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ORIGINAL ARTICLE

Social isolation is associated with future decline of physical performance in community-dwelling older adults: a 1-year longitudinal study

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Abstract

Background Social isolation and decline of physical function, such as muscle strength and physical performance, are known to be associated with deterioration of functional capacity. However, the relationship between social isolation and physical function has not been sufficiently clarified by a longitudinal observational study.

Aims The aim of this study was to examine whether social isolation is associated with a future decline in physical function in older people.

Methods The participants were 166 community-dwelling older people (aged ≥ 65 years). Social isolation and physical function were assessed using the 6-item Lubben Social Network Scale and handgrip strength, knee extensor strength, usual walking time, and the Timed Up and Go (TUG) test in both the baseline and follow-up surveys. To define the presence or absence of physical function decline over time, we used the minimal detectable change. The associations between social isolation and physical function were analyzed using logistic regression analysis adjusted for confounding factors. Further, to examine the possibility of drop-out bias, inverse probability weighting (IPW) was performed.

Results The results of the logistic regression analysis adjusted for confounding factors showed social isolation at baseline was significantly associated with future TUG decline (OR 2.88, 95% CI 1.15–7.22). Social isolation was not associated with a decline in other physical functions. Similar results were found in an analysis using IPW.

Conclusions Social isolation was an independent risk factor for future TUG decline in community-dwelling older people. Our results indicated that assessment of social isolation may be necessary to assess the risk of physical performance decline.

Keywords Social isolation · Physical function · Japanese · Older adults

Introduction

Basic activities of daily living (BADL) and instrumental activities of daily living (IADL) are fundamental functional capacities for older people. Decline of functions such as BADL and IADL has been associated with a greater risk of morbidity and mortality [1, 2]. Therefore, especially in developed countries with an aged society, including Japan, early identification of risk factors and effective interventions for the prevention of functional decline are important for successful aging.

Generally, it has been demonstrated that risk factors for the functional decline are multifactorial (e.g., physical, cognitive, psychological, and social factors) [3–5]. It is likely that these factors may be interrelated and have an impact on the functional decline. On the other hand, previous studies have indicated that social factors precede a decline in other

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factors (e.g., psychological factors such as cognitive functioning and depression, and physical factors such as muscle strength and physical performance) that influence functioning in older people [6]. Recently, a simple questionnaire consisting of four to five questions regarding daily social activities, social role, and social relationships (as measured by homeboundness, not visiting friends, not seeking help, living alone, and infrequent conversation) was developed. This questionnaire can be used to determine social frailty and has been shown to have good validity for screening for predicting the development of physical frailty and incident disability [7–9]. However, with respect to social factors, a variety of social aspects are assumed to influence physical function, such as muscle strength and physical performance in older adults [10], and the contents of the social frailty questionnaire described above did not clarify the type or kind of social factors that affect muscle strength and physical performance. It seems necessary to identify which social factors influence physical function to provide effective interventions to prevent early functional decline.

As for social factors relevant to health status in older people, a social network is one of the structural aspects of various social relationships characterized by size, density, and diversity, and it influences individuals' psychosocial mechanisms such as social support, or access to resources [11]. Some previous studies have shown an association between social network and decline in physical function [12, 13]. It is believed that social networks in older people can promote healthy behaviors, activate cognitive function through interactions with other people, and prevent a decline in physical function [12]. On the other hand, most of these studies evaluated physical function using participants' self-reports, not objective measurements. Furthermore, the participants in these studies included older people with physical frailty or functional disability. Therefore, there are few studies investigating the relationships between physical function using objective measurements and social network in older adults who are living independently and are in good physical condition.

In our previous report, we found that social isolation, as assessed by social networks, is associated with lower muscle strength and physical performance [14]. However, that was a cross-sectional survey; thus, a longitudinal relationship between social isolation and muscle strength and physical performance could not be clarified. That is, it was not clear whether social isolation is a risk factor for future decline in muscle strength and physical performance. Clarification of this association would make it possible to identify early decline in muscle strength and physical performance, and evaluating social isolation would be very useful as an assessment tool in the prevention of functional decline. The aim of this study was therefore to examine whether social isolation is associated with a future decline in muscle strength and physical performance in community-dwelling older people in a longitudinal, observational study.

Methods

Participants

People aged 65 years and over and living in the community participated in the present study. They were recruited from the participants in health check-ups for geriatric syndrome organized in 2016 by a university research team and a community sports facility in Sagamihara City, Kanagawa Prefecture, in Japan. We used community newsletters to recruit the participants. Baseline data were obtained from the 338 older people who attended health check-ups conducted from August to September 2018. Of these 338 participants, the present study finally included only the 166 participants who could participate in a 1-year follow-up survey; the number of participants and the duration of the survey were limited due to limitations in research personnel and research funding. The reasons why most participants could not participate in the follow-up survey were also personal, such as their schedules not matching the survey date. In this study, older people who were able to perform activities of daily living (ADLs) independently and could independently walk to the location of the research center for this study were included. The inclusion criteria were confirmed via a face-to-face interview by experienced researchers at the baseline survey. The exclusion criteria were as follows: individuals who had a disability certification through long-term care insurance in Japan; those who may have had significant cognitive impairment; and patients with pacemakers. Regarding cognitive impairment, individuals with a Trail Making Test part A (TMT-A) time of 120 s or more were excluded, because that value was reported to be the 90th percentile value of TMT-A in older adults without cognitive impairment [15].

The present study was approved by the Institutional Review Board of the School of Allied Health Sciences at Kitasato University (approval number 2018-008 B) and complied with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Written informed consent was obtained from each participant.

Social isolation

In this study, social isolation was assessed using the six-item Lubben social network scale (6LSNS) in both the baseline and follow-up surveys [16]. For the 6LSNS, cross-national and cross-cultural validation was confirmed by several studies, indicating it can be used to evaluate social networks among community-dwelling older adults [17, 18]. The 6LSNS evaluates the size of individuals' active and intimate networks with family and friends, with whom the participants could talk or upon whom they could call for help [18]. The 6LSNS consists of six items in a self-rated questionnaire, and each item was rated from 0 to 5 points according to the participant's subjective network size. The total score is an equally weighted sum of these six questions, with scores ranging from 0 to 30 points, and higher total scores indicating a larger social network. Based on a previous study, we categorized respondents with scores of < 12 points as being at risk of social isolation [17].

Muscle strength and physical performance measurements

To evaluate participants' muscle strength and physical performance, we performed two muscle strength tests (handgrip strength and knee extensor strength) and two physical performance tests (5-meter (m) walking time at a comfortable pace and the Timed Up and Go (TUG) test [19]). To measure the handgrip strength, a Smedley-type dynamometer (T.K.K.5401, TAKEI Scientific Instruments Co., Ltd., Niigata, Japan) was used on each participant's dominant hand in a standing position [20]. A handheld dynamometer was used to measure the isometric contraction of knee extensor strength in the right leg (μ-Tas F-1, Anima Co., Tokyo, Japan), while the participant was in a sitting position with the knee and hip joints flexed at 90 degrees [21]. To assess walking time, a stopwatch (ALBA W072; Seiko Watch Corporation, Tokyo, Japan) was used to measure the time at which participants passed 5-m on a 9-m walkway with 2-m acceleration and 2-m deceleration zones [22]. For the TUG, researchers instructed the participants to stand up from a chair without hand support, walk 3-m as quickly as possible, turn around a cone, walk back, and then sit down again [23]. A stopwatch was used to measure the time that the participant was required to complete this task (ALBA W072; Seiko Watch Corporation). All measurements were performed twice, and the best value of each measurement was used for statistical analysis. In the present study, muscle strength and physical performance were assessed in both the baseline and follow-up surveys. In addition, the rate of change in each muscle strength and physical performance measure was also calculated from the baseline and follow-up surveys.

Definition of muscle strength and physical performance decline

To define the presence or absence of muscle strength and physical performance decline over time in the present study, we used the minimal detectable changes (MDCs) for handgrip strength, knee extensor strength, 5-m walking time, and the TUG test, which were determined from a large amount of sample data on Japanese community-dwelling older adults [24]. Based on the results of a previous study, MDCs of the handgrip strength, knee extensor strength, 5-m walking time, and the TUG test were 5%, 12%, 7%, and 6%, respectively. These MDCs indicate the measurement error for each muscle strength and performance test, and are a useful indicator for detecting true changes in muscle strength and physical performance tests in community-dwelling older adults over time [24]. In this study, a decline in muscle strength and physical performance was operationally defined as when the change in muscle strength and performance test results declined by more than the MDC over time. On the other hand, changes within the MDC or increases by more than the MDC were defined as maintenance/improvement.

Measurements for confounding factors

As potential confounding factors in this study, age, sex, body mass index (BMI), comorbidity, medication, IADL, history of falls, depressive symptoms, and cognitive function were investigated in the baseline survey. These variables have been reported in previous studies as factors related to physical function decline and functional decline [1, 5]. Information about participants' comorbidities was collected using self-reported questionnaires. For comorbidity, absence or presence of hypertension, cerebrovascular disease, heart disease, diabetes mellitus, liver disease, kidney disease, respiratory disease, and other diseases was investigated by self-report questionnaire. The number of comorbidities was used for further statistical analysis. IADL were assessed using a subscale of the Tokyo Metropolitan Institute of Gerontology Index of Competence [25], with scores ranging from 0 to 5 points, and full marks (5 points) indicating independence in IADL. Regarding fall history, the presence or absence of falls during the previous 1 year was also investigated using a self-report questionnaire. Depressive symptoms were evaluated using the five-item version of the Geriatric Depression Scale (5-GDS) [26]. Scores on the 5-GDS range from 0 to 5 points. The participants with 2 points or more on the 5-GDS were categorized as having depressive symptoms; participants with 0 or 1 point were categorized as not having depressive symptoms [26]. For assessment of cognitive function, TMT-A was performed using a tablet computer (Inspiron 11, 3000 series, Dell Japan Inc., Kanagawa, Japan). The reliability and validity for assessment of TMT-A using a tablet computer were previously confirmed [27].

Statistical analyses

In this study, about half of the participants could not be followed up at 1 year. Therefore, to verify the presence or absence of bias between follow-up participants and non-follow-up participants, the differences between follow-up and non-follow-up participants were statistically analyzed for all variables. The differences between the two groups were analyzed using unpaired *t* tests, Mann–Whitney *U* test, or the Chi-squared test. To investigate the association between social isolation and muscle strength and physical performance decline, we conducted a multiple logistic regression analysis adjusting for potential confounding factors. In the multiple logistic regression analysis, the presence or absence of a decline in each muscle strength (handgrip strength/knee extensor strength) and physical performance (usual walking time/TUG) measure was set as the dependent variable, and the presence or absence of social isolation (≥ 12 points or < 12 points in 6LSNS) was set as the independent variable. Model 1 of the multiple logistic regression analysis was adjusted for age, sex, BMI, and each muscle strength and physical performance baseline value. In Model 2, number of comorbidities, IADL, and TMT-A were added to Model 1. In Model 3, depressive symptoms and fall history were added to Model 2. To examine the possibility of drop-out bias in the results of the association between social isolation and muscle strength and physical performance decline, the inverse probability weighting (IPW) method [28] was also performed. The propensity score for the IPW method was determined by logistic regression analysis with the presence or absence of follow-up as the dependent variable, and the variables with a probability of < 10% between follow-up and non-follow-up participants as the independent variables. As a sensitivity analysis, logistic regression analysis was conducted treating the independent variable, 6LSNS score, as a continuous variable. In this study, we hypothesized that social isolation would influence muscle strength and physical performance decline. On the other hand, we also examined the possibility of an inverse relationship. That is, extracting only participants who had 6LSNS ≥ 12 in the baseline survey, multiple logistic regression adjusted for age, sex, BMI, and baseline 6LSNS score was performed; the presence or absence of social isolation at the 1-year follow-up was set as the dependent variable, and each muscle strength and physical performance measure at baseline was set as an independent variable. JMP® Pro version 14.2 (SAS Institute Inc., Cary, NC) and R version 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria) were used to analyze the data, with the level of statistical significance set at 5%.

Results

Participant characteristics

A total of 166 participants completed the 1-year follow-up survey. In the comparison between follow-up and non-follow-up participants, the follow-up participants had a shorter TMT-A ($p=0.01$) and a greater number of comorbidities ($p=0.05$) than the non-follow-up participants, but the effect size estimated by Cohen's d was small (TMT-A: $d=0.29$, a number of comorbidities: $d=0.20$). No significant differences were found for the other variables. The mean age ± standard deviation (SD) of the participants (67.5% women) in the present study was 73.3 ± 4.5 years, and 95.2% could perform IADL independently. The mean score for 6LSNS was 16.3 ± 4.9, and the prevalence of social isolation (6LSNS < 12) was 17.5% (Table 1). The rates of the participants who were defined as having muscle strength and physical performance decline at the 1-year follow-up in the follow-up participants according to baseline social isolation status (6LSNS ≥ 12 points vs. 6LSNS < 12 points) were as follows: 5-m walking time (47.5% vs. 41.4%, $p=0.55$), handgrip strength (31.4% vs. 24.1%, $p=0.44$), knee extensor strength (24.1% vs. 31.0%, $p=0.43$), and TUG (32.9% vs. 51.7%, $p=0.05$).

Association between social isolation and physical function

Table 2 shows the results of the multiple logistic regression analysis of the associations between social isolation and muscle strength and physical performance decline at the 1-year follow-up. Social isolation was significantly associated with a decline of TUG at 1 year after adjusting for potential confounding factors (odds ratio [OR] = 2.88, 95% confidence interval: 1.15–7.22, $p=0.02$). On the other hand, social isolation was not associated with a decline of

Table 1 Summary of participant characteristics at baseline

	Participants ($n=166$)
	Mean (± SD)
Age, years	73.3 (4.5)
Body Mass Index, kg/m^2	22.0 (3.0)
Number of medications	1.9 (2.0)
Number of comorbidities	1.2 (1.0)
Trail Making Test-A, seconds	52.4 (14.9)
Timed Up and Go Test, seconds	5.5 (0.9)
Handgrip strength, kg	26.4 (6.2)
Knee extensor strength, kg	29.6 (9.9)
Usual walking time, seconds	3.3 (0.4)
Lubben Social Network Scale-6	16.3 (4.9)
	Number (%)
Women	112 (67.5)
Depressive symptoms (≥ 2 points)	21 (12.7)
Fall history (≥ 1 falls)	13 (7.8)
IADL (full marks)	158 (95.2)
Lubben Social Network Scale-6 (< 12)	29 (17.5)

IADL instrumental activities of daily living

Table 2 Results of the multiple logistic regression analysis of the associations between social isolation and physical function decline

Dependent variables	Model 1			Model 2			Model 3		
	OR	95% CI	*p* value	OR	95% CI	*p* value	OR	95% CI	*p* value
Timed up and go test (≥ 6% decline)	2.87	1.18–6.97	0.02	2.72	1.11–6.66	0.03	2.88	1.15–7.22	0.02
Handgrip strength (≥ 5% decline)	0.72	0.28–1.85	0.49	0.78	0.30–2.04	0.61	0.78	0.29–2.10	0.63
Knee extensor strength (≥ 12% decline)	1.35	0.52–3.53	0.53	1.46	0.54–3.89	0.45	1.59	0.59–4.30	0.36
Usual walking time (≥ 7% decline)	1.15	0.45–2.92	0.77	1.02	0.39–2.64	0.98	0.99	0.38–2.59	0.99

CI confidence interval; *IADL* instrumental activities of daily living; *OR* odds ratio; *TMT-A* Trail Making Test part A

Model 1: adjusted for age, sex, body mass index, each baseline value

Model 2: adjusted for Model 1 + number of comorbidities, IADL, TMT-A

Model 3: adjusted for Model 2 + depressive symptoms, fall history

usual walking time, handgrip strength or knee extensor strength. Furthermore, to consider the influence of drop-out bias on the results, IPW was also conducted. Consequently, the results of the association between social isolation and decline of TUG were still significant (OR = 2.81, 95% confidence interval: 1.48–5.31, $p = 0.002$). The sensitivity analysis showed that the 6LSNS score treated as a continuous variable was significantly associated with a decline of TUG. Thus, the results were similar to those for the analysis in which 6LSNS was treated as a categorical variable (S1 Table). In addition to the above results, we investigated whether baseline muscle strength and physical performance were associated with changes in social isolation at the 1-year follow-up. As a result, there were no associations between any of the baseline muscle strength and physical performance tests and social isolation at the 1-year follow-up (S2 and S3 Tables).

Discussion

The present longitudinal, observational study examined whether social isolation was associated with a future decline in muscle strength and physical performance in community-dwelling older people. In this study, about half of the participants could not be followed up at 1 year. Although there were differences in TMT-A and the number of comorbidities between follow-up and non-follow-up participants, the effect size of these variables was small. Therefore, the influence of the bias from differences between follow-up and non-follow-up participants on the results of the present study was thought to be small. Furthermore, as for the characteristics of the participants, almost all of the participants (about 95%) could perform IADL independently, and their mean usual walking time and TUG results were faster than the reference values for general community-dwelling Japanese older people [29, 30]. Furthermore, the mean total score for 6LSNS in this study was 16.3 points, and the prevalence of social isolation (6LSNS < 12) was 17.5%. In previous studies, the mean score of 6LSNS ranged between 16.1 and 17.9 points, and the prevalence of social isolation (6LSNS < 12) ranged from 11 to 20% [16, 17]. Therefore, the participants of the present study included a large number of older individuals with high functional capacities and social isolation was similar to that of previous studies.

This longitudinal study found that social isolation at baseline was associated with a future decline of TUG in community-dwelling, well-functioning older people, even after adjusting for potential confounding factors. Even if the effect of drop-out bias was considered by the use of the IPW method, its influence was suggested to be small as described above, and the significant association between social isolation and future decline of TUG remained. These results indicated that social isolation is independently associated with a future decline in physical performance such as TUG in community-dwelling, well-functioning older adults even after a time as short as 1 year. Our findings agree with previous research [12, 13, 31]. However, these previous studies included older people with physical frailty or disability in ADL; thus, functional capacities differed from the participants in our study. Therefore, the results of the present study have the strength of showing the association between social isolation and physical performance decline in well-functioning older people in a longitudinal, observation study.

Social isolation and TUG are known to be risk factors for disability [32–36]. In this study, social isolation was associated with lower TUG after 1 year. In contrast, baseline muscle strength and physical performance were not associated with social isolation at the 1-year follow-up. These results support those of previous studies showing that declines in social factors precede a decline in physical factors [6, 7]. These associations indicate that social isolation may be associated with deteriorated physical performance by limiting access to healthy lifestyles and decreasing the frequency of interactions with others [33, 34].

On the other hand, in the present study, social isolation was not significantly associated with usual walking time, handgrip strength, and knee extensor strength. Although usual walking time, handgrip strength, and knee extensor strength are easy to measure, these tests may not be suitable for assessing physical function in older adults with good functional reserve, such as the participants in this study. In fact, the walking time of the participants of this study was shorter than the reference value of the older adults in a previous study (mean 4.15 s [30]), and, moreover, most of our participants (95%) were independent in IADL (Table 1). In addition, usual gait time and handgrip strength are diagnostic criteria for physical frailty and sarcopenia [3, 20, 37], and are likely useful in the assessment of subjects with low physical function. On the other hand, TUG, which included tasks such as standing and turning around in addition to walking, is believed to be a relatively difficult performance test [38]. Therefore, it may be necessary to measure physical function with the degree of difficulty adapted to the subject's functional capacity.

There are several limitations to this study. First, the participants of this study had good muscle strength, physical performance, and functional capacities. If older adults with physical frailty, sarcopenia, and disability were included in the study sample, it cannot be clearly determined whether the results of the study would be the same. Second, this study did not obtain data for socioeconomic factors, such as income and education level, or exercise habits. Therefore, we could not determine the influence of socioeconomic factors and exercise habits on the results of this study. Third, participants with cognitive decline, such as mild cognitive impairment, may have been included among the study participants because cognitive function was assessed only using the TMT-A. We adopted the TMT-A, a simple tool for assessing executive function in older people because it was a convenient method of collecting data for this study; however, executive function is just one of the aspects of cognitive function. Thus, the assessment of cognitive function may be insufficient. Fourth, there are many studies that have investigated quantitative (e.g., size, frequency of contact) and qualitative (e.g., social support, strain) aspects of social factors related to functioning in older adults. In this study, we also focused on social isolation assessed by the size of social networks, but it is known that there are other aspects of social networks (diversity, contact frequency, and relation type) that may also have an influence. It was not clearly determined whether these factors are related to muscle strength and physical performance. Fifth, in this study, only TUG was found to be significantly associated with social isolation, and other muscle strength and physical performance tests were not. Therefore, we could not entirely deny that the influence of social isolation on TUG may be a spurious effect. Finally, about half of the participants could not be followed up at 1 year in this study. The bias from the low follow-up rate was estimated as low, and although we also performed the IPW method as part of the statistical analysis considering the effect of drop-out bias on the results, this may not have completely eliminated the bias. As mentioned above, an effect of the low follow-up rate on the results of this study cannot be completely ruled out.

In conclusion, the association between social isolation and physical performance was examined in this 1-year longitudinal, observational study. The results of this study showed that social isolation was an independent risk factor of future physical performance decline in community-dwelling older people. On the other hand, future social isolation was not induced by muscle strength and physical performance status at baseline. Our results indicated that, even in well-functioning older adults, social isolation was a risk factor for the future decline of physical performance; thus, assessment of social isolation may be necessary to assess the risk of physical performance decline and to develop adequate intervention for maintenance of physical performance in community-dwelling older people.

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Data availability The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Ethical approval All procedures in this study that involved human participants were performed in accordance with the ethical standards of the Institutional Review Board of the School of Allied Health Sciences at Kitasato University [approval number 2018-008B] and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Written informed consent was obtained from all individual participants included in the study.

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