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Association between Active Mobility Index and sarcopenia among Japanese community-dwelling older adults

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Abstract

Background A physically active lifestyle, including physical and social activities, is needed to maintain muscle mass, strength, and physical performance. A large life space characterizes an active lifestyle, but the association between life space with physical and social activities and sarcopenia is unclear. This study aimed to examine the association between life space with physical and social activities, assessed using the Active Mobility Index (AMI), and sarcopenia in community-dwelling Japanese older adults.

Methods This study used a large, cross-sectional cohort dataset from the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes (NCGG-SGS). Between 2013 and 2018, community-dwelling Japanese adults aged ≥60 years participated in the NCGG-SGS. Sarcopenia was identified by measuring muscle mass and strength based on the clinical definition. The secondary outcomes were sarcopenia indices, including lower muscle mass, lower muscle strength, and lower gait speed. AMI assessed life space with physical and social activities in each life space (distance from the respondent's home: <1, 1–10, or >10 km) during the past month by noting the frequency, primary purpose, type of transportation, interaction with others, and physical activity. The associations between quartile groups of AMI total, physical, and social scores and sarcopenia were examined using a logistic regression model.

Results From all participants, 21 644 participants (age 73.5 ± 5.8 years, 54.7% female) were included in the analysis. The prevalence of sarcopenia was 4.1% ($n = 894$). For the AMI total score, referred to Q1 group, Q3 and Q4 groups were significantly associated with a reduced odds ratio (OR) of sarcopenia after adjusting for all covariates [adjusted OR (aOR) (95% confidence interval), Q3: 0.71 (0.57–0.89), Q4: 0.69 (0.55–0.87)]. Q3 and Q4 of the AMI physical score groups were also significantly associated with reduced OR of sarcopenia [Q3: 0.71 (0.57–0.89), Q4: 0.67 (0.54–0.84)]. For the AMI social score, only the Q4 group showed reduced OR for sarcopenia [0.79 (0.62–1.01)]. Q3 and Q4 of the AMI total score and physical score were associated with reduced OR of all sarcopenia indices (aOR 0.55–0.82, all $P < 0.05$), whereas Q4 of AMI social score was associated with all indices (aOR 0.85–0.81, all $P < 0.05$).

Conclusions The extent of life space with physical activity was associated with sarcopenia in community-dwelling older adults. A longitudinal study is needed to examine whether life space with physical and social activities affect the development of sarcopenia.

Keywords Life space; Physical activity; Social activity; Musculoskeletal disease

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Introduction

Sarcopenia is an age-related loss of skeletal muscle mass and strength and is formally recognized as a muscle disease with an ICD-10-MC Diagnosis Code, M62.84.[1,2] Sarcopenia is a critical issue for older adults because it leads to a lack of independence and increased risk of falls, hospitalization, osteoporosis, cardiovascular diseases, disability, and mortality.[3,4] Among the risk factors for sarcopenia, inactivity is a modifiable factor, and enhancement of activity is expected to assist in coping with sarcopenia.[5]

An active lifestyle is needed to maintain muscle mass, strength, and physical performance. The importance of physical activity in sarcopenia has already been clarified.[6–8] In addition, previous studies report that engagement in social activity reduces the risk of mobility disability and motor decline, including gait speed, balance, and muscle strength.[9–11] A large life space, which has also been regarded as an essential factor for older adults' health, is crucial for an active lifestyle later in life.[12] Life space is defined as movement extending from within one's home to move beyond one's town or geographic region over a specified period.[13] Larger life space is associated with greater engagement in physical activity[14,15] and social involvement,[16,17] and constricted life space is thought to cause further loss of physiologic reserve, capacity, and frailty.[18] In a cross-sectional study, life space mobility was associated with variables related to frailty.[19] Although life space would associate with sarcopenia and its indices, the association is unclear. Furthermore, simultaneous evaluation of life space and related activities helps assess the risk of disability.[20] The Active Mobility Index (AMI) assesses physical and social activities in each life space.[20] Therefore, this study aimed to examine the associations between life space for physical and social activities assessed by the AMI and sarcopenia among community-dwelling older adults.

Methods

Participants

This study used a cross-sectional cohort dataset from the National Center for Geriatrics and Gerontology-Study of Geriatric Syndromes (NCGG-SGS). The NCGG-SGS is a community-based cohort study to establish a screening programme for geriatric syndromes and validate evidence-based interventions for their prevention.[21] From the NCGG-SGS, community-dwelling older people aged ≥60 years were recruited from Obu City, Midori Ward of Nagoya City, Takahama City, Tokai City, and Toyoake City in Aichi Prefecture, Japan. A total of 25 851 individuals were eligible for this study.

In the present study, participants were excluded if they had a self-reported basic activity of daily living (BADL) disability (n = 70); a medical history that included stroke, dementia, depression, or Parkinson's disease (n = 2316); a general cognitive impairment [Mini-Mental State Examination (MMSE) score $<$ 21; n = 472][22]; or missing data for all the variables (n = 1239). A total of 21 644 participants were included in the analysis. All participants provided written informed consent. This study was conducted according to the Declaration of Helsinki guidelines. The National Center for Geriatrics and Gerontology research ethics committee approved the study protocol.

Measurement

Sarcopenia

Sarcopenia was identified by both to muscle mass and muscle strength according to the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) recommendations.[3] We adopted cut-off values for each variable in the revised Asian Working Group for Sarcopenia criteria: low muscle mass defined by skeletal muscle mass index (SMI) $<$ 7.0 kg/m^2 in men and $<$5.7 kg/m^2 in women and low muscle strength defined by handgrip strength $<$ 28 kg in men and $<$18 kg in women.[23] In addition, because EWGSOP2 considers poor physical performance as a severe sarcopenia indicator, sarcopenia indices including low SMI, low muscle strength, and low gait speed ($<$1.0 m/s)[23] were set as outcomes for subanalyses.

Skeletal muscle mass was assessed using a multifrequency bioelectrical impedance analyser (MC-980A and MC-780A; TANITA, Tokyo, Japan). The participants grasped the surface of the hand electrode by each of the five fingers and placed heels and toes within a circular-shaped foot electrode. Participants were instructed to extend their limbs during the measurements and avoid touching any other body part. Six electrical frequencies (1, 5, 50, 250, 500, and 1000 kHz) were used for the bioelectrical impedance analysis instrument, and we adopted a value of 50 kHz to calculate the participants' appendicular skeletal muscle mass. The skeletal muscle mass of the participants was converted into SMI by dividing their muscle mass (kg) by the square of their height (m^2). In addition, handgrip strength was assessed by handgrip strength measured using a Smedley-type handheld dynamometer (Takei Ltd, Niigata, Japan).

Gait speed was measured by walking a 6.4 m path on a flat and straight surface at a comfortable pace. Two markers were used and placed in the middle of the path to indicate the start and end of a 2.4 m walking path to measure walking speed. A 2 m section before the start marker and beyond the

marker's end was used to ensure a consistent walking pace while on the timed path. Walking times were measured in seconds using a stopwatch with a sensor, and the participants' walking speed (m/s) was calculated.

Active Mobility Index

The participants' life space and related activities were assessed using AMI, and the detailed protocol has been described previously.[20] AMI assessed physical and social activities in three levels of life space in a recent month: <1, 1–10, and >10 km from the respondent's residence. In each area, participants were asked how often they visited the location per week (<1/1–3 days/4–6 days/every day); the purpose [mainly for physical activity (such as walking and exercise)/mainly for daily chores and appointments (shopping or meeting people)/both equally]; transportation (walking/bicycle/bus, train/car, or other); extent of interaction with others [how many people (0/1–2/3–4/≥5)]; and extent of physical activity [how much (almost none/very little/some/a lot)].

Life space score was computed for each level by multiplying the life space level (distance of <1 km = 1, distance of 1–10 km = 2, distance of 10 km = 3) and frequency (no = 0, <1 = 1, 1–3 days = 2, 4–6 days = 3, every day = 4). AMI physical and social scores were computed by multiplying the life space score and physical and social scores. Physical scores were the sum of the purpose (mainly for physical activity = 2, mainly for daily chores and appointments = 0, both 1 and 2 equally = 1), transportation (walking/bicycle = 1, bus/train = 0, car/other = 0), and the extent of physical activity (almost none = 0, very little = 1, some = 2, a lot = 3). Social scores were the sum of the purpose (mainly physical activity = 0, mainly daily errand = 2, both 1 and 2 equally = 1), transportation (walking/bicycle = 0, bus/train = 1, car/other = 0), and extent of interaction with others (0 = 0, 1–2 = 1, 3–4 = 2, ≥5 = 3). Each AMI physical and social score ranged from 0 to 144, with higher scores indicating greater life space with activities. According to the response to the purpose and transportation question, either physical or social score was high, or both scores were equal. The range of the AMI total score was the sum of AMI physical and social scores, from 0 to 216. The scoring sample can be found in the appendix of the original literature.[20]

Potential confounding factors

In addition to collated data on their sociodemographic characteristics (age, sex, and years of education), participants were asked about their lifestyle and medical information through a face-to-face interview. Participants were asked about their lifestyle, drinking habits (yes/no), smoking habits (current smoking/stopped smoking/no), living alone (yes/no), and whether they drove a car (yes/no). As the medical data, number of current medications, fall history in a year (yes/no), depressive symptoms, and cognitive function were assessed. Five or more medications were identified as polypharmacy.[24] Depressive symptoms were assessed using the 15-item Geriatric Depression Scale (GDS), consisting of 15 yes/no questions and a score ranging from 0 to 15.[25] Six or more scores identified depressive symptoms.[25] The MMSE was used to evaluate cognitive function.[26] An MMSE score ≤ 23 was identified as a general cognitive impairment.[27]

Statistical analysis

The differences in participants' characteristics among the quartile groups of AMI total score were examined using one-way analysis of variance for continuous variables and the χ^2 test for discrete variables. The Cochran–Armitage trend test examined whether quartile groups of AMI total, physical, and social scores were associated with a lower prevalence of sarcopenia. The associations between the quartiles of AMI total, physical, and social scores and sarcopenia were examined using binomial logistic regression models. Adjusted odds ratios (aORs) and 95% confidence intervals (CIs) of sarcopenia were calculated in the crude and fully adjusted models for all covariates. Similarly, the associations of the quartiles of AMI scores with each sarcopenia index were examined using binomial logistic regression models for subanalysis. The Cochran–Armitage trend test was performed using the JMP statistical package Version 16 (SAS Institute, Cary, NC, USA), and the other analyses were conducted using SPSS Version 25 (IBM, New York City, NY, USA). The level of statistical significance was set at $P < 0.05$.

Results

The characteristics of the 21 644 participants (73.5 ± 5.8 years old, 54.7% female, and 11.8 ± 2.4 years of education) and comparison by quartile groups of AMI total score are summarized in *Table* 1. Compared with the higher score groups, the lower score groups were older and had a lower proportion of men (all $P < 0.001$), and especially Q1 group showed a higher proportion of global cognitive impairment, depressive symptoms, polypharmacy, and fall history in a year (all $P < 0.001$). Regarding lifestyle factors, the lower score groups showed a lower proportion of drinkers and car drivers and a higher proportion of those living alone (all $P < 0.001$).

The prevalence of sarcopenia among the analysed subjects was 4.1% (n = 894). The prevalence in quartile groups of AMI total, physical, and social scores is described by the bar graph in *Figure* 1. The Cochran–Armitage trend test indicated that higher groups of each score showed a significantly lower prevalence of sarcopenia (all $P < 0.001$). Odds ratios (ORs) of sarcopenia for AMI scores in the logistic regression model are summarized in *Table* 2. In the AMI total score, referred to Q1 group, Q3 and Q4 groups were associated with reduced aOR of sarcopenia with a significant trend after adjusting

Table 1 Characteristics of overall participants and comparison between groups by quartile of AMI total score

Characteristic	Overall $n = 21\,644$	Quartile of AMI total score[a] Q1 $n = 5522$	Q2 $n = 5606$	Q3 $n = 5329$	Q4 $n = 5187$
Age, years	73.5 (5.8)	74.9 (6.4)	73.5 (5.9)	73.0 (5.5)	72.7 (5.3)
Female, *n* (%)	54.7	56.4	56.5	54.7	50.9
Education, years	11.8 (2.4)	11.3 (2.4)	11.8 (2.4)	12.0 (2.4)	12.1 (2.5)
BMI, kg/m^2	23.1 (3.1)	23.0 (3.3)	23.1 (3.1)	23.2 (3.0)	23.3 (3.0)
MMSE $\leq$ 23 score, %	9.5	12.2	8.5	8.4	8.8
GDS $\geq$ 6 score, %	12.0	21.2	12.0	9.2	5.2
Medications $\geq$ 5, %	23.5	29.2	24.7	20.8	19.0
Fall history, %	19.5	22.1	19.5	18.2	18.3
Drinking habit, %	40.9	35.2	40.2	43.0	45.7
Smoking habit, %					
Stopped	30.2	29.2	30.0	30.5	31.2
Yes	7.6	8.6	7.0	7.5	7.3
Living alone, %	12.9	15.0	12.5	11.5	12.4
Car driving, %	69.6	60.1	68.5	72.9	77.5
AMI total score	71.6 (29.3)	36.8 (10.9)	61.1 (5.5)	80.1 (5.8)	111.1 (18.8)
AMI physical score	31.4 (17.3)	15.1 (8.2)	26.5 (9.4)	35.3 (11.6)	50.0 (16.6)
AMI social score	40.2 (18.8)	21.8 (9.1)	34.6 (9.5)	44.8 (11.7)	61.1 (17.0)

AMI, Active Mobility Index; BMI, body mass index; GDS, Geriatric Depression Scale; MMSE, Mini-Mental State Examination.
All values are reported as mean (standard deviation) or %.
[a]Continuous variables and category variables between groups were compared using one-way analysis of variance and χ^2 test, respectively. All comparisons showed significant differences (all $P < 0.001$).

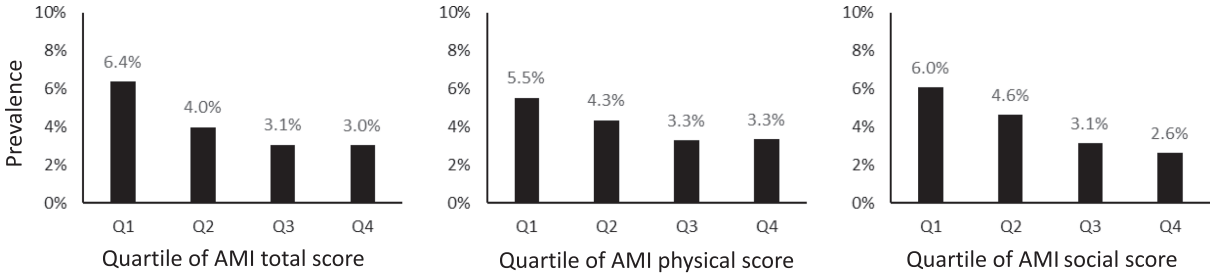

Figure 1 Prevalence of sarcopenia according to quartile of AMI scores. The differences between quartile groups of each score were verified using the Cochran–Armitage trend test ($P < 0.001$). AMI, Active Mobility Index.

for all covariates (aOR 0.69–0.71, both $P < 0.01$). Q3 and Q4 of the AMI physical score groups were significantly associated with reduced OR of sarcopenia (aOR 0.67–0.71, both $P < 0.01$). In the AMI social score, only the Q4 group showed a reduced OR of sarcopenia (aOR 0.79, 95% CI 0.62–1.01, $P = 0.057$).

The aORs of sarcopenia indices, including lower grip strength, lower muscle mass, and lower gait speed, for AMI scores in the logistic regression model are summarized in *Table* 3. Higher AMI total score, AMI physical score, and AMI social score were significantly associated with reduced aOR of lower grip strength and gait speed (lower grip strength: aOR 0.68–0.89, all $P < 0.05$; lower gait speed: aOR 0.48–0.84, all $P < 0.01$). Q3 and Q4 groups of AMI total score and AMI physical score were associated with reduced OR of lower muscle mass with a significant trend (aOR 0.68–0.83, all $P < 0.05$), while in the AMI social score, only the Q4 group was associated with lower muscle mass (aOR 0.81, 95% CI 0.68–0.96, $P = 0.017$).

Discussion

The present study examined the association between AMI scores and sarcopenia among community-dwelling older adults. The findings showed that higher AMI total and AMI physical scores were associated with reduced OR of sarcopenia, and the association between AMI social scores and sarcopenia was weakened in the adjusted model. In a sub-analysis, higher AMI total, physical, and social scores were associated with a reduced OR of low grip strength and low gait speed.

Table 2 Logistic regression model for the associations between AMI scores and sarcopenia

	AMI total score				AMI physical score				AMI social score			
	Crude		Adjusted		Crude		Adjusted		Crude		Adjusted	
Variable	OR (95% CI)	*P*	aOR (95% CI)	*P*	OR (95% CI)	*P*	aOR (95% CI)	*P*	OR (95% CI)	*P*	aOR (95% CI)	*P*
AMI score (ref: Q1)												
Q2	0.61 (0.51–0.72)	<0.001	0.87 (0.71–1.06)	0.167	0.78 (0.65–0.92)	0.004	1.02 (0.83–1.25)	0.864	0.75 (0.64–0.89)	0.001	1.05 (0.86–1.28)	0.650
Q3	0.46 (0.38–0.56)	<0.001	0.71 (0.57–0.89)	0.003	0.58 (0.48–0.70)	<0.001	0.71 (0.57–0.89)	0.003	0.50 (0.42–0.60)	<0.001	0.86 (0.70–1.07)	0.188
Q4	0.46 (0.38–0.56)	<0.001	0.69 (0.55–0.87)	0.002	0.59 (0.49–0.71)	<0.001	0.67 (0.54–0.84)	<0.001	0.42 (0.34–0.51)	<0.001	0.79 (0.62–1.01)	0.057
P for trend		<0.001		0.003		<0.001		<0.001		<0.001		0.087
Age			1.07 (1.05–1.08)	<0.001			1.07 (1.05–1.08)	<0.001			1.07 (1.05–1.08)	<0.001
Sex (ref: female)			5.96 (4.64–7.65)	<0.001			6.24 (4.85–8.03)	<0.001			5.86 (4.56–7.53)	<0.001
Education			0.95 (0.92–0.99)	0.006			0.95 (0.92–0.98)	0.003			0.95 (0.92–0.99)	0.005
BMI			0.48 (0.46–0.50)	<0.001			0.48 (0.46–0.49)	<0.001			0.48 (0.46–0.50)	<0.001
Medications (ref: ≥5)			0.76 (0.63–0.91)	0.003			0.76 (0.63–0.91)	0.003			0.75 (0.63–0.90)	0.002
MMSE (ref: ≤23 score)			0.82 (0.66–1.03)	0.090			0.82 (0.66–1.03)	0.092			0.82 (0.66–1.03)	0.089
GDS (ref: ≥6 score)			0.92 (0.74–1.13)	0.430			0.91 (0.74–1.13)	0.395			0.89 (0.72–1.09)	0.259
Fall history (ref: yes)			0.85 (0.70–1.03)	0.090			0.85 (0.70–1.03)	0.097			0.84 (0.70–1.02)	0.083
Drinking habit (ref: no)			1.32 (1.11–1.57)	0.002			1.31 (1.10–1.56)	0.002			1.33 (1.12–1.58)	0.001
Smoking habit (ref: no)												
Stopped smoking			0.80 (0.60–1.08)	0.153			0.82 (0.61–1.11)	0.200			0.78 (0.58–1.06)	0.110
Current smoking			0.91 (0.70–1.20)	0.519			0.93 (0.71–1.22)	0.615			0.90 (0.68–1.18)	0.432
Living alone (ref: yes)			0.98 (0.78–1.24)	0.889			0.98 (0.77–1.24)	0.853			0.99 (0.78–1.25)	0.907
Driving (ref: no)			0.80 (0.66–0.98)	0.031			0.79 (0.65–0.96)	0.019			0.80 (0.65–0.97)	0.025

AMI, Active Mobility Index; aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; GDS, Geriatric Depression Scale; MMSE, Mini-Mental State Examination; OR, odds ratio.

Table 3 Logistic regression model for the associations between AMI scores and sarcopenia indices

	Lower grip strength		Lower muscle mass		Lower gait speed	
AMI scores	aOR (95% CI)	*P*	aOR (95% CI)	*P*	aOR (95% CI)	*P*
AMI total score (ref: Q1)						
Q2	0.85 (0.77–0.94)	0.001	0.86 (0.73–1.02)	0.075	0.70 (0.64–0.76)	<0.001
Q3	0.72 (0.65–0.80)	<0.001	0.82 (0.69–0.97)	0.020	0.61 (0.56–0.67)	<0.001
Q4	0.71 (0.64–0.79)	<0.001	0.68 (0.57–0.81)	<0.001	0.55 (0.50–0.61)	<0.001
P for trend		<0.001		<0.001		<0.001
AMI physical score (ref: Q1)						
Q2	0.87 (0.79–0.96)	0.008	1.03 (0.87–1.22)	0.694	0.77 (0.71–0.84)	<0.001
Q3	0.72 (0.65–0.80)	<0.001	0.83 (0.70–0.98)	0.032	0.57 (0.52–0.63)	<0.001
Q4	0.68 (0.61–0.76)	<0.001	0.75 (0.64–0.89)	0.001	0.48 (0.44–0.53)	<0.001
P for trend		<0.001		<0.001		<0.001
AMI social score (ref: Q1)						
Q2	0.92 (0.84–1.02)	0.129	0.99 (0.84–1.17)	0.950	0.84 (0.77–0.92)	<0.001
Q3	0.89 (0.81–0.99)	0.029	0.93 (0.79–1.09)	0.374	0.76 (0.69–0.83)	<0.001
Q4	0.79 (0.71–0.89)	<0.001	0.81 (0.68–0.96)	0.017	0.75 (0.68–0.82)	<0.001
P for trend		0.001		0.069		<0.001

AMI, Active Mobility Index; aOR, adjusted odds ratio; CI, confidence interval.
aOR was adjusted for age, sex, education year, body mass index, medications (<5/≥5), Mini-Mental State Examination score (≤23/>23), Geriatric Depression Scale score (<6/≥6), fall history, drinking habit, smoking habit, whether the individual lives alone, and whether the individual drives car.

In addition, higher AMI total and AMI physical scores were associated with a reduced OR of lower muscle mass, while there was a weak association of AMI social score with lower muscle mass.

The findings on AMI total score and AMI physical score indicate that a larger life space with physical activity is protectively associated with sarcopenia and its indices. This is similar to other studies that reported associations between life space and physical performance, including grip strength and gait speed.[19,28–30] In addition, a longitudinal study reported that community-dwelling older women who left the neighbourhood less frequently had a higher risk of frailty,[18] which also supports our findings. Therefore, a large life space with physical activity may be associated with sarcopenia development. On the contrary, our previous longitudinal study reported that sarcopenia increased the risk of becoming homebound, defined as not going out at least once a week.[31] Future studies are required to examine the causality.

The association between AMI and physical function partly depends on the benefits of physical activity. Some studies have reported an association between life space and objectively measured physical activity among older adults. A longitudinal study reported lower step counts and less time in moderate activity at baseline, prospectively associated with a reduced life space mobility score over 2 years.[15] A cross-sectional study showed that older adults who moved beyond the neighbourhood more frequently were inclined to engage in longer moderate and low-intensity periods in physical activity and less sedentary behaviour.[14] A higher AMI score may be associated with a lower risk of sarcopenia through physical activity. A systematic review and meta-analysis targeting adults older than 40 years engaging in physical activity identified a reduced OR of sarcopenia in later life (OR 0.45, 95% CI 0.37–0.55).[8] Thus, further studies involving objectively measured physical activity are required to elucidate the association between AMI and physical activity.

In the AMI social score, associations with lower grip strength and slower gait speed were observed, while we did not find clear associations between sarcopenia and lower muscle mass. Longitudinal studies reported that engagement in social activity reduced the risk of mobility disability and motor decline,[9,10] which supports the findings of the associations of AMI social score with lower grip strength and slower gait speed. Although the correlation between AMI social score and physical activity has not been studied, the large life space with social activity may accompany physical activity and is associated with grip strength and gait speed. Cross-sectional studies that objectively measured physical activity using an accelerometer suggested the importance of the intensity of physical activity for sarcopenia; low-intensity physical activity showed a weak association with sarcopenia, while moderate to vigorous-intensity physical activity showed a clear association with reduced OR of sarcopenia.[32,33] Thus, in the present study, the weak association of the AMI social score with sarcopenia and lower muscle mass may indicate that a large life space with social activity is not accompanied by moderate to vigorous-intensity physical activity to maintain muscle mass. Therefore, future studies should examine the association between the AMI social score and the volume and intensity of physical activity.

The strength of the present study is that we could examine the association between AMI and sarcopenia using extensive cohort data. However, there were some limitations to our study. First, this study had a cross-sectional design and could not examine the causal relationships between AMI and sarcopenia. Future longitudinal studies are needed to examine this relationship. Second, there was a selection bias because the

participants were not randomly selected. They were relatively healthy and could access health check-ups from their homes, which might distort the associations between AMI and sarcopenia among community-dwelling older adults. Third, we evaluated skeletal muscle mass using a bioimpedance analyser, not the reference standard method, dual-energy X-ray absorptiometry (DXA). DXA provides a more precise measure of lean mass than the bioimpedance method,[34] but this study could not estimate the extent of misclassified sarcopenia. Fourth, we failed to address other potential confounders affecting the progression of sarcopenia, such as nutritional intake and drug therapy.

In conclusion, AMI was associated with sarcopenia in community-dwelling older Japanese adults. Our findings indicated that a large life space, mainly with physical activity, was significantly associated with sufficient muscle strength, muscle mass, and gait speed. Future longitudinal studies are needed to confirm the causality of AMI with respect to sarcopenia and the importance of life space with activity for preventing sarcopenia.

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Conflict of interest

S.K., T.D., K.T., S.N., Y.K., K.N., and H.S. declare that they have no conflicts of interest.

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