

MASTER THESIS ARTICLE in 2024 from OKRU

Factors associated with physical frailty in community-dwelling older people

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Disclosure: There are no conflicts of interest in this study.

Abstract

Purpose: The proportion of elderly people in Japan is rapidly increasing and there is a need to extend healthy life expectancy in order to maintain quality of life and to protect the social security system. Recent research has focused on frailty, which plays a part in the need for care and in healthy life expectancy in elderly people. In this study, we aim to elucidate the factors that are strongly associated with physical frailty.

Subjects/Methods: Health checks were conducted on 205 elderly volunteers recruited by newsletter in Kaizuka City, Japan. We collected data on basic attributes, physical measurements, physical function assessment and information on exercise habits. J-CHS (Japanese version of the cardiovascular health study) criteria were used to assess physical frailty. Volunteers with none of the five J-CHS criteria were classified as 'robust', those with one or two items were classified as 'physically prefrail' and those with three or more items were classified as 'physically frail'. Statistical analyses were then conducted to examine the factors associated with physical frailty.

Results: Robust subjects comprised 42.9% of the cohort, 54.1% were physically prefrail and 2.9% were physically frail. The physically prefrail group had significantly lower height and lower limb skeletal muscle mass and a higher proportion of falls in the past year than those in the robust group. The odds ratio for limb skeletal muscle mass was 0.62 and the odds ratio for history of falls in the past year was 2.69.

Conclusion: The study identified height, limb skeletal muscle mass, subjective sense of health and reduced frequency of going out as factors contributing to frailty. In addition, significant independent factors associated with increase in the risk of physical pre-frailty were limb skeletal muscle mass and falls in the past year.

Key words: Physical frailty, Risk of falling, Muscle mass

BACKGROUND

In an aging population, there is a need to extend healthy life expectancy, defined as the period during which a person can live without being limited in daily life by health problems. Healthy life expectancy in both men and women is shorter than average life expectancy, the discrepancy being approximately 9 years for men and 13 years for women, during which time daily life might be restricted and care might be required. Extending healthy life expectancy is an especially urgent task within Japan, a noted super-aging society (Kingston, 2017).

In old age, many people may enter a state of frailty, in which there is decline in physical functions and decline in physical activities, potentially requiring nursing care and/or assistance in daily activities. Im-

plementation of appropriate preventative care at each stage requires taking measures for frail people who may potentially require nursing care.

The state of physical and mental decline associated with ageing is said to include not only physical functions, but also cognitive, mental, psychological and social aspects, as it can easily lead to a variety of poor outcomes, such as reduced life function, need for nursing care, and death (Arai, 2014). Frailty has been defined as three or more of the following five conditions: weight loss, fatigue, decreased activity level, decreased physical function (decreased walking speed), and decreased muscle strength (decreased grip strength) (Fried, 2001). In the deficit accumulation model of frailty, one study proposed to count the presence of comprehensive factors (30-70 items,

including symptoms, diseases, physical dysfunction, and laboratory abnormalities) to select clinical interventions for frailty and to predict life expectancy and institutionalization, and to calculate the frailty index to predict life expectancy and institutionalization (Rockwood, 2005). Prefrailty is a stage that precedes frailty and is associated with a 4.6-fold increase in the risk of death or need for nursing care (Auyeung, 2008). Prefrailty is also a risk factor for the occurrence of falls and is a predictor of falls in older women who have never previously had a fall (Bartosch, 2020). It reportedly increases the risk of recurrent falls by 2.4-fold and the risk of sustaining a femur fracture by 1.2- to 1.4-fold (Xue, 2011). Falls can be a self-limiting activity, with physical consequences such as fear of falling and loss of confidence, leading to decreased physical function and social interaction (Clegg, 2012). Medical costs are also reported to increase by 54% for category 3 on the frailty score and by 101% frailty score for categories 4 and 5 when a person who is not frail becomes frail (Hajek, 2018).

Even in the prefrail stage, the risk of death or requiring long-term care increases 2.5-fold. Interestingly, however, frailty is characterized by reversibility. In a longitudinal study of community-dwelling older adults aged 70 years and older, the rate of transition from prefrail to robustness was 16.5% (Puts, 2017).

There are limited specific intervention methods and effects to prevent or improve frailty. Promoting early detection and intervention in high-risk individuals is considered to be important for improving healthy life expectancy. Comprehensive evaluation of frailty from multiple aspects is desirable, but there has not yet been an adequate establishment of evaluation indicators and determination methods (Makizako, 2017). Ascertaining the factors that are strongly associated with physical frailty is therefore important, and in the current study we investigate the trends and factors in the prevalence of physical frailty.

METHODS

Context and participants

Our participants were recruited through an item on a widely-distributed newsletter on a health checkup project in Kaizuka City, Osaka. After learning of the program, 249 elderly residents of Kaizuka City (67 men and 182 women), with an average age of 74.2 ± 6.8 years, voluntarily applied for the program. The recruitment period was set until July 2022, and the actual study was conducted for a total of 7 days in August/September 2022 at the city hall and two com-

munity centers. Exclusion criteria were: those using long-term care insurance services, pacemaker users, those under 65 years old, and those who did not complete the questionnaire.

Method

This cross-sectional study included descriptive and measurement surveys within the health check project.

Measurement items

Elementary items

Information was obtained from self-administered questionnaires on age, gender, whether the participant lives alone, whether they have a chronic disease, their educational history, whether or not they have fallen in the past year, their subjective sense of health, the frequency of them going out, and their fear of falling.

Body measurement and body composition

BMI was calculated using the actual measurements of height and weight, using the formula: $\text{bodyweight [kg]} / \text{height [m]}^2$. Body composition was measured using a bioelectrical impedance measuring device (InBody-270, InBody Japan Co., Ltd., Tokyo, Japan). Measurements were taken with shoes removed at two different frequencies (20 kHz and 100 kHz), for five different regions (right arm, left arm, trunk, right leg, and left leg). We calculated limb skeletal muscle mass and skeletal muscle mass index (skeletal muscle mass index = $\text{limb skeletal muscle mass [kg]} / \text{height [m]}^2$). Participants were also asked to confirm in advance that they were not wearing a pacemaker.

Physical function assessment

Grip strength was measured with a digital grip strength meter (Grip D-TKK5401, Takei Kiki Kogyo, Niigata City, Japan) as previously reported (Chen, 2022).

The subjects were instructed to walk at their normal speed during the 2.4 m normal walking speed (m/sec) measurement. The walking path was 6.4 m long, comprising 'run-ups' at the front and rear of 2 m each, and the actual measurement area in the center of 2.4 m. Measurements were taken five times, and the average value was used as the representative value (Saito, 2015).

Exercise habits

Regarding exercise habits, participants answered questions on how often they did light exercise or engaged in regular physical activities or sports. Potential responses were: every day, 5 or 6 days/week,

2 to 4 days/week, 1 day or less/week, and no regular exercise. Participants were divided into either the exercise habit group or the no exercise group according to their responses.

Cognitive function

The revised version of Addenbrooke's cognitive examination (ACE-R) was used to assess cognitive function; it is reportedly useful in the early detection of dementia and in differentiating Alzheimer's disease from frontotemporal lobe dementia (Dos Santos Kawata, 2012). ACE-R is comprised of a composite assessment of five cognitive domains: attention/orientation, memory, fluency, language, and visuospatial cognition. The total score is 100 points, and a higher score indicates better cognitive function.

History of falls

The participants were asked whether they had fallen in the past year (Kitayuguchi, 2021).

Subjective health

The participants were asked about how healthy they considered themselves to be, and they answered with one of four responses. Those who answered either 'very healthy' or 'healthy', were considered to have high subjective sense of health, and those who answered either 'not very healthy' or 'not healthy' were considered to have low subjective sense of health.

Frequency of going out

In the survey of frequency of going out, those who went out more than once every two days were categorized into the high frequency group, and those who went out less than once in a three-day period were categorized into the low frequency group (Shinkai, 2005).

Fear of falling

As for fear of falling, the respondents who responded that they were 'not at all afraid' or 'not afraid' were categorized into the low fear of falling group, and those who were 'somewhat afraid' or 'very afraid' were categorized into the high fear of falling group (Kawahara, 2015).

Definition of frailty

Physical frailty was assessed using the J-CHS criteria, (Katayama, 2022) a modified version for Japanese people of the phenotypic model (Fried, 2001). Unintentional weight loss was defined as 2-3 kg weight loss within 6 months, muscle weakness was

represented by low grip strength (<28 kg in men, <18 kg in women), fatigue was indicated by an affirmative response to whether they had felt tired without reason in the last 2 weeks, and decline in physical activity was indicated by feeling tired and normal walking speed < 1.0 m/sec. Regarding physical activity, we considered the responses to whether the participants did any exercise, sport, or physical activity at least one day a week.

The participant was considered to be physically frail if three or more of these items were applicable. Those who did not meet any of the five J-CHS criteria were classified as 'robust', those who met one or two items were classified as 'physically prefrail', and those who met three or more items were classified as 'physically frail'.

Statistical Analysis

We conducted statistical analysis to compare the basic attributes among the three groups in an inter-group comparison of physical frailty. The χ^2 test was used for categorical variables, and one-way ANOVA was used for continuous variables. Equal variances were performed for age, height, weight, grip strength, walking speed, and limb skeletal muscle mass using the Levene test. A one-way analysis of variance was then performed. In addition, a χ^2 test was performed with three groups of physical frailty, two groups of with/without falls in the past year, two groups on with/without subjective sense of health, two groups on with/without subjective sense of health, two groups of frequency of going out, and two groups of with/without fear of falling as categorical variables. Logistic regression analysis (forced assignment method) was then performed with the presence or absence of physical prefrailty as the dependent variable and the items that showed significant differences by univariate analysis as independent variables. SPSS Statistics 28 (IBM) was used for statistical analysis, and the significance level was set at 5%.

Ethical considerations

The study participants were informed orally and in writing of the purpose, content, and details of handling of personal information before participating in the study, and their written consent was obtained. This study was conducted with the approval of the Osaka Kawasaki Rehabilitation University Research Ethics Review Committee (22-020). The study consisted of physical measurements (5 min), body composition (5 min), physical function assessment (10 min), cognitive function assessment (30 min), and a

self-administered questionnaire (30 min) conducted by licensed physical therapists and students and faculty in the Department of Physical Therapy and the Department of Occupational Therapy.

RESULTS

Of the 249 study participants, 205 were analyzed, excluding 42 who met the exclusion criteria. Eighty-eight participants (42.9%) were robust, 111 (54.1%) were physically prefrail, and 6 (2.9%) were physically frail (Table 1).

Participants in the physically prefrail group had significantly lower height, limb skeletal muscle mass, and history of falls in the past year than the participants in the robust group. Participants in the physically frail group also had significantly lower

height, subjective sense of health, and frequency of going out than the participants in the robust group (Table 2).

In univariate analysis, logistic regression analysis (forced entry method) was performed using independent variables (educational history, limb skeletal muscle mass, subjective sense of health, and history of falls in the past year) and adjustment variables (gender and age) as those that showed significant differences, and the presence of physical frailty as the dependent variable, and the results showed that the odds ratio of skeletal muscle mass to physical prefrail was 0.62 (95% confidence interval 0.46-0.83, $p < 0.05$) and the odds ratio of history of falls in the past year was 2.69 (95% confidence interval 1.34-5.42, $p < 0.05$) as independent associated factors (Table 3).

Table 1. Basic participant attributes

Characteristics	Robust n=88	Prefrail n=111	Frail n=6	p-value	Post-test ¹⁾
Age (y)	75.0 ± 5.2	75.5 ± 5.7	79.3 ± 4.0	ns	
Sex (Women(%))	62.5	79.3	100.0	<0.05	a)
Height (cm)	157.9 ± 8.1	153.3 ± 8.5	148.9 ± 5.1	<0.05	a),b)
weight (kg)	55.1 ± 10.1	52.3 ± 10.0	53.9 ± 9.4	ns	
Education (y)	13.1 ± 2.4	12.4 ± 2.3	12.0 ± 1.7	ns	
ACE-R score	88.5 ± 8.9	89.2 ± 8.0	90.7 ± 4.8	ns	

1) : a) between robust and prefrail, b) between robust and frail, c) between prefrail and frail
Mean ± SD, ns: not significant, ACE-R: Addenbrooke's cognitive examination-revised

Table 2. Relation to physical frailty

	Robust n=88	Prefrail n=111	Frail n=6	p-value	Post-test ¹⁾
Grip (kg)	26.7 ± 7.1	20.5 ± 6.7	16.5 ± 2.1		a),b)
Walking speed (m/s)	1.4 ± 0.2	1.3 ± 0.2	0.9 ± 0.4		a),b),c)
SMI (kg/m ²)	6.2 ± 1.0	5.8 ± 1.0	5.6 ± 1.0	<0.05	a)
Question					
History of falls in the past year n (%)	Yes 15 (17.0%)	38 (34.2%)	3 (50.0%)	<0.05	a)
Subjective sense of health n (%)	Low 3 (3.4%)	10 (9.0%)	2 (33.3%)	<0.05	b)
Frequency of going out n(%)	Low 9 (10.2%)	17 (15.3%)	5 (83.3%)	<0.05	b)
Fear of falling n (%)	Yes 46 (52.9%)	71 (64.5%)	5 (83.3%)	ns	
Exercise regime n (%)	No 0 (0.0%)	21 (18.9%)	4 (66.7%)		

1) : a) between robust and prefrail, b) between robust and frail, c) between prefrail and frail
Mean ± SD, ns: not significant, SMI: skeletal muscle mass index

Table 3. Factors associated with prefrailty

	β	OR	95%CI	p-value
SMI	-0.478	0.62	0.46-0.83	$p < 0.05$
History of falls in the past year	0.989	2.69	1.34-5.42	< 0.05

β : standard regression coefficient, SMI: Skeletal muscle index

DISCUSSION

This study aimed to investigate the prevalence of physical frailty and its background factors among community-dwelling older adults. The results of the survey showed that 88 participants (42.9%) were categorized into the robust group, 111 (54.1%) into the physical prefrail group, and 6 (2.9%) into the physically frail group. Regarding background factors, the physical prefrail group had significantly lower height and limb skeletal muscle mass and a significantly higher percentage of falls in the past year than the robust group. The physically frail group also had significantly lower height, subjective sense of health, and frequency of going out compared with the robust group. In addition, limb skeletal muscle mass and falls in the past year were significant independent variables identified as factors increasing the risk of physical prefrailty.

Similar to in the present study, the prevalence rates in the study by Katayama et al. (Katayama, 2022) National Institute of Population and Social Security Research cross-sectional study were 39.0% and prefrail 51.7%, and physical frailty 9.3%, indicating a trend toward a robust group in this study compared with previous studies (Satake, 2020). The reported incidence of falls in community-dwelling elderly people over a one-year period is approximately 20% (Suzuki, 1999), but it was slightly higher at 27% in the present study.

Elsewhere, a relationship was reported between older age and the prevalence of physical frailty (Soh, 2021). Another study, which sought to provide a national estimate of physical frailty in elderly people, reported that the prevalence of physical frailty increased rapidly with age, from 9% of those aged 65-69 years to 38% of those aged 90 years and older

(Bandeem-Roche, 2015). The subjects in the current study had a high proportion of early-years elderly people, with an average age of 75.4 ± 5.5 years, so we do not believe that there was a significant difference in age. However, the average age in the robust group was 75.0 years old, 75.5 years old in the physically prefrail group, and 79.3 years old in the physically frail group, with the physically frail group tending to be +4.3 years older than the robust group.

A study of background factors related to questions applicable to each type of frailty within the questionnaire in participants who underwent health checkups in later life showed no significant difference in weight between those with and without physical frailty (Nagano, 2022). In addition, a study examining the association between nutritional status and risk of physical frailty found no significant differences in BMI between robust and physically frail individuals (Kim, 2018). However, there are reports (Bowen, 2012) that pre-frail obese individuals may be beneficial in some cases, such as being associated with reduced rates of functional limitations when compared with non-frail standard-weight individuals.

We also found no significant association between physical frailty and body weight, similar to that in previous studies, with a trend toward lower body weight in the physically frail group.

In another report, a physical frailty group had significantly lower MMSE scores than a robust group, with a mean difference of -5.2 points (Brigola, 2019). The mean scores of the ACE-R in this study were 87.5 for the robust group, 89.2 for the physically frail group, and 90.7 for the physically frail group, with the physically frail group averaging +1.2 points higher than the robust group, a result differing from those of previous studies.

The mean educational history in a previous report was 13.3 years for a robust group, 12.6 years for a physical prefrail group, and 11.2 years for a physical frailty group, with the physical frailty group reporting a lower educational history than the robust group (Bowen, 2012). In the present study, the robust group had a mean educational history of 13.1 years, and the physical frailty group had a mean of 12.0 years; the physical frailty group tended to have a lower educational history, but without significant difference.

Maintenance of regular physical activity is reportedly associated with improved maintenance of the level of frailty (Zhang, 2020) and it depends on the degree of social participation (Katayama, 2022). The subjects in our study applied to participate by post, and their active participation in the community and interest in their health may have resulted in a more robust group than those in previous studies.

In a previous study, past fall rates among physically frail elderly individuals ranged from 6.7% to 44% in a physically frail group, from 10.0% to 52.0% in a physically prefrail group, and from 7.6% to 90.4% in a robust group, and the association between variables in the physically frail and robust groups was reported as an odds ratio of 1.80 (95% CI 1.51-2.13) (Fhon, 2016). The odds ratio of a history of falls in the past year to physical prefrail in the present study was 2.69 (95%CI 1.34-5.42), similar to that in the previous study. Similarly, a study of community-dwelling 65-year-olds reported a higher risk of needing long-term care if they had a slower walking speed, even if they had the same physical prefrailty (Shimada, 2015). Elsewhere, slower walking speed was highly associated with falls (Montero-Odasso, 2005). Based on these findings, it is likely that there was also an association between physical prefrailty and falls in this study.

Regarding the need for an exercise intervention for physically frail individuals, a program to prevent recurrent falls was effective in improving muscle strength and endurance, balance, and psychological aspects in elderly female participants with a history of falls (Mi, 2014), suggesting the need for interventions such as fall recurrence prevention programs for those with physical prefrailty.

Identification of physical prefrailty also provides information on the high risk of falls, which supports previous studies (Bartosch, 2020). Physical prefrailty was found to have significant association with limb skeletal muscle mass and there is reported association between high grip strength and low physical frailty (Stringa, 2023). Grip strength is included in the

criteria for physical frailty, so limb skeletal muscle mass may be an important factor.

This study has several limitations. First, because it was a cross-sectional analysis, it was not possible to assess the longitudinal effects of long-term changes in physical frailty and falls, so longitudinal studies are required.

Second, participants all voluntarily signed up to this study. This may lead to an underestimation of the prevalence of physical frailty, because the participants were relatively healthy elderly people who were able to come for health checks on their own. Future studies will seek to expand the geographical area and increase the number of participants.

CONCLUSIONS

Compared with the robust group, the physically prefrail group had significantly lower height and limb skeletal muscle mass and a significantly higher percentage of falls in the past year in our cohort. The physically frail group also had significantly lower height, lower subjective sense of health, and lower frequency of going out compared with the robust group. Significant independent factors associated with increased risk of physical prefrailty were lower limb skeletal muscle mass and higher rate of falls in the past year. High incidence of falls was an identifier of risk of physical prefrailty, supporting previous studies. The Japanese version of this thesis content is submitted as a master's thesis at Osaka Kawasaki Rehabilitation University.

ACKNOWLEDGEMENTS

We would like to express our deep appreciation to the university staff, our voluntary student staff, and seminar students of the Imaoka Laboratory for their participation in this research.

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