

Original Paper

Exploratory Study on Fall History in Elderly People Using Day Care - Association between Physical Performance and Cognitive Function -

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Abstract

This study aimed to clarify the relationship between the presence of falls and the evaluation of cognitive and physical functions among elderly day care users. A total of 26 elderly people in day care participated in this study. Participants were divided into two groups, fall group and no-fall group, and their cognitive and physical functions were compared. The results showed that TMT-Part B, one-leg standing time, and Timed Up and Go (TUG) scores were significantly decreased in the fall group. TUG showed a moderate correlation with TMT-Part A and TMT-Part B, and the odds ratio of the fall was 7.5 for TUG and 6.0 for TMT-Part B. Therefore, these results suggest that a decrease in visual attention function may affect falls.

1. Introduction

Falls are one of the health problems associated with aging among elderly people and causes injury-related hospitalization, loss of independence, and reduced quality of life^{1,2}. Therefore, factors related to falls should be carefully considered and preventive measures should be examined. Previous studies have reported a relationship between physical function and factors associated with falling. The following have been indicated as physical factors responsible for falls: Lowering of walking speed³, lowering of leg muscle force⁴, and lowering of one-leg standing time with eyes open^{5,6}. The presence or absence of a relationship with cognitive decline and dementia risk has been reported as the factor affecting falls⁷⁻⁹.

In particular, a decline in executive function has been reported as a cause of falls^{10,11}. The executive function is defined as a set of cognitive functions required to plan, monitor, and execute a set of goal-oriented complex actions¹².

Decreased segmental and selective attention forming the basis of executive function are known to be more markedly reduced in elderly people with mild cognitive impairment (MCI) than in healthy elderly people^{13,14}. Decreased executive function is associated with decreased walking speed and increased risk of falls^{15,16}. Previous studies have often involved community-dwelling elderly people. However, some of the elderly people in the community need nursing services and social support, and the background factors seem to differ greatly.

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The purpose of this study was to investigate the relationship between falls and physical and cognitive functions of the elderly people in day care.

2. Methods

2.1 Participants

This study was conducted at Outpatient Rehabilitation RirakuRiha AIZU (Kiyose City, Tokyo, Japan). The subjects were elderly people aged ≥ 65 years, and out of 47 participants who received research cooperation between July 2018 and October 2019, 26 were able to perform all the test items in this study. The diseases included MCI (61.5%), Alzheimer's disease (23.1%), and others (15.4%). The exclusion criteria included informed consent not being obtained for patients' medical history of cerebrovascular and mental disorders and disease states causing delirium. In this study, we used the definition of falling provided by Gibson et al¹⁷, "unintentionally coming to the ground or some lower level and other than as a consequence of sustaining a violent blow, loss of consciousness, sudden onset of paralysis as in stroke or an epileptic seizure." Those who had fallen within 1 year from the evaluation point were defined as the fall group and those who did not fall were defined as the no-fall group. This study was approved by the Ethics Review Committee of Kawasaki University of Medical Welfare (Approval Number 18 -109).

2.2 Measurements

2.2.1 Physical function assessment

Physical functions were measured by grasping power of both hands, lower leg circumference diameters of both sides as an index of muscle force, maintenance time of one-leg standing position as an index of balance function, and Timed Up and Go (TUG) test as a dynamic test. The TUG test involves a task in which a person is asked to stand up from a sitting position, walk to a cone 3 m far, walk around the cone, and walk again to a chair 3 m far. Based on previous studies, the cutoff time for the one-leg standing test was set at 5 seconds to assess the presence or absence of balance impairment¹⁸. Then, the cutoff time for the TUG test was set to 13.5 s¹⁹.

2.2.2 Cognitive function assessment

Cognitive functions were measured using the Mini-Mental State Examination (MMSE), Raven's Colored Progressive Materials (RCPM), and Trail Making Test in Japanese version (TMT)²⁰. Based on the cutoff time of TMT set to each generation, with/without attention disorder was evaluated. Then, the Clinical Dementia Rating (CDR) was used to evaluate the general seriousness of dementia.

2.3 Statistical analysis

In the analyses, normality was determined using the Shapiro-Wilk test. Comparison of each measurement between the fall and no-fall groups was made using the Mann-Whitney U test, a nonparametric test, with normality testing. Then, the relationship between TUG and cognition function test was examined using the Spearman correlation coefficient. SPSS version 24 for Windows was used for the statistical analysis, and the significance level was 5%.

3. Results

3.1 Physical function

The attributes and test results of 14 subjects with falls and 12 subjects without falls are shown in Table 1. Regarding physical performance, the fall group showed a significant decrease in the left and right one-leg standing time and TUG compared with the no-fall group. There was no significant difference between the right and left grip strength and the left and right leg circumference in both groups. Based on the right leg one-leg standing time, 41.7% (5/12) in the group without fall and 78.6% (8/14) in the group with fall were judged as having balance disorder. The odds ratio of the right leg standing time was 1.8.

Based on the left leg one-leg standing time, 50% (6/12) in the group without fall and 71.4% (10/14) in the group with fall were judged as having balance disorder. The odds ratio of the left one-leg standing time was 2.5.

In the TUG test, those who did not fall and who fell for <13.5 s accounted for 75% (9/12) and 28.6% (4/14),

respectively, with an odds ratio for falling of 7.5 (Table 2).

3.2 Cognitive function

Table 3 shows the results of cognitive function tests in the no-fall group and fall group. In TMT-Part B,

Table 1 Patients' characteristics

Variable		Falls (n = 14)	No falls (n = 12)	p value
Age, years		82.7 ± 3.8	82.9 ± 4.4	0.899
Sex, male/female		7/7	8/4	–
CDR 0/0.5/1		2/9/3	2/7/3	–
Body weight [kg]		61.8 ± 12.0	53.0 ± 13.8	0.053
Grip strength [cm]	R	20.2 ± 6.7	20.7 ± 9.0	0.983
	L	18.3 ± 7.0	19.8 ± 9.3	0.899
Crus circumference	R	34.5 ± 3.8	32.9 ± 3.8	0.252
	L	34.6 ± 4.1	33.0 ± 3.6	0.347
One-leg standing Time [times]	R	4.7 ± 5.0	22.0 ± 19.2	0.017*
	L	3.1 ± 3.8	11.2 ± 13.4	0.041*
TUG [s]		18.15 ± 8.4	12.0 ± 2.1	0.031*

CDR, Clinical Dementia Rating, TUG; Timed Up and Go Test. *p < 0.05

Table 2 Odds ratio between one-leg standing time and TUG and history of falls

			Falls	No falls	Odds ratio
Balance disorder	R	+	8	5	1.8
		–	6	7	
	L	+	10	6	2.5
		–	4	6	
TUG	Cutoff less than		4	9	7.5
	excess		10	3	

TUG; Timed Up and Go Test.

Table 3 Cognitive function

	Falls (n = 14)	No falls (n = 12)	p value
MMSE	23.5 ± 3.7	24.3 ± 3.7	0.494
RCPM	24.1 ± 4.9	25.0 ± 6.0	0.462
TMT-A [s]	111.1 ± 64.8	72.6 ± 13.0	0.297
TMT-B [s]	299.6 ± 167.2	173.6 ± 72.26	0.027*

*p < 0.05

MMSE, Mini-Mental State Examination; RCPM, Raven's Colored Progressive Matrices Test; TMT-A, Trail Making Test Part A; TMT-B, Trail Making Test Part B

the fall group showed a significantly lower performance than the no-fall group. There were no significant differences in MMSE, RCPM, or TMT-Part A. In the TMT-Part B, 85.7% (12/14) of the subjects in the fall group exceeded the cut-off value. In the no-fall group, 50% (6/12) exceeded the cutoff value. The odds ratio for TMT-PartB was 6.0 (Table 4).

3.3 Correlation between TMT and physical performance

The relationship between TMT of cognitive function test and one-leg standing time with eyes opened and TUG of physical performance evaluation with significance between the two groups was examined using the Spearman's correlation coefficient. As a result, significant moderate correlations were observed between TUG and TMT-Part A ($r = 0.411$, $p < 0.05$) and between TUG and TMT-Part B ($r = 0.483$, $p < 0.05$) (Table 5).

Table 4 Trail making test and presence or absence of falls

			Falls	No falls	Odds ratio
TMT-A	attention deficit	+	9	7	1.3
		-	5	5	
TMT-B	attention deficit	+	12	6	6.0
		-	2	6	

TMT-A, Trail Making Test Part A; TMT-B, Trail Making Test Part B

Table 5 Relationship among TMT, one-leg standing time, and TUG

		TMT-A	TMT-B
One-leg standing time	R	-0.327	-0.130
	L	-0.295	-0.332
TUG		0.411*	0.483*

Spearman's rank correlation coefficient: * $p < 0.05$

TMT-A, Trail Making Test Part A, TMT-B, Trail Making Test Part B, TUG; Timed Up and Go Test.

4. Discussion

In this study, we classified elderly day care users into the no-fall group and fall group and investigated the relationship between physical performance and cognitive function related to falls.

4.1 Relationship between the cognitive function and the presence or absence of falls

Among the cognitive functions, significant difference was observed in TMT-Part B between the no-fall group and fall group. TMT-Part A mainly reflects the speed of visual retrieval, whereas TMT-Part B reflects the switching of information manipulation and attention in working memory²¹⁾. These functions are considered as the basis of execution functions. In particular, TMT-Part B had a higher odds ratio than TMT-Part A for the association with the presence of falls and was strongly associated with TUG. With regard to the relationship between performance and falls, a study demonstrated that people with reduced performance have lower walking speed and higher fall risk^{15,16)}.

Additionally, the visual attention function seems to be related to a person's attitude on the risk of the fall^{22,23)}.

MMSE and RCPM are indicators of verbal and nonverbal cognitive function, respectively. In the cognitive function test of the fall group in this study, the performance was lowered in TMT-Part B, and the correlation with TUG was also high. It is considered that higher attention functions such as working

memory and switching of attention were related to walking ability rather than memory and intellectual ability.

The study population had a high proportion of patients with MCI or mild Alzheimer's disease, and many of these patients had comorbid attention disorder or executive function. Therefore, MCI and lowering of visual attention function in patients with early Alzheimer-type dementia indicates the possibility of affecting falls.

On the other hand, one-leg holding time with eyes open was not related to visual attention function, and it seemed to become a factor related to the falls history as an independent factor of physical performance.

4.2 Comparison of physical performance

The TUG and one-leg standing time with eyes open were significantly lower in the fall group than in the no-fall group. The one-leg standing time with eyes open has been used as an index especially related to balance ability. In addition, the TUG test is internationally recommended in the guidelines as a fall risk assessment and is a comprehensive index related to falls¹⁹⁾. Also, the lower leg circumference has been associated with muscle strength. Therefore, it is possible that the physical performance related to balance ability and applied walking was lower than the muscle strength in the fall group in this study.

4.3 Relationship between physical performance and falls

The odds ratio associated with history of falls was higher in TUG than in one-leg standing time with both eyes opened. The TUG test evaluates the applied walking ability such as leg muscle strength, balance, walking ability, and easily tipping over, and the relationship with the daily life function is also high⁸⁾. Shumway-Cook et al. reported 87% sensitivity and 87% specificity scale with regard to the association of TUG with fall prediction (identifying elderly individuals who are prone to falls) in community-dwelling elderly people¹⁹⁾. Although the study participants were daycare users including those with MCI and mild Alzheimer's disease, TUG was considered to be an effective fall risk assessment index as well as the community-dwelling elderly people.

4.4 Study limitations

This study targeted the elderly people in day care. However, the number of cases was small, and the number of patients with MCI and mild Alzheimer-type dementia could not be controlled. In the future, we would like to increase the number of participants and examine the usefulness of TMT-Part B in the cognitive function test for predicting falls.

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Conflict of interest

This study is not associated with any conflicts of interest that should be disclosed.

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