The Relationship Between Physical Activity and the Presence of Sarcopenia in Older Adults: A Taiwanese Cross-sectional Study

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Abstract

To the best of our knowledge, none of Taiwanese studies on the relationship between physical activity (PA) and sarcopenia by the latest 2019 Asian Working Group for Sarcopenia (AWGS) cutoff points of sarcopenia has been published. We used the Taiwan version of international physical activity questionnaire-short version and the 2019 AWGS diagnostic criteria of sarcopenia to examine the relationship between PA and sarcopenia in older adults. Volunteers in this cross-sectional study were recruited from those attending senior health checkup program held at a regional hospital in Taipei City from May 2019 to Sep 2019. Muscle strength was assessed by grip strength, physical performance was assessed by usual gait speed on a 6-meter course, and muscle mass was measured by bioelectrical impedance analysis. Multiple logistic regression was used to analyze the relationship between PA and sarcopenia. 565 participants were recruited and data from 500 participants were used. 138 (27.6%) participants were classified as having sarcopenia, which included 87 women and 51 men. Among women, compared with those with low PA, moderate to high PA protected against the risk of sarcopenia with the adjusted odds ratio (aOR)=0.52 (95% CI: 0.27-0.98, p-value=0.043). As for men, the aOR was 0.34 (95% CI: 0.12-0.95, p-value=0.039). A significant protective effect of PA on sarcopenia was found among the older adults after adjusting for confounders, especially for the male participants.

Background

Sarcopenia describes an important change in body composition and function, which is characterized by age-related lean muscle mass decline and low muscle strength and/or performance. The consequences of sarcopenia are falls, fracture, disability, hospital admission or need for long-term care placement, poor quality of life, and even mortality, which lead to a heavy burden on an aging society [1–3]. Consequently, sarcopenia has been formally recognized as a muscle disease since 2016. In some countries, International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) diagnosis code for sarcopenia, M62.84, could be used to bill for care [4].

The prevalence of sarcopenia varied from 9.9–40.4%, depending on the definition used [5]. The definition and diagnosis of sarcopenia was inconsistent. In 2014, the Asian Working Group for Sarcopenia (AWGS) recommended using low muscle mass plus low muscle strength and/or low physical performance to diagnose sarcopenia with the following cut-off values: height-adjusted appendicular skeletal muscle mass as < 7.0 kg/m^2 in men and as < 5.7 kg/m^2 in women by using bio-electrical impedance analysis (BIA), handgrip strength as < 26 kg in men and as < 18 kg in women, and usual gait speed as < 0.8 m/s [6]. Recently, AWGS announced the 2019 diagnostic criteria of sarcopenia and revised the cut-off points of handgrip strength (< 28 kg for men) and usual gait speed (< 1.0 m/s) [7].

The risk factors of sarcopenia are multifactorial, such as aging, disease, malnutrition, and inactivity, etc. Physical activity (PA) is undoubtedly a protective factor for sarcopenia. The beneficial effects of PA on sarcopenia include: reduced apoptosis, reduced oxidative stress, anti-inflammation, improved insulin-glucose dynamics, enhanced quality and quantity of muscle proteins and mitochondria, skeletal muscle

hypertrophy, positive neuromuscular adaptations, and enhanced muscle blood supply [8]. In a systemic review including 37 randomized controlled studies (RCTs), PA increases muscle mass and function while interactive effect of nutrition on muscle function appears limited [9]. PA is one of the most important keys to prevent sarcopenia, which is a modifiable predictor and can improve the muscle quality and quantity [10].

According to the World Health Organization (WHO), the definition of PA is any bodily movement produced by skeletal muscles that requires energy consumption [11]. Physical inactivity has been recognized as the fourth leading risk factor for global mortality (6% of deaths globally) [12]. WHO recommends the amount of PA should be at least 150 minutes of moderate aerobic PA or 75 minutes of vigorous aerobic one per week for older adults [13].

PA assessment tools include report-based, monitor-based and criterion measures [14]. The majority of scientific evidence on the health benefits of PA has been accumulated with report-based measures predominantly. In many types of epidemiology studies, the main purpose was simply to classify individuals into general levels of PA participation. Report-based measures have been proven to provide sufficient accuracy to categorize individuals based on their level of PA [15].

Among self-report questionnaires for PA measurement, international physical activity questionnaire-short version (IPAQ-S) was designed to be easily adapted in many languages and countries [16]. The validity and reliability of the Taiwan version of IPAQ-S has been verified [1718]. Some studies have explored the relationship between PA and sarcopenia in older adults [19]. The potential confounders are aging, body mass index (BMI), gender, education level, albumin level, insulin resistance, lipid profiles, hemoglobin, uric acid, alcohol drinking, smoking, and institutionalization.

The definition of sarcopenia and the ways to evaluate PA were inconsistent. Moreover, there were still discrepancies between some associated factors and sarcopenia. To the best of our knowledge, none of studies on the relationship between PA and sarcopenia by the latest AWGS cutoff points of sarcopenia has been published, even though in the Asian populations. Therefore, the primary aim of this study is to use the Taiwan version of IPAQ-S and the 2019 AWGS diagnostic criteria of sarcopenia to examine the relationship between PA and the presence of sarcopenia in older adults. The secondary aim is to identify other associated factors of sarcopenia.

Methods

Study population

We conducted a cross-sectional study. 565 volunteers were recruited from those attending the senior health checkup program held at a regional hospital in Taipei City from May 2019 to Sep 2019. Those who could not perform the physical evaluation or answer the IPAQ-S were excluded. Besides, we also excluded participants with invalid or missing data while we did data analysis. The study had been approved by the

Taipei City Hospital Research Ethics Committee with the case number TCHIRB-10801017 and all the participants provided written informed consents. All methods were carried out in accordance with relevant guidelines and regulations of the Taipei City Hospital Research Ethics Committee.

Measurements

Assessment of sarcopenia

We defined sarcopenia according to the 2019 AWGS diagnostic criteria. Muscle strength was assessed by grip strength, which was measured by a dynamometer (BASELINE®, model 12-0286), and low grip strength was defined as <28 kg in men and <18 kg in women. Physical performance was assessed by usual gait speed (m/s) on a 6-meter course, and a slow walking speed was defined as slower than 1.0 m/s. Muscle mass was measured by BIA (InBody270). The height-adjusted ASM (ASMI) was defined as appendicular skeletal muscle mass (ASM) divided by height squared. Low muscle mass was defined as ASMI <7.0 kg/m^2 in men and <5.7 kg/m^2 in women. The reliability and validity of the tools had been appraised in a systematic review [20]. In a Chinese study involving 944 community-dwelling adults aged ≥60 years [21], quite high correlation coefficient between the BIA- (InBody720) and DXA-measured ASMs revealed that the tool was suitable for body composition monitoring.

Assessment of physical activity

PA was assessed using the Taiwan version of IPAQ-S. We have already obtained permission to use the questionnaire. IPAQ-S asks about activities undertaken in leisure time, domestic and gardening (yard), work-related, and transport-related PA in the past seven days. The structured items in the IPAQ-S provide separate scores on walking, moderate-intensity and vigorous-intensity activity.

The intensity of a PA would be expressed in metabolic equivalents (METs). According to the official IPAQ scoring protocol, MET-min per week for an activity were calculated as MET values (vigorous 8.0, moderate 4.0, walking 3.3) x min of activity per day x days per week, and we summed the total PA MET-min/week for each participant [22]. Three levels of PA were used to classify the participants: low, moderate and high.

Since the amount of PA that WHO recommended for older adults equaled to 600 MET-min/week, we decided to group PA into two categories: 1. Low PA and 2. Moderate to high PA.

Measurement of demographic factors, clinical factors and comorbidities

The questions listed in the questionnaire of the health checkup program include sex, age (birthday), current smoking status (Have you smoked in the last half year? (1) Never; (2) Seldom, social smoking; (3) ≤ 1 pack per day; and (4) > 1 pack per day. Answer 1 was classified as ‘No’; other answers were classified as ‘Yes’), alcohol drinking (Have you drank alcohol in the last half year? (1) Never; (2) Seldom, social drinking; and (3) Often. Answer 1 was classified as ‘No’; other answers were classified as ‘Yes’), education levels (We classified the items into 3 categories: (1) ≤ elementary school, (2) junior and senior high

school, and (3) ≥ university), history of diseases and so on. If the participants were living in long-term care institutions, we got tabulations from institutions. Body height and body weight were measured and then automatically converted to BMI after recording the data into the system.

The participants' blood samples have been collected during the health exam. We used the results of albumin, uric acid, fasting plasma glucose (FPG), total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglyceride (TG), and hemoglobin (Hb) as health indices and covariates.

Statistical analyses

RStudio macOS Version 1.1.456 was used for statistical analysis. SAS 9.4 was used to double check the results. For descriptive statistics, we used χ^2 test for categorical variables and t test or Mann-Whitney U test for continuous variables. Multiple logistic regression was used to analyze the relationship between PA and sarcopenia. Two-sided $P < 0.05$ was considered to be statistically significant. We set the level of power at 0.8 and used the software G*Power to calculate the sample size.

Potential associated factors of sarcopenia were specified in the statistical analysis included age, BMI, education level, FPG, serum albumin, uric acid, total cholesterol, LDL-C, HDL-C, TG, Hb, alcohol drinking, smoking, institutionalization, and the history of diabetes mellitus, hypertension, dyslipidemia, cardiovascular disease, and heart disease. We used Akaike's information criterion-based forward-backward selection for model selection.

Results

565 participants were recruited, after excluding those refused to participate (n = 12) and incomplete or invalid data ones (n = 53), data from 500 participants were used for the analysis (Fig. 1). The study participants had a mean age of 73.87 years old, with 47% men and 53% women. For both genders, the majority of participants' PA levels were moderate, with women (142/265, 53.5%) and men (131/235, 55.7%). The mean of handgrip was 19.54 kg in women and 31.43 kg in men. The mean of usual gait speed was 0.99 m/s in women and 1.03 m/s in men. The mean of ASMI was 5.75 kg/m^2 in women and 7.20 kg/m^2 in men. We compared the demographic and clinical characteristics between low PA and moderate to high PA groups for all of the participants, which comprised 265 women and 235 men (Table 1 to 2). Due to the limited institutionalized and smoking women, we didn't analysis these two covariates while we did multiple logistic regression.

A total of 138 (27.6%) participants were classified as having sarcopenia, among whom 87 were women and 51 were men (Table 3). Compared with the low PA group, the OR of moderate to high PA to sarcopenia was 0.52 (95% CI: 0.27–0.98, p-value = 0.043) in women, after adjusting for age, BMI, and albumin and hemoglobin levels. As for men, compared with the low PA group, the OR of moderate to high PA to sarcopenia was 0.34 (95% CI: 0.12–0.95, p-value = 0.039), after adjusting for age, BMI, history of cardiovascular disease, history of heart disease and institutionalization (Table 4).

Discussion

In this study, we observed that a significant protective effect of PA on sarcopenia was found among the older adults after adjusting for confounders for both genders. The prevalence of sarcopenia in this study population and our main findings were similar to most cross-sectional studies [5]. The prevalence was higher in women (32.8%) than men (21.7%). The relationship between PA, aging, BMI and sarcopenia were consistent with most of previous studies [19]. Furthermore, a stronger protective effect of PA on the male participants was noted, whereas higher BMI showed a protective effect on sarcopenia in both genders. Additionally, our results also showed that aging was a risk factor of sarcopenia.

Body muscle mass and strength are different in men and women (men greater than women) by nature. Besides, it is speculated that gender-related difference in regulation of muscle contraction may result in the more obvious frailty and impairment of muscle function in old women than in old men [23]. Further, in a survey of 2,264 older Korean adults, there were gender differences in the relationship between PA and sarcopenia, with stronger associations observed in men [24]. Hence, we analyzed both genders dividedly.

We tried to search similar cross-sectional studies using structural questionnaires to evaluate PA and both of muscle mass and function to diagnose sarcopenia. Compare to previous Asian studies, one China study showed PA was not related to sarcopenia, but this study analyzed both genders together [25]. In one Korean study, vigorous and moderate PA were not associated with sarcopenia, but if PA displayed in quantiles, the third and fourth quantiles PA of the subjects showed protect effect on sarcopenia in Korean men [26]. As for the gender differences, our study showed PA was a protective factor of sarcopenia and more obvious in men while one Korean study showed the relationship between PA and sarcopenia was significant statistically in men but not in women [24]. On the other hand, in the western countries, one study in Peruvian Andes found that age, female sex, a low BMI, and little PA were associated factors of sarcopenia [27]. However, an Italian study showed nutritional intake, PA, and level of comorbidity were not associated with sarcopenia [28]. Nevertheless, a multi-continent study enrolled 18363 people showed PA was a key factor for the prevention of sarcopenia [29].

Although aging is the main cause of sarcopenia, it is an inevitable process. Since we can see the obvious protective effect of PA on sarcopenia, we should advocate regular physical activity to the public. Our study is unique in that we classified the PA according to WHO's recommendation. Although previous researchers might explore the association between PA and sarcopenia via IPAQ, they classified the PA just according to the IPAQ protocol (into low, moderate and high), or by vigorous PA, moderate PA, and walking PA, or by quantiles [26]. Indeed, for additional benefits, older adults should increase their PA. However, in our daily clinical practice or health promotion activities, we found that when we tried to educate the older adults to do physical activity, some of them might refuse and mentioned that it was impossible for them to do 'exercise'. Besides, some experts doubt that the PA level of at least 600 MET-min per week is enough. However, in our findings, the global recommendation of PA already showed obvious benefit to the older adults in the prevalence of sarcopenia. Through this study, we can apply our

findings as an echo of WHO's recommendation to educate the public that older adults can accumulate PA in their daily, family and community lives.

The moderate to high PA group was composed of higher education level of male participants. However, the effect of education level on sarcopenia was not statistically significant in this study after we adjusted covariates. Although some studies showed the effect of education level on sarcopenia [28], there is much more health-related knowledge spreading through social media and community care centers than before, so the health literacy may be elevated in the older adults regardless of their educational levels.

Sarcopenia prevalence are usually higher in long-term care institutions. Besides, most of the residents may have several chronic diseases and comorbidities, who may have less PA compare to those living at homes. Hence, we expected to explore the association between institutionalization and sarcopenia based on the premise that confounders were adjusted. However, due to we only collected 4 women living in long-term care institutions, we did not analyze this relationship. As for the men, the OR of institutionalization to sarcopenia was 2.94 (95% CI: 0.97–8.90) despite this result was not significant statistically (p-value = 0.057). Although living in long-term care institutions similarly, those who can attend the health checkup program may be healthier compared to those who cannot or refuse to do so. Suppose we collect more institutionalized people, the association between institutionalization and sarcopenia may be clearer.

Metabolites, such as reactive oxygen species, reactive nitrogen species, and aldehydes are components of the cigarettes smoke, enter the bloodstream and arrive at the skeletal muscles of smokers and accelerate muscle wasting [30]. Based on the theory above, we assumed there should be association between smoking and sarcopenia. However, only one woman in this group was a smoker so we did not analyze the relationship. In the traditional Chinese society, it brought about a negative concept that a woman was a smoker. Consequently, some people might pretend that they were not smokers, which was one kind of social desirability bias. Moreover, the Taiwanese older generation didn't have smoking habit originally, which reflected on that smoking rate was low (0.7% in women) in adults above 65 years old according to the 2018 Adult Smoking Behavior Surveillance System. It was reasonably that we only recruited one smoking woman.

With increased lean body mass loss, associated mortality increased, which even could up to 100% when one person has lost 40% lean body mass [3]. One previous study showed increased sarcopenia prevalence with decreased BMI [31]. The association between BMI and mortality has been revealed to have a U- or J-shaped configuration, with better health-related outcomes and longevity observed for older adults in the overweight category of the BMI classification [32]. In the past, the traditional concept has been that being thin leads to longevity. Nowadays, more and more geriatricians and dietitians are saying that extremely low BMI is related to higher mortality. Our study proved that higher BMI was a protective factor of sarcopenia. Hence, we can do some education to the underweight older adults, encouraging them to keep a suitable weight for better health.

One of the strengths of our study was including demographic and clinical factors. Additionally, our study consisted of international physical activity and sarcopenia assessment tools, which can be compared with other countries. To our best knowledge, this is the first Taiwanese data using the latest AWGS diagnostic criteria to analyze the participants. We can use the result to appeal to the health care professionals to pay attention to the increasing sarcopenia population.

Our study had several limitations. First of all, it was a cross-sectional study which only revealed the association between PA and sarcopenia, but not illustrating the cause-effect relationship. In addition, the participants were recruited during the health exam and there might be a selection or sampling bias due to healthy user effect. Since this was a hospital-based study, rather than a community-based study, we just did convenience sampling. Hence, we could not collect enough institutionalized women. Besides, there was just one woman had smoking habit. Therefore, we could not explore the relationship between institutionalization and sarcopenia, and smoking and sarcopenia in women group. The participation bias might exist and thus the results cannot be extrapolated to the general population.

Conclusions

A significant protective effect of physical activity on sarcopenia was found among the older adults after adjusting for confounders, especially for the male participants. Higher BMI showed protective effect on sarcopenia, while aging was a risk factor of sarcopenia. Further cohort studies and even RCTs may be needed to confirm our findings.

Declarations

Competing interests

The authors declare no competing interests

Authors' contributions

Y.C. collected, analyzed and interpreted the data, and was a major contributor in writing the manuscript. Y.C. and W.C. conducted the statistical analysis. Y.C., T.Y. and W.C. contributed to the design of the study. Y.C., C.Y., and W.R. contributed to the data collection. W.R. contributed to the conceptualization of the manuscript. All authors provided feedback during manuscript development and approved the final manuscript.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due to legal restrictions imposed by the government of Taiwan in relation to the “Personal Information Protection Act”.

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Tables

Table 1
Basic demographic and clinical characteristics of the study participants

	Low PA (n = 106)	Moderate to High PA* (n = 394)	P-value
Sarcopenia			<0.0001
N	58 (54.7%)	304 (77.2%)	
Y	48 (45.3%)	90 (22.8%)	
Age, years			
Mean (SD)	75.0 (6.79)	73.6 (6.62)	0.045
Median [Min, Max]	74.0 [65.0, 91.0]	72.0 [63.0, 97.0]	0.039
Gender, n (%)			0.0003
Women	73 (68.9%)	192(48.7%)	
Men	33 (31.1%)	202(51.3%)	
BMI			
Mean (SD)	23.5 (3.31)	23.9 (3.22)	0.259
Median [Min, Max]	23.2 [14.6, 32.8]	23.6 [16.2, 40.5]	0.301
Institutionalization			0.0002
N	91 (85.8%)	379(96.2%)	
Y	15 (14.2%)	15 (3.8%)	
Alcohol drinking			0.020
N	97(91.5%)	321(81.5%)	
Y	9(8.5%)	73(18.5%)	
Smoking			1.000
N	100(94.3%)	374(94.9%)	
Y	6(5.7%)	20(5.1%)	
Education level			0.003
1 ≤ elementary school	39 (36.8%)	88 (22.3%)	
2 Junior/senior high school	23 (21.7%)	138 (35.0%)	
3 ≥ University	44 (41.5%)	268 (68.0%)	
Past history			

	Low PA (n = 106)	Moderate to High PA* (n = 394)	P-value
Hypertension	43 (40.1%)	138 (35%)	0.347
Diabetes Mellitus	14 (13.2%)	56 (14.2%)	0.915
Hyperlipidemia	24 (22.6%)	78 (19.8%)	0.611
Cardiovascular disease	10 (9.4%)	36 (9.1%)	1.000
Heart disease	18 (17.0%)	35 (8.9%)	0.026
Albumin, g/dL			
Mean (SD)	4.39 (0.231)	4.40 (0.243)	0.716
Median [Min, Max]	4.40 [3.70, 4.90]	4.40 [3.00, 5.10]	0.795
Uric acid, mg/dL			
Mean (SD)	5.37 (1.30)	5.55 (1.40)	0.244
Median [Min, Max]	5.30 [2.50, 8.80]	5.50 [2.50, 12.3]	0.332
Total Cholesterol, mg/dL			
Mean (SD)	179 (33.0)	181 (31.5)	0.517
Median [Min, Max]	176 [115, 254]	179 [106, 277]	0.401
AC sugar, mg/dL			
Mean (SD)	103 (21.7)	103 (20.8)	0.885
Median [Min, Max]	98.0 [77.0, 214]	99.0 [75.0, 232]	0.931
LDL, mg/dL			
Mean (SD)	102 (28.9)	103 (27.8)	0.610
Median [Min, Max]	98.5 [46.0, 166]	102 [28.0, 183]	0.442
HDL, mg/dL			
Mean (SD)	55.3 (12.7)	55.9 (14.3)	0.711
Median [Min, Max]	54.5 [26.0, 92.0]	53.0 [27.0, 108]	0.996
TG, mg/dL			
Mean (SD)	108.4 (49.6)	109.3 (50.6)	0.912
Median [Min, Max]	101 [38.0, 268]	101 [29.0, 372]	0.926
Hemoglobin, g/dL			

	Low PA (n = 106)	Moderate to High PA* (n = 394)	P-value
Mean (SD)	13.2 (1.21)	13.5 (1.35)	0.026
Median [Min, Max]	13.2 [10.1, 16.2]	13.6 [9.10, 17.9]	0.017
**Physical activity level according to IPAQ category*			

Table 2
Basic demographic and clinical characteristics of the study participants by gender

	Women (n = 265)			**Men (n = 235)**		
	Low PA (n = 73, 27.5%)	Moderate to High PA* (n = 192, 72.5%)	P-value	Low PA (n = 33, 14.0%).	Moderate to High PA* (n = 202, 86.0%)	P-value
Sarcopenia by 2019 AWGS			0.003			0.002
N	39 (53.4%)	139 (72.4%)		19 (57.6%)	165 (81.7%)	
Y	34 (46.6%)	53 (27.6%)		14 (42.4%)	37 (18.3%)	
Age, years						
Mean (SD)	74.3 (6.98)	72.8 (6.37)	0.090	76.5 (6.18)	74.3 (6.79)	0.073
Median [Min, Max]	74.0 [65.0, 91.0]	71.0 [63.0, 91.0]	0.123	79.0 [65.0, 88.0]	73.0 [65.0, 97.0]	0.036
BMI						
Mean (SD)	23.1 (3.35)	23.7 (3.32)	0.217	24.2 (3.15)	24.0 (3.12)	0.754
Median [Min, Max]	22.9 [14.6, 32.8]	23.4 [16.2, 35.9]	0.182	24.1 [17.2, 30.3]	23.8 [17.1, 40.5]	0.467
Institutionalization			0.305#			< 0.001#
N	71 (97.3%)	190 (99.0%)		20 (60.6%)	189 (93.6%)	
Y	2 (2.7%)	2 (1%)		13 (39.4%)	13 (6.4%)	
Alcohol drinking			0.690			0.051
N	68 (93.1%)	176 (91.7%)		29 (87.9%)	145 (71.8%)	
Y	5 (6.9%)	16 (8.3%)		4 (12.1%)	57 (28.2%)	
Education level			0.223			0.001

	Women (n = 265)			Men (n = 235)		
1 ≤ Elementary school	24 (32.9%)	50 (26.0%)		15 (45.5%)	38 (18.8%)	
2 Junior/senior high school	20 (27.4%)	74 (38.5%)		3 (9.1%)	64 (31.7%)	
3 ≥ University	29 (39.7%)	68 (35.4%)		15 (45.5%)	100 (49.5%)	
Medical history						
Hypertension	28 (38.4%)	66 (34.4%)	0.545	15 (45.5%)	72 (35.6%)	0.279
Diabetes mellitus	10 (13.7%)	25 (13.0%)	0.884	4 (12.1%)	31(15.3%)	0.753#
Hyperlipidemia	21 (28.8%)	45 (23.4%)	0.370	3 (9.1%)	33 (16.3%)	0.284
Cardiovascular disease	4 (5.48%)	12 (6.25%)	1.000#	6 (18.2%)	24 (11.9%)	0.395
Heart disease	13 (17.8%)	16 (8.33%)	0.027	5 (15.2%)	19 (9.41%)	0.349#

Table 2
Basic demographic and clinical characteristics of the study participants by gender (Continued)

	Women (n = 265)			**Men (n = 235)**		
	Low PA (n = 73, 27.5%)	Moderate to High PA* (n = 192, 72.5%)	P-value	Low PA (n = 33, 14.0%).	Moderate to High PA* (n = 202, 86.0%)	P-value
Albumin, g/dL						
Mean (SD)	4.39 (0.231)	4.40 (0.243)	0.716	4.32 (0.268)	4.39 (0.232)	0.141
Median [Min, Max]	4.40 [3.70, 4.90]	4.40 [3.00, 5.10]	0.795	4.30 [3.90, 4.90]	4.40 [3.00, 5.00]	0.113
Uric acid, mg/dL						
Mean (SD)	5.37 (1.30)	5.55 (1.40)	0.244	6.05 (1.54)	6.04 (1.37)	0.985
Median [Min, Max]	5.30 [2.50, 8.80]	5.50 [2.50, 12.3]	0.332	6.20 [2.50, 8.80]	5.90 [2.50, 12.3]	0.630
Total Cholesterol, mg/dL						
Mean (SD)	179 (33.0)	181 (31.5)	0.517	167 (34.6)	173 (29.4)	0.275
Median [Min, Max]	176 [115, 254]	179 [106, 277]	0.401	158 [115, 248]	173 [114, 255]	0.145
FPG, mg/dL						
Mean (SD)	103 (21.7)	103 (20.8)	0.885	103 (20.1)	104 (20.0)	0.784
Median [Min, Max]	98.0 [77.0, 214]	99.0 [75.0, 232]	0.931	100 [77.0, 183]	99.5 [75.0, 231]	0.877
LDL-C, mg/dL						
Mean (SD)	102 (28.9)	103 (27.8)	0.610	96.7 (30.8)	100 (26.5)	0.468
Median [Min, Max]	98.5 [46.0, 166]	102 [28.0, 183]	0.442	87.0 [46.0, 153]	99.0 [48.0, 181]	0.338
HDL-C, mg/dL						

	Women (n = 265)			Men (n = 235)		
Mean (SD)	55.3 (12.7)	55.9 (14.3)	0.711	50.6 (11.2)	51.9 (12.6)	0.579
Median [Min, Max]	54.5 [26.0, 92.0]	53.0 [27.0, 108]	0.996	50.0 [26.0, 72.0]	51.0 [27.0, 89.0]	0.833
TG, mg/dL						
Mean (SD)	108.4 (49.6)	109.3 (50.6)	0.912	98.3 (47.2)	104 (49.6)	0.536
Median [Min, Max]	101 [38.0, 268]	101 [29.0, 372]	0.926	90.0 [38.0, 262]	95.0 [29.0, 372]	0.460
Hemoglobin, g/dL						
Mean (SD)	13.2 (1.21)	13.5 (1.35)	0.026	13.3 (1.49)	14.0 (1.32)	0.006
Median [Min, Max]	13.2 [10.1, 16.2]	13.6 [9.10, 17.9]	0.017	13.4 [10.1, 16.2]	14.0 [9.10, 17.9]	0.014
Smoking			1.000[#]			0.134[#]
N	73 (100%)	191 (99.5%)		27 (81.8%)	183 (90.6%)	
Y	0 (0%)	1 (0.05%)		6 (18.2%)	19 (9.4%)	

*Physical activity level according to IPAQ category [#]Fisher's exact test

FPG, fasting plasma glucose; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TG, triglyceride.

Table 3
Comparisons of covariates in non-sarcopenia and sarcopenia participants according to the 2019 AWGS diagnostic criteria of sarcopenia

	Women (n = 265)			**Men (n = 235)**		
	Non-Sarcopenia (N = 178)	Sarcopenia (N = 87)	P-value	Non-Sarcopenia (N = 184)	Sarcopenia (N = 51)	P-value
Physical activity			0.005			0.004
Low	39 (53.4%)	34 (46.6%)		19 (57.6%)	14 (42.4%)	
Moderate to high	139 (72.4%)	53 (27.6%)		165 (81.7%)	37 (18.3%)	
Institutionalization			0.203			0.001
No	177 (67.8%)	84 (32.2%)		171 (81.8%)	38 (18.2%)	
Yes	1 (100.0%)	3 (0.0%)		13 (50.0%)	13(50.0%)	
Alcohol drinking			0.500			0.087
No	162 (66.4%)	82 (33.6%)		131 (75.3%)	43 (24.7%)	
Yes	16 (76.2%)	5 (23.8%)		53 (86.9%)	8 (13.1%)	
Smoking			1.000			0.970
No	177 (67.1%)	87 (32.9%)		165 (78.6%)	45 (21.4%)	
Yes	1 (100.0%)	0 (0.0%)		19 (76.0%)	6 (24.0%)	
Education level			0.205			0.044
≤ Elementary school	44 (59.5%)	30 (40.5%)		35 (66.0%)	18 (34.0%)	
Junior/senior high school	68 (72.3%)	26 (27.7%)		56 (83.6%)	11 (16.4%)	
≥ University	66 (68.0%)	31 (32.0%)		93 (80.9%)	22 (19.1%)	

Table 3
Comparisons of covariates in non-sarcopenia and sarcopenia participants according to the 2019 AWGS diagnostic criteria of sarcopenia (Continued)

	Women (n = 265)			**Men (n = 235)**		
	Non-Sarcopenia (N = 178)	Sarcopenia (N = 87)	P-value	Non-Sarcopenia (N = 184)	Sarcopenia (N = 51)	P-value
Medical history—hypertension			0.519			0.901
No	112 (65.5%)	59 (34.5%)		115 (77.7%)	33 (22.3%)	
Yes	66 (70.2%)	28 (29.8%)		69 (79.3%)	18 (20.7%)	
Medical history—diabetes mellitus			0.702			0.352
No	153 (66.5%)	77 (33.5%)		154 (77.0%)	46 (23.0%)	
Yes	25 (71.4%)	10 (28.6%)		30 (85.7%)	5 (14.3%)	
Medical history—hyperlipidemia			0.207			0.310
No	129 (64.8%)	70 (35.2%)		153 (76.9%)	46 (23.1%)	
Yes	49 (74.2%)	17 (25.8%)		31 (86.1%)	5 (13.9%)	
Medical history—cardiovascular disease			0.493			0.018
No	169 (67.9%)	80 (32.1%)		166 (81.0%)	39 (19.0%)	
Yes	9 (56.2%)	7 (43.8%)		18 (60.0%)	12 (40.0%)	
Medical history—heart disease			0.212			0.157
No	162 (68.6%)	74 (31.4%)		162 (76.8%)	49 (23.2%)	
Yes	16 (55.2%)	13 (44.8%)		22 (91.7%)	2 (8.3%)	

Table 3

Comparisons of covariates in non-sarcopenia and sarcopenia participants according to the 2019 AWGS diagnostic criteria of sarcopenia (Continued)

	Women (n = 265)			**Men (n = 235)**		
	Non-Sarcopenia (N = 178)	Sarcopenia (N = 87)	P-value	Non-Sarcopenia (N = 184)	Sarcopenia (N = 51)	P-value
Age	72.0 (6.12)	75.8 (6.74)	< 0.0001	73.4 (6.10)	78.9 (7.24)	< 0.0001
BMI	24.3 (3.37)	22.0 (2.63)	< 0.0001	24.5 (3.13)	22.3 (2.38)	< 0.0001
Albumin	4.42 (0.25)	4.36 (0.23)	0.058	4.40 (0.235)	4.31 (0.235)	0.011
Uric acid	5.08 (1.20)	4.97 (1.19)	0.490	6.07 (1.34)	5.95 (1.59)	0.610
Total cholesterol	186.2 (31.4)	191.5 (31.4)	0.198	173.8 (29.3)	167.1 (33.1)	0.164
FPG	104.1 (21.7)	101.7 (21.8)	0.402	103.7 (20.4)	102.8 (18.7)	0.773
LDL-C	104.6 (27.9)	108.3 (29.9)	0.326	101.3 (26.8)	94.8 (28.1)	0.132
HDL-C	58.6 (14.0)	60.8 (14.9)	0.227	51.2 (11.7)	53.8 (14.7)	0.182
Triglyceride	114.9 (50.9)	112.1 (51.1)	0.679	106.2 (51.1)	92.2 (40.6)	0.072
Hemoglobin	13.0 (1.18)	13.0 (0.98)	0.982	14.1 (1.34)	13.2 (1.22)	< 0.0001

Table 4
Adjusted model for associated factors of sarcopenia in the study population according to the 2019 AWGS diagnostic criteria of sarcopenia[a]

	Women		**Men**	
	Adjusted Model Odds Ratio (95% CI)	P-value	Adjusted Model Odds Ratio (95% CI)	P-value
Moderate to High PA	0.52 (0.27, 0.98)	0.043	0.34 (0.12, 0.95)	0.039
Age	1.11 (1.06, 1.17)	< 0.0001	1.12 (1.05, 1.18)	0.0002
BMI	0.73 (0.65, 0.81)	< 0.0001	0.75 (0.65, 0.87)	0.0001
Albumin	0.37 (0.10, 1.40)	0.143	-	-
Hemoglobin	1.28 (0.96, 1.7)	0.092	-	-
Medical history of cardiovascular disease	-	-	2.43 (0.90, 6.55)	0.080
Medical history of heart disease	-	-	0.21 (0.04, 1.20)	0.079
Institutionalization	-	-	2.94 (0.97, 8.90)	0.057

[a]Adjusted simultaneously for all the variables listed.

Figures

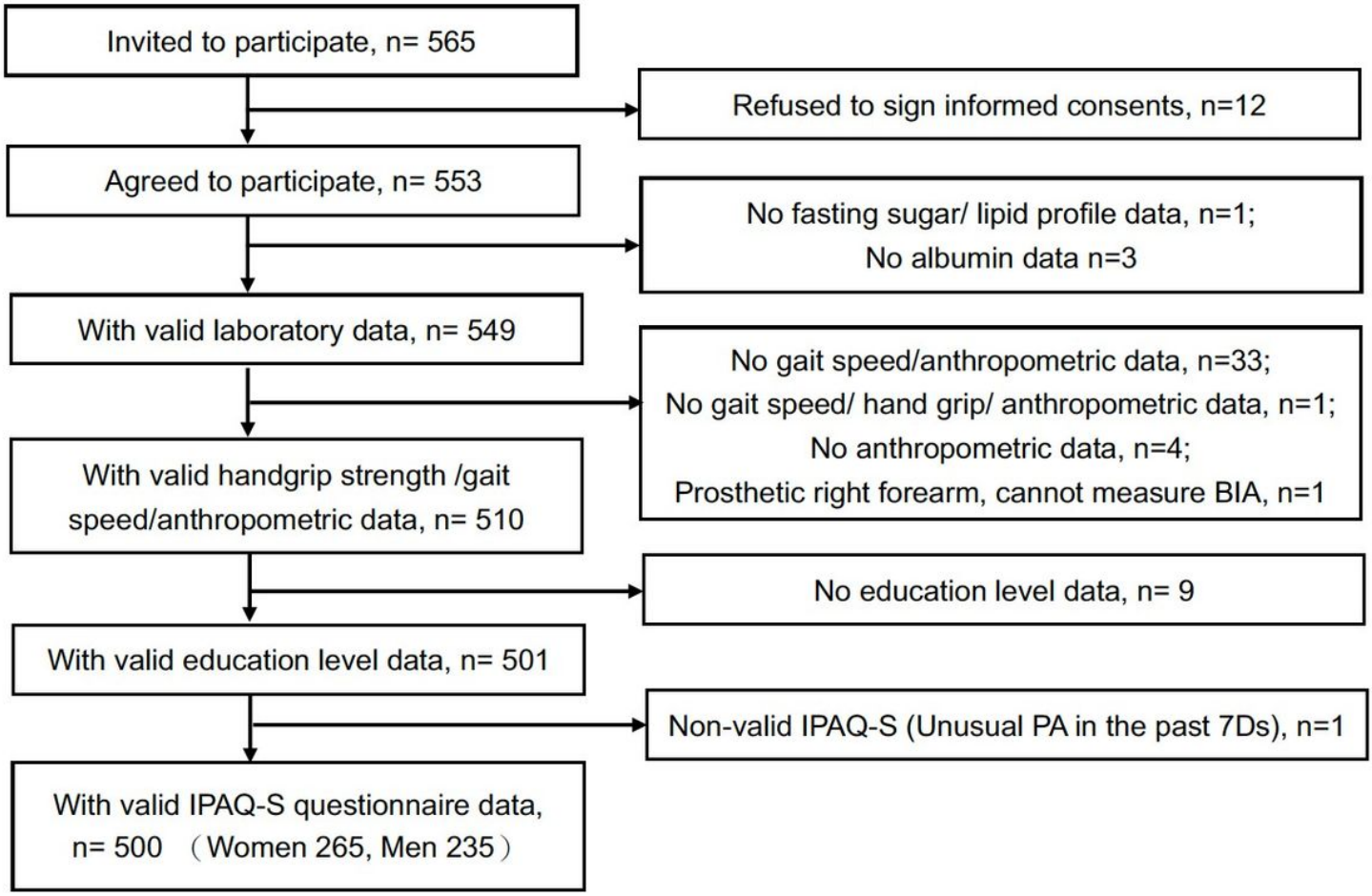

Figure 1

Study flowchart