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Relationship between subjective fall risk assessment and falls and fall-related fractures in frail elderly people

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Abstract

Background: Objective measurements can be used to identify people with risks of falls, but many frail elderly adults cannot complete physical performance tests. The study examined the relationship between a subjective risk rating of specific tasks (SRRST) to screen for fall risks and falls and fall-related fractures in frail elderly people.

Methods: The SRRST was investigated in 5,062 individuals aged 65 years or older who were utilized day-care services. The SRRST comprised 7 dichotomous questions to screen for fall risks during movements and behaviours such as walking, transferring, and wandering. The history of falls and fall-related fractures during the previous year was reported by participants or determined from an interview with the participant's family and care staff.

Results: All SRRST items showed significant differences between the participants with and without falls and fall-related fractures. In multiple logistic regression analysis adjusted for age, sex, diseases, and behavioural variables, the SRRST score was independently associated with history of falls and fractures. Odds ratios for those in the high-risk SRRST group (≥ 5 points) compared with the no risk SRRST group (0 point) were 6.15 ($p < 0.01$) for a single fall, 15.04 ($p < 0.01$) for recurrent falls, and 5.05 ($p < 0.01$) for fall-related fractures. The results remained essentially unchanged in subgroup analysis accounting for locomotion status.

Conclusion: These results suggest that subjective ratings by care staff can be utilized to determine the risks of falls and fall-related fractures in the frail elderly, however, these preliminary results require confirmation in further prospective research.

Background

Falls and fall-related fractures are a common cause of disability in elderly people [1], and preventing falls is an urgent medical and social issue. Numerous studies have identified factors that predict an increased risk of falls, and many validated assessment tools have been developed to determine fall risks for elderly people [2,3]. Although falls can be caused by multiple factors, mobility impairments such as gait and balance disorders are among the most common predisposing conditions [4,5].

Our previous studies have identified the best mobility tests [6] and a physical performance test [7] for predicting falls in the elderly. These objective measurements can be used to identify people who are appropriate for and who will gain benefit from targeted falls prevention interventions. However, we found that about half of the frail elderly subjects could not complete physical performance tests such as the functional reach test and tandem walk test [7]. In addition, cognitive impairment, particularly confusion, impaired orientation, and misperception of functional ability, is one of the most important risk factors for falls in elderly people [8,9] and is likely to be an important inclusion in a screening tool. Successful strategies for preventing falls in frail elderly people with cognitive impairments are yet to be identified conclusively [10] and appropriate screening tools for these individuals are needed.

Some subjective assessments by care staff have been developed for identifying fall risks in frail elderly adults [11-13]. In a residential facility, staff members possess knowledge of their residents' potential fall risk over a

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24-hour period, and this encompasses both predisposing and precipitating factors. Therefore, their global assessment of fall risk could have the highest predictive validity in relation to falls [13]. These global assessment scales are composed of one item, e.g. 'how do you judge the risk that Mr or Mrs x will fall within 6 months–high or low?' [11,13], which can be used easily in clinical settings, but a global assessment cannot identify specific fall risks and appropriate interventions in frail elderly persons who have multifactorial risks for falls. We determined seven specific tasks with high risks of falls based on a nationwide survey of falls in the frail elderly [7,14], and identified the relationship between these tasks and falls in our preliminary study [15]. However, it was not clear that these tasks were related independently with falls and fall-related fractures in a large population study.

The purpose of this study was to develop the subjective risk rating of specific tasks (SRRST) for screening for the risk of falls and fall-related fractures. Subjects were frail elderly people enrolled in the Tsukui Ordered Useful Care for Health (TOUCH) program which provides day-care services.

Methods

Participants

This study recruited 5,062 elderly participants (mean age, 82.6 ± 7.4 years) enrolled in the TOUCH program. To enrol in TOUCH, an individual must be aged 65 or older and have been certified as needing long-term care by the Japanese public long-term care insurance system [16]. The TOUCH sites are located throughout Japan and provide comprehensive, facility-based day-care services. TOUCH clients have some physical disability and frailty, as defined by the presence of weakness, reduced physical activity or slow gait, which is in accordance with the widely accepted definition of frailty [17]. We limited the participants of this study to those who were aged less than 65 years and who had missing value in measurements. Informed consent was obtained from all participants or a family member prior to their inclusion in the study and the Ethics Committee of the Tokyo Metropolitan Institute of Gerontology approved the study protocol.

Study procedures

This study was performed by cross-sectional design and falls and fall-related fractures were investigated retrospectively for a one-year period. Prior to the commencement of the study, all staff received a measurement manual which mentioned the correct protocols for administering all of the assessment measures included in the study.

Falls and fall-related fractures during the previous year

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" [18,19]. Falls and fall-related fractures were measured retrospectively for a one-year period via a self-report questionnaire and care records. 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.

Subjective risk rating of specific tasks (SRRST)

The SRRST was conducted by day-centre staff who had nursing, allied health or similar qualifications, and they were familiar with their clients. The staff answered the questions of the SRRST based on the present status of the participants. 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 in bed room, toilet, or bath room?"; 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 response to each item in the SRRST was designated as "yes" (1 point) or "no or not applicable" (0 points) [15]. The information of the SRRST and history of falls was obtained at the same time. Prior to the commencement of the study, three raters completed the SRRST twice at weekly intervals (n = 4 × 2 × 30), and test-retest and inter-rater (one physical therapist, one nurse, and two caregivers) reliability comparisons of total scores revealed intraclass correlation coefficients (ICCs) of 0.84 to 0.96 and 0.81, respectively [20].

Potential confounding factors of falls

With reference to previous studies [2,21-24], we selected two demographic variables, eight primary diseases or general health statuses, and two behavioural variables as possible confounding factors of falls (Table 1). 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 disease, dementia, poor vision, urinary incontinence or frequency, psychotropic use, and walking aid use. Absence of habitual exercise and daily use of slippers or sandals were investigated as behavioural variables.

Table 1 Number of participants with falls and fall-related fractures and odds ratios of potential risk factors

	Single fall		Recurrent falls		Fractures	
	Number (%)	Odds ratio (95% CI)	Number (%)	Odds ratio (95% CI)	Number (%)	Odds ratio (95% CI)
Subjective risk rating of specific tasks						
Risk of falls during walking, yes	1068 (41.5)†	2.21 (2.01-2.43)	633 (24.6)†	3.15 (2.71-3.66)	123 (4.8)†	1.83 (1.36-2.46)
Risk of falls during transferring, yes	823 (41.7)†	1.80 (1.66-1.96)	504 (25.5)†	2.43 (2.14-2.76)	103 (5.2)†	1.89 (1.43-2.51)
Risk of falls during toileting, yes	568 (42.9)†	1.66 (1.53-1.80)	361 (27.3)†	2.18 (1.93-2.47)	65 (4.9)†	1.49 (1.11-2.00)
Risk of falls during stair ascending/ descending, yes	1140 (39.2)†	2.13 (1.93-2.36)	685 (23.6)†	3.55 (2.99-4.22)	139 (4.8)†	2.10 (1.53-2.90)
Risk of falls during wandering, yes	453 (44.9)†	1.68 (1.55-1.83)	2.89 (28.7)†	2.16 (1.90-2.44)	66 (6.5)†	2.18 (1.63-2.91)
Risk of falls because of risky behaviors, yes	672 (41.6)†	1.66 (1.53-1.80)	424 (26.3)†	2.24 (1.98-2.54)	79 (4.9)†	1.55 (1.17-2.06)
Risk of falls because of agitation, yes	479 (45.0)†	1.70 (1.57-1.85)	316 (29.7)†	2.32 (2.05-2.62)	55 (5.2)†	1.55 (1.14-2.11)
Potential confounding factors						
Age, years‡	82.9 ± 7.5		83.0 ± 7.5		84.3 ± 6.9†	
Falls or fractures						
No falls or fractures	82.5 ± 7.4		82.6 ± 7.4		82.6 ± 7.4	
Sex, female	1062 (30.1)	0.97 (0.89-1.06)	560 (15.8)	0.90 (0.79-1.03)	151 (4.3)†	1.77 (1.24-2.52)
Stroke, yes	345 (32.0)	1.07 (0.97-1.18)	175 (16.2)	0.99 (0.85-1.16)	41 (3.8)	1.03 (0.74-1.45)
Knee osteoarthritis and pain, yes	659 (36.7)†	1.36 (1.26-1.48)	362 (20.1)†	1.41 (1.25-1.60)	77 (4.3)	1.26 (0.95-1.67)
Dementia, yes	670 (34.3)†	1.23 (1.13-1.34)	387 (19.8)†	1.40 (1.23-1.58)	80 (4.1)	1.18 (0.89-1.57)
Poor vision, yes	239 (37.9)†	1.30 (1.16-1.45)	131 (20.8)*	1.32 (1.12-1.56)	26 (4.1)	1.13 (0.74-1.73)
Parkinson disease, yes	163 (44.7)†	1.53 (1.35-1.73)	104 (28.5)†	1.85 (1.55-2.20)	16 (4.4)	1.20 (0.73-1.98)
Use of psychotropics, yes	525 (37.0)†	1.33 (1.22-1.45)	283 (19.9)†	1.33 (1.17-1.52)	57 (4.0)	1.12 (0.82-1.51)
Urinary incontinence or frequency, yes	702 (36.2)†	1.35 (1.25-1.47)	403 (20.8)†	1.53 (1.35-1.73)	82 (4.2)	1.24 (0.94-1.65)
Absence of habitual exercise, yes	975 (33.7)†	1.31 (1.20-1.43)	561 (19.4)†	1.58 (1.38-1.81)	110 (3.8)	1.06 (0.80-1.41)
Use of slippers or sandals, yes	415 (36.3)†	1.27 (1.16-1.39)	185 (16.2)	0.99 (0.85-1.14)	63 (5.5)†	1.73 (1.28-2.32)
Use of walking aid, yes	887 (36.7)†	1.49 (1.37-1.63)	492 (20.3)†	1.60 (1.41-1.82)	109 (4.5)†	1.51 (1.14-2.01)

*p < .05, †p < .01, ‡Mean ± standard deviation.

Statistical analysis

Each SRRST item and potential confounding factor was compared between the participants with and without a single fall, recurrent falls, and fall-related fractures using *t*-tests for age and chi-square tests for categorical variables. Odds ratios (ORs) of potential risk factors were also calculated for categorical variables.

Multiple logistic regression analysis was performed to explore the independent associations between total SRRST score and falls and fall-related fractures with potential confounding factors. Multiple logistic regression models included total SRRST score as an independent variable, which was categorized into no risk (0 point), low risk (1 to 2 points), moderate risk (3 to 4 points), and high risk (≥ 5 points). The SRRST categories were assessed by their P-values for trend and were used to calculate the OR and 95% confidence interval (95% CI) relative to the category of 'no risk' for each higher category. Covariates were added sequentially to the logistic model to evaluate the associations at different levels of adjustment. Model 1 included the SRRST category plus age and sex, and model 2 included the model 1 variables plus other possible confounding factors. The participants were divided into dependent walking and independent walking groups for subgroup analysis. Logistic regression analysis (model 2) was performed in each group. The validity of the model was quantified using the C-Index and Hosmer-Lemeshow statistic for goodness of fit. Sensitivity and specificity statistics were used to determine the ability of classification in the SRRST. Sensitivity and specificity for falls and fall-related fractures were calculated in each SRRST score. Cut-points for maximizing the sensitivity and specificity for each score were determined using the closest-to-(0, 1) criterion [25]. All data management and statistical computations were performed using the SPSS 17.0 software package (SPSS Inc., Chicago, IL, USA).

Results

The participants were recruited from 88 TOUCH demonstration sites (35% of all sites) and completed the investigation. About 65% of the TOUCH sites (about 19,800 elderly people) could not complete the investigation. Table 2 shows the characteristics of the participants (Table 2).

Table 2 Characteristics (number and percent) of the participants (n = 5,062)

Age*	83 (41)
Women	3,541 (70.0)
Single fall during a one-year period	1,536 (30.3)
Recurrent falls during a one-year period	828 (16.4)
Fall-related fracture during a one-year period	188 (3.7)
Femoral fracture	74 (1.5)
Fracture of the skull, trunk, pelvic, and lower legs	68 (1.3)
Fracture of the arms	46 (0.9)
Stroke	1,077 (21.3)
Knee osteoarthritis with pain	1,798 (35.5)
Dementia	1,953 (38.6)
Poor vision	630 (12.4)
Parkinson disease	365 (7.2)
Use of psychotropics	1,420 (28.1)
Urinary incontinence or frequency	1,941 (38.3)
Absence of habitual exercise	2,889 (57.1)
Use of slippers and sandals	1,144 (22.6)
Use of a walking aid	2,418 (47.8)
Mobility status	
Independent gait	2,930 (57.9)
Independent transfers	953 (18.8)
Independent sit up	589 (11.6)
Dependent sit up	590 (11.7)

* median (range).

Number of participants with falls and fall-related fractures

Of the 5,062 elderly people, 1536 (30.3%) reported a single fall in the previous year, 828 (16.4%) had recurrent falls, and 188 (3.7%) experienced fall-related fractures. Of the participants with fractures, 74 (39.4%) had a femoral fracture, 68 (36.2%) participants had a fracture of the skull, trunk, pelvic, or lower leg, and 46 (24.5%) experienced a fracture of the arm.

Comparison between participants with and without falls and fall-related fractures

All SRRST items showed significant differences between those with and without a fall, recurrent falls, and fall-related fractures. In terms of potential confounding variables, there were significant differences for all except history of stroke when single fallers and non fallers were compared. When recurrent fallers were compared with non-recurrent fallers there was a significant difference for all potential confounders except for history of stroke and daily use of slippers or sandals. Compared with participants without fractures, those with fractures were significantly more likely to report daily use of slippers or sandals or use of walking aids (Table 1).

Among the SRRST items, ORs of the participants with risk to those without risk were 1.66 to 2.21 for a single fall, 2.16 to 3.55 for recurrent falls, and 1.49 to 2.18 for fall-related fractures. The ORs of significant confounders were 1.23 to 1.53 for a single fall, 1.32 to 1.85 for recurrent falls, and 1.51 to 1.73 for fall-related fractures. The highest ORs for a single fall, recurrent falls, and fall-related fractures were recognized for the SRRST items of risk of falls during walking, stair ascending/descending, and wandering, respectively (Table 1).

Risk factors for falls

The multiple logistic regression models showed significant relationships between falls and fall-related fractures and SRRST categories (Table 3). Participants who had higher fall risk on the SRRST had higher rates of falling and fall-related fractures (Figure 1). In model 1, which adjusted for age and sex, the OR for a single fall, recurrent falls, and fall-related fractures increased as the SRRST score increased, and P for trend of all models showed significance. The ORs of the high-risk group compared with the no-risk group were 7.56 (95% confidence interval (95% CI); 6.07-9.42) for single fall; 17.71 (95% CI; 12.32-25.45) for recurrent falls, and 4.65 (95% CI; 2.73-7.94) for fall-related fractures (P for trend < 0.01). The results remained essentially unchanged after controlling for other confounders (Table 3, model 2). The highest ORs of factors related to single fall, recurrent falls, and fall-related fractures were for the high-risk group in the SRRST in all logistic models. The p-values of the Hosmer-Lemeshow statistics were > 0.05 in both logistic models (p = 0.12-0.72) and the C-index showed moderate model-fit in nearly all cases (0.67-0.74). In the subgroup analysis, the significant odds ratios remained essentially the same in the dependent walking and independent walking groups, with the exception of fall-related fracture. Regarding fall-related fractures in the dependent walking group, there were no significant odds ratios when the low and moderate risk groups were compared to the no-risk group of the SRRST (Figure 2).

Sensitivity and specificity

Table 4 shows the sensitivity and specificity of each SRRST score for falls and fall-related fractures. Cut-points for maximizing the sensitivity and specificity were 2/3 point in all of a single fall, recurrent falls and fall-related fractures. Sensitivity and specificity of 2/3 cut-point in a single fall, recurrent falls and fall-related fractures were 0.66 and 0.63, 0.75 and 0.60, and 0.68 and 0.55, respectively.

Discussion

There are many distinct and multifactorial causes for falls in elderly people, including low muscle strength, balance and gait disturbances, cognitive function decline, environmental hazards, and low or high activity levels. Objective measures such as physical tests can provide

Table 3 Odds ratios for falls and fall-related fractures by SRRST category and confounders

	Single fall		Recurrent falls		Fractures	
	Model 1 Odds ratio (95% CI)	**Model 2 Odds ratio (95% CI)**	**Model 1 Odds ratio (95% CI)**	**Model 2 Odds ratio (95% CI)**	**Model 1 Odds ratio (95% CI)**	**Model 2 Odds ratio (95% CI)**
Subjective risk rating of specific tasks						
No risk, 0 points	1.00‡	1.00‡	1.00‡	1.00‡	1.00‡	1.00‡
Low risk, 1-2 points	2.65 (2.14-3.28)†	2.40 (1.94-2.98)†	4.17 (2.88-6.06)†	3.88 (2.67-5.64)†	1.80 (1.03-3.15)*	1.77 (1.01-3.12)*
Moderate risk, 3-4 points	5.06 (4.11-6.23)†	4.21 (3.39-5.23)†	9.11 (6.36-13.05)†	7.94 (5.5-11.47)†	3.24 (1.91-5.48)†	3.22 (1.86-5.57)†
High risk, ≥ 5 points	7.56 (6.07-9.42)†	6.15 (4.85-7.8)†	17.71 (12.32-25.45)†	15.04 (10.29-22)†	4.65 (2.73-7.94)†	5.05 (2.83-9.03)†
P for trend	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Potential confounding factors						
Age, years	1.01 (1.00-1.01)	1.01 (1.00-1.02)	1.01 (0.99-1.02)	1.00 (0.99-1.02)	1.02 (1.00-1.05)*	1.03 (1.01-1.05)*
Sex, female	0.97 (0.84-1.11)	0.94 (0.81-1.09)	0.91 (0.77-1.08)	0.89 (0.74-1.06)	1.72 (1.19-2.50)†	1.76 (1.20-2.58)†
History of stroke with symptoms of hemiparesis		1.04 (0.88-1.22)		0.88 (0.72-1.08)		1.32 (0.91-1.93)
Knee osteoarthritis with pain		1.28 (1.12-1.47)†		1.31 (1.11-1.54)†		1.00 (0.73-1.37)
Parkinson disease		1.44 (1.14-1.81)†		1.51 (1.16-1.96)†		1.10 (0.64-1.88)
Dementia		0.93 (0.81-1.08)		0.95 (0.80-1.14)		0.87 (0.62-1.22)
Poor vision		1.05 (0.87-1.27)		1.00 (0.80-1.25)		0.87 (0.56-1.34)
Urinary incontinence or frequency		1.09 (0.95-1.26)		1.06 (0.89-1.26)		0.96 (0.69-1.34)
Use of psychotropics		1.22 (1.06-1.40)†		1.07 (0.90-1.28)		0.95 (0.68-1.32)
Use of walking aid		1.20 (1.05-1.38)†		1.14 (0.96-1.35)		1.07 (0.78-1.47)
Absence of habitual exercise		1.04 (0.90-1.19)		1.15 (0.96-1.37)		0.81 (0.59-1.12)
Daily use of slippers or sandals		1.23 (1.06-1.43)†		0.81 (0.67-0.98)*		1.67 (1.21-2.30)†
C-index, value (95% CI)	0.68 (0.66-0.70)†	0.70 (0.68-0.71)†	0.72 (0.71-0.74)†	0.74 (0.72-0.75)†	0.67 (0.63-0.71)†	0.69 (0.65-0.73)†
Hosmer-Lemeshow test, p value	0.51	0.48	0.72	0.57	0.72	0.12

*p < .05, †p < .01.
‡Odds ratios in the SRRST category were calculated in the low, moderate, and high risk relative to the no risk.

accurate information in accordance with the task tested, but predictive validity of these tests are inadequate in frail elderly people with multiple risks of falls. This may be explained by the multifactorial nature of falls, which makes the notion of a single screening tool with excellent predictive accuracy an unrealistic goal. Nordin (2008) reported that staff members' assessment of their residents' fall risk as well as history of previous falls appeared superior to performance-based measures of falls in frail elderly people [13]. We therefore examined the utility of an objective assessment tool to identify useful measures for screening frail elderly people for fall risk.

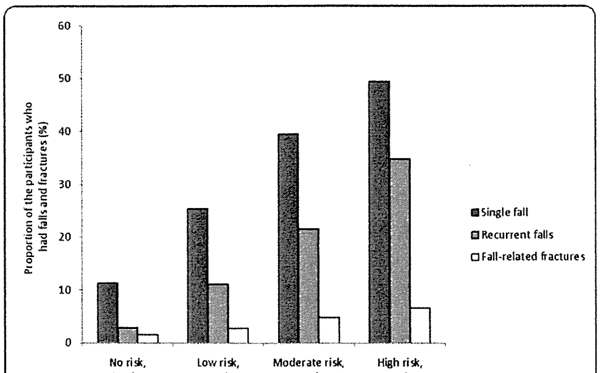

Figure 1 Proportion of the participants who had single fall, recurrent falls, and fall-related fractures according to fall risk. Frail, elderly participants were categorized into four **fall risk** groups by SRRST score. The rate of single fall, recurrent falls, and fall-related fractures increased in accordance with the risk of falls based on the SRRST score.

In the comparative analysis, when compared with non-fallers, participants who had experienced falling were more likely to have a fall risk (with the exception of history of stroke and use of slippers and sandals). In contrast, when compared with those without fall-related fractures, participants who had fall-related fractures did not show significant differences in many potential confounding factors, although all SRRST items showed significant differences. These results suggest that the subjective assessment used in the SRRST was useful to examine the risk of fractures in the frail elderly.

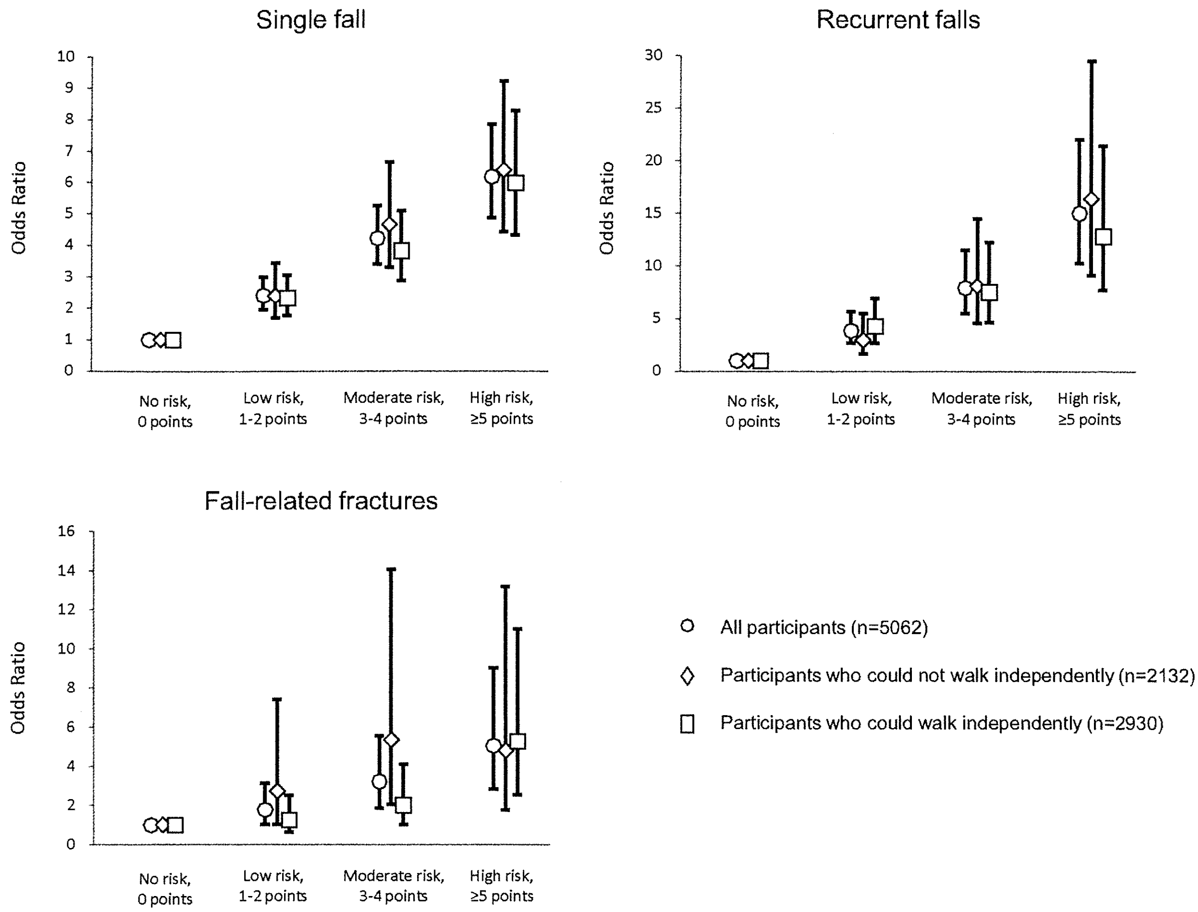

Figure 2 Odds ratios and 95% confidence intervals of SRRST categories for a single fall, recurrent falls, and fall-related fractures. Models were adjusted for all confounding factors (model 2). The participants were divided into dependent-walking and independent-walking groups.

Table 4 Sensitivity and specificity of SRRST scores for falls and fall-related fractures

SRRST score	Single fall		Recurrent falls		Fractures	
	Sensitivity (95% CI)	Specificity (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)	Sensitivity (95% CI)	Specificity (95% CI)
0/1 point	0.91 (0.90 to 0.92)	0.30 (0.29 to 0.32)	0.96 (0.94 to 0.97)	0.28 (0.26 to 0.29)	0.90 (0.85 to 0.94)	0.24 (0.23 to 0.26)
1/2 point	0.80 (0.78 to 0.82)	0.47 (0.45 to 0.49)	0.87 (0.85 to 0.90)	0.44 (0.42 to 0.45)	0.79 (0.72 to 0.84)	0.39 (0.38 to 0.41)
2/3 point	0.66 (0.63 to 0.68)	0.63 (0.61 to 0.64)	0.75 (0.72 to 0.78)	0.60 (0.58 to 0.61)	0.68 (0.61 to 0.74)	0.55 (0.53 to 0.56)
3/4 point	0.48 (0.46 to 0.51)	0.76 (0.75 to 0.78)	0.58 (0.55 to 0.62)	0.74 (0.73 to 0.76)	0.50 (0.43 to 0.57)	0.70 (0.68 to 0.71)
4/5 point	0.30 (0.28 to 0.32)	0.87 (0.86 to 0.88)	0.39 (0.36 to 0.42)	0.86 (0.85 to 0.87)	0.32 (0.26 to 0.39)	0.82 (0.81 to 0.83)
5/6 point	0.14 (0.13 to 0.16)	0.94 (0.93 to 0.95)	0.22 (0.20 to 0.25)	0.93 (0.92 to 0.94)	0.13 (0.09 to 0.19)	0.91 (0.90 to 0.92)
6/7 point	0.07 (0.06 to 0.09)	0.97 (0.97 to 0.98)	0.10 (0.08 to 0.12)	0.97 (0.96 to 0.97)	0.02 (0.01 to 0.05)	0.96 (0.95 to 0.96)

Multiple regression models revealed that the SRRST score was associated with falling as well as fall-related fracture, even when adjusted for many confounding factors. Odds ratios were markedly higher for recurrent falls than for single fall and fall-related fractures. A previous study suggested that infrequent or isolated falls are more unpredictable events than multiple falls and less likely to result from underlying neurologic or musculoskeletal problems [18]. The incidence of fall-related fractures is also influenced by low bone density which was not measured in this study [26-28]. These factors may have weakened the relationships between the SRRST and a single fall and fall-related fractures. Higher odds ratios, however, remained between the SRRST and history of falling and fractures than previously reported odds ratios calculated from the cut-off points of objective performance tests in frail elderly people who participated in the TOUCH [7]. Cut-points for maximizing the sensitivity and specificity were 2/3 point in all of a single fall, recurrent falls and fall-related fractures. Care providers may require attention to risk of falls and fall-related fractures in the frail elderly adults who have a score 3 points and over in the SRRST.

Why did staff assessments show close relationships with falls and fall-related fractures? Falling is induced by multidimensional factors, and the primary cause of falling may vary among frail elderly adults who have many risk factors for falls. Thus, it is difficult to determine the primary risks for falls in all frail elderly adults using objective measures that can identify only specific issues. In contrast, subjective evaluations can determine combined risks of falling based on various information such as physical functions, daily activity status, and risky behaviors, although these evaluations cannot give clear, specific and objective risks for falling. The combined information is important for identifying risks of falls and preventing falls in frail elderly people, because correct risk-assessments by care staff may lead to successful assessment and interventions for preventing falls [29,30]. We reported previously that an intervention study using supervision technique based on the assessment of fall-risk behaviors can reduce the risk of falling in institutionalized elderly people [31]. Thus, we considered that the assessment and intervention used in the SRRST may be useful for preventing falls in frail elderly people. Furthermore, the SRRST has the strength of being designed for frail elderly people. Although risk factors for falls differ between elderly adults who can and cannot stand unaided [32], nearly all risks identified by the SRRST showed significant odds ratios for falls and fall-related fractures in the dependent walking and independent walking groups. Future research should include a prospective measurement of falls in order to more accurately determine the validity of the SRRST for this population and perform an intervention study to reveal the effects of the SRRST on intervention.

One of the limitations of our study is that we performed a cross-sectional study and analysed retrospectively recalled falls. This is known to be a less accurate measure than prospectively recalled falls [33]. It is possible that underreporting of falls by participants may have led an underestimation of the rates of falls. Therefore, further investigation of the validity of these tests in predicting falls in frail elderly people using a prospective study design is recommended. Second, the investigations of the SRRST and history of falls were investigated at the same time. Thus, the information of the history of falls might affect subjective judgments of the testers. However, correct judgments of the SRRST may require multidimensional information included the history of falls in the elderly adults and testers, i.e. care providers, may know history of falls of their clients through daily care. In other words, testers who had information of falls history in the subjects could measure correctly the risk of falls using the SRRST.

Conclusion

In conclusion, this study developed the SRRST as a subjective assessment for identifying risk of falls in the frail elderly people. Numerous studies developed fall risk assessment tools which evaluate using objective physical or cognitive measurements [2]. Unfortunately, some frail elderly adults cannot perform objective assessments to screen fall risks although these assessment tools may judge almost frail elderly as high risk individuals and identify multiple risks for falling [7]. The SRRST can evaluate easily the specific fall risks and have high feasibility in the elderly. This study provides the evidence that subjective assessment by staff was associated with risk of falling and fall-related fractures in frail elderly people. We encourage providing a fall prevention strategy to the frail elderly who had some risks for falls in your subjective judgments. Future research need to determine the predictive validity of incidence of falls and fractures in the frail elderly people.

Abbreviations

SRRST: Subjective Risk Rating of Specific Tasks; TOUCH: Tsukui Ordered Useful Care for Health; ICC: intraclass correlation coefficient; OR: Odds Ratio; 95% CI: 95% confidence interval.

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Authors' contributions

HS and MS were responsible for the study concept and design. HS was responsible for the draft of the manuscript. MI, TI, KH, and TS were responsible for the critical revision of the manuscript for important intellectual content. KK was responsible for the coordination of acquisition of data. All authors were responsible for the final approval of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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References

1. Ministry of Health, Labor and Welfare: **National nutrition survey in Japan 2002.** Tokyo: Ministry of Health, Labor and Welfare; 2002.
2. Lord SR, Sherrington C, Menz HB, Close JCT: **Falls in older people: risk factors and strategies for prevention.** Cambridge: Cambridge University Press, 2 2007.
3. Scott V, Votova K, Scanlan A, Close J: **Multifactorial and functional mobility assessment tools for fall risk among older adults in community, home-support, long-term and acute care settings.** *Age Ageing* 2007, 36(2):130-139.
4. Robbins AS, Rubenstein LZ, Josephson KR, Schulman BL, Osterweil D, Fine G: **Predictors of falls among elderly people. Results of two population-based studies.** *Arch Intern Med* 1989, 149(7):1628-1633.
5. Lord SR, Menz HB, Tiedemann A: **A physiological profile approach to falls risk assessment and prevention.** *Phys Ther* 2003, 83(3):237-252.
6. Tiedemann A, Shimada H, Sherrington C, Murray S, Lord S: **The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people.** *Age Ageing* 2008, 37(4):430-435.
7. Shimada H, Suzukawa M, Tiedemann A, Kobayashi K, Yoshida H, Suzuki T: **Which neuromuscular or cognitive test is the optimal screening tool to predict falls in frail community-dwelling older people?** *Gerontology* 2009, 55(5):532-538.
8. Salgado R, Lord SR, Packer J, Ehrlich F: **Factors associated with falling in elderly hospital patients.** *Gerontology* 1994, 40(6):325-331.
9. Stevenson B, Mills EM, Welin L, Beal KG: **Falls risk factors in an acute-care setting: a retrospective study.** *Can J Nurs Res* 1998, 30(1):97-111.
10. Jensen J, Nyberg L, Gustafson Y, Lundin-Olsson L: **Fall and injury prevention in residential care–effects in residents with higher and lower levels of cognition.** *J Am Geriatr Soc* 2003, 51(5):627-635.
11. Lundin-Olsson L, Jensen J, Nyberg L, Gustafson Y: **Predicting falls in residential care by a risk assessment tool, staff judgement, and history of falls.** *Aging Clin Exp Res* 2003, 15(1):51-59.
12. Izumi K, Makimoto K, Kato M, Hiramatsu T: **Prospective study of fall risk assessment among institutionalized elderly in Japan.** *Nurs Health Sci* 2002, 4(4):141-147.
13. Nordin E, Lindelöf N, Rosendahl E, Jensen J, Lundin-Olsson L: **Prognostic validity of the Timed Up-and-Go test, a modified Get-Up-and-Go test, staff's global judgement and fall history in evaluating fall risk in residential care facilities.** *Age Ageing* 2008, 37(4):442-448.
14. Suzukawa M, Shimada H, Makizako H, Watanabe S, Suzuki T: **[Incidence of falls and fractures in disabled elderly people utilizing long-term care insurance].** *Nippon Ronen Igakkai zasshi* 2009, 46(4):334-340.
15. Suzukawa M, Shimada H, Tamura M, Suzuki T, Inoue N: **The relationship between the subjective risk rating of specific tasks and falls in frail elderly people.** *J Phys Ther Sci* 2011, 23(3):425-429.
16. Tsutsui T, Muramatsu N: **Japan's universal long-term care system reform of 2005: containing costs and realizing a vision.** *J Am Geriatr Soc* 2007, 55(9):1458-1463.
17. Fried LP, Ettinger WH, Lind B, Newman AB, Gardin J: **Physical disability in older adults: a physiological approach. Cardiovascular Health Study Research Group.** *J Clin Epidemiol* 1994, 47(7):747-760.
18. Nevitt MC, Cummings SR, Kidd S, Black D: **Risk factors for recurrent nonsyncopal falls. A prospective study.** *JAMA* 1989, 261(18):2663-2668.
19. Cumming RG, Sherrington C, Lord SR, Simpson JM, Vogler C, Cameron ID, Naganathan V, Prevention of Older People's Injury Falls Prevention in Hospitals Research Group: **Cluster randomised trial of a targeted multifactorial intervention to prevent falls among older people in hospital.** *BMJ* 2008, 336(7647):758-760.
20. Hashidate H, Shimada H, Shiomi T, Sasamoto N: **Usefulness of the subjective risk rating of specific tasks for falling in frail older people.** *J Phys Ther Sci* 2011, 23(3):519-524.
21. Rubenstein LZ, Josephson KR: **The epidemiology of falls and syncope.** *Clin Geriatr Med* 2002, 18(2):141-158.
22. Tinetti ME, Speechley M, Ginter SF: **Risk factors for falls among elderly persons living in the community.** *N Engl J Med* 1988, 319(26):1701-1707.
23. Fleming BE, Pendergast DR: **Physical condition, activity pattern, and environment as factors in falls by adult care facility residents.** *Arch Phys Med Rehabil* 1993, 74(6):627-630.
24. Kiely DK, Kiel DP, Burrows AB, Lipsitz LA: **Identifying nursing home residents at risk for falling.** *J Am Geriatr Soc* 1998, 46(5):551-555.
25. Perkins NJ, Schisterman EF: **The inconsistency of "optimal" cutpoints obtained using two criteria based on the receiver operating characteristic curve.** *Am J Epidemiol* 2006, 163(7):670-675.
26. Dargent-Molina P, Favier F, Grandjean H, Baudoin C, Schott AM, Hausherr E, Meunier PJ, Bréart G: **Fall-related factors and risk of hip fracture: the EPIDOS prospective study.** *Lancet* 1996, 348(9021):145-149.
27. Cummings SR, Nevitt MC, Browner WS, Stone K, Fox KM, Ensrud KE, Cauley J, Black D, Vogt TM: **Risk factors for hip fracture in white women. Study of Osteoporotic Fractures Research Group.** *N Engl J Med* 1995, 332(12):767-773.
28. Chandler JM, Zimmerman SI, Girman CJ, Martin AR, Hawkes W, Hebel JR, Sloane PD, Holder L, Magaziner J: **Low bone mineral density and risk of fracture in white female nursing home residents.** *JAMA* 2000, 284(8):972-977.
29. Shimada H, Obuchi S, Furuna T, Suzuki T, Nishizawa S, Kojima M: **Risk factors of falls in the elderly people with dementia.** *Gerontol Geriat Int* 2003, 3:S198.
30. Shimada H, Ota M, Yabe N, Obuchi S, Furuna T, Kojima M, Suzuki T: **[Effect of predict falls for behavioral analysis in the elderly with dementia].** *Rigaku ryohogaku* 2004, 31:124-129.
31. Shimada H, Tiedemann A, Lord SR, Suzuki T: **The effect of enhanced supervision on fall rates in residential aged care.** *Am J Phys Med Rehabili* 2009, 88(10):823-828.
32. Lord SR, March LM, Cameron ID, Cumming RG, Schwarz J, Zochling J, Chen JS, Makaroff J, Sitoh YY, Lau TC, Brnabic A, Sambrook PN: **Differing risk factors for falls in nursing home and intermediate-care residents who can and cannot stand unaided.** *J Am Geriatr Soc* 2003, 51(11):1645-1650.
33. Cummings SR, Nevitt MC, Kidd S: **Forgetting falls. The limited accuracy of recall of falls in the elderly.** *J Am Geriatr Soc* 1988, 36(7):613-616.

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Effects of Exercise and Amino Acid Supplementation on Body Composition and Physical Function in Community-Dwelling Elderly Japanese Sarcopenic Women: A Randomized Controlled Trial

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OBJECTIVES: To evaluate the effectiveness of exercise and amino acid supplementation in enhancing muscle mass and strength in community-dwelling elderly sarcopenic women.

DESIGN: Randomized controlled trial.

SETTING: Urban community in Tokyo, Japan.

PARTICIPANTS: One hundred fifty-five women aged 75 and older were defined as sarcopenic and randomly assigned to one of four groups: exercise and amino acid supplementation (exercise + AAS; n = 38), exercise (n = 39), amino acid supplementation (AAS; n = 39), or health education (HE; n = 39).

INTERVENTION: The exercise group attended a 60-minute comprehensive training program twice a week, and the AAS group ingested 3 g of a leucine-rich essential amino acid mixture twice a day for 3 months.

MEASUREMENTS: Body composition was determined using bioelectrical impedance analysis. Data from interviews and functional fitness parameters such as muscle strength and walking ability were collected at baseline and after the 3-month intervention.

RESULTS: A significant group × time interaction was seen in leg muscle mass ($P = .007$), usual walking speed ($P = .007$), and knee extension strength ($P = .017$). The within-group analysis showed that walking speed significantly increased in all three intervention groups, leg muscle mass in the exercise + AAS and exercise groups, and knee extension strength only in the exercise + AAS group (9.3% increase, $P = .01$). The odds ratio for leg muscle mass and knee extension strength improvement was more than four times as great in the exercise + AAS group (odds ratio = 4.89, 95% confidence interval = 1.89–11.27) as in the HE group.

CONCLUSION: The data suggest that exercise and AAS together may be effective in enhancing not only muscle strength, but also combined variables of muscle mass and walking speed and of muscle mass and strength in sarcopenic women. J Am Geriatr Soc 60:16–23, 2012.

Key words: sarcopenic women; exercise; amino acid supplementation; muscle mass; muscle strength

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Sarcopenia, defined as age-related involuntary loss of skeletal muscle mass and strength,[1,2] has been associated with physical disability, functional decline, falls, impaired mobility, and mortality in elderly people.[3,4] Therefore, treating or reversing sarcopenia is important in the maintenance of health and life expectancy in the elderly population. Although many factors, such as chronic disease, physical inactivity, and decreased muscle protein synthesis, may contribute to loss of muscle mass,[5-7] it has been suggested that only skeletal muscle disuse and undernutrition are potentially preventable or reversible with targeted interventions.[8]

Many studies have shown a strong relationship between resistance exercise and strength improvement, through which the efficacy of resistance exercise for the prevention and treatment of sarcopenia has been confirmed.[9] The previous studies have also shown that ingestion of essential amino acids can induce muscle protein anabolism in elderly adults.[10,11] One study showed that the combination of resistance exercise and essential amino acid supplementation (AAS) augmented muscle protein

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synthesis, suggesting it as a strategy to reverse sarcopenia[12] but in a small sample size. There are few randomized controlled trials (RCTs) on the effects of exercise and AAS on body composition and functional capacity.

The purpose of this study was to investigate the effects of exercise and AAS on muscle mass, strength, and walking ability in sarcopenic women.

METHODS

Subjects

A letter outlining the comprehensive geriatric health examination survey, describing its objective and the way that the personal data would be used, was mailed to the women randomly selected from the Basic Resident Register of 5,932 people aged 75 and older residing in the Itabashi ward of metropolitan Tokyo inviting them to participate in the study. Two thousand eighteen people responded to the mailed letters of invitation to participate in the study, with 1,670 people agreeing and 348 people declining to participate. The baseline assessment was conducted at the Tokyo Metropolitan Institute of Gerontology (TMIG) from October 12 to November 3, 2008. One thousand three hundred eighty-three women aged 75 and older were screened; 287 who originally agreed to participation were absent. Written informed consent was obtained for baseline screening; six people did not sign the informed consent form and were not included in this study.

Three hundred four of 1,377 women (22.1%) were operationally defined as sarcopenic (Figure 1), with selection based on categorization into one or more of the following inclusion criteria groups: appendicular skeletal muscle mass/height^2 less than 6.42 kg/m^2 and knee extension strength less than 1.01 Nm/kg[13,14] (n = 68), appendicular skeletal muscle mass/height^2 less than 6.42 kg/m^2 and usual walking speed less than 1.22 m/s (n = 65),[14] body mass index (BMI) less than 22.0 kg/m^2[14] and knee

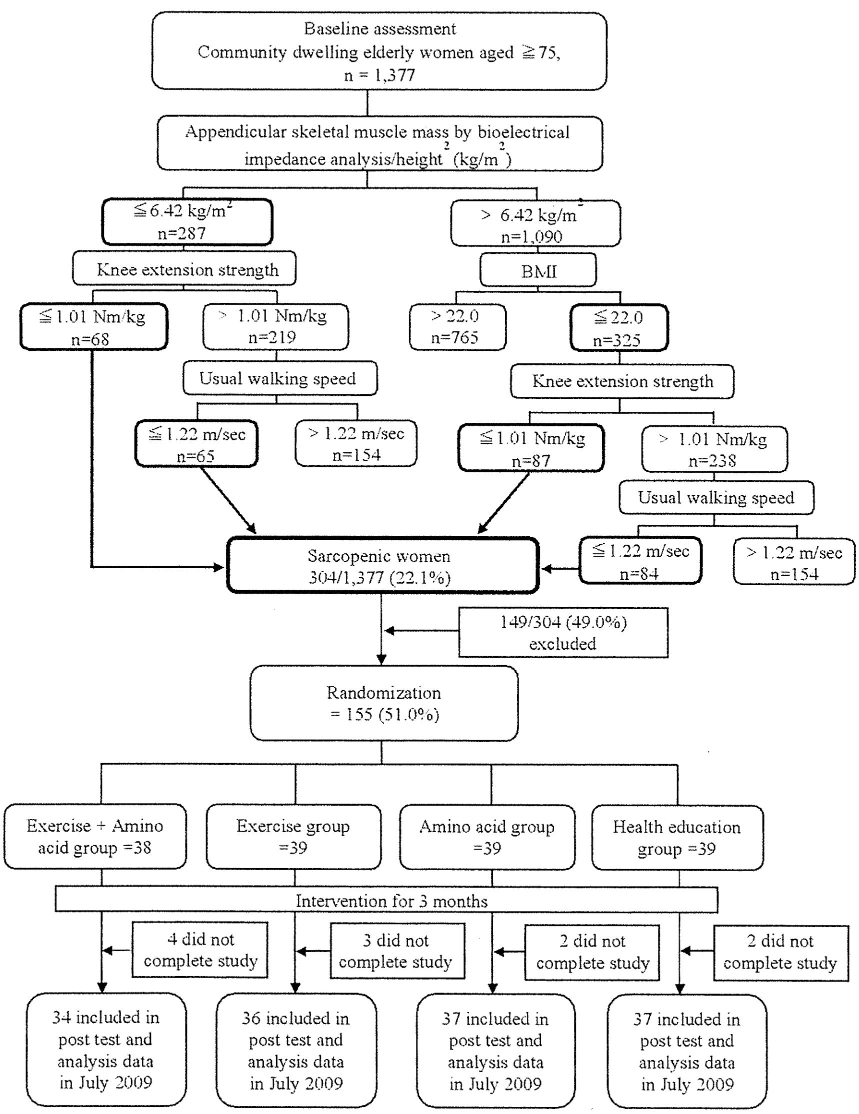

Figure 1. Algorithm for the selection of women who were operationally defined as sarcopenic and flowchart of participants in the randomized controlled trial of exercise and amino acid supplementation.

extension strength less than 1.01 Nm/kg (n = 87), and BMI less than 22.0 kg/m^2 and usual walking speed less than 1.22 m/s (n = 84). Exclusion criteria were severe knee or back pain; severely impaired mobility; impaired cognition (Mini-Mental State Examination (MMSE) score < 24);[16] missing baseline data; and unstable cardiac conditions such as ventricular dysrhythmias, pulmonary edema, or other musculoskeletal conditions. One hundred forty-nine (49.0%) of the potential sarcopenic participants were excluded because they were classified into one or more of the exclusion criteria or declined participation. The Clinical Research Ethics Committee of TMIG approved the study protocol. The intervention procedures were fully explained to all participants, and written informed consent was obtained (Figure 1).

Randomization

Randomization was performed after the baseline assessment; any variable that identified personal information was not included in the randomization process. Computer-generated random numbers were assigned to 155 participants who were then sorted and divided into four equal groups. The groups were randomly assigned to one of the four interventions groups: exercise + AAS (n = 38), exercise (n = 39), AAS (n = 39), or health education (HE; n = 39). All participants agreed to the group allocations that were mailed to them. There was no attempt to equalize the size of the groups based on their characteristics or to recruit subjects with specific characteristics. The co-investigators were blind to the randomization procedure and group allocations, separate physical therapy staff members who were also blind to the allocation of treatments collected data.

Outcome Measures

Outcome measures were evaluated according to data collected from interviews, body composition assessments using bioelectrical impedance analysis (BIA), and physical fitness tests at baseline and after the 3-month intervention.

Interview Survey

Face-to-face interviews were conducted to assess the individual's history of fractures and falls over the previous year, number of falls, cause of falls, urinary incontinence, exercise habits, smoking status, and MMSE score.

Body Composition Assessment

Measurements of height and weight were used to calculate BMI (kg/m^2). Body composition was measured using a segmental multifrequency BIA instrument that operated at frequencies of 5, 50, 250, and 550 kHz (Well-Scan 500, Elk Corp., Tokyo, Japan). Participants removed their socks, stood on two metallic electrodes on the floor scale barefoot, and held metallic grip electrodes placed in the palm of the hand with the fingers wrapped around the handrails. Using segmental body composition and muscle mass values of both legs, both arms, and the trunk, appendicular skeletal muscle mass and leg muscle mass values were obtained and used for analysis by summing the appropriate segmental muscle mass values.[13,17,18] Reliability of body composition measurements in all 155 participants in this study was not analyzed, although for the AAS group (n = 39), measurements were taken for a second time 1 week after baseline testing, and reliability was examined; the intraclass correlation coefficients (ICC) were: 0.98 for the right arm, 0.97 for the left arm, 0.97 for the right leg, 0.96 for the left leg, and 0.93 for the trunk.

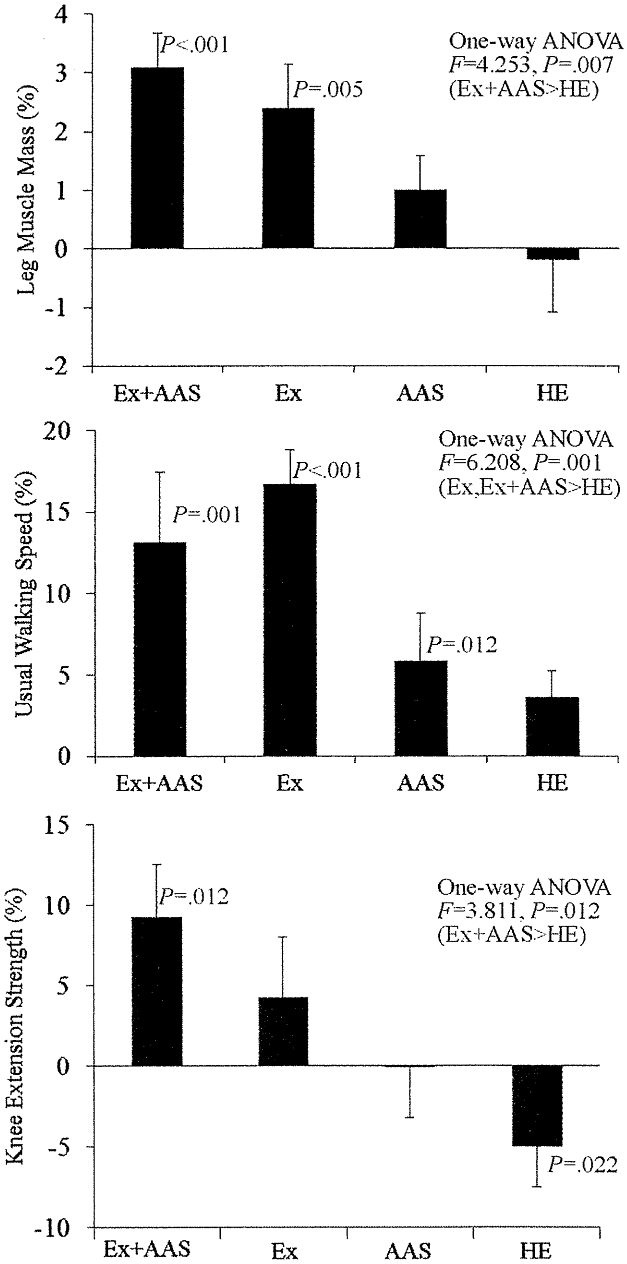

Figure 2. Mean percentage changes (standard errors) in leg muscle mass, usual walking speed, and knee extension strength after exercise (Ex), amino acid supplementation (AAS), both (Ex + AAS), or health education (HE). Bars indicate average changes from baseline to after the 3-month intervention. ANOVA = analysis of variance.

Functional Fitness Test

Calf girth and functional fitness variables including usual and maximum walking speeds and knee extension strength were measured. In measures of walking speed, participants were allowed to use assistive walking devices only if they expressed strong concerns about walking without a device or if there was any danger of falling. The knee extension strength measurement was taken twice, and the higher value divided by body weight (Nm/kg) were analyzed. The procedures for the functional fitness tests have been described in detail in previous reports.[19,20]

Intervention

Exercise

A comprehensive physical fitness and muscle mass enhancement training program of moderate intensity was provided for the participants in the exercise groups. The exercise intervention consisted of 60-minute exercise sessions held at the TMIG twice per week for 3 months. Each exercise intervention group was divided into two subgroups, with participants exercising together within their assigned group in one of four exercise sessions offered per day.

Each exercise session consisted of a 5-minute warm-up, 30 minutes of strengthening exercise, 20 minutes of balance and gait training, and 5 minutes of cool down. The strengthening exercises were performed in a progressive sequence from seated to standing positions. For each type of exercise, participants were instructed to complete up to eight repetitions of the movements. When the exercises were properly executed without significant fatigue or loss of proper execution, the resistance was increased. The progressive resistance was provided through the use of resistance bands or ankle weights. Intensity was maintained at approximately 12 to 14 on the Borg Rate of Perceived Exertion scale.[21] The principal investigator, along with the exercise instructor and assistant trainers, assessed each individual's ability to increase intensity.

Chair exercise: The chair-seated exercises were used in the early stages of the program because the participants were frail older adults and it provided a secure and stable position. Repetitions of toe raises, heel raises, knee lifts, knee extensions, and others were performed while seated on a chair. Hip flexions, lateral leg raises, and repetitions of other exercises were performed standing upright behind the chair and holding the back of the chair for stability.

Ankle-weight exercise: To strengthen lower extremities, a fixed weight was placed on the ankle while participants performed strengthening exercises. Weights of 0.50, 0.75, 1.00, and 1.50 kg were prepared and used in accordance with each participant's strength level as the resistance progressively increased. The exercises performed using these ankle weights included seated knee flexion and extension and standing knee flexion and extensions.

Exercises using a resistance band: Resistance bands were used to strengthen the upper and lower body. Lower body exercises included leg extension and hip flexion. Upper body exercises included double-arm pull downs and biceps curls.

Balance and gait training: The balance training was focused on improvement of static, dynamic, and lateral balancing ability. Exercises included standing on one leg, multidirectional weight shifts, tandem stand, and tandem walk. Participants practiced proper gait mechanics that focused on the maintenance of stability during walking and increasing stride length, toe elevation of the forward limb, heel elevation of the rear limb, frequency of stepping, and heel–floor angle. Exercises included raising the toes (dorsiflexion) during the forward swing of the leg, kicking off the floor with the ball of the foot, walking with directional changes, and gait pattern variations.

Amino Acid Supplementation

Essential AAS was provided for the participants in the AAS groups every 2 weeks. Packets of powdered amino acid supplements (42.0% leucine, 14.0% lysine, 10.5% valine, 10.5% isoleucine, 10.5% threonine, 7.0% phenylalanine, and 5.5% other) were provided for the participants to be taken with water or milk, and they were instructed to take the 3-g supplement two times a day (6 g daily) every day for 3 months.[22] To monitor their amino acid intake accurately, participants were given record sheets that were collected every 2 weeks on which they recorded what time of day they took the supplement and the amount of amino acid taken every day.

Health Education

Participants in the HE group took a class once a month for 3 months, a total of three times. The classes focused on cognitive function, osteoporosis, and oral hygiene. Participants were asked to continue their regular lifestyle habits, and no specific instructions on diet or physical activity were given.

Data Analysis

Sample size calculations using univariate one-factor repeated-measures analysis of variance (ANOVA) to examine significant differences in means at baseline and after the 3-month intervention ($\alpha = 0.05$, power = 0.80) with an effect size of 0.15 required a sample size of 28 participants. Esimating a potential attrition rate of 25%, 38 subjects per group were required.[23] One-way ANOVA was used to test any differences in baseline measures and percentage changes between groups, and chi-square tests were performed on categorical variables. Percentage changes in muscle mass and functional fitness after the intervention were calculated using the following formula: % change = ((postintervention value–baseline value)/(baseline value) × 100). Two-way repeated-measures ANOVA was used to evaluate the differences in the effect of the intervention on the outcome measures between groups, and a post hoc test was done on variables showing significant differences to determine which groups were different. Multiple logistic regressions were performed to compare the effects of the four intervention groups on each outcome variable after 3 months of intervention. All analyses were performed using SPSS version 15.0 of Windows (SPSS, Inc., Tokyo, Japan).

RESULTS

The baseline demographic, fitness, and interview variables of the participants in the four groups are summarized in Table 1. All of the baseline characteristics were similar between the groups.

The mean attendance rates during the 3-month intervention were 70.3% in the exercise + AAS group, 80.5% in the exercise group, 72.2% in the AAS group, and 71.8% in the HE group. Eleven participants (exercise + AAS = 4, exercise = 3, AAS = 2, HE = 2) were unable to complete the study after randomization because of spouse care (n = 3), admission to nursing home (n = 2), lack of motivation (n = 2), severe knee or back pain (n = 1), death (n = 1), falls and hip fracture (n = 1), and hospitalization (n = 1; Figure 2).

In comparing the pre- and postintervention changes in body composition and functional fitness of the groups (Table 2), there was a significant group × time interaction for leg muscle mass ($F = 4.253$, $P < .007$; exercise + AAS > HE), usual and maximum walking speeds (exercise and exercise + AAS > HE), and knee extension strength ($F = 3.558$, $P = .02$; exercise + AAS > HE).

The within-group analysis showed significant changes in leg muscle mass in the exercise + AAS ($P < .001$) and exercise ($P = .005$) groups and changes in usual walking speed in the exercise + AAS ($P = .001$), exercise ($P < .001$), and AAS groups ($P = .01$). Knee extension strength improved significantly only in the exercise + AAS group ($P = .01$), no improvement was seen in exercise or AAS, and a statistically significant decrease was observed in the HE group ($P = .02$; Figure 1).

Table 3 shows the effects of the type of intervention on changes in combined variables of muscle mass and physical function. Significant increases in leg muscle mass and knee extension strength (odds ratio (OR) = 4.89, 95% confidence interval (CI) = 1.89–11.27) and leg muscle mass and usual walking speed (OR = 4.11, 95% CI = 1.33–13.68) were observed in only the exercise + AAS group.

DISCUSSION

Although many definitions of sarcopenia have been reported,[1–3,24] there has recently been a focus not only on the loss of appendicular skeletal muscle mass, but also on functional decline.[25] In this study, sarcopenic women were operationally defined based on declines in muscle strength or walking ability that accompany the loss of skeletal muscle mass or low BMI. Because defining sarcopenia was beyond the scope of this study, the focus of the discussion will be on the effects of the intervention. To evaluate the intervention effects, the changes observed in the single variables as well as the combined variables will be discussed.

Many studies have focused on exercise or nutrition as interventions to reverse sarcopenia, but the results of these studies have not always been consistent.[8,9,12,26]

This study demonstrated that appendicular muscle mass and walking speed increased with the combination of exercise and essential amino acid ingestion, as well as with the separate exercise and amino acid interventions, but muscle strength improved only with the combination of exercise and amino acid ingestion.

A recently published meta-analysis[9] and a Cochrane review article also confirmed that resistance training two to three times a week can improve physical function and functional limitations and can reduce disability and muscle weakness in older people.[27] Previous studies have demonstrated that resistance training in elderly people produces

Table 1. Selected Variable Characteristics of Participants at Baseline According to Study Group

Characteristic	Exercise + AAS (n = 38)	Exercise (n = 39)	AAS (n = 39)	Health Education (n = 39)	F-Value*	P-Value*
Age, mean ± SD	79.5 ± 2.9	79.0 ± 2.9	79.2 ± 2.8	78.7 ± 2.8	0.577	.63
Height, cm, mean ± SD	147.1 ± 6.7	147.7 ± 4.4	145.8 ± 4.5	146.5 ± 4.9	0.960	.41
Body weight, kg, mean ± SD	39.5 ± 5.5	41.1 ± 4.7	40.1 ± 3.2	40.4 ± 3.9	0.874	.46
Body mass index, kg/m^2, mean ± SD	18.3 ± 2.5	18.9 ± 2.0	18.9 ± 1.6	18.8 ± 1.7	0.745	.53
Calf girth, cm, mean ± SD	18.3 ± 2.5	18.9 ± 2.0	18.9 ± 1.6	18.8 ± 1.7	0.745	.53
Lean body mass, kg, mean ± SD	29.1 ± 3.4	30.0 ± 2.6	28.8 ± 2.0	29.3 ± 2.4	1.505	.22
Muscle mass, kg, mean ± SD	26.9 ± 3.1	27.7 ± 2.3	26.5 ± 1.8	27.0 ± 2.2	1.538	.21
Appendicular muscle mass, kg, mean ± SD	13.3 ± 1.6	13.7 ± 1.3	13.1 ± 1.0	13.3 ± 1.2	1.502	.22
Legs muscle mass, kg, mean ± SD	9.8 ± 1.2	10.1 ± 1.0	9.7 ± 0.7	9.9 ± 0.9	1.570	.20
Usual walking speed, m/s, mean ± SD	1.26 ± 0.27	1.29 ± 0.28	1.29 ± 0.20	1.18 ± 0.22	1.701	.17
Maximal walking speed, m/s, mean ± SD	1.62 ± 0.37	1.67 ± 0.31	1.67 ± 0.27	1.55 ± 0.32	1.150	.33
Knee extension strength, Nm, mean ± SD	45.9 ± 11.3	46.6 ± 11.1	46.7 ± 7.8	47.4 ± 10.5	0.139	.94
Falls, %	21.1	17.9	15.4	20.5	0.519	.91
Exercise habit, %	26.3	25.6	38.5	33.3	2.029	.57
Urinary incontinence, %	44.7	38.5	41.0	25.6	3.414	.33
Osteoporosis history, %	36.8	43.6	48.7	30.8	2.987	.39
Heart disease history, %	10.5	15.4	12.8	17.9	0.977	.81
Diabetes mellitus history, %	7.9	5.1	5.1	12.8	2.156	.54

* One-way analysis of variance for continuous variables and chi-square test for categorical variables.

AAS = amino acid supplementation; SD = standard deviation.

Table 2. Comparison of Muscle Mass and Functional Fitness Variables Between Groups After 3-Month Intervention

Variable	Group	Mean ± Standard Deviation: Baseline	Mean ± Standard Deviation: After 3-Month Intervention	Analysis of Variance (Group × Time), *P*-Value	Post Hoc Analysis*
Muscle mass, kg	Exercise + AAS	26.76 ± 2.77	27.26 ± 3.04	*F* = 1.076, .36	
	Exercise	28.09 ± 1.90	28.51 ± 2.39		
	AAS	26.25 ± 1.81	26.53 ± 2.10		
	HE	27.48 ± 2.04	27.66 ± 2.23		
Appendicular muscle mass, kg	Exercise + AAS	13.25 ± 1.35	13.59 ± 1.53	*F* = 1.354, .26	
	Exercise	13.90 ± 1.06	14.19 ± 1.33		
	AAS	12.86 ± 0.99	13.03 ± 1.10		
	HE	13.57 ± 1.16	13.67 ± 1.05		
Legs muscle mass, kg	Exercise + AAS	9.76 ± 1.01	10.07 ± 1.13	*F* = 4.253, .007	Exercise + AAS > HE
	Exercise	10.28 ± 0.81	10.53 ± 1.05		
	AAS	9.55 ± 0.73	9.65 ± 0.83		
	HE	10.14 ± 0.87	10.11 ± 0.81		
BMI, kg/m^2	Exercise + AAS	18.30 ± 2.64	18.14 ± 2.68	*F* = 0.606, .61	
	Exercise	18.80 ± 1.30	18.50 ± 1.41		
	AAS	18.84 ± 1.43	18.56 ± 1.62		
	HE	18.83 ± 1.75	18.77 ± 1.67		
Usual walking speed, m/s	Exercise + AAS	1.27 ± 0.25	1.43 ± 0.29	*F* = 4.213, .007	Exercise and Exercise + AAS > HE
	Exercise	1.31 ± 0.24	1.50 ± 0.23		
	AAS	1.30 ± 0.18	1.36 ± 0.18		
	HE	1.19 ± 0.21	1.22 ± 0.23		
Maximum walking speed, m/s	Exercise + AAS	1.64 ± 0.34	1.92 ± 0.37	*F* = 9.374, <.001	Exercise and Exercise + AAS > HE
	Exercise	1.72 ± 0.27	2.04 ± 0.27		
	AAS	1.71 ± 0.28	1.92 ± 0.27		
	HE	1.57 ± 0.31	1.64 ± 0.31		
Knee extension strength, Nm/kg	Exercise + AAS	1.15 ± 0.27	1.23 ± 0.29	*F* = 3.558, .02	Exercise + AAS > HE
	Exercise	1.12 ± 0.30	1.14 ± 0.26		
	AAS	1.15 ± 0.25	1.14 ± 0.25		
	HE	1.14 ± 0.26	1.00 ± 0.26		

* A post hoc analysis was performed using the Scheffe method.
AAS = amino acid supplementation; HE = health education; BMI = body mass index.

Table 3. Change in Leg Muscle Mass and Functional Fitness After Intervention According to Study Group

Dependent Variable*	Adjusted Odds Ratio (95% Confidence Interval): AAS	Exercise	Exercise + AAS
Change in leg muscle mass and knee extension strength	1.99 (0.72–5.65)	2.61 (0.88–8.05)	4.89 (1.89–11.27)
Change in leg muscle mass and usual walking speed	1.35 (0.45–4.08)	2.41 (0.79–7.58)	4.11 (1.33–13.68)

Reference: health education.
* 1 = improve, 0 = no change or decrease.
AAS = amino acid supplementation.

9% to 15% increases in strength and approximately 5% in thigh muscle volume.[28,29] Also, many studies have shown that resistance training in elderly people must be conducted at high intensities and volumes to see improvements.[9,27] In contrast, less-intense resistance exercise programs have produced little or no strength gains.

The data in this study show improvements of 2.4% in leg muscle mass, 2.0% in appendicular muscle mass, and 4.3% in leg strength in the exercise group. The moderate-intensity exercise provided in this trial produced strength gains that were smaller than those seen in previous studies, but the combination of moderate intensity exercise and AAS increased muscle mass 3.1% and muscle strength 9.3%, gains that are comparable with those observed in previous studies of high-intensity exercise.[28]

The results of the current study showed that total muscle mass, appendicular muscle mass, and walking speed significantly increased in the exercise group, suggesting that exercise is effective in the improvement of muscle mass and functional fitness, but increases in muscle strength were not observed. These results indicate that exercise alone is insufficient for recovery in sarcopenic elderly women.

Previous studies have indicated that declines in muscle mass are related to declines in muscle protein synthesis rates in older adults and that leucine-enriched essential amino acid mixtures are primarily responsible for the amino acid-induced muscle protein anabolism in elderly people.[11,22] These studies investigated the effects of different amino acid dosages (from 6.7 to 20.0 g/d) on protein synthesis, and the 6.0-g/d dosage provided in this study is lower than in previous studies, but the mean weights of the subjects in such studies were from 71.0 to 81.3 kg, making the dosage of amino acid between 0.090 and 0.246 g/kg of body weight. The amino acid dosage in the current study was 0.151 g/kg, which is comparable with the amounts found in the literature.[11,22,26] The results of the current study showed that muscle mass, appendicular muscle mass, and leg muscle mass significantly increased in the AAS group, which is consistent with previous findings.

Many studies have demonstrated an increase in muscle mass from nutritional supplementation, but an increase in muscle strength does not always accompany an increase in muscle mass. A recent study concluded that essential AAS alone was not sufficient to increase muscle strength.[26] Similarly, although the results of the current study showed that AAS alone increased muscle mass, improvement in muscle strength was not observed. The results of the present study showed that muscle mass increased significantly with exercise or essential AAS, although muscle strength, measured according to knee extension strength, improved significantly only in the exercise + AAS group.

Next, the discussion will focus on the changes in the combined variables. One study that investigated the effects of resistance exercise and nutritional supplementation on muscle mass and strength in older adults concluded that high-intensity resistance exercise was beneficial in increasing muscle mass and muscle strength, but the nutritional supplementation, which contained only a small percentage of a soy-based protein within a mixture of mainly carbohydrates, did not contribute to those gains.[8] As illustrated in Figure 2, exercise alone was effective in enhancing single variables such as leg muscle mass or usual walking speed. Similarly, the AAS group improved usual walking speed, but rationally, to treat sarcopenia, improvements in single variables are not sufficient. Improvements observed in the combined variables would presumably lead to the most-efficient reversal of sarcopenia. Significant improvements in the combinations of leg muscle mass, knee extension strength, and walking speed were seen only in the exercise + AAS group. Although whether exercise + AAS was better than either intervention alone remains inconclusive, these results suggest that exercise + AAS may be necessary for benefits in muscle mass and strength.

This study has several limitations. First is the measurement of body composition estimated using BIA. Although magnetic resonance imaging (MRI), computed tomography, and dual-energy X-ray absorptiometry are common, accurate clinical methods of measuring muscle mass,[30,31] they are cost ineffective and are not always appropriate for field studies. BIA is simple, noninvasive, and inexpensive and has been widely used in field studies. The comparison of MRI and BIA measurements has revealed a strong correlation between the two, confirming the validity of the BIA method for muscle mass measurement in older adults.[13,17,18] Therefore, the validity of the data collected using BIA has little influence on the interpretation of the results of this study. Second, it has been reported that AAS enhances muscle protein synthesis,[11,22,32] but the mechanism of the increase in muscle mass from AAS was not explored in the current investigation. Therefore, the results of this study were interpreted based on the assumption that muscle protein synthesis had been enhanced. Third, the effects of the exercise + AAS should have been determined with the use of placebos, but placebo treatments were not provided in this study, so future research should include placebos to observe the effects of exercise and AAS on physical function and muscle strength. Fourth, the total number of dropouts in this study was 11 people, and they were not included in the data analysis. Many studies have used intention-to-treat (ITT) analyses to determine the effects of RCTs, and the use of ITT analyses are increasing, although one previous study found that only approximately 35% of 274 RCTs used ITT analyses.[33] The current study was not an ITT analysis because it confirmed that there were no significant differences between the dropouts and the participants who completed the study, and the exclusion of the 11 dropouts from the analysis did not affect the integrity of the baseline randomization. Finally, previous research has shown that milk contains essential amino acids.[34,35] Because some of the participants took the AAS with milk, the exact essential amino acid dosage in this study could not be determined, and the effect of drinking milk on the results of this study was not confirmed. Future research should avoid the intake of milk with amino acids when investigating the effects of amino acids on muscle strength and mass and physical function.

This study demonstrated that exercise and nutrition may be necessary for the basic treatment of increasing muscle mass and strength to reverse the effects of sarcopenia in community-dwelling sarcopenic women. Exercise and AAS together have significant effects on enhancing not only muscle strength, but also the combined variables of muscle mass and walking speed and of muscle mass and strength in this study population, but further follow-up studies on larger populations are required to confirm these results.

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Author Contributions: H. Kim developed the study concept and design, recruited subjects, developed the intervention program, analyzed and interpreted the data, and prepared the manuscript. S. Takao interpreted the data and reviewed the manuscript for accuracy. K. Saito assisted in AAS and supervised the interview survey. Y. Hideyo assisted in subject recruitment, supervised the

interviewers, and interpreted the data. M. Kobayashi assisted in AAS and subject recruitment and interpreted the data. H. Kato assisted in assisted AAS and body composition assessment. M. Katayama assisted in AAS and interview survey.

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REFERENCES

1. Rosenberg IH. Summary comments. Am J Clin Nutr 1989;50:1231–1233.
2. Evans WJ. What is sarcopenia? J Gerontol A Bio Sci Med Sci 1995;50A:5–8.
3. Baumgartner RN. Body composition in healthy aging. Ann N Y Acad Sci 2000;904:437–448.
4. Janssen I, Baumgartner RN, Ross R et al. Skeletal muscle cutpoints associated with elevated physical disability risk in older men and women. Am J Epidemiol 2004;159:413–421.
5. Baumgartner RN, Waters DL, Gallagher D et al. Predictors of skeletal muscle mass in elderly men and women. Mech Ageing Dev 1999;107:123–136.
6. Iannuzzi-Sucich M, Prestwook KM, Kenny AM. Prevalence of sarcopenia and predictors of skeletal muscle mass in healthy, older men and women. J Gerontol A Biol Sci Med Sci 2002;57A:M772–M777.
7. Bortz WM II. Disuse and aging. JAMA 1982;248:1203–1208.
8. Fiatarone MA, O'Neill EF, Ryan ND et al. Exercise training and nutritional supplementation for physical frailty in very elderly people. N Engl J Med 1994;330:1769–1775.
9. Peterson MD, Rhea MR, Sen A et al. Resistance exercise for muscular strength in older adults: A meta-analysis. Ageing Res Rev 2010;9:226–237.
10. Paddon-Jones D, Sheffield-Moore M, Katsanos CS et al. Differential stimulation of muscle protein synthesis in elderly humans following isocaloric ingestion of amino acids or whey protein. Exp Gerontol 2006;41:215–219.
11. Katsanos CS, Kobayashi H, Sheffield-Moore M et al. Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids. Am J Clin Nutr 2005;82:1065–1073.
12. Drummond MJ, Dreyer HC, Pennings B et al. Skeletal muscle protein anabolic response to resistance exercise and essential amino acids is delayed with aging. J Appl Physiol 2008;104:1452–1461.
13. Chien MY, Huang TY, Wu YT. Prevalence of sarcopenia estimated using a bioelectrical impedance analysis prediction equation in community-dwelling elderly people in Taiwan. J Am Geriatr Soc 2008;56:1710–1715.
14. Manini TM, Visser M, Won-Park S et al. Knee extension strength cutpoints for maintaining mobility. J Am Geriatr Soc 2007;55:451–457.
15. Kulminski AM, Arbeev KG, Kulminskaya IV et al. Body mass index and nine-year mortality in disabled and nondisabled older U.S. individuals. J Am Geriatr Soc 2008;56:105–110.
16. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–198.
17. Janssen I, Heymsfield SB, Baumgartner RN et al. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol 2000;89:465–471.
18. Tengvall M, Ellegard L, Malmros V et al. Body composition in the elderly: Reference values and bioelectrical impedance spectroscopy to predict total body skeletal muscle mass. Clin Nutr 2009;28:52–58.
19. Kim H, Suzuki T, Yoshida Y et al. Effectiveness of multidimensional exercise for the treatment of stress urinary incontinence in elderly community-dwelling Japanese women: A randomized, controlled, crossover trial. J Am Geriatr Soc 2007;55:1932–1939.
20. Suzuki T, Kim H, Yoshida H et al. Randomized controlled trial of exercise intervention for the prevention of falls in community-dwelling elderly Japanese women. J Bone Miner Metab 2004;22:602–611.
21. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc 1982;14:377–381.
22. Katsanos CS, Kobayashi H, Sheffield-Moore M et al. A high proportion of leucine is required for optimal stimulation of the rate of muscle protein synthesis by essential amino acids in the elderly. Am J Physiol Endocrinol Metab 2006;291:E381–E387.
23. Cohen J. A power primer. Psychol Bull 1992;112:155–159.
24. Baumgartner RM, Koehler KM, Gallagher D et al. Epidemiology of sarcopenia among the elderly in New Mexico. Am J Epidemiol 1998;147:755–763.
25. Cruz-Jentoft AJ, Baeyens JP, Bauer JM et al. Sarcopenia: European consensus on definition and diagnosis. Age Ageing 2010;39:412–423.
26. Dillon EL, Moore MS, Jones DP et al. Amino acid supplementation increases lean body mass, basal muscle protein synthesis, and insulin-like growth factor-I expression in older women. J Clin Endocrinol Metab 2009;94:1630–1637.
27. Liu C, Latham NK. Progressive resistance strength training for improving physical function in older adults. Cochrane Database Syst Rev 2009;3: CD002759.
28. Borst SE. Interventions for sarcopenia and muscle weakness in older people. Age Ageing 2004;33:548–555.
29. Roth SM, Ivey FM, Martel GF et al. Muscle size responses to strength training in young and older men and women. J Am Geriatr Soc 2001;49:1428–1433.
30. Wang Z, Visser M, Ma R et al. Skeletal muscle mass: Evaluation of neutron activation and dual-energy X-ray absorptiometry methods. J Appl Physiol 1996;80:824–831.
31. Mitsiopoulos N, Baumgartner RN, Heymsfield SB et al. Cadaver validation of skeletal muscle measurement by magnetic resonance imaging and computerized tomography. J Appl Physiol 1998;85:115–122.
32. Volpi E, Kobayashi H, Sheffield-Moore M et al. Essential amino acids are primarily responsible for the amino acid stimulation of muscle protein anabolism in healthy elderly adults. Am J Clin Nutr 2003;78:250–258.
33. Herman A, Botser IB, Tenenbaum S et al. Intention-to-treat analysis and accounting for missing data in orthopaedic randomized clinical trials. J Bone Joint Surg Am 2009;91:2137–2143.
34. Elliot TA, Cree MG, Sanford AP et al. Milk ingestion stimulates net muscle protein synthesis following resistance exercise. Med Sci Sports Exerc 2006;38:667–674.
35. Wilkinson SB, Tarnopolsky MA, MacDonald MJ et al. Consumption of fluid skim milk promotes greater muscle protein accretion after resistance exercise than does consumption of an isonitrogenous and isoenergetic soy-protein beverage. Am J Clin Nutr 2007;85:1031–1040.

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高齢者の安全な薬物療法　第 27 回

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薬剤起因性歩行障害

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薬剤起因性歩行障害

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高齢者は複数の慢性疾患を抱え，訴えも多いため服用薬剤数が多くなりやすい．不用意な鎮静催眠薬，抗うつ薬，抗精神病薬の使用は転倒を誘発すること，また，消化管運動調整薬の長期連用はパーキンソニズムを誘発することに留意すべきである．もし，めまい，ふらつき，歩行障害，易転倒性のある患者をみた場合，「お薬手帳」で投薬内容を確認し，薬剤による副作用を念頭に置くべきである．

症例呈示

73歳/女性

主訴：ふらつき，歩行障害，転倒．

生活歴：夫と2人暮らしで家事は本人が行う．

現病歴：高血圧，脂質異常症のためA医院でベザフィブラート(ベザトール®SR)，オルメサルタン(オルメテック®)，ドンペリドン(ナウゼリン®)，酸化マグネシウム，また，69歳時に診断されたうつ病のためB医院(精神科クリニック)にてアモキサピン(アモキサン®：三環系抗うつ薬)，フルボキサミン(デプロメール®：抗うつ薬(SSRI))，トラゾドン(レスリン®：抗うつ薬)，ビペリデン(アキネトン®：抗コリン薬)，エチゾラム(デパス®：抗不安薬)，ブロチゾラム(レンドルミン®：睡眠薬)の処方を受けていた．特に，抗うつ薬の服用開始後，動作緩慢，脱力，右手の震えが生じ，72歳のときからふらつき，前傾歩行，突進歩行，転倒するようになった．これに対してB医院でアモキサピンの増量を行ったところ，ふらつきが増悪したため，娘に付き添われて当院外来を受診した．

身体所見：異常所見として寡動，仮面用顔貌，口唇の不随意運動，右上肢の振戦を認めた．

検査所見：肝，腎，甲状腺機能を含めて血液検査所見上特記すべき異常なし．頭部CT異常なし．

臨床経過：抗うつ薬，抗不安薬によるふらつき，歩行障害とドンペリドンによる薬剤性パーキンソニズムと考え，順次薬剤を減量・中止した(図1)．これにより，ふらつき，歩行障害は顕著に改善し，また，パーキンソン徴候(寡動，仮面用顔貌，不随意運動)もほぼ消失，意欲の向上がみられ，初診から7カ月後に終診とし，かかりつけ医(A医院)のみに通院することになった．

解説

本症例では，SSRI以外の抗うつ薬であるアモキサピン，トラゾドン，ならびに抗不安薬エチゾラムを減量・中止し，また薬剤性パーキンソニズムの原因になっていると考えられるドン

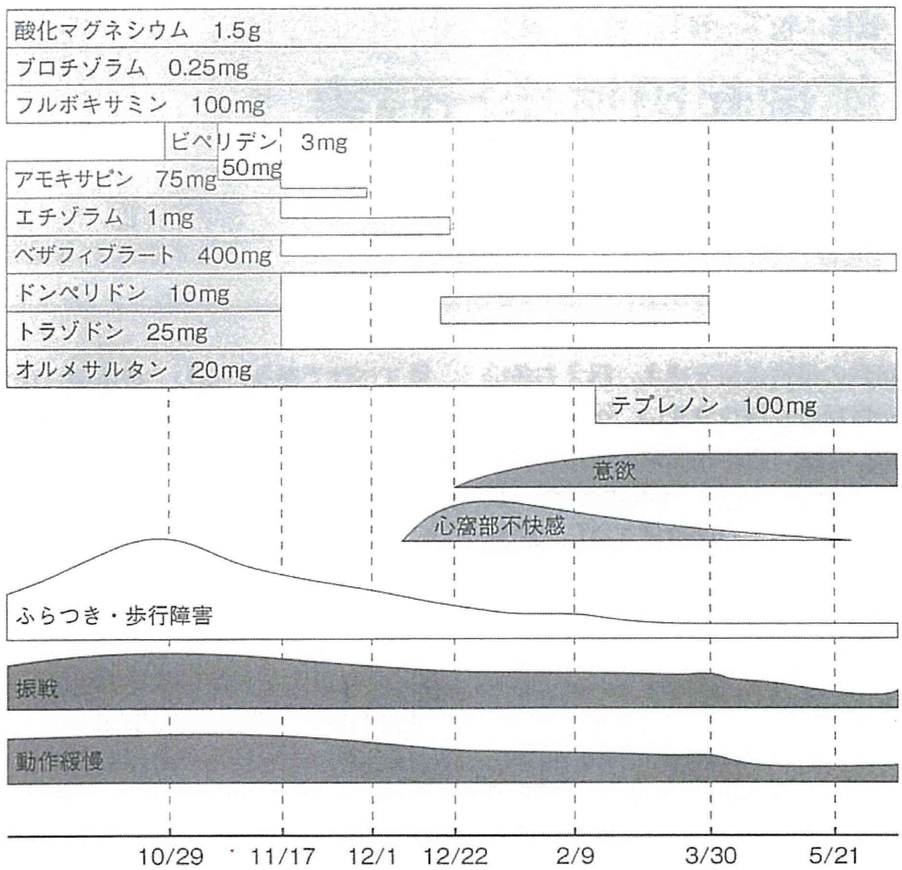

図1 症例の経過

ペリドンを中止したことが効を奏したと考えられる．なお，薬剤の減量・中止は症状の推移をみながら慎重に行うべきであり，患者ならびに家族に対してくれぐれも自己判断で中止しないよう説明する必要がある．

薬剤によるふらつき，転倒

転倒を起こしやすい主な薬剤を表1に示す．これらの薬剤が転倒を起こすのは，鎮静作用，眠気，注意力低下，筋弛緩作用，起立性低血圧，錐体外路症状などが関係している．眠気，ふらつき，注意力の低下など意識や平衡覚を低下させる薬剤として，ベンゾジアゼピン系および非ベンゾジアゼピン系の鎮静睡眠薬が代表的である．加えて，これらの薬剤は筋弛緩作用をもつものが多く，下肢の脱力とともに転倒を誘発する危険がある．また，鎮静睡眠薬，抗うつ薬，抗パーキンソン薬，β遮断薬，H_2ブロッカーはせん妄を起こすことによって転倒を誘発する危険がある．起立性低血圧は自律神経による血圧調節がうまくいかないために起こり，高齢者に多く認められる．降圧薬は一般に低血圧を起こす危険があるが，特にα遮断薬と利尿薬(脱水を起こしやすいため)の使用の際には注意が必要である．

高齢者は不眠を訴えることが多く，睡眠薬を使用する機会が多いが，夜間トイレに行く際に覚醒不良のため転倒する危険がある．これを防ぐために，服用前にトイレを済ませておくこと，トイレへの動線を明るくすること，つっかけ式のスリッパを使わないことなど具体的な生活指導を行う必要がある．使用薬剤としては半減期が短く，筋弛緩作用の弱いゾピクロン(アモバ

表1　転倒を起こしやすい薬物

系統	代表的薬剤(商品名)
鎮静催眠薬 　ベンゾジアゼピン系 　非ベンゾジアゼピン系	 トリアゾラム(ハルシオン®)，ブロチゾラム(レンドルミン®)，エスタゾラム(ユーロジン®)，ニトラゼパム(ベンザリン®)，ジアゼパム(セルシン®)，ロラゼパム(ワイパックス®)，エチゾラム(デパス®) ペントバルビタール(ラボナ®)，バルビタール(バルビタール)，合剤(ベゲタミン®)
抗うつ薬 　三環系 　そのほか	 アミトリプチン(トリプタノール)，イミプラミン(トフラニール®)，クロミプラミン(アナフラニール®) マプロチリン(ルジオミール®)
抗精神病薬 　フェノチアジン系 　ブチロフェノン系 　ベンズアミド系	 クロルプロマジン(コントミン®，ウィンタミン®) ハロペリドール(セレネース®，リントン®) スルピリド(ドグマチール®，アビリット®)
利尿薬，そのほかの降圧薬	フロセミド(ラシックス®)，ドキサゾシン(カルデナリン®)
抗ヒスタミン薬	ジフェンヒドラミン(レスタミン)，d-クロルフェニラミン(ポララミン®)
抗てんかん薬	クロバザム(マイスタン®)，フェノバルビタール(フェノバール®)

表2　パーキンソン徴候を起こす可能性のある薬物

系統	代表的薬剤(商品名)
定型抗精神病薬 　フェノチアジン系 　ブチロフェノン系 　ベンズアミド系	 レボメプロマジン(ヒルナミン®，レボトミン®)，クロルプロマジン(コントミン®，ウィンタミン®)など ハロペリドール(セレネース®，リントン®)，チミペロン(トロペロン®)，ブロムペリドール(インプロメン®)など スルピリド(ドグマチール®，アビリット®)，チアプリド(グラマリール®)，スルトプリド(バルネチール®)
消化管運動調整薬 　ドパミン受容体拮抗薬	 メトクロプラミド(プリンペラン®)，ドンペリドン(ナウゼリン®)，スルピリド(ドグマチール®，アビリット®)

ン®)，ゾルピデム(マイスリー®)，リルマザホン(リスミー®)，クアゼパム(ドラール®)，ブロチゾラム(レンドルミン®)などが使いやすいようである．

薬剤性パーキンソニズム

一部の薬剤でパーキンソン徴候(動作緩慢，仮面様顔貌，振戦，ふらつき，小刻み歩行，すくみ足)が出現することがあり，特にふらつきや小刻み歩行，すくみ足を起こすために転倒しやすくなる．誘発頻度の高い薬剤を表2に示す．多くの定型抗精神病薬は抗ドパミン作用があるため，パーキンソン徴候を起こす可能性がある．このような場合，非定型抗精神病薬であるリスペリドン，クエチアピン，オランザピンなどのセロトニン・ドパミンアンタゴニストへの変更を検討すべきである．そのほか，定型抗精神病薬は遅発性ジスキネジア(口唇や舌の不随意運動や四肢の粗大な振戦)，アカシジア(静座不