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Physical factors underlying the association between lower walking performance and falls in older people: A structural equation model

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ABSTRACT

The purpose of this study was to determine the interrelationships between lower limb muscle performance, balance, gait and falls in older people using structural equation modeling. Study participants were two hundred and thirteen people aged 65 years and older (mean age, 80.0 ± 7.1 years), who used day-care services in Japan. The outcome measures were the history of falls three months retrospectively and physical risk factors for falling, including performance in the chair stand test (CST), one-leg standing test (OLS), tandem walk test, 6 m walking time, and the timed up-and-go (TUG) test. Thirty-nine (18.3%) of the 213 participants had fallen at least one or more times during the preceding 3 months. The fall group had significantly slower 6 m walking speed and took significantly longer to undertake the TUG test than the non-fall group. In a structural equation model, performance in the CST contributed significantly to gait function, and low gait function was significantly and directly associated with falls in older people. This suggests that task-specific strength exercise as well as general mobility retraining should be important components of exercise programs designed to reduce falls in older people.

1. Introduction

Falling is the leading cause of severe injury, such as hip fracture, in older people (Lord et al., 2001), and fall-related fractures are recognized as the third most important factor used in calculating care insurance for frail older people in Japan (Ministry of Health, Labour and Welfare, 2002). Many studies have identified physical risk factors for falls, including: muscle weakness (Whipple et al., 1987; Tinetti et al., 1988; Campbell et al., 1989; Nevitt et al., 1989; Robbins et al., 1989; Studenski et al., 1991), inability to maintain static or dynamic balance (Overstall et al., 1977; Brocklehurst et al., 1982; Tinetti et al., 1988; Campbell et al., 1989; Nevitt et al., 1989; Studenski et al., 1991; Clark et al., 1993; Lord et al., 1994), reduced walking speed (Himann et al., 1988; Campbell et al., 1989; Nevitt et al., 1989), and poor tandem gait (Buchner and Larson, 1987; Nevitt et al., 1989). Falls result from interactive etiological factors, not simply from the additive effects of multiple pathologies or physical disabilities. It is clear from the evidence that at least a previous fall and/or poor balance and a gait disorder may be predictive of those at highest risk (NICE, 2004). Furthermore, muscle weakness makes a considerable contribution to falling and is a marker of physical functioning in older people (Perell et al., 2001).Muscle weakness, poor balance, and lower walking performance are independently associated with falling in older people. De Rekeneire et al. (2003), for example showed with multivariate logistic regression models that white race, slow 6 m walking speed, poor standing balance, inability to do five chair stands, urinary incontinence, and poor leg muscle strength are independently associated with falling in older men. If these physical risks are independently associated with falling, exercise programs that improve muscle strength and balance and include gait exercises, should be effective in preventing falls in older people. Despite this being evident in individually tailored exercise programs for preventing falls (Campbell et al., 1997, 1999; Robertson et al., 2001), the effects of single component exercise programs are not clear. Furthermore, the published evidence suggests that the interaction between falls, muscle weakness, poor balance, and lower walking performances in older people is unclear. It would therefore be useful to identify the interactions between risk factors for falls on the one hand and the occurrence of

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falls on the other, because a better understanding of these interactions will allow for more effective targeting of intervention strategies.

The purpose of this study was to explore the interrelationships among measures of physical function and falls in older people using structural equation modeling. A structural equation model was developed based on a theoretical model of the relationships between falls and the physical measurements previously found to be associated with the risk of falling (Perell et al., 2001; NICE, 2004). To select the structural equation model, we considered the WHO classification of disabilities and our previous study (WHO, 1980; Lord et al., 1996). In this classification, the parameters are separated into the following two categories: lower muscle function and poor balance resulting from impaired sensorimotor functions; and lower functional mobility resulting from lower muscle and balance functions. Thus, the structural equation model was constructed in two stages by explanatory variables that were associated with falls. We considered that lower muscle function and poor balance were indirectly associated with falls and lower functional mobility was directly associated with falls because approximately 65% of falls occur during ambulation or during postural transfers (Tinetti et al., 1988; Arnold and Faulkner, 2007).

2. Subjects and methods

2.1. Participants

The participants were 213 people aged 65 years or older (65–96 years) who had used day-care services in Japan in the previous year. The exclusion criteria for the study were an inability to walk independently or perform the physical assessments, or cognitive impairment (3 or more errors on a validated mental status questionnaire, Kahn et al., 1960). Table 1 shows the characteristics of the study participants, which includes dependence in activities of daily living (ADL) and the MOS Short-Form 8-Item Health Survey™ (SF-8) (Fukuhara and Suzukamo, 2004). The dependent status in toileting, incontinence, and climbing/descending stairs was evaluated as basic ADL. The SF-8 as a measurement of health related quality of life was scored on the norm-based metrics, standard value 50 points and standard deviation 10 points, using Excel macro-program.

Informed consent was obtained from all participants prior to the commencement of study participation. The Ethics Committee of the Tokyo Metropolitan Institute of Gerontology approved the study protocol.

2.2. Measurements

2.2.1. Falls

A fall was defined as an event that resulted in a person coming to rest unintentionally on the ground or other lower level, not as the result of a major intrinsic event or an overwhelming hazard (Nevitt et al., 1989). Participants or their caregivers recorded via a questionnaire falls experienced in the previous three months. A three-month period was chosen as it has been shown that under estimation of fall history results from the use of longer-term recall methods in older adults (Cummings et al., 1988).

Table 1
Characteristics of the participants.

Parameters	
Age (year): median (IQR)	81.0 (12.0)
Female, *n* (%)	130 (61.0)
Dependent in ADL, *n* (%)	
Toileting	2 (0.9)
Incontinent	10 (4.7)
Climbing/descending stairs	62 (29.1)
Mental status questionnaire (error response), median (IQR)	1.0 (2.0)
SF-8, median (IQR)	
Summary score for physical component[a], mean ± S.D.	45.4 ± 10.6
Summary score for mental component[a], mean ± S.D.	49.3 ± 11.3

[a] *Note*: There were 10 missing values.

2.2.2. Physical assessments

All participants were assessed for functional lower limb strength with the CST, 5 times, for balance function with the OLS and tandem walk tests, and for functional mobility with the 6 m walking time and TUG-test. The assessment measures were conducted by day-center staff who had nursing, allied health or similar qualifications. Prior to the commencement of the study, all staff received training from the authors (HS and MS) in the correct protocols for administering all of the assessment measures included in the study. The assessors conducted introduction and practice of the physical assessments to facilitate understanding of the tests to the participants before the tests. The assessors were not blinded to fall data.

The CST is traditionally used as a measure of lower limb muscle function (Csuka and McCarty, 1985) and is included in a number of comprehensive falls risk assessment tools (Tinetti, 1986; Berg et al., 1992; Smith, 1994). The CST task in this study involved sitting down and standing up five times from a standing position. The participants who could not sit to stand without support were permitted to use their arms. The task in the CST was completed as quickly as possible and the time taken, in seconds, was the score. The CST is usually performed without using one's arms. However, we used the results of the CST with and without arms as the CST to ensure sufficient participants.

The OLS test consisted of attempting to stand on one leg for 120 s. For the OLS, two trials were performed and the maximum time obtained was the final score. The participants performed the OLS task on preferred leg. The OLS test has confirmed reliability (Curb et al., 2006). The tandem walk test measures participants' ability to walk with the feet placed in the tandem position (one foot directly in front of the other) during the double support period of the gait cycle. The constraint placed on the foot position presents a challenge to the postural control system, as the base of dynamic support is significantly reduced, causing a reduction in medio-lateral stability (Lord et al., 2001). The tandem walk test was measured by counting the number of successful steps while the participants walked toe to heel. The scoring method is similar to the functional gait assessment which has confirmed reliability (Wrisley et al., 2004). In this study, participants attempted twice to walk for a maximum of ten steps.

Slowed gait speed has previously been associated with an increased risk of falls (Imms and Edholm, 1981; Bootsma-van der Wiel et al., 2002) and it is a factor that is included in several falls risk assessment scales with a variety of protocols (Podsiadlo and Richardson, 1991; Piotrowski and Cole, 1994). In this study, the participants walked once on a flat surface at their "comfortable walking speed" for 6 m. Two markers indicated the start and end of the 6-m path. A 3-m approach was allowed before reaching the start marker so that the participants were walking at their normal pace within the timed path. The participants were also instructed to continue walking past the end of the 6-m path for a further 3 m to ensure that their walking pace was consistent throughout the task. The time taken to complete the task, measured in seconds, was the score.

The TUG test was measured once at the participant's comfortable pace. The TUG test includes basic mobility skills, including rising from a chair, walking 3 m, turning, returning to the chair and sitting down. Podsiadlo and Richardson (1991) validated the TUG in 60 elderly patients at a geriatric day hospital. It correlates significantly with the Berg balance scale (BBS) (r = 0.81), gait speed (r = 0.61), and the Barthel index (BI) (r = 0.78). The TUG test is one of the most frequently utilized test of gait for assessing fall risk in older people (NICE, 2004). If a walking aid was usually used inside the home, then the walking aid was used during the 6-m walking test and the TUG test.

2.2.3. Statistical analysis

The participants were categorized into faller and non-faller groups based on their three-month fall histories. Mann–Whitney test and χ^2 test were used to compare the differences in age, sex, physical tests, and using arms during the CST task between the faller and non-faller groups because these variables showed non-normally distribution for Kolmogorov–Smirnov test. Spearman correlation coefficient was calculated for setting up a structural equation model. A structural equation model provides estimates of the magnitude and significance of the hypothesized simultaneous causal connections between the risk factors and falls. Structural equation modeling is an extension of the general linear model, in which a hypothesis-driven diagram is constructed to explain the direction of associations between multiple dependent variables simultaneously (Stevens, 1996). Our hypothesized model in interrelation between falls and physical tests was composed of two stages: direct relationship between falls and physical tests; and indirect relationships mediated by gait performance between falls and the CST and balance. The absolute and relative goodness of fit were then assessed using the χ^2 statistic, the Tucker–Lewis index (TLI), and the comparative fit index (CFI). Variables with non-normally distribution were $\log_{10}$ transformed in structural equation modeling. Descriptive and basic statistical analyzes of the data were performed using the SPSS 15.0 software package (SPSS Inc., Chicago, USA), and Analysis of Moment Structures (AMOS) Graphics Version 7 software (Small Waters Corp., Chicago, USA) was used to investigate structural equation modeling.

3. Results

3.1. Differences in age, sex, physical tests, and using arms during the CST task between the faller and non-faller groups

During the three-month follow-up period, 39 participants (18.3%) experienced at least one fall. The fall group had significantly slower 6 m walking speed and took significantly longer to undertake the TUG test than the non-faller group (Table 2). There were no significant differences on the other physical measurements and using arms during the CST task between the faller and non-faller groups.

3.2. Relationship between physical tests

Slight correlations were shown between the CST and the 6 m-walking time and TUG, and between the OLS and tandem walk, 6-m-walking time and TUG (r = −0.18 to 0.39). The 6-m-walking time and TUG correlated moderately in the older participants (r = 0.69) (Table 3).

Table 2
Comparison of age, sex, and physical assessments between fallers and non-fallers.

Parameters	Non-fall group	Fall group	p value
Age (year), median (IQR)	81.0 (11.0)	80.0 (16.0)	0.964
Sex, n (%)			
Male	64 (77.1)	19 (22.9)	0.167
Female	110 (63.2)	20 (15.4)	
CST (s), median (IQR)	12.0 (6.1)	12.1 (7.7)	0.834
OLS (s), median (IQR)	4.0 (6.0)	3.0 (4.0)	0.310
Tandem walk (step), median (IQR)	4 (8.3)	2.0 (8.0)	0.125
6-m-walking time (s), median (IQR)	7.6 (4.6)	9.4 (4.5)	0.012
TUG (s), median (IQR)	13.3 (6.0)	16.0 (10.0)	0.030

Table 3
Correlation matrix of physical performance measurements.

Parameters	CST	OLS	Tandem walk	6m-walking time	TUG
CST	1.00	−0.05	0.06	0.37**	0.39**
OLS		1.00	0.34**	−0.18*	−0.23**
Tandem walk			1.00	−0.13	−0.12
6m-walking time				1.00	0.69**
TUG					1.00

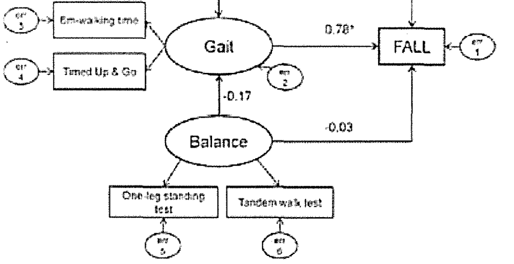
* $p < 0.05$.
** $p < 0.01$.

3.3. Interrelationships between functional lower limb strength, balance, gait and falls

The structural equation model is shown in Fig. 1. Standardized regression weights are shown for the associations between each variable. Functional lower limb strength and balance function contributed significantly to gait function, and low gait function was significantly associated with falls in the older participants. The χ^2 test was not significant (χ^2 = 2.9, df = 6, p = 0.82), indicating a good model fit. The TLI value (1.06) and the CFI value (1.00) also indicated a good model fit.

4. Discussion

The faller group showed significantly decreased performances in the 6 m-walking time and TUG test as a gait performance compared to the non-faller group although functional lower limb strength and balance did not show significant differences between the groups. The walking speed at a comfortable pace was the best test for use as a screening tool of falls in frail older adults when feasibility and validity were considered (Shimada et al., 2009). The TUG test is widely used as a measure to screen for fall risk, and recent studies support the predictive ability of this test for use with older people (Large et al., 2006; Kristensen et al., 2007). These significant tests showed moderate correlation in the older participants. The results suggest that the gait tests (TUG and 6m walking speed) were better at discriminating between older fallers and non-fallers than the CST, OLS, and tandem walk tests.



χ^2 = 2.9, df = 6, p = 0.82; TLI = 1.06; CFI = 1.00

Fig. 1. The structural equation model illustrating the association between falls and the risk factors for falling. The structural equation model was constructed in two stages by explanatory variables that were associated with falls. The two stages included lower muscle function and poor balance resulting from impaired sensorimotor functions and lower functional mobility resulting from lower muscle and balance functions. *Notes*: * $p < 0.05$, ** $p < 0.01$, standardized regression weights are shown for the associations between each variable.

When a structural equation model was devised to illustrate the causal relationship between falls and the physical study measures, gait function (as measured by the TUG and 6 m walk tests) was directly associated with falls. Additionally, functional lower limb strength (as measured with the CST) was included in the model as a significant underlying explanatory variable of gait function which was indirectly associated with falls. These results suggest that of the variables included in this analysis, gait function was the strongest correlate of falls and it was underpinned by tests of functional lower limb strength, which indirectly affected the occurrence of falls. The validity of the model in this study is supported by a previous study which identified lower limb muscle strength as a predictors of variable gait parameters (Lord et al., 1996). Moreover, rising from a chair and sitting down, which are components of the CST task, includes the TUG task.

One of the limitations of this study was that falls were measured retrospectively with a self-report method, which is known to be less accurate than prospective measurement. This may have led to an underreporting of falls in the study sample, although the participants only recalled the history of falls over three months. Second, we acknowledge that, because the study design excluded the frailest people who were immobile and could not undergo the physical examinations and people with cognitive impairment, the primary findings regarding the relationship between falls and the parameters tested cannot be generalized to these groups. Third, the structural equation model was constructed from the CST, OLS, tandem walk test, 6-m walking time, and TUG tests. Thus, the result of our model is limited by the measurement variables.

These study results have implications for the prevention of falls in older people. The model developed suggests the importance of gait interventions in preventing falls and that exercise programs which aim to reduce fall risk factors should include specific gait training elements.

In summary, the structural equation model revealed the associations between reduced performances in the CST and balance and falls were mediated primarily by impairments in gait function. This suggests that task-specific strength and balance training as well as general mobility retraining should be important components of exercise programs designed to reduce falls in older people.'

Conflict of interest statement

None.

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The Relationship between the Subjective Risk Rating of Specific Tasks and Falls in Frail Elderly People

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Abstract. [Purpose] The purpose of this study was to determine whether a subjective risk rating for falls is more valuable than other screening tools in relating falls in frail elderly people. [Subjects] The study included 232 elderly subjects (48 men, 184 women, mean age 82.8 ± 6.3 years) who had been using day care services. [Methods] Data included history of falls during the previous year, the subjective risk rating of specific tasks (SRRST), which is composed of seven questions, and potential confounding factors including demographic variables, primary diseases or general health status, physical performance, and behavioral variables. To determine the independent factors related to falls, a multiple logistic regression analysis was used to measure odds ratios adjusted for all measurement variables. [Results] Eighty-one subjects (34.9%) had fallen during the previous year. In the multiple logistic regression analysis, a significant relationship was found only with the SRRST score (odds ratio; 1.22). [Conclusion] The SRRST is related independently with falls, and may be useful for determining interventions for preventing falls, such as the supervision approach in the frail elderly people.
Key words: Falls, Aged, Day care service

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INTRODUCTION

Frail elderly adults have a higher risk of falls and fall-related injuries than healthy elderly people[1]. In our previous study of 8,335 frail elderly adults utilizing day-care services, the rates of falls and fall-related fractures during a 1-year period were 25.3% and 9.7%, respectively[2]. That national survey revealed that frail elderly people utilizing long-term care insurance had a higher rate of fall-related fractures than healthy elderly people[3]. Fall-related fractures, especially hip fractures, cause disability in activities of daily living (ADL) in this population[1,4]; thus, health care providers must take care to prevent falls in their clients.

For prevention of falls in the elderly adults, numerous studies have identified risk factors associated with falling in the frail elderly adults. Moreland et al. studied falls in institutionalized elderly adults and reported the following critical risk factors: low cognitive functions, depression, urinary incontinence, hypotension, dizziness, hearing and visual impairment, balance and gait disturbances, lower extremity impairments, ADL disability, use of a walking aid, low physical activity, use of psychotropics and analgesics, and mechanical restraint[5]. The frail elderly have multiple risks for falls and some risks cannot be improved by intervention[6]. Thus, a multifactorial evaluation and intervention is required to determine how to prevent falls in the frail elderly adults[7]. However, we have found that about half of frail elderly subjects cannot complete physical performance tests such as the functional reach test and tandem walk test[8].

Some subjective assessments by care staff have been developed for identifying the fall risks in frail elderly adults[9–11]. Care staff members possess knowledge of their residents' potential fall risk, and this encompasses both predisposing and precipitating factors. Therefore, their global assessment of fall risks could have the highest predictive value[11]. In this study we aimed to clarify whether a subjective risk evaluation of falls is more valuable than other assessment measures in relating falls in frail elderly adults.

SUBJECTS AND METHODS

The study included 232 elderly people (48 men, 184 women, mean age 82.8 ± 6.3 years) who had received certification for long-term care, and who used day-care services between September 2009 and March 2010. Exclusion criteria were as follows: heart attack or stroke within the previous 6 months, acute inflammation, systolic blood pressure ≥180 mmHg or diastolic blood pressure ≥110 mmHg, resting heart rate ≥120, severe cognitive impairment (mental status questionnaire (MSQ) score 9 to 10), or an order by a general practitioner to stop all physical activity. General practitioners ruled on participation in the study by subjects with any of the following conditions: cerebrovascular disease, Alzheimer's disease, heart disease, diabetes, orthopaedic pain and neurological symptoms. Table 1 shows the characteristics of the study subjects. The ethical consideration in this study was secured by performing the study after having received the approval of the Ethical Review Board of Tokyo Metropolitan Institute of Gerontology, and the contents of this research was based on the Declaration of Helsinki.

Table 1. Characteristics of the subjects

Demographic variables	n = 232
Age (years)	82.8 ± 6.3
Sex (female)	184 (79.3)
Category of Japanese Long-Term Care Insurance	
Support Level 1	30 (12.9)
Support Level 2	50 (21.6)
Care Level 1	75 (32.3)
Care Level 2	48 (20.7)
Care Level 3	24 (10.3)
Care Level 4	5 (2.2)
Care Level 5	0 (0)
Primary diseases or general health status	
History of stroke (yes)	26 (11.2)
Parkinson disease (yes)	13 (5.6)
Knee osteoarthritis with pain (yes)	76 (32.8)
Poor vision (yes)	14 (6.0)
Urinary incontinence or frequency (yes)	64 (27.6)
Psychotropic use (yes)	79 (34.1)
Walking aid use (yes)	99 (42.7)
Physical performances	
Chair Stand Test (s)	12.5 ± 5.2
Timed Up and Go test (s)	15.6 ± 8.5
Behavioural variables	
Absence of habitual exercise (yes)	126 (54.3)
Daily use of slippers or sandals (yes)	70 (30.2)

Variables presented as mean ± standard deviation, or number (%)

The subjective risk rating of specific tasks (SRRST) was conducted by day-care center staff who had nursing, allied health or similar qualifications. Prior to the commencement of the study, all staff received a manual which set out correct protocols for administering all the assessment measures included in the study. The raters of the SRRST were limited to the care staff who well knew the ADL status of their clients. The SRRST consisted of the following items: 1) "Do you feel there is a risk of falls when the client (Mr or Mrs X) is walking?"; 2) "Do you feel there is a risk of falls when the client is transferring to the bedroom, toilet, or bathroom?"; 3) "Do you feel there is a risk of falls when the client is toileting?"; 4) "Do you feel there is a risk of falls when the client is ascending or descending stairs?"; 5) "Do you feel there is a risk of falls when the client is wandering?"; 6) "Do you feel there is risk of falls because the client exhibits risky behavior?"; 7) "Do you feel there is a risk of falls because the client is agitated?". The responses to each item in the SRRST were designated as "yes" (1 point) or "no or not applicable" (0 point). The SRRST and history of falls were obtained at the same time. Prior to the commencement of the study, three assessors completed the SRRST twice at weekly intervals for 30 subjects (n = 3 × 2 × 30), and the test-retest and inter-rater reliability comparisons of total scores revealed intraclass correlation coefficients (ICCs) of 0.91 (ICC 1, 1) and 0.85 (ICC 2, 3), respectively.

A fall was defined as "an event that resulted in a person coming to rest unintentionally on the ground or another lower level that did not result from a major intrinsic event or an overwhelming hazard"[12,13]. Falls and fall-related fractures were measured retrospectively for a 1 year period via a self-report questionnaire. A caregiver or family member provided information on the participant's annual incidence of falls and fall-related fractures when the trained nurses or care workers recognized that a participant had problems recalling such events.

With reference to previous studies[14–18], we selected two demographic variables, seven primary diseases or general health statuses, two physical performance tests, and two behavioural variables as possible confounding factors for falls (Table 2). The demographic variables were sex and age. Primary diseases or general health status were recorded by the care staff, who identified the chronic condition from care records or symptoms. The following diseases and general health status were included in the analysis: history of stroke with symptoms of hemiparesis, knee osteoarthritis with pain, Parkinson's disease, poor vision, urinary incontinence or frequency, psychotropic use, and walking aid use. Physical performances were measured using chair stand test (CST) and timed 'up & go' test (TUG). The CST was used as an index to reflect the strength of the legs[19]. The time required for standing up and sitting down five times as fast as possible was measured twice, with the quickest value taken as the representative value. The TUG

Table 2. Comparison of all measures between the fallers and non-fallers

	Fallers (n = 81)	Non-fallers (n = 151)
Age (years)	83.4 ± 6.6	82.5 ± 6.1
Sex (female)	64 (79.0)	120 (79.5)
Category of Japanese Long-Term Care Insurance (care level 3 to 5)	14 (17.3)	15 (9.9)
History of stroke (yes)	9 (11.1)	17 (11.3)
Parkinson disease (yes)	3 (3.7)	10 (6.6)
Knee osteoarthritis with pain (yes)	31 (38.3)	45 (29.8)
Poor vision (yes)	5 (6.2)	9 (6.0)
Urinary incontinence or frequency (yes)	31 (38.3)	33 (21.9) **
Psychotropic use (yes)	27 (33.3)	52 (34.4)
Walking aid use (yes)	43 (53.1)	56 (37.1)*
Chair Stand Test (sec)	12.6 ± 5.7	12.4 ± 5.0
Timed Up and Go test (sec)	17.1 ± 10.0	14.9 ± 7.5
Absence of habitual exercise (yes)	47 (58.0)	79 (52.3)
Daily use of slippers or sandals (yes)	27 (33.3)	43 (28.5)
SRRST (points)	3.1 ± 1.8	2.2 ± 2.0**

*p < 0.05; **p < 0.01. SRRST: subjective risk rating of specific tasks

Table 3. Relationship between history of falls and potential risk factors of falls

	Odds ratio	95% CI
Age (years)	1.01	0.97 - 1.06
Sex (female)	0.89	0.43 - 1.85
Category of Japanese Long-Term Care Insurance (care level 3 to 5)	1.52	0.65 - 3.57
History of stroke (yes)	1.60	0.63 - 4.05
Parkinson disease (yes)	2.99	0.67 - 13.32
Knee osteoarthritis with pain (yes)	1.05	0.54 - 2.04
Poor vision (yes)	1.35	0.39 - 4.76
Urinary incontinence or frequency (yes)	0.58	0.29 - 1.15
Psychotropic use (yes)	0.96	0.51 - 1.79
Walking aid use (yes)	0.68	0.35 - 1.30
Chair Stand Test (sec)	0.96	0.91 - 1.03
Timed Up and Go test (sec)	1.02	0.98 - 1.06
Absence of habitual exercise (yes)	1.33	0.68 - 2.63
Daily use of slippers or sandals (yes)	0.80	0.43 - 1.52
SRRST (points)	1.22	1.03 - 1.45*

*: p < 0.05

is a movement ability test for elderly people advocated by Podsiadlo et al.[20] and applies the Get-up and Go test by Mathias et al.[21] which measures the speed of accomplishing a round trip of a 3 m walking distance from a seated position. Absence of habitual exercise and daily use of slippers or sandals were investigated as behavioural variables.

To examine group differences in measurements regarding experience of falls during the previous year, we performed an analysis by the Student t-test and the chi-square test. In addition, to clarify independent risk factors regarding falls, a multiple logistic regression analysis was performed with falls as the dependent variable, and the SRRST and possible confounding factors as the independent variables, and the odds ratio (OR) was calculated. The statistical analysis was performed using PASW Statistics 18, and the significant level was set at 5%.

RESULTS

Eighty one subjects had fallen during the previous year (34.9%). In the group comparison between the subjects with and without the falls, the faller group showed significantly higher rates in urinary incontinence or frequency (faller 38.3%, non-faller 21.9%) and walking aid use (faller 53.1%, non-faller 37.1%), and a higher SRRST than the non-faller group (faller 3.1 ± 1.8, non-faller 2.2 ± 2.0) (Table 2).

The multiple logistic regression models revealed a significant relationship between falls and SRRST while possible confounding factors were not significant (Table 3). The OR of the SRRST score was 1.22 (95% confidence interval (95% CI); 1.03 - 1.45) for falls.

DISCUSSION

In the comparison of fallers and non-fallers, the fallers were found to have higher rates of urinary incontinence and frequency than the non-fallers. Regarding the relationship between urinary incontinence and urinary frequency and falling, we hypothesize that the elderly might trip when they rush to the toilet trying to avoid incontinence[22]. The fallers were more likely to use a walking aid than the non-fallers, although physical performances, i.e., the CST and TUG, were not different between the fallers and non-fallers. The results suggest that the subjects experiencing falls used a walking aid as a strategy to prevent falls while maintaining good physical performances. However, a walking aid may not prevent falls by those with an imbalance between physical capacity and physical activity level. Those with the highest activity levels had a significant lower risk of falls, but those with intermediate levels had no reduced risk of falls[23].

In the multiple logistic model adjusted for all confounding factors, only SRRST was associated independently with falls in our frail elderly subjects. Furthermore, the SRRST had some advantages compared with objective measurements. The SRRST can be evaluated in a short period, and may be used to draw attention to ADLs with high risks. Shimada et al. reported previously on an enhanced supervision approach based on a subjective risk rating method for the prevention of falls among institutionalized elderly people[24]. A falls prevention intervention reduced the number of fallers and fall rates in the frail elderly adults through close supervision, active interventions, and environmental modifications of targeted fall-risk factors. The SRRST may be a basic assessment tool for identifying the need for an enhanced supervision approach in the frail elderly people. However, future studies need to determine whether the significant relationship between the SRRST score and falls in a longitudinal study is confirmed in a prospective investigation.

In conclusion, the SRRST was significantly associated with falls in frail elderly adults, while potential confounding factors did not have a significant association. The subjective risk rating of falls in the frail elderly may be useful for determining which tasks have a fall risk and interventions, such as the supervision approach.

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The Relationship Between Pulmonary Function and Physical Function and Mobility in Community-Dwelling Elderly Women Aged 75 Years or Older

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Abstract. [Purpose] The purpose of the present study was to evaluate the relationship between pulmonary function and the physical function and mobility of community-dwelling elderly women aged ≥75 years. [Methods] The subjects were 1,022 women aged ≥75 years who were living in an urban environment. We measured their vital capacity (VC) and forced expiratory volume in 1 s (FEV1.0) by spirometry, and assessed their physical function and mobility. [Results] Older women exhibited inferior pulmonary function as well as reduced physical function and mobility. These findings highlight the impact of diminished pulmonary function on physical function in old age. [Conclusions] Women of advanced age have diminished pulmonary function, physical function, and mobility, and diminished pulmonary function is associated with declining physical function. When an examination is required, spirometry should be included as an examination modality for its diagnostic value.
Key words: Pulmonary function, Physical function and mobility, Elderly women

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INTRODUCTION

An investigation that estimated the characteristics of population dynamics in Japan over the next 50 years reported that only the proportion of elderly individuals aged ≥75 years is expected to increase in the near future[1]. We have never experienced so great an aging of the population in our society which is facing a future of relatively fewer children as well as a decline in the population . Among the elderly population aged ≥75 years, declines in psychosomatic and vital functions frequently appear with aging. In particular, because women have a longer average life span, they will require healthcare for longer and the major reason for this is that the age-related changes in the muscular and skeletal systems are more remarkable in women than in men[2].

Older individuals are severely affected with regard to the performance of activities of daily living (ADL) due to a decline in physical function[3–5].

Many physiological functions deteriorate with increasing age, and pulmonary function is no exception. It is very important that we understand the physiological changes seen in the lungs with aging[10,11] as pulmonary function deteriorates linearly with age[12]. Respiratory effort increases with age due to costochondral calcification. In addition, elastic tissues in the lungs, such as in the alveoli, are degraded and the lungs expand[13–15]. Therefore, although the total lung capacity remains unchanged, the residual volume increases with age[16–18]. Furthermore, the maximum expiratory and inspiratory muscular strengths deteriorate with increasing age[19–21]. In addition spirometric measurements have shown that both vital capacity (VC) and forced expiratory volume in 1 s (FEV1.0) decline with age[22–24].

Functional disorders negatively affect physical function and mobility, and it is generally acknowledged that diminishing physical function and mobility influence the quality of life[25]. Studies of physical function of the elderly are becoming more important[6–9]. Regarding the evaluation of the physical function of the elderly, diminished capabilities are commonly encountered in hand-grip strength, gait velocity, timed up-and-go (TUG) at a comfortable speed, and one leg standing time with eyes open. However, the contribution of pulmonary function to the decline in physical function has not been evaluated in any detail. As a result, the relationship between diminishing pulmonary function and physical function and mobility among the elderly population remains unclear.

The purpose of the present study was to evaluate the relationships between pulmonary function and physical function and mobility of community-dwelling elderly women aged ≥75 years.

SUBJECTS AND METHODS

Subjects

We performed systematic comprehensive mass health examinations for elderly women living in the community in order to devise new strategies to increase physical fitness and to prevent the need for long-term care[2]. The participants in the examinations conducted in November 2008 were women aged ≥75 years who were living in Itabashi-ku, Tokyo at that time. From among 1,289 women who provided consent, we included 1,022 women in the present study for whom complete data were available. For the examination, we invited each participant to a meeting and conducted a medical examination and verbal interview. After receiving an explanation of the nature of the study and evaluation methods, all subjects provided their informed consent to voluntarily participate. This study was approved by the Ethical Review Board of Tokyo Metropolitan Institute of Gerontology.

Methods

We measured VC and FEV1.0 by spirometry, and assessed physical function and mobility. We divided the participants by age into two groups (75–79 years and 80–84 years) and compared each measurement result between these groups to examine the influence of age. We also classified pulmonary functional disorders roughly into four categories based on ventilatory characteristics: 1) Normal; 2) Narrowing of the bronchi, and obstructive ventilatory impairment with inadequate expiration; 3) Restrictive ventilatory impairment with inadequate air intake due to insufficient thoracic movement; and 4) A mixed type of the disorders described in 2) and 3). We used these categories to compare each measurement result and examined the influence of these pulmonary functional disorders on the results.

The technical characteristics of the instruments used in addition to the training of technicians are important for obtaining reliable results and for quality control of spirometry. Staff members were specifically trained and received lectures aimed at teaching and reviewing the rationale and practice of spirometric procedures. All pulmonary function tests used in the present study were performed in accordance with the prescribed guidelines[26]. Spirometry was performed using a Chest MI Spirometer (HI-801; Chest, Tokyo, Japan). Each study participant was informed about the methods used for measurements and was given an explanation of the procedures of the examination along with appropriate practice. Spirometric maneuvers were performed with the participants seated in a comfortable position, wearing a nose clip, and the participants expired air was fed to the spirometer via a mouthpiece. All technicians were instructed to perform a minimum of two maneuvers to ensure that the participants produced the highest possible peak flow rates. Participant's VC and FEV1.0 were measured after a rest period of several minutes between maneuvers. Satisfactory exhalation was considered to have been achieved if 1) there was no change in the exhaled volume (plateau on the volume-time curve) for 1 s after an exhalation time of at least 6 s, 2) there was a reasonable duration or plateau in the volume-time curve, or 3) the participant was unable to continue to exhale. The spirometer automatically made the following calculations. Predicted VC = [0.032 × height (cm) − 0.018 × age − 1.178]. From the result obtained, %VC = [VC (measured)/VC (predicted)] × 100 and %FEV1.0 = (FEV1.0 /FVC) × 100, where FVC indicates forced VC. We used %VC and %FEV1.0 for analysis.

The participants also underwent tests for hand-grip strength, knee joint extension strength, comfortable and maximal gait velocities, TUG at comfortable and maximal speeds, and one-leg standing time with eyes open. We evaluated hand-grip strength of the dominant hand with a hand-held dynamometer (TKK5401, Hata Company) and isometric contraction of knee joint extension on the dominant side with a mechanical dynamometer (F1, Anima Company). To test knee joint extension strength, we asked the participants to extend the knee joint through 90 degrees to the best of their ability. To test walking velocity, we asked the participants to walk on a straight and flat walkway, 11 m in length, once at their usual speed and once again at their maximum speed. Walking velocity was measured over a 5 m distance between marks at 3 m and 8 m marked from the end of the walkway. To test TUG[27], we asked participants to stand up from a chair, walk 3 m, turnaround and walk another 3 m, and then sit down on the chair. This task was performed once at the participants' usual speed and then again at their maximum speed. The TUG test was measured as a series of movements using a stopwatch. For the one leg standing time with eyes open, we asked participants to look straight ahead at a spot 1 m in front of them. We then asked them to stand on their preferred leg with their eyes open and hands dangling freely alongside their body. The time until balance was lost, up to a maximum of 60 s, was recorded. We used the better of two trials for analysis.

We used the Life-Space Assessment (LSA) as an index of mobility[28]. LSA is used to assess mobility associated with physical function, health condition, and instrumental ADL (IADL), which are necessary for evaluating the mobility of older individuals[29]. LSA is used to identify the distance over which a person reports moving during the 4 weeks prior to the assessment. The LS zones range from a person's bedroom to beyond their home town. Specific questions are: 1) "During the past 4 weeks, have you been to other rooms of your home besides the room where you sleep?" (level 1) 2) "During the past 4 weeks, have you been to an area immediately outside your home, such as your porch, deck, or patio, to the hallway of an apartment building, or garage?" (level 2) 3) "During the past 4 weeks, have you been to places in your immediate neighborhood, but beyond your own property or apartment building?" (level 3) 4) "During the past 4 weeks, have you been to places outside your immediate neighborhood but within your town?" (level 4) and 5) "During the past 4 weeks, have you been to places outside your immediate town?" (level 5) For each LS level, participants were asked how often they traveled to the particular area (<once a week, 1–3 times each week, 4–6 times each week, daily) and whether they needed assistance from another person or from an assistive device ("yes" or "no"). LSA was scored by assigning a value to each of the five levels and then adding the scores of each level. The level scores were obtained by multiplying the level number (1–5) by a value for independence (2 = "no assistance," 1.5 = "use of equipment only," 1 = "use of another person and/or equipment") further multiplied by a value for the frequency of movement (1 = once a week, 2 = 1–3 times each week, 3 = 4–6 times each week, and 4 = daily) The LSA scores ranges from 0 ("totally bed-bound") to 120 ("traveled out of town every day without assistance").

Data on ADL were collected by interviewing the participants. IADL was assessed using a subscale of the Tokyo Metropolitan Institute of Gerontology index of competence, which contains five questions concerning "Instrumental self-maintenance" (shopping for daily living, preparing meals, paying bills, managing bank deposits and savings, and utilizing public transportation)[30]. The response to each item is "yes" (able to do) or "no" (unable). The total score is the number of items answered with a "yes." Thus, a higher score indicates a higher functional capacity.

Data were analyzed using SPSS software (Version 10.4; SPSS Inc., Chicago, IL).

The subjects were divided into two age groups: 75–79-year-olds and 80–84-year-olds. We used a χ^2 test to compare certifications of need for long-term care, presence of disease, IADL, and LSA, and non-paired t-tests to compare other variables.

We classified pulmonary functional impairments into four categories based on ventilatory characteristics. Obstructive ventilatory impairment (OVI) was defined as %FEV1.0 < 70%, restrictive ventilatory impairment (RVI) as %VC < 80%, combined ventilatory impairment (CVI) as %FEV1.0 < 70% and %VC < 80%, and normal ventilatory capacity (NVC) as %FEV 1.0 ≥ 70% and %VC ≥ 80%. We compared the characteristics, the physical function, and mobility between the ventilatory function categories by one-way analysis of variance (ANOVA). When ANOVA indicated a significant effect, we used the Bonferroni post hoc test.

A p-value of <0.05 was considered to indicate statistical significance.

RESULTS

Table 1 presents the subject characteristics of the study participants. The height, body weight and grip strength of the subjects were similar to the national average[31]. Accordingly, there was no regional deviation from the

Table 1. Characteristics of study subjects

Age (years)	75–79	80–84
Number	661	361
Height (cm)	148.5±5.4	146.9±5.6
Body weight (kg)	50.3±7.7	48.9±7.9
BMI (kg/m^2)	22.8±3.5	22.7±4.6
SBP (mmHg)	138.9±18.9	139.0±19.6
DBP (mmHg)	76.8±10.3	75.1±10.6
Pulse (beats/min)	77.6±10.8	78.7±10.9
Certification of care need	51(7%)	73(20%)**
Contraction of disease		
High blood pressure	350 (53%)	206 (57%)
Hyperlipemia	259 (39%)	134(37%)
Anemia	12 (2%)	13 (4%)
Apoplexy	26 (4%)	25 (7%)
Diabetes	58 (9%)	29 (8%)
Heart disease	88 (13%)	60(17%)
Osteoarthritis of the knee	136 (21%)	92 (26%)
Osteoporosis	187 (28%)	132 (37%)**

BMI: Body Mass Index
SBP: Systolic Blood Pressure
DBP: Diastolic Blood Pressure

mean ± standard deviation
**: p<0.01

Table 2. Physical function and mobility of study subjects

Age (years)	75–79	80–84
Number	661	361
Instrumental activity of daily living	4.7±0.6	4.5±0.9**
Life Space Assesment	91.8±15.4	85.2±18.4**
Grip strength(kg)	19.0±4.0	17.3±4.2**
Knee joint extension strength (newton•meter/kg)	1.2±0.3	1.1±0.3**
Comfortable gait velocity (meter/second)	1.3±0.2	1.1±0.3**
Maximal gait velocity (meter/second)	1.7±0.3	1.4±0.3**
Timed up-and-go (second)	9.5±2.6	11.3±4.0**
Maximal Timed up and go (second)	6.9±1.6	8.1±2.0**
One leg standing time with eyes open (second)	29.6±22.0	19.7±19.6**

mean ± standard deviation
**: p<0.01

Table 3. Pulmonary function of study subjects

Age (years)	75–79	80–84
Number	661	361
VC (L)	2.1±0.4	1.9±0.4**
Predicted VC (L)	2.1±0.02	2.0±0.02
%VC (%)	99.8±18.3	96.5±19.7**
FEV1.0 (L)	1.5±0.4	1.3±0.3**
FVC (L)	1.8±0.4	1.6±0.4**
%FEV1.0 (%)	83.9±11.1	81.9±11.7**

mean ± standard deviation
**: p<0.01

VC: vital capacity
Predicted VC=0.032×height(cm)–0.018×age–1.178
%VC=VC/Predicted VC(0.032×height(cm)–0.018×age–1.178)×100
FEV1.0: forced expiratory volume in 1 second
FVC:forced vital capacity
%FEV 1.0=FEV1.0 /FVC×100

national average. The frequencies of certification of care need and osteoporosis were significantly higher in the group aged 80–84 years than the group aged 75–79 years (p<0.01). Table 2 presents the results of physical functions and mobility tests and Table 3 shows the pulmonary function results. For all the measured variables in these tables, the group aged 80–84 years showed significantly inferior results compared to the group aged 75–79 years (p<0.01).

Table 4 lists the participants' physiological characteristics and the results of mobility assessments determined according to ventilatory function categories. Ventilatory function did not significantly affect the subject' physiological characteristics or mobility. Table 5 presents the results of the physical function tests as per ventilatory function category. Ventilatory function had statistically significant effects on the physical function as evidenced by one-way ANOVA. From the results of post hoc tests, the ventilatory disorder categories of RVI and CVI were found to be significantly associated with worse outcomes than the NVC and OVI disorder categories for many of the physical results.

DISCUSSION

Medical examinations of the elderly individuals generally serve the purpose of a screening examination for geriatric syndrome involving physical function, mobility, cognitive ability, and nutritional status. It has been hypothesized that the clinical deterioration of physical function and mobility are associated with pulmonary functional disorders. However, very few measurement variables for elucidating the functional integrity of the cardiac and pulmonary systems are known. In recent years,

Table 4. Influence of ventilatory function on mobility

ventilatory functions	Normal Ventilatory Capacity	Obstructive Ventilatory Impairment	Restructive Ventilatory Impairment	Combined Ventilatory Impairment
Number	791	73	136	22
Age	78.3±2.6	78.7±2.7	78.9±2.8	78.7±2.7
Height (cm)	148.2±5.4	148.7±5.8	146.5±5.6	145.6±4.7
Body weight (kg)	50.1±7.5	49.2±7.5	48.7±8.5	45.6±9.3
BMI (kg/m^2)	22.6±4.7	22.4±5.2	22.1±4.7	21.7±5.6
SBP (mmHg)	139.4±18.8	137.8±20.3	137.9±20.2	134.4±21.5
DBP (mmHg)	76.6±10.2	75.9±10.7	74.6±10.9	72.1±12.6
Pulse (beats/min)	78.3±10.9	77.9±9.9	75.7±10.5	78.8±11.1
Instrumental activity of daily living	4.6±0.8	4.6±0.7	4.5±0.9	4.5±0.6
Life Space Assesment	89.9±16.8	92.2±13.4	86.2±17.7	84.8±18.6

Obstructive Ventilatory Impairment: %FEV 1.0<70%
Restructive Ventilatory Impairment: %VC<80%
Combined Ventilatory Impairment: %FEV 1.0<70% and %VC<80%

mean ± standard deviation

Table 5. Influence of ventilatory functions on physical function

Ventilatory function	Normal Ventilatory Capacity	Obstructive Ventilatory Impairment	Restructive Ventilatory Impairment	Combined Ventilatory Impairment	Bonferroni post hoc test
Grip strength (kg)	18.8±4.1	18.6±3.7	16.6±3.8	16.4±4.8	NVC vs RVI** NVC vs CVI* OVI vs RVI**
Knee joint extension strength (newton•meter/kg)	1.2±0.3	1.1±0.3	1.0±0.3	1.0±0.4	NVC vs RVI**
Comfortable gait velocity (meter/second)	1.3±0.2	1.3±0.2	1.1±0.2	1.0±0.2	NVC vs RVI** NVC vs CVI** OVI vs RVI** OVI vs CVI**
Maximal gait velocity (meter/second)	1.6±0.3	1.6±0.3	1.4±0.3	1.4±0.4	NVC vs RVI** NVC vs CVI* OVI vs RVI** OVI vs CVI**
Timed up-and-go (second)	9.9±3.1	9.9±2.6	11.2±4.1	12.1±4.8	NVC vs RVI** NVC vs CVI** OVI vs RVI* OVI vs CVI*
Maximal Timed up-and-go (second)	7.2±1.8	7.1±1.4	8.0±1.8	8.5±3.0	NVC vs RVI** NVC vs CVI** OVI vs RVI** OVI vs CVI**
One leg standing time with eyes open (second)	26.8±21.7	28.8±23.2	21.3±19.8	21.2±23.9	NVC vs RVI*

Obstructive Ventilatory Impairment: %FEV 1.0≤70%
Restructive Ventilatory Impairment: %VC≤80%
Combined Ventilatory Impairment: %FEV 1.0≤70% and %VC≤80%

mean±standard deviation
*: $p<0.05$
**: $p<0.01$

it has been reported that chronic obstructive pulmonary disease, which requires treatment by spirometry, occurs at a considerably high frequency in middle and old-aged residents of Japan[32]. Consequently, the use of spirometry for the elderly population has been promoted; however, the actual optimal state of pulmonary function in the elderly and relationships between pulmonary function and physical function and mobility remain unclear.

Many studies have reported that pulmonary function declines with increasing age, and the rate of decline is accelerated among those of advanced aged[23]. However, Pfitzenmeyer et al. found that individuals in the advanced age population who demonstrated good pulmonary function were stronger and generally survived for a longer time[24]. Our results, like many other studies, indicate that advanced age as well as diminished physical function and mobility are associated with inferior (declining) pulmonary function.

Pulmonary function is related to exercise tolerance[33] and nutritional status[34,35]. However, we do not agree with the opinion that a relationship exists between pulmonary function and mobility[36,37]. Our results did not demonstrate a clear relationship between pulmonary function and mobility. According to Kazuhide et al., even if pulmonary function deteriorates in the elderly, it does not have an immediate influence on mobility[38]. Further, Carlos et al. reported that pulmonary function could predict the possibility of future health problems and possibly death[39]. A restrictive ventilatory disorder is dependent on thoracic flexibility that is associated with ventilatory and respiratory muscular strength, both of which are susceptible to aging; it is believed that this influences mobility at some point in the future. The results of our study suggest that diminished pulmonary function is related to the physical function that support mobility. As for clinical implications, our results offer significant value for promoting preventive care. However, the group afflicted with OVI was not different from the group with NVC. For this reason, we believe that 65% of those with mild disease severity have RVI[40].

An age-stratified study model must be used to clarify whether diminished pulmonary function influences mobility. In addition, males should also be included because the rates of decline of pulmonary function and physical function show sex differences. We can also prevent the decline of pulmonary function by certain specific interventions; however, we must clarify whether these measures would improve or maintain mobility. In this way, we may be able to contribute to a reduction in medical costs and improvements in the quality of life of the elderly.

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Usefulness of the Subjective Risk Rating of Specific Tasks for Falls in Frail Elderly People

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Abstract. [Purpose] The purpose of this study was to examine the reliability and clinical usefulness of a subjective risk rating of specific tasks (SRRST) for assessing risks of falls in frail elderly people. The participants were 30 elderly individuals who utilized day-care services. [Subjects and Methods] Participants were investigated the SRRST, grip strength, one repetition maximum of leg-press machine (1RM), one-leg standing time (OLS), functional reach, timed up and go test (TUG), and 10 m-walking speed, Barthel index, Tokyo Metropolitan Institute of Gerontology index, and history of falls in the previous year. The SRRST is comprised of 7 dichotomous questions screening of fall risk during activities of daily living such as walking, transferring, and wandering, and was scored twice a week by four raters. [Results] Intra-rater reliabilities of the SRRST were high (ICC (1,1) = 0.727 to 0.914, ICC (1,2) = 0.842 to 0.955), and inter-rater reliabilities of the SRRST were moderate to high (ICC (2,1) = 0.513, ICC (2,4) = 0.808). In comparison to the non-faller group, the faller group showed significantly lower 1RM and higher the SRRST. The SRRST showed moderate correlations with the OLS and TUG. [Conclusion] The SRRST showed moderate to high reliability and concurrent validity for assessing the fall risks in frail elderly people.
Key words: Fall, Subjective risk rating of specific tasks, Frail elderly people

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INTRODUCTION

Numerous studies have developed many assessment tools to detect the fall risks in community dwelling elderly people[1,2)]. Using these assessment tools for frail elderly people, a lot of subjects are judged to have fall risks[3)]. For intensive intervention to prevent falls, it is necessary to detect those with high risk of falls among frail elderly people[4)]. Because there are many frail elderly subjects who cannot perform functional tests, in a previous study, subjective fall risk assessment based on observations by care staff was developed and its usefulness as a fall risk predictor was examined[5,6)]. However, the subjective fall risk assessment was not developed to assess multiple fall risks of specific tasks or behaviors in activities of daily living (ADL). Falls are induced by multidimensional factors particular during walking, ascending/descending stairs, toileting, and transferring in the bedroom, toilet, or bathroom[3)]. A subjective fall risk assessment should consist of multiple items related to mobility, such as walking, transferring, toileting, and ascending/descending stairs, items of basic ADL which are commonly performed by elderly people. Additionally, among the frail elderly, dementia is the major fall risk factor[3,7)], and the subjective fall risk assessment needs to have applicability to specific risky behaviors such as wandering, agitating, and the other risky behaviours exhibited by frail elderly people with cognitive impairment.

The purpose of the present study was to develop a subjective risk rating of specific tasks (SRRST) for the risk of fall during execution of ADL related to mobility, and to examine its reliability and association with falls, and fall-related physical performances or the functional status in frail elderly people utilizing adult day-care services.

SUBJECTS AND METHODS

The participants in this study were 30 elderly adults aged 65 and older, who utilized day-care services. Prior to testing, all subjects claimed no severe cognitive

Table 1. Subjective risk rating of specific tasks

Assessment	Yes	No or not applicable
Do you feel there is a risk of falls when the client (Mr or Mrs X) is walking?	1	0
Do you feel there is a risk of falls when the client is transferring in bedroom, toilet, or bathroom?	1	0
Do you feel there is a risk of falls when the client is toileting?	1	0
Do you feel there is a risk of falls when the client is ascending or descending stairs?	1	0
Do you feel there is a risk of falls when the client is wandering?	1	0
Do you feel there is risk of falls because the client exhibits risky behaviour?	1	0
Do you feel there is a risk of falls because the client is agitated?	1	0

impairment. Exclusion criteria were neurological, cardiovascular or major musculoskeletal impairments that precluded participants from walking for 20 m without the assistance of another person. All subjects provided their written informed consent.

Subjective fall risk was investigated by the SRRST. The SRRST consists of 7 items asking about the subjective fall risk of specific tasks during ADL related to mobility. It was designed to assess the performance of elderly people with or without cognitive impairment in ADL such as walking, transferring, toileting, ascending/descending stairs, wandering, exhibiting risky behaviour, agitating (Table 1). The response to each item in the SRRST is designated as "yes" (1 point) or "no or not applicable" (0 points), and the total score which is used as the representative value ranges from 0 to7. Four raters (one physical therapist, one nurse, and two caregivers) rated all the subjects with the SRRST twice a week, individually. The SRRST and information about the experience of falls in the previous year were obtained at the same time. In this study, a fall was defined as unintentional loss of balance resulting in the person landing on a lower surface or the ground.

Grip strength (GS)[8], lower-extremity muscle strength measured as the one repetition maximum (1RM) on a leg press machine[9], postural balance function (one leg standing time (OLS)[10], functional reach (FR)[11]), gait function (timed "up and go" test (TUG)[12], and walking speed (WS)[13]) were performed using indices of physical performance with demonstrated reliability and validity. GS was measured using a digital handgrip dynamometer. The subjects were asked to stand, and the dynamometer was adjusted till the proximal interphalangeal joints were flexed to 90° with the elbow straightened. The subjects were instructed to increase the handgrip force to the maximum and sustain the contraction for 3 seconds, and the peak force recorded was considered the maximum handgrip strength. For measurement of 1RM on the leg press, subjects started in a sitting position of approximately 90° of knee flexion and extended their legs to a position approximating 0°. A standardized protocol was executed that consisted of warm-up repetitions and a sequence of progressively increased resistance approaching the subjects' 1RM each separated by fixed rest periods. The resistance was then adjusted, and 1RM attempts were performed, each separated by a set rest period, until 1RM was determined. In the OLS test, subjects were instructed to start in a standing position with a comfortable base of support, with eyes open and arms by the side of the trunk and then stand unassisted on either leg. The OLS was timed in seconds from the time one foot was lifted from the floor to when it touched the ground or the standing leg. In the FR test, each subject was positioned next to a wall with one arm raised 90° with the fingers extended, and a yardstick was mounted on the wall at shoulder height. The distance in centimeters that a subject was able to reach forward from an initial upright posture to the maximal anterior leaning posture without moving or lifting the feet was measured by visual observation of the position of the third finger tip on a mounted yardstick as the FR score. In the TUG test, subjects were asked to stand up from a chair, walk a 3-m distance at a normal pace, turn, walk back to the chair, and sit down. The time measured in seconds began at the word "go" and ended when the subject's hip touched the seat of the chair. In the WS test, subjects were instructed to walk 16 m with 3 m to accelerate and decelerate before and after the 10 m test distance at their normal comfortable speed; the required time to walk the distance was measured with a stopwatch. WS was calculated and the distance for 1 minute was extrapolated. For investigation of functional status, the Barthel index (BI)[14] and Tokyo Metropolitan Institute of Gerontology index of competence (TMIG-IC)[15] were administered. The BI is used for the evaluation of basic ADL (score range: 0-100), and includes feeding, bathing, toileting, dressing, bowel and bladder control, grooming, transferring, mobility, and ascending and descending stairs, with a higher score indicating better ADL ability. The TMIG-IC assesses functional capacity of ADL and is divided into three sections: 5 questions about instrumental self-maintenance, 4 questions about intellectual activity, and 4 questions about social role in ADL. The answer to each question is "yes" or "no", and is scored 1 for "yes" and 0 for "no". The total score is the sum total of the 13 questions (score range: 0–13).

Intraclass correlation coefficients (ICC) were calculated to ascertain the intra-rater and inter-rater reliability for the SRRST. A group comparison was then performed to evaluate the differences in characteristics, physical performances, and functional status between non-fallers and fallers using the chi-square test and the Mann-Whitney U-test. Spearman correlation coefficient was calculated for the SRRST and physical performances and functional status. All of these analyses were performed using SPSS12.0, and the level of significance for all statistics was chosen as $p<0.05$.

RESULTS

The results of the SRRST were shown in Table 2. The SRRST took an average of 1 minute per subject for each rater to perform. Intra-rater reliabilities of ICC (1, 1) and (1, 2) for the SRRST of each rater were 0.727 to 0.914 and 0.842 to 0.955, respectively (Table 3). The inter-rater reliabilities for the SRRST, ICC (2, 1) and (2, 4) were 0.513 and 0.808 for the four raters, and ICC (2, 1) and (2, 2) were 0.503 and 0.669 for the two caregivers (Table 4). In comparison to the non-faller group, the faller group showed significantly lower 1RM and higher SRRST than the group of non-fallers (Table 5). The chi-square test showed that those with the SRRST score of 2 (or 3) or more had greater rate of presence of faller than those with the SRRST score of 1 (or 2) and below, although a significant difference was not found between those with the SRRST score of 0 and those with the SRRST score of 1 or more (Table 6). Spearman correlation coefficients showed that the SRRST correlated with OLS ($rs = -0.433$, $P = 0.017$), and TUG ($rs = 0.441$, $P = 0.015$) (Table 7).

Table 2. Results of subjective risk rating of specific tasks in each rater

subjective fall risk assessment	Physical therapist		Nurse		Caregiver1		Caregiver2	
Do you think patient has a risk of fall ...	1st	2nd	1st	2nd	1st	2nd	1st	2nd
during walking (number)	16	18	8	11	25	27	8	10
during transferring (number)	7	8	8	7	23	27	11	16
during toileting (number)	7	8	5	7	1	0	1	0
during stair ascending/descending (number)	18	22	15	15	29	27	22	28
during wandering (number)	11	9	10	14	3	0	0	0
because of risky behaviors (number)	17	13	27	25	29	29	24	28
because of agitation (number)	16	12	27	25	24	22	0	1
average (point)	3.1	3.0	3.3	3.5	4.5	4.4	2.2	2.8
standard deviation (point)	2.6	2.7	2.2	2.4	1.2	1.1	1.4	1.2
median (point)	2.0	2.0	2.5	3.0	5.0	5.0	2.0	3.0
minimum (point)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
maximum (point)	7.0	7.0	7.0	7.0	6.0	5.0	5.0	5.0

Table 3. Intraclass correlation coefficient for intrarater reliability of subjective risk rating of specific tasks

	ICC (1,1)	95% confidence interval	
		lower confidence limit	upper confidence limit
Physical therapist	0.914*	0.828	0.958
Nurse	0.880*	0.765	0.941
Caregiver1	0.772*	0.578	0.884
Caregiver2	0.727*	0.504	0.859
	ICC (1,2)	95% confidence interval	
		lower confidence limit	upper confidence limit
Physical therapist	0.955*	0.906	0.978
Nurse	0.936*	0.867	0.969
Caregiver1	0.872*	0.732	0.939
Caregiver2	0.842*	0.670	0.924

*: $p < 0.001$

Table 4. Intraclass correlation coefficient for interrater reliability of subjective risk rating of specific tasks

	Four raters	95% confidence interval	
		lower confidence limit	upper confidence limit
ICC (2,1)	0.513**	0.331	0.692
ICC (2,4)	0.808**	0.665	0.900
	Two raters	95% confidence interval	
		lower confidence limit	upper confidence limit
ICC (2,1)	0.503*	0.180	0.728
ICC (2,2)	0.669*	0.305	0.842

Four raters: one physical therapist, one nurse, two caregivers
Two raters: two caregivers
*: $p < 0.01$, **: $p < 0.001$

Table 5. Comparison of functional status and activity between non-faller and faller

	non-faller (n=13)	faller (n=17)
gender (number)		
male	6	9
female	7	8
support or care level (number)		
support level 1	3	4
support level 2	1	6
care level 1	6	5
care level 2	3	2
disease (number)		
cerebrovascular disease	4	4
Parkinson disease	0	0
femoral neck fracture	1	1
osteoarthritis	1	6
height (cm)	154.9 ± 11.4	151.8 ± 8.9
weight (kg)	58.2 ± 14.8	52.0 ± 9.3
body mass index (kg/m^2)	24.0 ± 4.4	22.5 ± 3.1
GS (kg)	22.8 ± 8.5	19.0 ± 7.8
1RM (kg)	59.4 ± 16.3	44.6 ± 19.6*
OLS (s)	12.3 ± 14.2	6.5 ± 5.1
FR (cm)	35.2 ± 5.2	32.4 ± 9.3
TUG (s)	12.9 ± 4.7	16.7 ± 12.2
WS (m/min)	48.5 ± 17.8	42.9 ± 17.3
BI (point)	97.7 ± 3.3	97.6 ± 5.0
TMIG-IC (point)	6.7 ± 3.9	8.1 ± 3.9
SRRST (point)	2.1 ± 2.5	3.8 ± 2.5*

GS: grip strength, 1RM: one repetetion maximum of leg press machine, OLS: one legged standing time, FR: functional reach, TUG: timed up and go test, WS: walking speed, BI: Barthel index, TMIG-IC: Tokyo Metropolitan Institute of Gelontology - index of competence, SRRST: subjective risk rating of specific tasks
*: $p < 0.05$