and Culham, E.G. (1994) Lower-Extremity Muscle Force and Balance Performance in Adults Aged 65 Years and Older. *Physical Therapy*, **79**, 1177-1185. https://doi.org/10.1093/ptj/79.12.1177

[5] Mecagni, C., Smith, J.P., Roberts, K.E. and O'Sullivan, S.B. (2000) Balance and Ankle Range of Motion in Community-Dwelling Women Aged 64 to 87 Years: A Correlational Study. *Physical Therapy*, **80**, 1004-1011. https://doi.org/10.1093/ptj/80.10.1004

[6] Hiroshi, H. (2000) Factors of Longevity: Lifestyle and Disease in Okinawan Society. Kyushu University Press, 10-17.

[7] Shin, M. and Akira, T. (2005) Relationship between Falling and QOL of Disabled Elderly People Living at Home. *Japanese Journal of Health Promotion*, **7**, 141-148.

[8] Ministry of Health, Labour and Welfare (2015) Ethical Guidelines for Epidemiological Research. http://www.mhlw.go.jp/general/seido/kousei/i-kenkyu/sisin2.html

[9] Katoi, M. and Yamasaki, H. (2002) Measurements of Isometric Hip Abduction Force with a Hand-Held Dynamometer-Effect for Interrater Reliability Using Fixing-Belt. *Kochi Rehabilitation College Bulletin*, **4**, 7-11.

[10] Toshinobu, O. (2005) Up & Go Test. *Physical Therapy*, **22**, 129-139.

[11] Ikai, T., Tatsuno, H. and Miyano, S. (2006) Relationship between Walking Ability and Balance Function. *The Japanese Journal of Rehabilitation Medicine*, **43**, 828-833. https://doi.org/10.2490/jjrm1963.43.828

[12] Japan Sports Agency (2023) New Physical Fitness Test Implementation Guidelines. https://www.mext.go.jp/sports/b_menu/sports/mcatetop03/list/detail/1408001.htm

[13] Horak, F., Shupert, C. and Mirka, A. (1989) Components of Postural Dyscontrol in the Elderly: A Review. *Neurobiology of Aging*, **10**, 727-738. https://doi.org/10.1016/0197-4580(89)90010-9

[14] Tanaka, S., Murata, S., Yamasaki, S., Horie, J., Miyazaki, J., Kubo, A., *et al.* (2014) Effects of Lower Limb Strength on Balance and Motion Ability in Community. *Japanese Journal of Health Promotion and Physical Therapy*, **3**, 163-167. https://doi.org/10.9759/hppt.3.163

[15] Noriaki, I. (2010) Exercise Therapy for Functional Impairment in the Elderly. Bunkoudou. https://www.bunkodo.co.jp

[16] Forssberg, H. and Nashner, L. (1982) Ontogenetic Development of Postural Control in Man: Adaptation to Altered Support and Visual Conditions during Stance. *The Journal of Neuroscience*, **2**, 545-552. https://doi.org/10.1523/jneurosci.02-05-00545.1982