J Nutr Health Aging. 2020;24(3):312-318

COMBINED IMPACT OF PHYSICAL FRAILTY AND SOCIAL ISOLATION ON RATE OF FALLS IN OLDER ADULTS

T. HAYASHI[1,2], H. UMEGAKI[3], T. MAKINO[1,2], C.H. HUANG[3], A. INOUE[2], H. SHIMADA[4], M. KUZUYA[2,3]

1. Department of Rehabilitation and Care, Seijoh University, 2-172 Fukinodai, Tokai, Aichi 476-8588, Japan; 2. Institutes of Innovation for Future Society, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan; 3. Department of Community Healthcare and Geriatrics, Nagoya University Graduate School of Medicine, 65 Tsuruma-cho, Showa-ku, Nagoya 466-8550, Japan; 4. Department of Preventive Gerontology, Center for Gerontology and Social Science, National Center for Geriatrics and Gerontology, 35 Gengo, Morioka-machi, Obu, Aichi 474-8511, Japan. Corresponding author: Hiroyuki Umegaki, Department of Community Healthcare and Geriatrics, Nagoya University Graduate School of Medicine, 65 Tsuruma-cho, Showa-ku, Nagoya 466-8550, Japan, Tel: +81-52-741-2364, Fax: +81-52-744-2371, Email: umegaki@med.nagoya-u.ac.jp

Abstract: *Objectives:* The aim of this study was to examine the impact of the combination of physical frailty and social isolation on falling in community-dwelling older adults. *Design:* A cross-sectional study of data obtained at registration in a randomized control trial. *Setting:* Community-based study of participants recruited from Toyota, Japan. *Participants:* 380 community-dwelling older adults (47.9% women, mean age = 72.3 ± 4.6 years). *Measurements:* Participants were categorized as non-frail or pre-frail/frail based on the Fried frailty criteria (slowness, weakness, exhaustion, low activity, and weight loss). Social isolation was examined using the Lubben Social Network Scale (LSNS-6), and scores lower than 12 points indicated social isolation. Participants were divided into four groups depending on pre-frail/frail status and social isolation, and experiences of multiple falls over the past year were compared between the groups. *Results:* Participants were classified into robust (n = 193), physical frailty (PF; n = 108), social isolation (SI; n = 43), and PF with SI (PF+SI; n = 36) groups. A total of 38 (10.0%) participants reported multiple falls. Logistic regression analysis showed that PF and SI groups were not independently associated with falling (PF: OR 1.64, 95% CI 0.65–4.16, SI: OR 2.25, 95% CI 0.77–6.58), while PF+SI group was significantly associated with falling compared with the robust group (OR 3.06, 95% CI 1.00–9.34, p = 0.049) after controlling for confounding factors. *Conclusion:* Our findings support the assertion that coexistence with physical frailty and social isolation were associated with falling in the older adults.

Key words: Physical frailty, social isolation, falling, cross-sectional study.

Introduction

Falls have been identified as a disabling problem associated with injury and increased mortality in community-dwelling older adults (1, 2). Each year, approximately one-third of non-institutionalized older adults fall at least once (3), and the rate of falls is expected to increase in accordance with population trends regarding aging. By 2020, expenditures related to injuries sustained as a result of falls by older people are projected to cost nearly $59.7 billion (4). Therefore, prevention of falls in older people is an urgent concern that aging societies face. Previous studies have shown several factors to be associated with falling, including older age, female gender, reduced muscle strength and balance ability, cognitive impairment, and depression (5-7). Exercise interventions that include muscle strength and balance training have also been found to prevent falls (8).

Recent studies have demonstrated a relationship between falls and physical frailty (9-12). Degree of frailty, classified as robust, pre-frail, or frail status, is commonly assessed using five clinical indicators (grip strength, walk speed, exhaustion, physical activity, and unintentional body weight loss), as in the Cardiovascular Health Study (13). The main features of physical frailty include weakness, balance, and gait problems, all of which are also recognized as risk factors for falls (14). Some studies have reported a higher risk for falls in frail older people compared with robust older people (9, 10). Moreover, several studies have indicated that pre-frail older people exhibit a higher risk of falls than robust older people (10, 11). A recent systematic review indicated that frailty leads to recurrent falls and that older adults who enter the pre-frailty stage are also more likely to experience falls (12).

Social isolation can be defined objectively using criteria such as having few contacts, little involvement in social activities, and living alone. Recent reports have predicted that social isolation is experienced by 15%–25% of older people worldwide (15-17). Coyle et al. found that individuals who experienced social isolation were 43% more likely to have fair or poor health (18). Moreover, social isolation has been linked with increased mortality, incident heart disease, and functional decline (19-21). Similarly, social isolation is associated with an increased rate of falling in older community-dwelling older adults. A cohort study of American older adults indicated that social isolation predicted a fall within the following year, and that with each increase in social isolation score the probability of falling increased (22).

As described, previous data indicate that both physical frailty and social isolation each increase the risk of falling. Moreover, high levels of social isolation are associated with an increased risk of becoming physically frail (23), possibly increasing the severity of physical frailty in those who have a combination of physical frailty and social isolation. However, the combined

Received October 23, 2019
Accepted for publication November 5, 2019

Published online January 6, 2020, http://dx.doi.org/10.1007/s12603-020-1316-5

effects of physical frailty and social isolation on falling remain unclear.

In the present study, we aimed to examine the impact of the combination of physical frailty and social isolation on falling in community-dwelling older adults. Moreover, we examined group differences in frailty status according to the Frailty Index, which we developed.

Methods

We analyzed cross-sectional baseline data from the TOPICS (the Toyota Preventional Intervention for Cognitive decline and Sarcopenia) trial. TOPICS was a randomized controlled trial performed to assess the effects of different types of exercise (aerobic, resistance, and a combination of both) on cognition in older individuals with a slight decline in memory function.

The study protocol was approved by our university's Ethics Committee (Graduate School of Medicine, Nagoya University, approval no. 2014-0155-2) and registered with the University Hospital Medical Information Network (UMIN) clinical trials registry, no. UMIN000014437. Written informed consent was obtained from all participants prior to their inclusion in the study.

Participants

Participants were screened via a questionnaire that comprised 25 self-completed items (Kihon Checklist) (24) including the three following items concerning subjective cognitive decline. Q18: 'Do your family or friends point out your memory loss? (e.g., You ask the same question over and over again)'. Q19: 'Do you make a call by looking up phone numbers?' Q20: 'Do you find yourself not knowing today's date?' Respondents who answered yes to Q18 or Q20 or who answered no to Q19 were regarded as being at high risk of cognitive decline (25). The questionnaire was mailed to community-dwelling residents aged 65–85 years in selected areas in the city of Toyota, Aichi, Japan. Residents who met the criteria for being at risk of cognitive decline according to at least one of the three questionnaire items described above were recruited through letters describing the interventional study project.

In the current study, we excluded any candidates who (1) met the clinical criteria for dementia according to the Diagnostic and Statistical Manual of Mental Disorders 4th edition (26); (2) had any disability affecting the basic and instrumental activities of daily living; (3) required support or care from the Japanese public long-term care insurance system; (4) had a Mini-Mental State Examination (MMSE) score of ≤ 19; (5) had a severe visual impairment; (6) had been diagnosed with a neurodegenerative disease (i.e., Parkinson's disease); (7) had medical contraindications to exercise; (8) had a psychiatric disease (i.e., psychosis or major depression); (9) had a history of serious cardiovascular, musculoskeletal, respiratory, or cerebrovascular disease or other severe health issue; or (10) for whom data were missing regarding variables that we examined. A total of 399 participants were included in the analysis.

Falling

A fall was defined as 'an unexpected event in which the person comes to rest on the ground, floor, or lower level'. The participants answered the question: 'Have you had any falls in the past year?' by selecting 'multiple times', 'once', or 'none'. The first category was used as the outcome measure and the latter two categories were combined (27). We defined a 'faller' as a respondent who reported multiple falls. In previous studies, fallers were defined as those who had fallen on at least two occasions in the previous 12 months, and non-fallers were defined as those who had not fallen or who had fallen only once in the previous 12 months (28). Multiple falls are thought to be associated with an intrinsic predisposition to falling, whereas isolated falls are not (29).

Frailty assessment

Based on the original studies by Fried et al. (13), we considered the physical frailty phenotype to be characterized by three of more of the following limitations: slowness, weakness, exhaustion, low activity, and weight loss. Participants who had none of these limitations were considered to be robust, while those with one or more were considered to be pre-frail and frail. The limitations were defined as follows:

Walking speed was measured in seconds using a stopwatch. Participants were asked to walk on a flat and straight surface at a comfortable walking speed. Two markers were used to indicate the start and end of a 5-m walk path, and participants traversed a 2-m section before passing the start marker so that they were walking at a comfortable pace by the time they reached the timed path. Slowness was established according to a cutoff value (< 1.0 m/s). Weakness was defined according to maximum grip strength. Grip strength was measured in kilograms using a Smedley-type handheld dynamometer (GRIP-D; Takei Ltd, Niigata, Japan). Weakness was established according to the Asian Working Group for Sarcopenia consensus report (< 26 kg for men and < 18 kg for women) (30). Exhaustion was considered present if the participant responded 'yes' to the following question, which is included in the Kihon-Checklist (24): 'In the last 2 weeks, have you felt tired without a reason?' We evaluated the role of physical activity by asking the following questions about time spent engaged in sports and exercise: (1) 'Do you engage in moderate levels of physical exercise or sports aimed at health?' and (2) 'Do you engage in low levels of physical exercise aimed at health?' If participants answered 'no' to both of these questions, we considered them to engage in low levels of activity. Weight loss was assessed by a response of 'yes' to the question 'Have you experienced weight loss > 5% in the previous two or three years?'

Table 1
Four types of studies, categorized according to Physical Frailty and Social Isolation

		Physical Frailty	
		Robust (0)	**Prefrail and Frail (1 component or more)**
Lubben Social Network Scale	Non- Social Isolation (12 points or more)	Robust	Physical Frailty (PF)
	Social Isolation (less than 12points)	Social Isolation (SI)	Physical Frailty & Social Isolation (PF+SI)

Frailty Index

A battery of comprehensive neuropsychological tests, physical assessments, and blood tests were conducted by a group of nurses, clinical psychologists, speech therapists, and occupational therapists who were blinded to the group membership of participants. Details regarding the obtained data and cross-sectional findings are publicly available (31, 32). In the present study, we created an 88-item Frailty Index consisting of five components according to a standardized protocol (Appendix 1) (33, 34). Items for which more than 5% of the values were missing were discarded (33). Participants were excluded from the analysis if more than 20% of the values were missing (35). The total Frailty Index scores were constructed by dividing the total deficit values, which reflected the severity of deficits, by the total number of included items. The mood component was assessed using the Geriatric Depression Scale-15 (GDS-15) (36) and General Anxiety Disorder scale (GAD-7) (37). Physical factors were evaluated according to the fall efficacy scale (38), skeletal muscle mass index (SMI) (appendicular skeletal muscle mass/height^2 < 7 kg/m2 in men or 5.7 kg/m^2 in women), unintentional weight loss (2 kg in the previous 6 months), weakness (grip strength < 26 kg in men or 18 kg in women), slow walking speed (< 1 m/s), and low physical activity (no engagement in moderate or low levels of physical exercise or sports aimed at health) according to the Japanese version of the Cardiovascular Health Study criteria (39). The disease component included eleven age-related chronic diseases. The influence of cognition was evaluated according to the Everyday Memory Questionnaire and the MMSE (40). Quality of life (QOL) was measured using the life satisfaction index (41). Details regarding the Frailty Index variables are displayed in Appendix 2.

Social Isolation

We used the Lubben Social Network Scale (LSNS-6), which has been widely employed to assess social integration and to screen for social isolation (42). The reliability and validity of the Japanese version of the LSNS-6 have been previously confirmed (43). The measure comprises a set of three questions that evaluate family ties and a comparable set of three questions that evaluate friendship ties, as follows: (1) 'How many relatives do you see or hear from at least once a month?'; (2) 'How many relatives do you feel close to such that you could call on them for help?'; (3) 'How many relatives do you feel at sufficient ease with to talk about private matters?'; (4) 'How many of your friends do you see or hear from at least once a month?' (5) 'How many friends do you feel close to such that you could call on them for help?' and (6) 'How many friends do you feel sufficiently at ease with to talk about private matters?' The possible responses and corresponding scores were: 'none' (0 points), 'one' (one point), 'two' (two points), 'three or four' (three points), 'five to eight' (four points), and 'nine or more' (five points). The total score thus ranged from 0 to 30. As suggested by Lubben et al., (42) we classified individuals with scores of less than 12 as being socially isolated.

Other covariates

Age, sex, family status, walking aids, body mass index (BMI, weight/height^2), and educational years were recorded as demographic data. Medical conditions (hypertension, heart disease, and diabetes mellitus) and the number of medications taken were recorded using a questionnaire regarding medical status. Physical function was measured in terms of normal walking speed, grip strength, muscle strength in the lower extremities (5 chair stand test (44)), and balance ability (Timed Up & Go test (45)). Depressive symptoms were measured using the 15-item GDS. Cognitive function was measured using the MMSE.

Statistical analysis

We categorized the participants into four groups: robust participants without physical frailty and social isolation (robust), participants with physical frailty and without social isolation (PF), participants with social isolation and without physical frailty (SI), and participants with physical frailty and with social isolation (PF+SI). First, we compared participant characteristics between groups using an ANOVA for continuous variables and a chi-square test for categorical variables. Post-hoc analysis of the ANOVA data was carried out using Bonferroni's multiple comparison test. Next, we carried out multiple logistic regression analysis to explore independent associations between groups (PF, SI, PF+SI) compared with the robust group and falls compared with 'not falls.' We calculated the odds ratios (OR) and 95% confidence intervals (95% CI) with both a crude model and adjusted models (Models 1–3). Variables that were marginally significant ($p < 0.10$) in the univariate analyses were selected as covariates for subsequent multivariate analyses. In Model 1, age, sex, walking aids, years of education, and number of medications taken were added to a crude model. In Model 2,

Table 2
Participant characteristics

	Total (n = 380)	Robust (n = 193)	PF (n = 108)	SI (n = 43)	PF+SI (n = 36)	P-value
Age, y	72.3±4.6	71.7±4.1	73.7±5.2†	71.3±4.2‡	72.7±5.1	0.001
Sex, (% women)	47.9%	53.2%	50.9%	30.2%	36.1%	0.026
Living alone (%)	7.4%	5.2%	9.3%	11.6%	8.3%	0.375
Walking aids use (%)	2.4%	1.6%	1.9%	2.3%	8.3%	0.101
Educational history, y	11.5±2.4	11.8±2.3	10.6±2.4†	12.0±2.1‡	11.9±2.9‡	< 0.001
Body mass index, kg/m^2	22.8±2.8	22.6±2.6	23.1±2.6	23.1±3.2	22.9±3.6	0.464
Medical condition (%)						
Hypertension	41.6%	38.9%	47.2%	44.2%	36.1%	0.463
Heart disease	13.7%	10.9%	17.6%	16.3%	13.9%	0.403
Respiratory disease	8.9%	8.3%	11.1%	9.3%	5.6%	0.744
GDS-15, (% ≥5)	35.0%	22.3%	42.6%	34.9%	80.6%	< 0.001
LSNS	15.9±5.8	18.5±4.1	17.7±4.0	7.7±2.5†‡	7.0±3.1†‡	< 0.001
MMSE, score	26.4±2.6	26.5±2.5	26.2±2.6	26.5±2.7	25.9±2.7	0.438
Grip strength, kg	28.2±7.8	28.8±7.4	25.4±7.6†	31.2±7.5‡	29.6±8.6‡	< 0.001
Walking speed, m/s	1.44±0.20	1.46±0.19	1.40±0.20	1.44±0.19	1.36±0.21†	0.007
5 chair stands test	9.1±2.4	8.7±2.2	9.6±2.4†	9.0±2.5	9.6±2.9	0.003
Timed Up & Go Test	7.8±1.4	7.6±1.2	8.1±1.6†	7.6±1.1	8.2±1.4	0.003
Medication use, n	2.3±2.1	1.9±1.9	2.8±2.4†	2.4±1.8	2.5±2.2	0.009
Fall, (% multiple faller)	10.0%	6.2%	11.1%	14.0%	22.2%	0.019

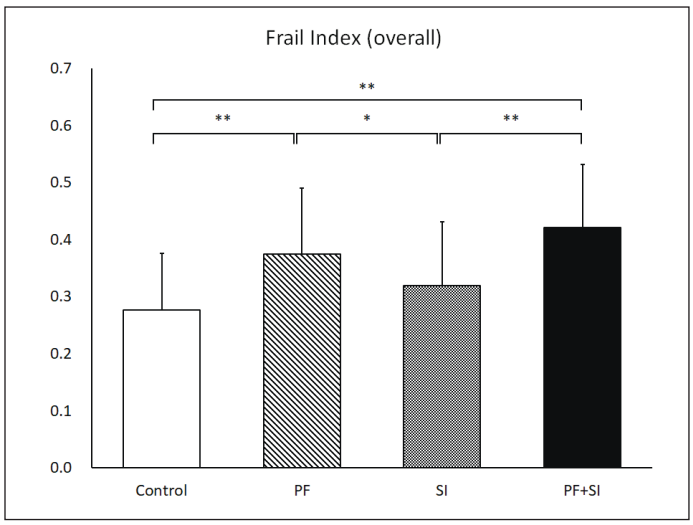
†Significant differences compared with the robust groups, post-hoc analysis using Bonferroni's multiple comparison test (P < 0.05). ‡Significant differences compared with the physical frail (PF) groups, post-hoc analysis using Bonferroni's multiple comparison test (P < 0.05). Group differences were tested using an ANOVA or χ2-test. PF, physical frailty; SI, social isolation; PF+SI, physical frailty with social isolation, GDS, Geriatric Depression Scale; LSNS, Lubben Social Network Scale; MMSE, Mini-Mental State Examination

normal walking speed, grip strength, results from the chair stand test, and balance ability were added to Model 1. In Model 3, the GDS data were added to Model 2. Last, we conducted an ANOVA, and used post-hoc analysis to compare the Frailty Index between groups. We used SPSS version 24 (IBM, Armonk, NY, USA) for all analyses, with a 2-tailed significance level set at 5%.

Results

Table 2 shows the participant baseline characteristics. Among the 380 participants (47.9% women, mean age 72.3 ± 4.6 years), 193 (50.8%) were classified as robust, 108 (28.4%) were classified as belonging to the PF group, 43 (11.3%) were in the SI group, and 36 (9.5%) were classified as belonging to the PF+SI group. The proportion of those living alone, those using walking aids, and those with medical conditions did not significantly differ among the groups. Furthermore, the BMI and MMSE data did not significantly differ between the groups. A total of 38 (10.0%) participants reported falls in the past year. The PF+SI group had a higher proportion of recurrent fallers (robust 6.2%, PF 11.1%, SI 14.0%, PF+SI 22.2%, p < 0.019).

Figure 1
Comparison of Frail Index (overall) score between each group



*Compared between groups using Bonferroni's multiple comparison test, P < 0.05. **Compared between groups using Bonferroni's multiple comparison test, P < 0.01. PF, physical frailty; SI, social isolation.

Table 3
Association between physical frailty, social isolation, and falls

Group	Crude			Model 1			Model 2			Model 3		
	OR	(95%CI)	P-value	OR	(95%CI)	P-value	OR	(95%CI)	P-value	OR	(95%CI)	P-value
Robust	reference			reference			reference			reference		
PF	2.45	(0.86-6.93)	0.092	2.35	(0.82-6.75)	0.112	2.33	(0.80-6.74)	0.119	2.25	(0.77-6.58)	0.138
SI	1.89	(0.82-4.36)	0.138	1.99	(0.83-4.75)	0.121	1.70	(0.68-4.27)	0.256	1.64	(0.65-4.16)	0.296
PF+SI	4.31	(1.62-11.47)	0.003	3.98	(1.46-10.82)	0.007	3.46	(1.24-9.65)	0.018	3.06	(1.00-9.34)	0.049

Model 1: Adjusted for age, sex, walking aids, years of education, number of medications taken. Model 2: Model 1+ normal walking speed, grip strength, 5 chair stands test, Timed Up and Go test. Model 3: Model 2+Geriatric Depression Scale-15. OR, odds ratio; CI, confidence intervals; PF, physical frailty; SI, social isolation; PF+SI, physical frailty with social isolation

Table 3 shows the univariate and multivariate odds ratios (OR) and 95% CIs for falling based on physical frailty and social isolation. The PF+SI group was significantly associated with falling compared with the robust group for all models. In the crude model, the OR for participants in the PF+SI group was significantly lower than that in the robust group at 4.31 (95% CI: 1.62–11.47). After adjusting for demographic factors and medical conditions, this OR was attenuated slightly but the association remained statistically significant (Model 1). After further adjusting for physical function including muscle strength and balance ability (Model 2), the OR for the participants in the PF+SI group was attenuated to 3.46 (95% CI: 1.24–9.65) (from 3.98, 95% CI 1.46–10.82). We observed the same trend when psychological factors (Model 3) were added to the covariate in Model 2 (3.06, 95% CI 1.00-9.34).

The results of the post-hoc analysis for the Frailty Index between groups are shown in Figure 2. The robust and SI groups had lower scores than the PF and PF + SI groups. The scores in the robust and SI groups did not differ. Similar results were observed in the PF and PF + SI groups.

Discussion

To our knowledge, this is the first study to examine the combined impact of physical frailty and social isolation on falling. We found that participants with both physical frailty and social isolation (PF+SI) reported fewer falls than both participants with physical frailty without social isolation (PF) and those with social isolation without physical frailty (SI).

Many previous studies have shown that participants with frailty have an increased risk of falls (9, 10). In a recent meta-analysis, Cheng et al. suggested that frailty leads to recurrent falls in older adults (12). However, the present study showed that the PF group was not associated with an increased risk of falling. In the present study, the majority of the participants in the PF group were pre-frailty participants. Previous studies that investigated falling among robust and pre-frailty individuals who had sustained multiple falls evaluated physical frailty according to the Cardiovascular Health Study and did not obtain a unified view (11, 46). A study of 3,132 participants conducted by Ensrud et al. reported that the incidence of multiple falls was significantly higher in the pre-frailty group than in the robust group (46). However, in a study of 765 participants conducted by Kiely et al., the authors reported no significant association (11). That we did not find a significant association in the present study may have been due to the relatively low number of participants (380 participants).

Few studies have examined the relationship between social isolation and falling. In a recent cohort data analysis, Pohl et al. showed that social isolation predicted a fall within the following year (22). However, Faulkner et al. reported that social isolation, as evaluated using the Lubben Social Network Scale, was not significantly predictive of falls (47). Therefore, it is possible that we found no relationship between SI group and falls because we used the Lubben Social Network Scale as an index of social isolation.

The combination of physical frailty and social isolation is associated with falls. Previous studies have shown that deficits in both physical frailty and social isolation are independently related to fall risk among older adults (9-11, 22). Therefore, in the present study, we adjusted many factors there have been associated with falls. We found that the relationship between the PF+SI group and rate of falls weakened after adjusting for demographic factors and medical conditions (Model 1), physical function (Model 2), and physiological factors (Model 3). However, an association between the PF+SI group and falls was present. This may be due to the influence of unmeasured factors such as social factors. It is possible that the relationship between physical frailty and social isolation is bidirectional such that greater social isolation leads to an increase in physical frailty. Gale et al. suggested that high social isolation was associated with an increased risk of becoming physically frail in men (23). Another possibility is that physical frailty leads to an increase in social isolation. Some studies have supported an association between frailty and social relationships, but to the best of our knowledge, a relationship between frailty and social isolation has not been established (48). As for individuals with a combination of physical frailty and social isolation, further studies are needed to clarify whether falls are more common among those who were physically frail before becoming

socially isolated or whether the opposite is true.

Finally, we found that the Frailty Index scores in the PF and PF+SI groups were significantly higher than those in the robust and SI groups. However, there was no significant difference in scores between the PF and PF+SI groups. This indicates that the severity of frailty status was not different between the groups. This may indicate that although our Frailty Index included factors associated with mood, physical health, disease, cognition, and QOL, it did not include sufficient social factors.

Several limitations of the present study should be mentioned. As this study used a questionnaire format, self-reports of falls may not have been accurate (49). Therefore, a prospective study that includes a daily record of falls is desirable. In addition, we did not categorize participants who fell only once as "fallers". Furthermore, as this study was a cross-sectional analysis, we cannot determine a causal relationship. Future studies with a longitudinal design will be helpful in investigating causal relationships.

Conclusion

The results of the present cross-sectional study indicate that participants with a combination of physical frailty and social isolation (PF+SI) had fewer falls compared with both participants with physical frailty without social isolation (PF) and those with social isolation without physical frailty (SI), even after adjusting for several confounders. However, we found no difference in the severity of frailty status between the PF+SI and PF groups. Further studies are required to clarify the interrelationship between physical frailty and social isolation.

Acknowledgments: The Toyota Preventional Intervention for Cognitive decline and Sarcopenia study is supported by the Center of Innovation Program (COI STREAM), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and the Japan Science and Technology Agency (JST).

Disclosure statement: The authors declare no conflict of interest.

Ethical standards: The study followed the principals of the Declaration of Helsinki. The study was approved by the ethical committee of the Nagoya University Graduate School of Medicine.

References

1. Gates, S., Fisher, J. D., Cooke, M. W., et al. Multifactorial assessment and targeted intervention for preventing falls and injuries among older people in community and emergency care settings: systematic review and meta-analysis. BMJ 2008;336: 130-133.
2. Rubenstein, L. Z. Falls in older people: epidemiology, risk factors and strategies for prevention. Age Ageing 2006;35 ii37-ii41.
3. Shimada, H., Suzukawa, M., Ishizaki, T., et al. Relationship between subjective fall risk assessment and falls and fall-related fractures in frail elderly people. BMC Geriatrics 2011;11: 40-40.
4. Solutions, H. H. Overcoming obstacles to policies for preventing falls by the elderly FINAL REPORT.
5. American Geriatrics Society British Geriatrics Society and American Academy of Orthopaedic Surgeons Panel on Falls Prevention. Guideline for the prevention of falls in older persons J Am Geriatr Soc 2001;49: 664-672.
6. Borges Sde, M., Radanovic, M. & Forlenza, O. V. Fear of falling and falls in older adults with mild cognitive impairment and Alzheimer's disease. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn 2015;22: 312-321.
7. Lin, C. H., Liao, K. C., Pu, S. J., et al. Associated factors for falls among the community-dwelling older people assessed by annual geriatric health examinations. PLoS One 2011;6: e18976.
8. Sherrington, C., Whitney, J. C., Lord, S. R., et al. Effective exercise for the prevention of falls: a systematic review and meta-analysis. J Am Geriatr Soc 2008;56: 2234-2243.
9. Samper-Ternent, R., Karmarkar, A., Graham, J., et al. Frailty as a predictor of falls in older Mexican Americans. J Aging Health 2012;24: 641-653.
10. Bandeen-Roche, K., Seplaki, C. L., Huang, J., et al. Frailty in Older Adults: A Nationally Representative Profile in the United States. J Gerontol A Biol Sci Med Sci 2015;70: 1427-1434.
11. Kiely, D. K., Cupples, L. A. & Lipsitz, L. A. Validation and comparison of two frailty indexes: The MOBILIZE Boston Study. J Am Geriatr Soc 2009;57: 1532-1539.
12. Cheng, M. H. & Chang, S. F. Frailty as a Risk Factor for Falls Among Community Dwelling People: Evidence From a Meta-Analysis. J Nurs Scholarsh 2017;49: 529-536.
13. Fried, L. P., Tangen, C. M., Walston, J., et al. Frailty in older adults: evidence for a phenotype. J Gerontol A Biol Sci Med Sci 2001;56: M146-156.
14. Clegg, A., Young, J., Iliffe, S., et al. Frailty in elderly people. Lancet 2013;381: 752-762.
15. Iliffe, S., Kharicha, K., Harari, D., et al. Health risk appraisal in older people 2: the implications for clinicians and commissioners of social isolation risk in older people. Br J Gen Pract 2007;57: 277-282.
16. Hawthorne, G. Perceived social isolation in a community sample: its prevalence and correlates with aspects of peoples' lives. Soc Psychiatry Psychiatr Epidemiol 2008;43: 140-150.
17. Shimada, K., Yamazaki, S., Nakano, K., et al. Prevalence of Social Isolation in Community-Dwelling Elderly by Differences in Household Composition and Related Factors: From a Social Network Perspective in Urban Japan. J Aging Health 2014;26: 807-823.
18. Coyle, C. E. & Dugan, E. Social isolation, loneliness and health among older adults. J Aging Health 2012;24: 1346-1363.
19. Shankar, A., McMunn, A., Demakakos, P., et al. Social isolation and loneliness: Prospective associations with functional status in older adults. Health Psychol 2017;36: 179-187.
20. Barth, J., Schneider, S. & von Kanel, R. Lack of social support in the etiology and the prognosis of coronary heart disease: a systematic review and meta-analysis. Psychosom Med 2010;72: 229-238.
21. Pantell, M., Rehkopf, D., Jutte, D., et al. Social isolation: a predictor of mortality comparable to traditional clinical risk factors. Am J Public Health 2013;103: 2056-2062.
22. Pohl, J. S., Cochrane, B. B., Schepp, K. G., et al. Falls and Social Isolation of Older Adults in the National Health and Aging Trends Study. Res Gerontol Nurs 2018;11: 61-70.
23. Gale, C. R., Westbury, L. & Cooper, C. Social isolation and loneliness as risk factors for the progression of frailty: the English Longitudinal Study of Ageing. Age Ageing 2018;47: 392-397.
24. Arai, H. & Satake, S. English translation of the Kihon Checklist. Geriatr Gerontol Int 2015;15: 518-519.
25. Maki, Y., Ura, C., Yamaguchi, T., et al. Effects of intervention using a community-based walking program for prevention of mental decline: a randomized controlled trial. J Am Geriatr Soc 2012;60: 505-510.
26. American Psychiatric Association. Diagnostic and Statistical Manual. 4th edn. Washington, DC: APA Press, 1994.
27. Doi, T., Shimada, H., Park, H., et al. Cognitive function and falling among older adults with mild cognitive impairment and slow gait. Geriatr Gerontol Int 2015;15: 1073-1078.
28. Ochi, A., Yokoyama, S., Abe, T., et al. Differences in muscle activation patterns during step recovery in elderly women with and without a history of falls. Aging Clin Exp Res 2014;26: 213-220.
29. Faulkner, K. A., Redfern, M. S., Cauley, J. A., et al. Multitasking: association between poorer performance and a history of recurrent falls. J Am Geriatr Soc 2007;55: 570-576.
30. Chen, L. K., Liu, L. K., Woo, J., et al. Sarcopenia in Asia: consensus report of the Asian Working Group for Sarcopenia. J Am Med Dir Assoc 2014;15: 95-101.
31. Hayashi, T., Umegaki, H., Makino, T., et al. Association between sarcopenia and depressive mood in urban-dwelling older adults: A cross-sectional study. Geriatr Gerontol Int, 2019.
32. Umegaki, H., Makino, T., Shimada, H., et al. Cognitive Dysfunction in Urban-Community Dwelling Prefrail Older Subjects. J Nutr Health Aging 2018;22: 549-554.
33. Rockwood, K., Song, X., MacKnight, C., et al. A global clinical measure of fitness and frailty in elderly people. CMAJ 2005;173: 489-495.
34. Searle, S. D., Mitnitski, A., Gahbauer, E. A., et al. A standard procedure for creating a frailty index. BMC Geriatr 2008;8: 24.
35. Theou, O., Brothers, T. D., Mitnitski, A., et al. Operationalization of frailty using eight

commonly used scales and comparison of their ability to predict all-cause mortality. J Am Geriatr Soc 2013;61: 1537-1551.
36. Schreiner, A. S., Hayakawa, H., Morimoto, T., et al. Screening for late life depression: cut-off scores for the Geriatric Depression Scale and the Cornell Scale for Depression in Dementia among Japanese subjects. Int J Geriatr Psychiatry 2003;18: 498-505.
37. Spitzer, R. L., Kroenke, K., Williams, J. B., et al. A brief measure for assessing generalized anxiety disorder: the GAD-7. Arch Intern Med 2006;166: 1092-1097.
38. Helbostad, J. L., Taraldsen, K., Granbo, R., et al. Validation of the Falls Efficacy Scale-International in fall-prone older persons. Age Ageing 2010;39: 259.
39. Satake, S., Shimada, H., Yamada, M., et al. Prevalence of frailty among community-dwellers and outpatients in Japan as defined by the Japanese version of the Cardiovascular Health Study criteria. Geriatr Gerontol Int 2017;17: 2629-2634.
40. Kazui, H., Watamori, T. S., Honda, R., et al. [The validation of a Japanese version of the Everyday Memory Checklist]. No To Shinkei 200355: 317-325.
41. Neugarten, B. L., Havighurst, R. J. & Tobin, S. S. The measurement of life satisfaction. J Gerontol 1961;16: 134-143.
42. Lubben, J., Blozik, E., Gillmann, G., et al. Performance of an abbreviated version of the Lubben Social Network Scale among three European community-dwelling older adult populations. Gerontologist 2006;46: 503-513.
43. Kurimoto, A., Awata, S., Ohkubo, T., et al. [Reliability and validity of the Japanese version of the abbreviated Lubben Social Network Scale]. Nihon Ronen Igakkai Zasshi 2011;48: 149-157.
44. Hirsch, C. H., Fried, L. P., Harris, T., et al. Correlates of performance-based measures of muscle function in the elderly: the Cardiovascular Health Study. J Gerontol A Biol Sci Med Sci 1997;52: M192-200.
45. Podsiadlo, D. & Richardson, S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc 1991;39: 142-148.
46. Ensrud, K. E., Ewing, S. K., Cawthon, P. M., et al. A comparison of frailty indexes for the prediction of falls, disability, fractures, and mortality in older men. J Am Geriatr Soc 2009;57: 492-498.
47. Faulkner, K. A., Cauley, J. A., Zmuda, J. M., et al. Is social integration associated with the risk of falling in older community-dwelling women? J Gerontol A Biol Sci Med Sci 2003;58: M954-959.
48. Hoogendijk, E. O., Suanet, B., Dent, E., et al. Adverse effects of frailty on social functioning in older adults: Results from the Longitudinal Aging Study Amsterdam. Maturitas 2016;83: 45-50.
49. Ganz, D. A., Higashi, T. & Rubenstein, L. Z. Monitoring falls in cohort studies of community-dwelling older people: effect of the recall interval. J Am Geriatr Soc 2005;53: 2190-2194.