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Association between Physical Activity in Rural Life and Sarcopenia in Community-Dwelling Middle-Aged and Older Japanese Adults: A Cross-Sectional Study

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Physical activity is crucial to prevent sarcopenia, but there is scant data on the link between sarcopenia and physical activity in rural communities. Therefore, this study investigated associations of farming activity and snow removal with sarcopenia in a middle-aged and older population in rural Japan. This cross-sectional study enrolled 3,056 residents aged ≥ 40 years (49.2% men; mean age, 64.2 years) in Yuzawa, Japan. Information on farming activity and snow removal were collected via questionnaire from May through November and from December through April, respectively. Sarcopenia was assessed by the SARC-F (strength, ambulation, rising from a chair, stair climbing, and history of falling) score. Associations of farming activity and snow removal with sarcopenia were assessed using multivariable logistic regression analysis with adjustment for potential confounders. Participants who engaged in farming activity, snow removal, and both accounted for 3.8%, 40.5%, and 29.4% of the total, respectively. In the multivariable logistic regression analysis, adjusted odds ratios [95% confidence intervals (CI)] of sarcopenia for farming activity and snow removal were 0.80 (0.63-1.03) and 0.68 (0.53-0.87), respectively. Compared with participants who did not engage in farming activity or snow removal, participants who engaged in both had a significantly lower adjusted odds ratio of sarcopenia [0.63 (95% CI 0.47-0.86)]. Participants who engaged in snow removal and those who engaged in both farming activity and snow removal showed inverse associations with sarcopenia. Our findings further support the importance of physical activity in preventing or mitigating sarcopenia in rural communities.

Keywords: agriculture; exercise; musculoskeletal diseases; rural population; seasons
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Introduction

"Healthy aging" is defined by the World Health Organization as "the process of developing and maintaining the functional ability that enables well-being in older age" (Beard et al. 2016). Functional ability is affected by individual capacities, environmental characteristics, and their interaction. Skeletal muscle plays a crucial role in maintaining physical function, metabolic health, and overall well-being (Smith et al. 2013). Aging-related loss of skeletal muscle is a determinant of sarcopenia, which leads to poor prognosis in terms of quality of life, disability, and mortality (Cruz-Jentoft et al. 2019). The prevalence of sarcopenia is around 22% among older Japanese adults aged

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65-89 years (Yamada et al. 2013), whereas the global estimate is 10% among healthy adults aged 60 years or older (Shafiee et al. 2017). Skeletal muscle undergoes its own aging process, and physical activity is a potent countermeasure against aging-related muscle loss.

Physical activity is a daily free-living activity and can be distinguished as either leisure-time or non-leisure-time physical activity. Regular physical activity is a modifiable factor for reducing the risk of sarcopenia (Cartee et al. 2016; Marzetti et al. 2017), but most related studies have focused only on leisure-time physical activity (i.e., exercise), which is reported to account for only 5% of the population's total energy expenditure (Dong et al. 2004). A previous study found that non-leisure-time physical activity such as housework accounted for the majority of physical activity in the older population (Morgan and Clarke 1997) and was associated with all-cause mortality (Arrieta and Russell 2008). Moreover, physical activity varies by season and whether one lives in a rural or urban setting (Matthews et al. 2001; Matz et al. 2015). Winter season and rural setting are considered to be factors contributing to reduced physical activity but no study has simultaneously assessed physical activity in rural life such as farming activity in the green season and snow removal in the snow season. Horticultural therapy is reported to improve subjective well-being and physical function in older adults (Lai et al. 2018; Lin et al. 2022), while snow removal is reported to maintain physical function in hemodialysis patients (Sato and Iino 2022). Indeed, physical activity in rural life was shown to have a cross-sectional association with well-being (Kabasawa et al. 2021) and thus might be a potential measure for healthy aging with respect to preventing sarcopenia.

This study investigated the association between physical activity in rural life (specifically, farming activity and snow removal) and sarcopenia in community-dwelling middle-aged and older Japanese adults, using baseline data from the Yuzawa Cohort Study in Niigata Prefecture, Japan. Our findings provide new insights into the health effects of physical activity in rural life from the perspective of healthy aging in the community.

Materials and Methods

Study design and participant

This cross-sectional study used baseline data from the Yuzawa Cohort Study, which targeted all 5,560 residents aged 40 years or older in Yuzawa at baseline (FY 2015) (Kabasawa et al. 2020). The self-administered questionnaires were delivered to residents by neighborhood association staff, while some were mailed. Among the residents of Yuzawa, 3,449 (62.0%) agreed to participate in the study by completing the questionnaire. After excluding participants with missing data [farming activity, n = 118, snow removal, n = 19, body mass index (BMI), n = 17, SARC-F score, n = 203] and BMI outliers [greater than mean ± 3 standard deviations (SD), n = 36], the present study included 3,056 participants for analysis. All participants provided written informed consent to participate in the study. The protocol for the study was approved by the Niigata University Ethics Committee (No. 2015-2140).

Briefly, Yuzawa is located at N36° E138° in the Uonuma region in Niigata Prefecture, Japan (https://www.town.yuzawa.lg.jp/). The total area of the town is 357 km^2, of which about 92% is mountain forest. In 2015, the population was 8,046, with 33.9% of the population aged 65 years or older. Of the 3,455 households, 342 were farm households (including part-time and full-time). The area has abundant snow accumulation almost every year, with a snow depth of about 1-3 m and an annual cumulative snowfall of about 5-10 m.

Assessment of physical activity in rural life

Physical activity in rural life was assessed in terms of farming activity and snow removal, based on the responses to the questionnaire. For farming activity from May to November, participants were asked how many hours per day on average they spent (1) operating agricultural machinery (e.g., transporting and planting rice with a tractor, combine harvester, or truck) (2) performing moderate tasks in the fields (e.g., planting, weeding, or harvesting) (3) performing hard tasks in the fields (e.g., transporting rice, harvested goods, or materials). For snow removal from December to April, participants were asked how many hours per day on average they spent (1) using a snow blower, (2) using a shovel to remove snow from the roof, and (3) using a sleigh shovel to remove snow from the roof. The exercise intensity for each physical activity was determined based on a previous report (Ainsworth et al. 2011). For farming activity, 2.8 metabolic equivalents (METs) were used for operating machinery, 4.3 METs for moderate tasks, and 6 METs for hard tasks. For snow removal, 2.5 METs were used for using a snow blower, 5.3 METs for using a snow shovel, and 7.5 METs for using a sleigh shovel. The exercise intensity of farming activity and snow removal per day (METs × minutes per day) was calculated by multiplying these METs by the time spent working.

Assessment of sarcopenia

Sarcopenia was assessed by the screening tool SARC-F, which is a five-item self-report questionnaire consisting of items on muscle strength, walking, standing up from a chair, climbing stairs, and falling (Malmstrom and Morley 2013). Scores for each component ranged from 0-2 points, with a total score ranging from 0 (best) to 10 (worst). Participants with a total score ≥ 4 were considered to have sarcopenia (Cruz-Jentoft et al. 2019). The Japanese version of the SARC-F was previously validated, with a specificity as high as 85.8% for men and 72.4% for women (Ida et al. 2017).

Other variables

Information on other covariates was obtained via self-administered questionnaire. BMI was calculated by divid-

ing the self-reported weight by the square of the self-reported height. Medical history included self-reported histories of cancer, heart disease, diabetes, stroke, and fractures. Physical activity without seasonal variation was calculated using data from the Japan Public Health Center-based prospective study-physical activity questionnaire (JPHC-PAQ) (Kikuchi et al. 2020). The JPHC-PAQ collects information on non-leisure-time activities (commuting, work, and housework) and leisure-time activities without seasonal variation in the previous year. The JPHC-PAQ was assessed in terms of MET-minutes per day, which is the MET intensity multiplied by the time spent engaged in each activity per day. MET intensities were set as follows (Kikuchi et al. 2020): leisure-time activities (slow walking, 2.8 METs; fast walking, 4.0 METs; light- to moderate-intensity exercise, 3.0 METs; high-intensity exercise, 6.0 METs), non-leisure-time activities (sitting, 1.3 METs; standing, 2.0 METs; walking, 3.0 METs; vigorous work, 6.0 METs), sleep (0.9 METs), and other (1.3 METs).

Statistical methods

Participant characteristics are summarized as mean ± SD, median (25th-75th percentiles), or number (percentage) by overall, age category (< 65 years and ≥ 65 years), and activity groups; (1) Farming activity only (Farming activity), (2) Snow removal only (Snow removal), (3) None, and (4) Both. Differences in the baseline characteristics among age groups and activity groups were assessed using one-way analysis of variance or the Kruskal–Wallis test for continuous variables (depending on normal or skewed distribution, respectively) and the chi-square test for categorical variables, respectively. The correlations between farming activity, snow removal, and JPHC-PAQ were assessed using Spearman's correlation coefficients.

The associations of farming activity and snow removal with sarcopenia were tested by performing a logistic regression analysis modeled with each physical activity as an independent variable and sarcopenia as a dependent variable. In this model, farming activity or snow removal are included in all, regardless of the presence or absence of snow removal or farming activity, respectively. Model 1 was adjusted for sex, age, and BMI; Model 2 was adjusted for the covariates in Model 1 plus medical history; and Model 3 was adjusted for the covariates in Model 2 plus JPHC-PAQ score. Next, we performed a multivariable logistic regression analysis (Model 3) to compare the following three groups: (1) neither farming activity nor snow removal (None, reference), (2) either farming activity or snow removal (Either), and (3) both farming activity and snow removal (Both). *P*-trend values were estimated by this model, which included the groups (an independent variable) treated as an ordinal variable. We repeated these analyses among the participants without any medical history. Furthermore, a similar multivariable logistic regression analysis (Model 3) was performed for both the participants who engaged in some farming activity and those who engaged in some snow removal in order to assess the dose–response relationship of each physical activity intensity × time (in quartiles) with sarcopenia.

Finally, we performed a subgroup analysis by age. The participants were divided into those aged 65 years and over and those under 65 years of age, and a multivariable logistic regression analysis (Model 3) was performed.

All statistical analyses were performed using SPSS version 28.0 (IBM Corp., Armonk, NY, USA). The significance level was set at less than 5%.

Results

The mean (± SD) age and prevalence of sarcopenia were 63.7 (± 12.5) years and 11.5% in men and 64.7 (± 13.2) years old and 18.6% in women, respectively. Table 1 shows the baseline characteristics for participants overall and by age category (< 65 years old or ≥ 65 years). The prevalence of sarcopenia was 5.4% in the younger group and 24.6% in the older group. The older group was more likely to engage in farming activity and snow removal, to have any medical history, and to have a lower JPHC-PAQ score compared with the younger group. Supplementary Table S1 shows the baseline characteristics according to the four groups; participants who engaged in farming activity, snow removal, both, and neither. The farming activity group was older and more likely to have sarcopenia compared with the other groups. The snow removal group was younger and less likely to have sarcopenia compared with the other groups. The None group was more likely to have a medical history (except for fractures in men), to live alone, and to have a lower JPHC-PAQ score compared with the other groups. There was a modest correlation between farming activity and snow removal, with a Spearman's correlation coefficient of 0.364. The Spearman's correlation coefficients for JPHC-PAQ were 0.319 for farming activity and 0.219 for snow removal.

Table 2 shows the associations of farming activity and snow removal with sarcopenia. For farming activity, the association with sarcopenia was significant in Models 1 and 2, but its association was attenuated by the adjustment for JPHC-PAQ in Model 3 [Adjusted odds ratio (AOR) = 0.80 (95% CI 0.63-1.03), $P = 0.08$ overall] (Table 2A). Regarding snow removal, the association with sarcopenia was slightly attenuated by the adjustment for covariates but remained significant in Model 3 overall and for both sexes (Table 2B).

Fig. 1 shows the AOR and 95% CI of sarcopenia for the None (reference), Either, and Both groups. The Either group was not significant but the Both group was significantly associated with sarcopenia [AOR = 0.63 (95% CI 0.47-0.86)] (Fig. 1A). Also, in both sexes, the Both group was significantly associated with sarcopenia but the Either group was not (Fig. 1B, C). *P*-trend values for these associations were significant for participants overall as well as for both sexes (*P*-trend = 0.003 overall, 0.027 for men, and 0.047 for women).

Table 1. Baseline characteristics according to physical activity: farming activity, snow removal.

	Overall	< 65 years	≥ 65 years	*P*-value[a]
n	3,056	1,512	1,544	
Age, years	64.2 (±12.9)	53.5 (± 7.4)	74.7 (± 7.3)	< 0.001
Men	1,503/3,056 (49.2%)	765/1,512 (50.6%)	738/1,544 (47.8%)	0.122
Body mass index, kg/m^2	22.7 (± 3.1)	22.8 (± 3.1)	22.7 (± 3.1)	0.636
Farming activity, MET-minutes/day	361.7 [147.4-816.9]	221.1 [73.7-610.7]	442.3 [184.3-921.4]	0.002
Snow removal, MET-minutes/day	438.9 [181.7-900.0]	382.7 [160.7-774.6]	522.0 [214.3-1,002.9]	< 0.001
Medical history				
Cancer	285/3,056 (9.3%)	66/1,512 (4.4%)	219/1,544 (14.2%)	< 0.001
Heart disease	159/3,056 (5.2%)	34/1,512 (2.2%)	125/1,544 (8.1%)	< 0.001
Diabetes mellitus	243/3,056 (8.0%)	69/1,512 (4.6%)	174/1,544 (11.3%)	< 0.001
Stroke	118/3,056 (3.9%)	31/1,512 (2.1%)	87/1,544 (5.6%)	< 0.001
Fracture	169/3,056 (5.5%)	46/1,512 (3.0%)	123/1,544 (8.0%)	< 0.001
Living alone	364/3,056 (11.9%)	136/1,512 (9.0%)	228/1,544 (14.8%)	< 0.001
JPHC-PAQ, MET-minutes/day	2,482.0 (± 646.5)	2,558.0 (± 653.1)	2,407.4 (± 631.2)	< 0.001
Sarcopenia	462/3,056 (15.1%)	82/1,512 (5.4%)	380/1,544 (24.6%)	< 0.001

[a]One-way analysis of variance or Kruskal–Wallis test for continuous variables and chi-square test for categorical variables.
MET, metabolic equivalent of task; JPHC-PAQ, the Japan Public Health Center-based prospective study-physical activity questionnaire.
Values are shown as means (± SD), median [25-75 percentiles], or number (%).

Table 2. Odds ratios [95% CIs] of sarcopenia for farming activity and snow removal.

	Overall	Men	Women
A. Farming activity			
Crude	0.97 [0.79-1.20]	0.95 [0.68-1.32]	1.09 [0.83-1.45]
Model 1	0.66 [0.52-0.83]	0.65 [0.46-0.92]	0.67 [0.49-0.91]
Model 2	0.68 [0.54-0.86]	0.69 [0.49-0.98]	0.67 [0.49-0.92]
Model 3	0.80 [0.63-1.03]	0.79 [0.55-1.15]	0.81 [0.58-1.13]
B. Snow removal			
Crude	0.35 [0.29-0.43]	0.37 [0.26-0.52]	0.39 [0.30-0.51]
Model 1	0.58 [0.46-0.74]	0.51 [0.35-0.74]	0.64 [0.47-0.87]
Model 2	0.60 [0.48-0.77]	0.55 [0.38-0.80]	0.65 [0.48-0.88]
Model 3	0.68 [0.53-0.87]	0.61 [0.41-0.90]	0.73 [0.54-0.99]

Model 1 was adjusted for age and body mass index (models for Overall includes sex as an adjustment); Model 2 was adjusted for Model 1 plus medical history; and Model 3 was adjusted for Model 2 plus physical activity without seasonal variation.
CI, confidence intervals. Values are shown as odds ratios and 95% CIs, calculated using a logistic regression analysis.

We performed a similar logistic regression analysis (Model 3) of the participants without a medical history (n = 2,364). Farming activity showed a marginal relationship with sarcopenia [AOR = 0.74 (95% CI 0.54-1.00), *P* = 0.051], while snow removal was significantly associated with sarcopenia [AOR = 0.71 (95% CI 0.52-0.96), *P* = 0.025]. Compared with the None group, the Either group was not significantly associated with sarcopenia [AOR= 0.97 (95% CI 0.69-1.37)] but the Both group showed a significant association with sarcopenia [AOR= 0.61 (95% CI 0.42-0.89)].

Next, each physical activity was treated in quartiles (Q1 as the least and Q4 as the highest in intensity × time per day) to test the dose–response relationship for each association with sarcopenia (Table 3). Regarding farming activity, there was no dose–response relationship with sarcopenia (Table 3A). Regarding snow removal, compared with the Q1 group, the Q2 group had a significantly lower odds ratio of sarcopenia but a dose–response relationship was not observed (Table 3B).

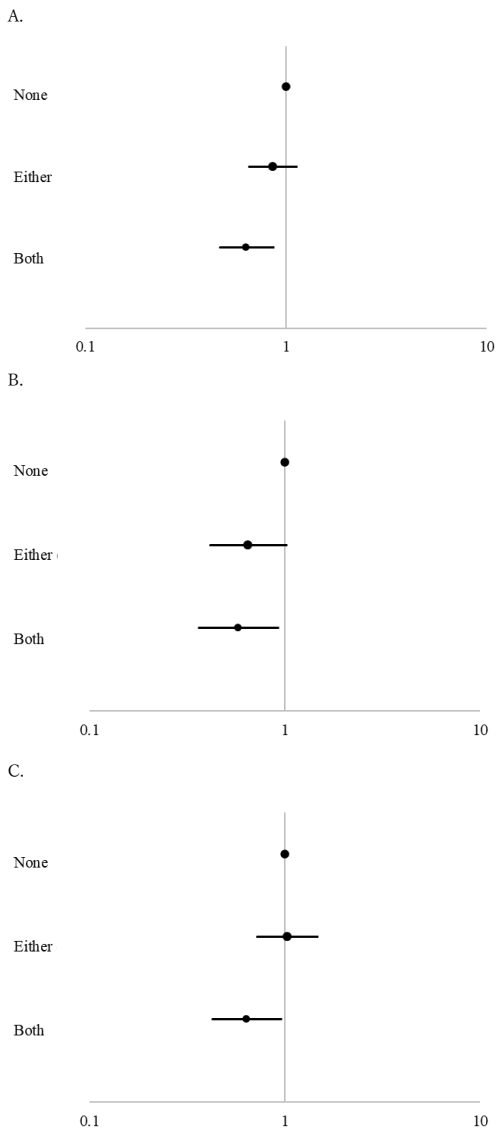

Fig. 1. Adjusted odds ratios of sarcopenia according to physical activity: none, either, both.
A. Overall; B. Men; C. Women. Black points and bars indicate adjusted odds ratios and 95% confidence intervals, respectively. Adjusted odds ratios were estimated by a multivariable logistic regression model with adjustment for sex (only for overall), age, body mass index, medical history, and JPHC-PAQ score.

Table 4 shows the subgroup analysis results by age for the associations of farming activity and snow removal with sarcopenia. In the younger participants (age < 65 years), farming activity was significantly associated with sarcopenia but snow removal was not. In the older participants (age ≥ 65 years), although farming activity was not associated with sarcopenia, snow removal was significantly associated with sarcopenia.

Discussion

To our knowledge, this is the first study to examine the association of physical activity in rural life (specifically, farming activity and snow removal) with sarcopenia in the middle-aged and older Japanese population. The study found that participants who engaged in snow removal and those who engaged in both farming activity and snow removal showed inverse associations with sarcopenia.

This study found an inverse association between snow removal (but not farming activity) and sarcopenia, even after adjusting for physical activity without seasonal variation. Farming activity and snow removal would seem to be similar activities in rural life but might differ in terms of intensity. Although we can choose the degree to which we engage in farming activity, snow removal is a necessary task to maintain daily life, and the degree of engagement depends not on our personal preference but rather the environment (climate). Typically, the intensity of snow removal is high (Ainsworth et al. 2011) and therefore it requires a high level of physical function. We should carefully consider its temporality due to the study design. Our results may reflect the fact that people with high physical function who can perform snow removal tend to have a low prevalence of sarcopenia, but this was not necessarily the case for farming activity.

We also found no association between sarcopenia and engaging in either farming activity or snow removal alone. Even if a person is physically able to perform snow removal, this alone is not associated with sarcopenia. Future studies are needed to confirm whether a causal relationship exists between snow removal and sarcopenia, but we may be able to emphasize the importance of engaging in farming activity in the green season as well as snow removal in the snow season from the perspective of preventing or mitigating sarcopenia. Environmental factors such as weather and infrastructure are important determinants of health and might be barriers to physical activity (Alessy et al. 2023); however, engaging in year-round physical activity in line with environmental conditions may have a positive effect on sarcopenia.

This study also found a significant inverse association between snow removal and sarcopenia in the older group (age ≥ 65 years). This suggested that snow removal may be a worthwhile activity for older adults in order to prevent sarcopenia. However, we should mention that prolonged snow removal in a poor posture can lead to adverse events such as low back injuries and falls (Watson et al. 2011). Low back pain itself is a risk for sarcopenia (Lin et al. 2023). Thus, in the older group, it is necessary to enhance their understanding of the appropriate working posture and the equipment used so that they can safely perform the work.

This study has several limitations that should be noted. First, because of the cross-sectional study design, we cannot determine causality in the relationship between physical activity in rural life and sarcopenia. The Yuzawa Cohort Study and similar studies should longitudinally assess the association between physical activity in rural life and sarcopenia in the future. Second, although the Asian Working Group for Sarcopenia recommends diagnosing sarcopenia

Table 3. Association between each physical activity (time × intensity) and sarcopenia.

	Q1	Q2	Q3	Q4	*P*-trend
A. Farming activity, METs × minutes/day					
Cases/n (%)	37/252 (14.7%)	35/256 (13.7%)	43/254 (16.9%)	36/254 (14.2%)	
Adjusted odds ratio [95% CI]	1(Ref)	0.64 [0.36-1.12]	0.68 [0.39-1.17]	0.66 [0.36-1.20]	0.222
B. Snow removal, METs × minutes/day					
Cases/n (%)	64/525 (12.2%)	41/543 (7.6%)	51/532 (9.6%)	72/537 (13.4%)	
Adjusted odds ratio [95% CI]	1(Ref)	0.61 [0.39-0.94]	0.70 [0.46-1.07]	1.09 [0.73-1.63]	0.502

Each physical activity was treated in quartiles, with Q1 as the least and Q4 as the highest intensity × time of physical activity. Multivariable logistic regression analysis was used to estimate the adjusted odds ratios [95% CIs] for sarcopenia and *P*-trend values. The model was adjusted by sex, age, body mass index, medical history, and the JPHC-PAQ score for participants with farming activity or snow removal.
CI, confidence intervals.

Table 4. Odds ratios [95% CIs] of sarcopenia for farming activity and snow removal, respectively, according to age group.

	< 65 years (n = 1,512)	≥ 65 years (n = 1,544)
A. Farming activity		
Crude	0.61 [0.34-1.10]	0.74 [0.58-0.93]
Model 1	0.52 [0.28-0.95]	0.72 [0.56-0.94]
Model 2	0.52 [0.28-0.95]	0.75 [0.58-0.98]
Model 3	0.51 [0.28-0.93]	1.04 [0.78-1.38]
B. Snow removal		
Crude	0.69 [0.42-1.14]	0.39 [0.31-0.50]
Model 1	0.80 [0.48-1.35]	0.54 [0.41-0.71]
Model 2	0.82 [0.49-1.38]	0.56 [0.43-0.74]
Model 3	0.80 [0.47-1.36]	0.67 [0.51-0.89]

Model 1 was adjusted by sex, age, and body mass index; Model 2 was adjusted by the covariates in Model 1 plus medical history; and Model 3 was adjusted by the covariates in model 2 plus the JPHC-PAQ score.
CI, confidence intervals. Odds ratios and 95% CIs were calculated using a logistic regression analysis.

based on criteria such as muscle mass, muscle strength, and physical function, this study used SARC-F, a screening tool for sarcopenia. The Japanese version of SARC-F has been reported to have high specificity but low sensitivity (Ida et al. 2017), and thus it might lead to misclassification in the assessment of outcomes. Third, because this study was conducted in Yuzawa, a rural town in Japan, the results may not be broadly generalizable. The town of Yuzawa provides subsidies for hiring snow removal services as well as for home renovations aimed at realizing snow-resistant houses. The town also provides snow removal services for sick and older residents who live alone. These unique aspects may influence the basic characteristics of the study participants; for example, some participants engaged only in farming activity and participants in the None group were more likely to live alone. Finally, the results were adjusted for major confounders but we cannot rule out the possibility of residual confounding. Also, climate factors such as temperature and snow accumulation continue to change, so our results might be affected by uncertainty in environmental factors.

This study has several potential implications. When considering outcomes of aging in rural settings, it is important to understand how older people experience and interact with their environment, community, and society at large (Andrews et al. 2013). Indeed, in rural areas, both farming activity and snow removal are considered types of community practice that can provide opportunities for social engagement and regular physical activity. Our findings further support that the choice to continue engaging in farming activity in later life is worthwhile for maintaining physical function. Meanwhile, some studies have reported health risks associated with snow removal, including low back injuries and accidents during snow removal (Watson et al. 2011; Yamaguchi et al. 2017; Hatakeyama et al. 2020) and cardiovascular events (Franklin et al. 2001). Therefore, snow removal is not necessarily recommended for everyone, and its safety should be carefully considered. Taken together, the findings suggest the possibility that farming activity and snow removal may facilitate healthy aging in rural communities; however, further studies are needed to establish the safety of snow removal and its potential applications in other areas.

In conclusion, this study observed an inverse association between snow removal and sarcopenia in middle-aged and older Japanese adults. Notably, the participants who engaged in both farming activity and snow removal showed an inverse association with sarcopenia, even after adjusting for physical activity without seasonal variation. These findings suggest the possibility of benefits from engaging in physical activity in rural life for healthy aging in rural communities and provide further evidence of the importance of environmental factors on our health. Further studies are needed to confirm the temporality and causality of the association between physical activity in rural life and sarcopenia.

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Conflict of Interest

The authors declare no conflict of interest.

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Supplementary Files

Please find supplementary file(s);
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