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Subjective and Objective Physical Activity Measurement Methods for the Prediction of Possible Sarcopenia

Cheng Zhu[1]; Ying Du[1,2]; Yanan Zhao[1]*

[1]School of Sports Science and Physical Education, Nanjing Normal University, Nanjing, Jiangsu, China.

[2]Tsinghua Middle School, Xuzhou, Jiangsu, China.

***Corresponding Author:** Yanan Zhao*

Email: zhaoyn125@qq.com

Abstract

Background: Early detection and prevention of sarcopenia are essential for maintaining the functional health of older adults. There is a close association between sarcopenia and physical activity levels. Possible sarcopenia is a precursor to sarcopenia, which can accurately predict sarcopenia. According to the tertiary prevention system, the diagnosis of possible sarcopenia has significant implications for the early detection of sarcopenia and the reduction of its Prevalence.

Objective: This study aimed to investigate the relationship between subjective and objective physical activity measurement methods with possible sarcopenia and its prediction.

Methods: A total of 146 community-dwelling older adults (≥65 years old) in Nanjing were recruited to measure fundamental physical indicators and possible sarcopenia indicators. According to the Asian Sarcopenia Working Group (AWGS) diagnostic criteria for possible sarcopenia, the participants were divided into possible and non-possible sarcopenia groups. The participant's physical activity level was measured using PASE and ActiGraph (GT3X).

Results: PASE showed a significant correlation with grip strength and five-time chair stand test. GT3X had many indicators that showed a significant correlation with possible sarcopenia indicators. The area under the curve (AUC) of PASE was 0.402 ($p=0.167$). The AUC of GT3X was 0.856 ($p<0.05$). The AUC of PASE combined with GT3X was 0.855 ($p<0.05$). Conclusion: Objective measurement methods have more indicators correlated with diagnostic indicators of possible sarcopenia than subjective measurement methods and have higher correlation and prediction accuracy. The subjective combined with objective measurement method has higher prediction accuracy than the subjective measurement alone, and the integrated application may improve the accuracy of identifying possible sarcopenia in primary care.

Keywords: Physical activity; Measurement; Possible sarcopenia; Prediction.

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Introduction

In recent years, the population of ageing tendency in China has been increasingly severe; in 2050, the proportion of older adults will account for more than 25% of the total population [1]. With the advancing age, many organs and functions of the human body inevitably appear to deteriorate and decline, causing numerous adverse effects [2-4]. Ageing may lead to a decrease in myocyte regenerative capacity, an imbalance in protein turnover, and a change of fat and fibrotic components in the muscle [5], leading to sarcopenia. Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength, which is closely associated with adverse outcomes such as disability, decreased quality of life, and death [6]. Older adults have been reported with high risks of sarcopenia [7]. The current prevalence of sarcopenia in Chinese communities is about 10.4% [8], and the number increases with age. Early identification and timely intervention are of great importance [9].

In 2019, the Asian Working Group on Sarcopenia (AWGS) was updated based on the previous consensus [10,11], introducing the definition of possible sarcopenia and its diagnostic criteria. Possible sarcopenia is the decline of muscle strength accompanying or without the decline of physical performance. Diagnostic indicators include muscle mass (measured by calf circumference; CC) and muscle function (measured by grip strength or the five-time chair stand test; 5CST) [12,13]. Possible sarcopenia showed a high predictive value for sarcopenia [14]. According to the tertiary prevention system, the diagnosis of possible sarcopenia has tremendous significance for early identification and prevention of sarcopenia [15].

There are various methods for predicting and detecting sarcopenia, including the red flag method, anthropometric prediction equations [16], and biomarker methods [17]. From the perspective of physical activity, older adults with sedentary lifestyles are at high risk of sarcopenia [18], indicating a close relationship between physical activity level and sarcopenia. However, there are few studies on the associations between possible sarcopenia and physical activity level. To date, both subjective and objective methods exist for testing physical activity levels. Given the economical and convenient property, the subjective method would be preferred for population surveys [19,20] but may lack accuracy. Objective measurements have higher accuracy but would be costly and difficult to translate [21,22].

The Physical Activity Scale for the Elderly (PASE) is a reliable and valid subjective measurement method of physical activity for older adults. It was designed to measure work-related, household, and leisure time activities in the past week [23]. The triaxial accelerometer ActiGraph (GT3X) is a wearable objective measurement that measures physical activity levels with less burden, and its accuracy has been proven [24-26]. This study aimed to investigate the relationship and predictive role of PASE and GT3X as representatives of subjective and objective measurements of physical activity with possible sarcopenia.

Methods

Participants

This study enrolled 146 community-dwelling older adults (≥65 yrs) from Nanjing (Men=41). The qualified participants should be those with independent living ability, without mobility, communication and cognitive impairment. Excluded criteria were physical disabilities, recently received major surgery or surgery history of fewer than six months, with severe chronic diseases. All participants signed the consent form before the tests. This study was approved by the Nanjing Normal University Ethical Review Committee (NNU202206009).

Procedures

In the first place, participants finished the basic information scale and PASE. Subsequently, participants underwent evaluation of basic fundamental body indicators (height, weight, BMI, waist circumference, hip circumference) and possible sarcopenia indicators (CC, left/right right-hand grip strength, 5CST). Lastly, we helped participants wear the GT3X correctly at the right hip after the test. We ensured safety during the trial. The period of GT3Xs' measurement was four days after the field test (r^2 = 0.91). Each participant was required to wear it all day during the measurement period, except for bathing and swimming. Recycle after four days, followed by data processing and analysis.

Measures

Physical indicators

The physical indicators included height (m), weight (kg), body mass index (BMI; kg/m^2), waist circumference (cm), and hip circumference (cm). The BMI is calculated by actual weight (kg) / squared height ($m)^2$. Waist circumference, hip circumference, and CC were measured using a measuring tape. Waist circumference was the distance between the midpoint of the lower last rib and the midpoint of the superior iliac crest of participants [27]. Hip circumference was measured around the most prominent part of the hip horizontally.

Possible sarcopenia indicators

Possible sarcopenia indicators include CC (cm), left/right-hand grip strength (kg), and 5CST (s). The CC was measured with the patient in a sitting position, with the knee at 90° flexion, and the maximum circumference measured on each side [28] (cutoff values were <34 cm for men and <33 cm for women as proposed by the AWGS 2019). Grip strength was measured using a grip strength gauge (Model JAMAR 30107041, Preston, Jackson, MI.). Participants should be in the sitting position with 90°elbow flexion, the maximum value from measuring each side three times was recorded (cutoff values of <28 kg for men, <18 kg for women). The 5CST was measured as the time taken to rise from a seated position and sit down five times as quickly as possible. Patients were instructed to cross their arms in front of their chest and not use the armrests as support during the 5CST [29]. The test was repeated three times and took the best performance (cutoff value of ≥12 s).

Physical activity assessment

The Chinese version of PASE was a subjective physical activity measurement method used to assess participants' usual physical activity. The PASE has 12 components about leisure time activity (five components), household activity (six components) and work-related activity (one component) over the past 7 days. In this study, the Chinese version of PASE was modified by including the popular adopted exercise by Chinese older adults. The modified PASE showed high reliability and validity. PASE scores ranged from 0 to 360 or more, where higher scores represent higher physical activity levels [30]. The total PASE score was computed by multiplying the amount of time spent in each activity (hours/week) or participation (yes/no) in an activity by the empirically derived item weights and summing over

all activities.

The GT3X was an objective physical activity measurement method used to measure the physical activity of older adults. The data were analyzed based on Actilife (Version 6.13.3) to obtain indicators of Physical Activity Energy Expenditure (PAEE), step counts, MET, counts, and other indicators, where the PAEE formula was chosen from Freedson Combination (1998), step counts and MET calculation formula was determined from Freedon Adult (1998). Sedentary (SED) Time (cutoff value of <100 cpm), Light Physical Activity (LPA) Time (cutoff value of 100 cpm-1951 cpm), and Moderate and Vigorous Physical Activity (MVPA) Time (cutoff value of 1952 cpm-9498 cpm) were obtained based on physical activity intensity thresholds [31].

Statistical analysis

The participants were assigned to the "possible sarcopenia" and "non-possible sarcopenia" groups using excel according to the AWGS 2019 criteria. The baseline characteristics of the sample are expressed as mean ± standard deviation. The differences between the two groups were analyzed using the independent t-test. Using Spearman's rank correlation coefficient to explore the correlation of possible sarcopenia indicators with PASE scores and GT3X indicators. The associated indicators were analyzed by binary logistic regression. A receiver operating characteristic (ROC) analysis assessed the area under the curve and determined the PASE, GT3X and the combination of both for correctly discriminating against possible sarcopenia status along with sensitivity and specificity. All analyses were computed using Statistical Package for Social Sciences (SPSS, version 26, Chicago, IL).

Results

Baseline characteristics of all participants

The sample consisted of 146 older adult participants, with a mean age of 72.6 ± 5.6 years, 105 (72%) were female and 41 (28%) were male. Table 1 shows the baseline characteristics of all participants, including body indicators, possible sarcopenia indicators, PASE score, and GT3X indicators, according to AWGS definition and diagnostic algorithm.

In body indicators, weight and BMI showed significant differences between the two groups ($p < 0.05$). The possible sarcopenia group had lower body weight overall. Possible sarcopenia indicators showed significant differences between the two groups ($p < 0.05$), indicating that the possible sarcopenia group may have impaired muscle function. There was no significant difference in PASE scores between the two groups. However, in GT3X indicators, PAEE and MET showed significant differences, indicating that physical activity level was lower in possible sarcopenia patients. These results were consistent with previous studies [32].

Table 1: Baseline characteristics of all participants.

Characteristics	Total (n=146, 100%)	Possible sarcopenia		
		Yes (n=19,13%)	No (n=127,87%)	p-value
Body indicators				
Age, years	72.6 ± 5.6	75.0 ± 6.3	72.3 ± 5.5	0.054
Female, n(%)	105 (72%)	12 (63%)	93 (73%)	
Height, cm	157.8 ± 7.7	156.2 ± 6.6	158.0 ± 7.8	0.337
Weight, kg	61.9 ± 9.6	54.5 ± 7.1	63.0 ± 9.4	<0.001*
BMI, kg/m^2	24.8 ± 3.3	22.5 ± 3.2	25.2 ± 3.2	0.001*
Possible sarcopenia indicators				
CC(L), cm	34.2 ± 2.8	31.2 ± 1.1	34.7 ± 2.7	<0.001*
CC(R), cm	34.3 ± 2.8	31.2 ± 1.3	34.7 ± 2.7	<0.001*
Grip strength(L), kg	22.9 ± 8.0	16.8 ± 5.4	23.8 ± 7.9	<0.001*
Grip strength(R), kg	23.5 ± 7.8	16.7 ± 4.5	24.5 ± 7.7	<0.001*
5CST,s	11.6 ± 3.6	13.8 ± 4.7	11.3 ± 3.3	0.004*
PASE component				
Leisure time activity	34.0 ± 27.1	26.1 ± 18.5	35.1 ± 28.1	0.177
Household activity	77.1 ± 36.0	64.7 ± 40.8	78.9 ± 35.0	0.109
Work-related activity	5.7 ± 25.5	6.6 ± 24.3	5.5 ± 25.7	0.868
PASE score	112.6 ± 53.8	97.4 ± 56.5	114.9 ± 53.3	0.187
GT3X indicators				
SED, min/wk	4628.1 ± 734.8	4656.7 ± 755.7	4623.8 ± 734.6	0.856
LPA, min/wk	1195.5 ± 566.6	987.8 ± 434.2	1226.6 ± 578.8	0.087
MVPA,min/wk	1061.8 ± 869.3	774.9 ± 1036.4	1104.8 ± 837.7	0.123
PAEE,kcal	1908.5 ± 1218.7	1101.7 ± 657.7	2029.2 ± 1238.7	<0.001*
step counts,steps/wk	53855.7 ± 30206.0	49003.3 ± 33332.8	54581.7 ± 29785.5	0.455
MET	7.9 ± 0.8	7.4 ± 0.4	8.0 ± 0.8	<0.001*

BMI: Body Mass Index; SED:Sitting Activity Time; LPA: Light Physical Activity; MVPA: Moderate And Vigorous Physical Activity; PAEE: Physical Activity Energy Expenditure; CC: Calf circumference; 5CST: 5-time chair stand test

The correlation between PASE, GT3X and possible sarcopenia indicators

Results of the correlation between PASE and possible sarcopenia indicators showed in Table 2. Leisure time activity score was significantly correlated with left/right hand grip strength (ρs=0.267/ρs=0.235,p<0.05), and 5CST (ρs=-0.164,p<0.05). Household activity score was significantly negatively correlated with 5CST (ρs=-0.213,p<0.05). Total PASE score was significantly associated with left/right hand grip strength (ρs=0.205/ρs=0.183,p<0.05) and 5CST (ρs=-0.297,p<0.05), which could indicate muscle strength.

Results of the correlation between GT3X and possible sarcopenia indicators showed in Table 3. Compared with PASE, GT3X had more significantly correlated indicators with possible sarcopenia indicators. The SED was significantly negatively correlated with right grip strength (ρs=−0.178, p<0.05). The LPA was significantly negatively correlated with 5CST (ρs=−0.183, p<0.05). The MVPA was significantly positively correlated with left/right hand grip strength (ρs=0.299/ρs=0.338, p<0.05) and negatively correlated with the 5CST (ρs=−0.372, p<0.05). Step counts and counts were significantly associated with left/right hand grip strength and the 5CST. PAEE and MET were significantly correlated with all possible sarcopenia indicators to different degrees. Previous studies also showed that older adults with sarcopenia had lower energy expenditure in physical activity [33]. The results of this study added to the supporting evidence.

Table 2: PASE and possible sarcopenia indicators.

	Leisure time activity		Household activity		Work-related activity		PASE score	
	ρs	p-value	ρs	p-value	ρs	p-value	ρs	p-value
CC(L), cm	0.097	0.244	0.034	0.682	0.115	0.168	0.060	0.469
CC(R), cm	0.097	0.245	0.057	0.496	0.089	0.287	0.084	0.312
Grip strength(L), kg	0.267*	0.001	0.135	0.103	0.153	0.066	0.205*	0.013
Grip strength(R), kg	0.235*	0.004	0.132	0.112	0.157	0.059	0.183*	0.027
5CST,s	-0.164*	0.049	-0.213*	0.010	-0.056	0.499	-0.297*	<0.01

CC=Calf circumference; 5CST=5-time hair stand test

Table 3: GT3X and possible sarcopenia indicators.

	SED	LPA	MVPA	PAEE	step counts	MET	counts
	ρs	ρs	ρs	ρs	ρs	ρs	ρs
CC(L),cm	0.032	0.052	0.078	0.334*	0.006	0.262*	0.039
CC(R),cm	0.052	0.049	0.049	0.310*	−0.033	0.231*	0.032
Grip strength(L), kg	−0.147	0.069	0.299*	0.327*	0.253*	0.370*	0.190*
Grip strength(R), kg	−0.178*	0.079	0.338*	0.367*	0.276*	0.409*	0.237*
5CST,s	0.038	−0.183*	−0.372*	−0.366*	−0.359*	−0.371*	−0.332*

*p<0.05; s: Spearman's rank correlation coefficient
CC: Calf circumference; 5CST: 5-time chair stand test; SED: Sitting Activity Time; LPA: Light Physical Activity; MVPA: Moderate and Vigorous Physical Activity; PAEE:Physical Activity Energy Expenditure.

Table 4: ROC results.

	AUC (95%CI)	sensitivity (95%CI)	Specificity (95%CI)	p-value
PASE	0.402	26.3%	81.1%	0.167
GT3X	0.856	84.2%	79.5%	<0.001
PASE and GT3X	0.855	84.2%	80.3%	<0.001

AUC: Area under the curve

Prediction accuracy of PASE and GT3X for possible sarcopenia

The area under the curve (AUC) using the total PASE score was 0.402 (95% CI=0.256-0.548; p=0.167) with a sensitivity of 26.3% and a specificity of 81.1%. The AUC using GT3X was 0.856 (95% CI = 0.774-0.939; p<0.05), with a sensitivity of 84.2% and a specificity of 79.5%. The AUC using PAEE, MET, MVPA, and counts were 0.263, 0.268, 0.355 and 0.337 (p<0.05). The AUC using PASE combined with GT3X was 0.855 (95% CI=0.772-0.939; p<0.05), with a sensitivity of 84.2% and a specificity of 80.3%. The results showed GT3X had higher prediction accuracy than PASE for possible sarcopenia, and PASE combined with GT3X had higher prediction accuracy than PASE alone.

Discussion

This study investigated the relationship and predictive role of PASE and GT3X as representatives of subjective and objective measurements of physical activity with possible sarcopenia. In previous studies, insufficient physical activity is an important risk factor for sarcopenia in older adults [34]. In this study, two selected physical activity measurement methods correlated with possible sarcopenia diagnostic indicators in different degrees, further providing indirect evidence for the association between sarcopenia and physical activity.

In this study, the possible sarcopenia group had significantly lower weight and BMI than average values. Ageing accompanied by weight loss usually indicates that some underlying disease is occurring. It not only suggests the possibility of sarcopenia but is also one of the characteristics of the state of “nutritional weakness”. “Nutritional weakness” is a sign of organic weakness eventually. Underweight older adults can take steps

consciously to improve their current physical status [35]. In addition, the overweight rate among Chinese adults has increased significantly in recent years [36]. In this study, the BMI of all participants was higher than the standard, in the overweight range [37]. It might be due to the widespread fat phenomenon in the non-possible sarcopenia group being generally higher than average.

Further calculated the waist-to-hip ratio (WHR) of all participants. WHR can better predict several metabolic risk factors [38]. According to the threshold value of WHR for obesity [39], 82 women and 23 men were higher than the standard, accounting for 72% of the total sample. The data reflects the severity of the overweight phenomenon.

The prevalence of possible sarcopenia was 17% and 11.4%, respectively in the male and female elderly in this study. There are different findings about the association between gender and sarcopenia. Some studies showed that the decrease in muscle mass is more severe in older men than women [40,41]. Prevalence of sarcopenia was 50% in 80-year-old men, compared to 43.8% in women in the same age group [42-44]. Another study showed a higher prevalence of sarcopenia in women under 80 years of age. The faster decrease in steroid hormones in women than men might be a potential reason [45]. Various endogenous and exogenous factors may influence the prevalence of sarcopenia [46]. A larger sample size is needed in future studies to further explore the association between gender and possible sarcopenia.

In this study, the PASE scores of the possible and non-possible sarcopenia groups did not show significant differences. The reason might be the small sample size of this study. PASE was significantly correlated with muscle strength indicators. It is further speculated that PASE could identify a decrease in muscle strength to predict possible sarcopenia.

The PAEE and MET were significantly lower in the possible sarcopenia group than non-possible sarcopenia group, indicating that the physical activity level of older adults with possible sarcopenia was lower than that of older adults without the disease. In addition, many indicators of GT3X showed different degrees of significant correlation with indicators of possible sarcopenia, indicating an association between GT3X and possible sarcopenia. This result was consistent with previous studies using subjective and objective measurements to measure physical activity. A longitudinal survey of physical activity level and lean body mass in Japanese residents aged 65-84 showed that older adults with high physical activity level scores on objective measures were at lower risk of having muscle mass below the sarcopenia threshold than sedentary older adults [47]. In a study of the relationship between physical activity and sarcopenia in older Koreans, the results showed that increased physical activity was associated with a reduced risk of sarcopenia in older adults [48]. Further demonstrated the importance of physical activity to maintain muscle function and prevent sarcopenia.

The results showed that GT3X had a higher degree of correlation with possible sarcopenia diagnostic indicators and a higher prediction accuracy than PASE. It suggested that objective measurement methods might be better predictors of possible sarcopenia than subjective measurement methods. Such results were consistent with the previous study [49]. There were also many studies with different opinions. In a study to assess the prevalence of endometrial cancer in women, subjective measurement methods showed the same or even better results than objective measurements [50]. A previous study evaluating sleep quality showed that both subjective and objective measurement methods should be included in the study for a comprehensive assessment [51]. The results of this study support such an argument. The prediction accuracy of PASE in combination with GT3X is higher than that of PASE alone.

In summary, this study showed that objective measurement methods had better prediction accuracy than subjective measurement methods, and the combination of both ways had higher prediction accuracy than using subjective measurement methods alone. Considering the different characteristics of subjective and objective measurement methods, the mixture methods may be more effective in predicting other physical activity-related disorders in the future. Further research is needed in the future to investigate the degree of reproducibility of subjective or objective measurement methods.

On the one hand, in this study, the participants were community-dwelling older adults who participated voluntarily. This study could not accurately plan the number of male and female participants, so there were differences in the number of subjects by gender. On the other hand, GT3X was worn at the hip, which might be difficult to measure some upper body movements, such as climbing and weight-bearing [52].

Conclusion

Objective measurement methods have more indicators correlated with diagnostic indicators of possible sarcopenia than subjective measurement methods and have higher correlation and prediction accuracy. The prediction accuracy of subjective combined with objective measurement methods is higher than using subjective measurement methods alone. The integrated application may improve the accuracy of identifying possible sarcopenia in primary care.

Declarations

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Author contributions: C Zhu: data analysis, writing-original draft. YD: data collection. YNZ: conceptualization, methodology, review & editing, supervision.

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