


BMJ Open Correlation of sarcopenia and depressive mood in older community dwellers: a cross-sectional observational study in China

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ABSTRACT

Objective Whether sarcopenia is detrimental to depression is still controversial, which may be due to the three components of the sarcopenia. Our objective was to define the correlation between depression and sarcopenia in older Chinese community dwellers.

Design The study has a cross-sectional design.

Setting The study was conducted in Jiangsu, China.

Participants A total of 101 men and 149 women aged 60 years or older were recruited.

Outcome measures Lean tissue mass was measured by dual-energy X-ray absorptiometry. Muscle strength in the upper and lower limbs was measured by a handheld dynamometer and a chair stand test, respectively. Physical performance was assessed by gait speed and standing balance tests. Depressive mood was assessed using the Geriatric Depression Scale-30 (range 0–30).

Results Participants in the sarcopenia group had a higher mean depression score than the normal group ($p=0.002$). Pearson's correlation analysis showed that depression was negatively associated with muscle strength (handgrip strength: $R=-0.170$, $p=0.028$ for women, $R=-0.196$, $p=0.048$ for men; chair stand test performance: $R=0.252$, $p=0.002$ for women, $R=0.311$, $p=0.001$ for men) and physical performance (gait speed: $R=-0.200$, $p=0.009$, standing balance test performance: $R=-0.224$, $p=0.006$, Short Physical Performance Battery (SPPB): $R=-0.218$, $p=0.007$ for women; SPPB: $R=-0.252$, $p=0.01$ for men). Multiple linear regression models revealed that depressive mood was inversely associated with chair stand test ($\beta=0.325$, $p<0.001$), gait speed ($\beta=-0.009$, $p=0.041$) and standing balance test ($\beta=-0.24$, $p=0.016$) after adjusting for confounding factors, while no significant correlation was observed between depressive mood and muscle mass.

Conclusion The diagnostic components of sarcopenia—strength of the leg muscles (chair stand test) and physical performance (gait speed and standing balance test)—were associated with depressive mood.

INTRODUCTION

Over the last few decades, with the ageing of the global population, sarcopenia has risen to be an important public health problem. As we all known, skeletal muscle comprises approximately 40% of the total body mass

Strengths and limitations of this study

- Our findings highlight the significance of muscle strength and function but not muscle mass in relation to depression in older Chinese community dwellers.
- It would have been improved if we had acquired data on activity levels and dietary habits.
- A cross-sectional study cannot establish a causal relationship between depressive mood and sarcopenia.
- Since the enrolled participants were relatively healthy, it is necessary to recruit more participants with large variability in parameters to avoid selection bias.
- Another limitation was the lack of the interventions and follow-up due to their time-consuming nature as well as the poor compliance of participants.

in a healthy weight individual.¹ Sarcopenia is defined as the loss of muscle mass, muscle strength and decreased physical performance due to ageing.² Therefore, sarcopenia is a potential risk factor for frailty, fall, disability, delayed wound healing, diabetes, cardiovascular disease and so on in older adults.³ At present, methods of delaying sarcopenia constitute a hot topic in the field of geriatric medicine, and physical exercise is one of the most effective ways to maintain and gain muscle mass and strength.⁴

Depression is characterised by significant and lasting sadness and is the most common type of mood disorder. Clinically, a patient's level of depression can range from extreme grief to feelings of inferiority, pessimism, world-weariness and serious suicidal behaviour.⁵ It is generally accepted that depression is a leading cause of disability worldwide and a major contributor to the overall global burden of disease.⁶ An article published in 2017 on the official website of the WHO reported that 322 million people suffered from depression worldwide and that

the number of patients increased by 18.4% between 2005 and 2015. China is the country with the largest number of people suffering from depressive disorders, with a prevalence of 4.2%.⁷ However, compared with other psychiatric patients, patients with depression have poor treatment compliance, and they often refuse any treatment due to their shame regarding the condition. Exercise can not only improve the mood of patients with depression but also promote the recovery of social function and reduce shame. To date, the strongest evidence for the benefits of physical activity in depression comes from randomised controlled trials, which report that exercise intervention using a physical activity programme had positive effects on depressive status.⁸ In addition, several large prospective cohort studies have indicated an inverse relationship between physical activity and depressive symptoms.^{9 10}

Given that physical exercise can not only delay sarcopenia but also treat depression, and muscle tissue is the largest exercise and endocrine metabolism organ, a number of studies have investigated the relationship between sarcopenia and depressive mood.¹¹ For example, a cross-sectional sample of a longitudinal cohort from the Ansan Geriatric (AGE) Study reported that depression in elderly Koreans was associated with low body mass and sarcopenia, especially in men.¹² In addition, a statistically significant relationship was observed between sarcopenia and depression in older male patients with diabetes.¹³ A recent study involving Japanese urban-dwelling older adults revealed that depressive mood was not associated with decreased muscle mass but was associated with low muscle strength and low physical performance.¹⁴ In contrast, results from the 2010–2011 Korean National Health and Nutrition Examination Survey showed that sarcopenia was not associated with depression in Korean adults.¹⁵ Therefore, the exact relationship between depressive mood and the components of sarcopenia is still unknown.

In this study, we chose healthy community dwellers aged 60 years or older who did not suffer from diseases that might affect muscle metabolism. Our aim was to explore the correlation between depressive mood and the diagnostic components of sarcopenia in older Chinese community dwellers.

MATERIALS AND METHODS

Study participants

The study participants were selected from older community dwellers who participated in the annual health screening programme at Huaqiao Road Community Health Service Center in Jiangsu, China. The inclusion criterion was an age of 60 years or older. Participants were excluded if they had diseases that might affect muscle metabolism such as inflammatory myopathy, Parkinson's disease, stroke, myocardial infarction, significant liver disease, a creatinine clearance of <30 mL/min or cancer. The mental status of the study participants was assessed by the Mini-Mental Status Examination (MMSE) and

participants with cognitive impairment were excluded. Participants who failed to go through the assessment of sarcopenia were also excluded. Finally, 101 men and 149 women were recruited for the study.

Height and weight were measured by standard methods with participants wearing light clothing without shoes. Body mass index (BMI) was calculated as $BMI (kg/m^2) = \text{Weight (kg)} / \text{height}^2 (m^2)$.

Ethical and legal considerations

The participants themselves gave their written informed consent to participate in the study and were informed that they could refuse to participate at any stage.

Muscle mass, muscle strength and physical performance assessment

A dual-energy X-ray absorptiometry scanner (Hologic, Bedford, Massachusetts, USA) was used to measure appendicular skeletal muscle mass (ASM). As absolute muscle mass correlates with height, the appendicular skeletal muscle mass index (SMI) was calculated as $SMI (kg/m^2) = ASM (kg) / \text{height}^2 (m^2)$. All scans were obtained by the same certified technician. The instruments used in this study exhibited stable long-term performance (coefficient of variation <0.5%) and satisfactory in vivo precision.

The grip strength of each participant's dominant hand was measured three times with a hand dynamometer (Jamar, Los Angeles, California, USA). Three attempts separated by a 1 min interval were recorded, and the maximum value (in kg) was recorded for further analysis. The chair stand test, also called the chair rise test, can be used as a proxy to assess the strength of the leg muscles (quadriceps muscle group). The participants were required to rise five times from a seated position as fast as possible without using his or her arms. The time was recorded manually with a stopwatch.

Physical performance was assessed by gait speed and the standing balance test.¹⁶ For the gait speed, participants were asked to walk along a straight walkway on a flat floor at their usual speed without deceleration. They walked over a 4 m distance between markers placed at 3 m and 7 m from the start of the walkway. The time was measured manually with a stopwatch and then the mean walking speed (m/s) was calculated. The test was performed twice, with the faster of the two walks used for analysis. For the standing balance test, participants were asked to stand in three positions (with feet together, with the inside of the heel of the front foot close to the big toe of the rear foot and with one foot forward and one backward), using arms or other means to maintain balance without moving the feet.

The Short Physical Performance Battery (SPPB) comprises the measurements of gait speed, standing balance and the chair stand test. The maximum individual test score is 4 and the maximum total SPPB score is 12.

Depression assessment

The severity of depressive mood was evaluated using the 30-item Geriatric Depression Scale (GDS-30) developed by *Yesavage et al* in 1982.¹⁷ The GDS-30 was rater-administered in a standardised manner with the interviewer questioning the subjects and recording their responses to the individual items.

All items in the GDS-30 are rated as 0 or 1; specifically, 1 = 'No' and 0 = 'Yes' for some items (1, 5, 7, 9, 15, 19, 21, 27, 29, 30) but 0 = 'Yes' and 1 = 'No' for the remaining items. Item scores are summed, resulting in a possible total score of 0–30. High scores represent more severe depression.

Diagnosis of sarcopenia

According to the Asian Working Group for Sarcopenia (AWGS) criteria in older people,¹⁸ sarcopenia is defined according to muscle mass, muscle strength and physical performance. Possible sarcopenia is determined by low muscle strength or low physical performance (five-repeat chair stand test ≥ 12 s). Sarcopenia is defined as low muscle mass plus either diminished muscle strength or low physical performance.

Low muscle mass was defined as an SMI below 7.0 kg/m² for men and 5.4 kg/m² for women. Low muscle strength was defined as handgrip strength <28 kg for men and <18 kg for women. Low physical performance was defined as gait speed <1.0 m/s or an SPPB score ≤ 9 .

Statistical analysis

Descriptive data are presented as the means \pm SDs or medians (first to third quartile). The associations between depression score and muscle mass, muscle strength and physical performance were examined using Pearson's correlation analysis. Multiple linear regression models were used to analyse SMI, handgrip strength, the chair stand test, gait speed and the SPPB score using age, gender and BMI data as confounding variables. All statistical analyses were performed using SPSS V.20.0 (IBM Corp, Armonk, New York, USA), and $p < 0.05$ was considered statistically significant.

Patient and public involvement

No patient was involved in developing the research questions, outcome measurements or design of the study. We are unable to disseminate the findings of the research directly to the study participants.

RESULTS

General characteristics, muscle mass, muscle strength and function and depressive mood of participants

Table 1 shows the participants' demographic characteristics. The analysis included data from 250 older Chinese community dwellers, of whom 149 were men (mean age: 69.82 \pm 6.84 years) and 101 were women (mean age: 67.69 \pm 6.20 years). The mean GDS-30 scores in the male and female groups were 4.43 \pm 3.53 and 4.62 \pm 4.11 points,

Table 1 Anthropometrics, muscle mass, muscle strength and physical performance of the participants

Parameter	Men	Women
n	101	149
Age (years)	69.82 \pm 6.84	67.69 \pm 6.20
Height (cm)	168 \pm 5.79	155 \pm 5.72
Weight (kg)	69.22 \pm 9.10	58.42 \pm 8.60
BMI (kg/m ²)	24.42 \pm 2.77	24.09 \pm 3.11
Muscle strength		
Handgrip strength	38.86 \pm 7.89	24.48 \pm 4.38
Chair stand test	9.18 \pm 3.18	9.47 \pm 5.56
Muscle mass		
ASM (kg)	20.16 \pm 2.73	13.65 \pm 2.02
SMI (kg/m ²)	7.10 \pm 0.79	5.63 \pm 0.72
Physical performance		
Gait speed (m/s)	1.27 \pm 0.29	1.26 \pm 0.24
Standing balance test (score)	3.80 \pm 0.54	3.76 \pm 0.64
SPPB (score)	11.36 \pm 1.31	11.47 \pm 1.16
MMSE (score)	27.68 \pm 1.93	27.47 \pm 2.17
Depression (score)	4.43 \pm 3.53	4.62 \pm 4.11

Variables are expressed as mean \pm SD.

ASM, appendicular skeletal muscle mass; BMI, body mass index; MMSE, Mini-Mental Status Examination; SMI, appendicular skeletal muscle mass index; SPPB, Short Physical Performance Battery.

respectively. The mean relative muscle mass (SMI) was 7.10 \pm 0.79 kg/m² for men and 5.63 \pm 0.72 kg/m² for women. We evaluated the strength of the upper and lower limbs by the handgrip strength test (38.86 \pm 7.89 kg for men, 24.48 \pm 4.38 kg for women) and the chair stand test (9.18 \pm 3.18 s for men, 9.47 \pm 5.56 s for women), respectively. The assessment of physical performance involved the measurement of gait speed, the standing balance test and the SPPB score.

Correlation between depressive mood and muscle mass, muscle strength and physical performance

We carried out a Pearson correlation analysis of the above data, and no significant correlation was observed between muscle mass and depressive mood in either men or women (**figure 1**). Then we found that depression scores correlated significantly with muscle strength in both sexes, in terms of handgrip strength ($R = -0.196$, $p = 0.048$ for men, $R = -0.170$, $p = 0.028$ for women) and chair stand test performance ($R = 0.311$, $p = 0.001$ for men, $R = 0.252$, $p = 0.002$ for women) (**figure 2**). Moreover, as shown in **figure 3**, in women, depression was negatively associated with physical performance measured by gait speed ($R = -0.200$, $p = 0.009$), standing balance test performance ($R = -0.224$, $p = 0.006$) and SPPB score ($R = -0.218$, $p = 0.007$). There was also a negative correlation between depressive mood and the SPPB score in men ($R = -0.252$,

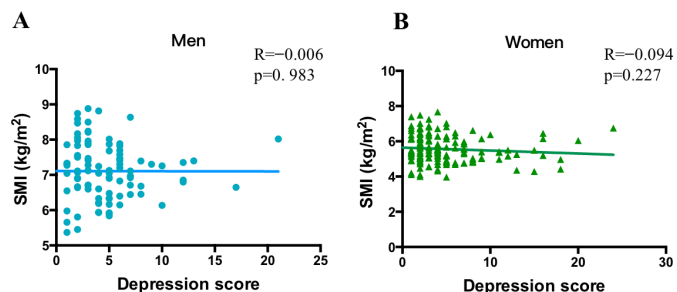


Figure 1 Pearson's correlation between SMI and the depression score in men (A) and women (B). SMI, appendicular skeletal muscle mass index.

$p=0.010$) but not gait speed or standing balance test performance.

Multiple regression analysis of depressive mood, muscle mass, muscle strength and physical function

Given the significant independent relationships between age, sex, BMI, glucose, lipid metabolism and parameters of sarcopenia, we performed multiple linear regression analyses. In our multiple linear regression models (table 2), depressive mood was inversely associated with chair stand test ($\beta=0.325$, $p<0.001$), gait speed ($\beta=-0.009$, $p=0.041$), standing balance test scores ($\beta=-0.24$, $p=0.016$) and SPPB scores ($\beta=-0.061$, $p=0.002$), while no significant correlation was found between depressive mood and muscle mass.

Depression scores in different stages of sarcopenia

We further analysed the depression scores of subjects exhibiting different stages of sarcopenia, such as possible-sarcopenia and sarcopenia. Following the AWGS criteria, the numbers of participants in normal, possible-sarcopenia and sarcopenia groups were 121, 74 and 55, respectively.

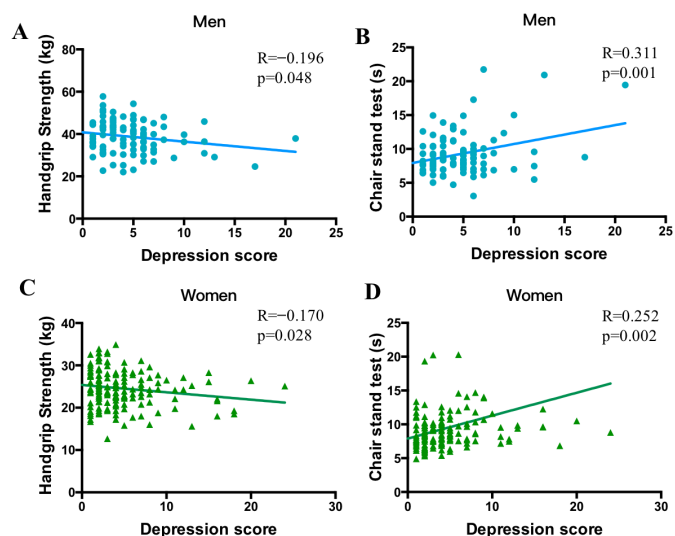


Figure 2 The strength of the upper and lower limbs in relation to the depression score. (A, C) Handgrip strength and depression score. (B, D) Chair stand test and depression score. $p<0.05$ indicates a statistically significant difference.

As expected, the participants' depression scores gradually increased with the extent of muscle loss. Participants with sarcopenia had higher depression scores than the normal group ($p=0.002$), while there was no significant difference between the depression scores of the possible-sarcopenia and sarcopenia groups (figure 4).

DISCUSSION

Overall, our data revealed an association between depressive mood and sarcopenia in adults aged 60 years and over. This was consistent with the results of a meta-analysis, whose authors concluded that patients with sarcopenia were likely to present with depression.¹⁹ Furthermore, we found that depressive mood was negatively associated with the strength of leg muscles and physical performance measured by gait speed and the standing balance and SPPB scores, even after adjusting for confounding factors. However, no significant correlation was observed between muscle mass and depressive mood in either men or women.

Although depression is not an inevitable result of ageing, depressive diseases of the older population are a common and serious health problem that are related to coexisting diseases, functional impairment, excessive use of healthcare resources and increased mortality (including suicide). The incidence of depression in the older individuals living in the community is between 2% and approximately 10%. The incidence of depression is higher in the older adults with coexisting medical diseases and in those in comprehensive medical institutions. The prevalence of depression in the older adults in hospitals is more than 30%.²⁰ Thus, early detection of depression-related risk factors and early intervention are particularly important in the context of a single course of antidepressant treatment in the face of poor patient compliance.

The definition of sarcopenia widely used worldwide comprises three important elements: muscle mass, muscle strength and physical performance.²¹ Past studies on sarcopenia in old adults have often focused on muscle mass.²² After 10 years of research, the EWGSOP2 has identified decreased muscle strength as a key feature of sarcopenia and muscle function as an indicator of severe sarcopenia.²³ In addition, muscle strength and function are recognised as being more predictive of adverse outcomes in older adults than muscle mass.

Considering that our data clearly linked parameters of physical performance to depression, we speculate that exercise interventions for muscle strength and function may lead to improvement in depressive mood. Researchers began to study the relationship between motion and emotion in the early 1990s,²⁴ and recent evidence has shown that exercise but not nutritional support may be beneficial in patients with depression.²⁵ Dunn *et al*⁸ reported that the remission rate was 47% in a high-intensity exercise group and 30% in a low-intensity exercise group after 12 weeks of intervention, while that of the control group was 29%. These researchers also

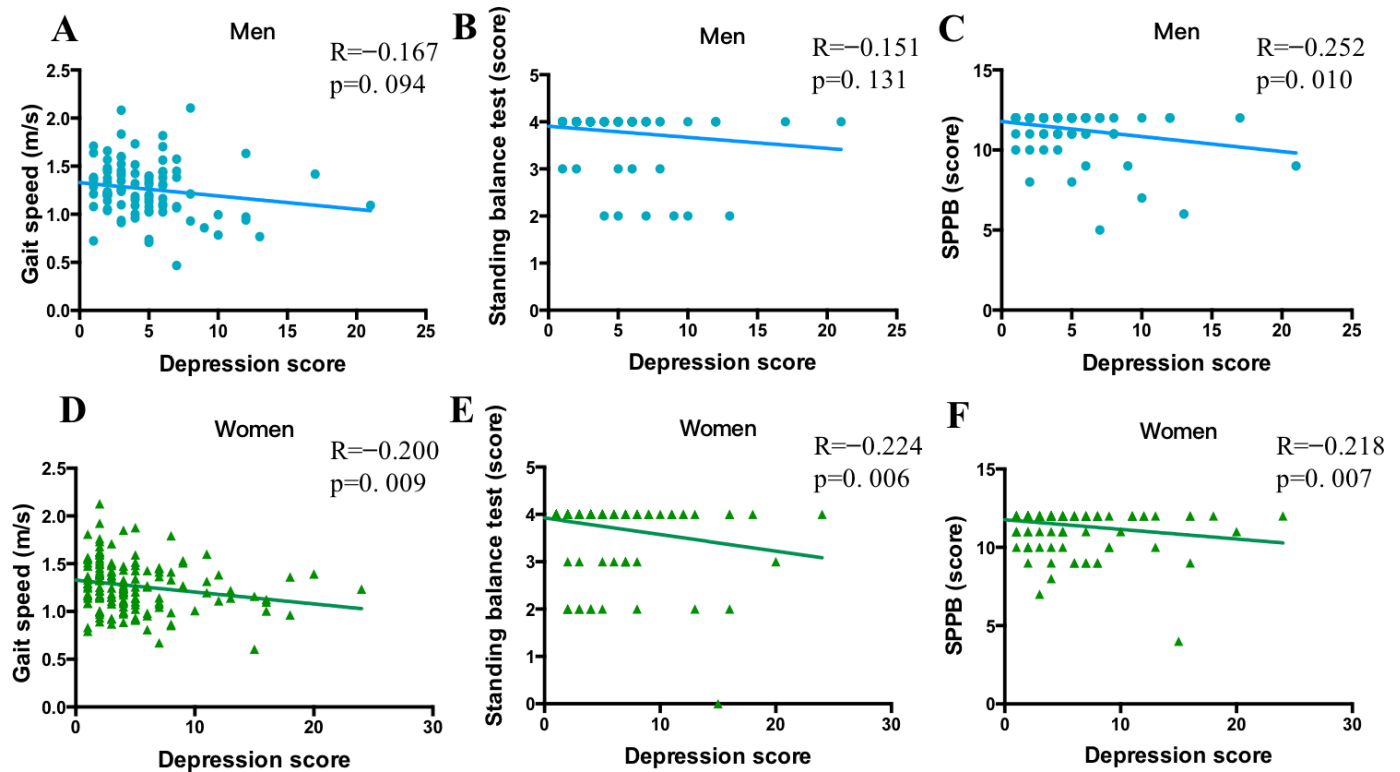


Figure 3 Pearson's correlation between physical performance and depression score in men or women. (A, D) Gait speed correlation with depression score. (B, E) Standing balance test correlation with depression score. (C, F) SPPB correlation with depression score. $p < 0.05$ indicates a statistically significant difference. SPPB, Short Physical Performance Battery.

observed no significant difference between exercise three times a week and five times a week. Hence, these results suggest that exercise intensity, not frequency, has a beneficial role in depression treatment. In addition, no clear side effects of exercise therapy have been reported, and there are no withdrawal symptoms, unlike the weight gain, dry mouth and insomnia that may occur after withdrawal from drug therapy.

Furthermore, there are some links between sarcopenia and depressive mood.²⁶ First, they seem to share several common risk factors, such as upregulation of inflammatory factors.²⁷ Second, muscle is not only a motor organ but also an effective, metabolically active endocrine organ. For example, skeletal muscle cells are highly abundant and myokine signalling has also been linked to brain neurogenesis and cognitive functions.²⁸ Agudelo *et al*²⁹ revealed that there are possible therapeutic avenues for the treatment of depression that would involve targeting the PGC-1 α 1-PPAR axis in skeletal muscle, without the need to cross the blood–brain barrier.

Previous studies on the effects of the components of sarcopenia on depression have found sex differences. For example, in a recent study involving Japanese adults, decreased muscle mass (sarcopenia) was related to depression in older men with diabetes but not in older women.¹³ Contrary to these previous studies, our data indicated that depressive mood was inversely associated with chair stand test performance, gait speed and standing balance test performance in both men and women. This difference

in results might be explained by the inclusion of relatively ‘young’ older subjects (the average age was no more than 70 years), by the low severity of the reported depression or the small sample size in our study.

There were certain limitations to this study. For example, since better physical function is associated with improvement of sarcopenia and a lower incidence of depressive symptoms, we believe that being able to add physical activity is beneficial to analyse the risk factors for depression and sarcopenia. We will acquire data on activity levels, such as with the International Physical Activity Questionnaire (IPAQ), in future studies. Second, the mean SPPB scores of men/women in the study were 11.36/11.47, which means that the enrolled participants were relatively healthy. It is necessary to recruit more participants with large variability in their parameters to avoid selection bias. Third, a cross-sectional study cannot establish a causal relationship between depressive mood and sarcopenia, and future prospective studies will be needed to address this gap. Fourth, another limitation was the lack of the interventions and follow-up due to their time-consuming nature as well as the poor compliance of participants. Finally, our study sample was small; a larger sample would allow direct comparisons of subjects with similar levels of depressive mood, which would generate findings with greater applicability. These shortcomings merit further study.

In conclusion, our study demonstrated that depressive mood was inversely associated with physical function in

Table 2 Multiple linear regression analyses of the effects of muscle mass, muscle strength and physical function on depression

	SMI		Handgrip strength		Chair stand test		Gait speed		Standing balance test		SPPB	
	β	P value	β	P value	β	P value	β	P value	β	P value	β	P value
Age	-0.006	0.366	-0.22	0.001***	0.08	0.132	-0.009	0.002**	-0.019	0.002**	-0.031	0.011*
Gender	-1.485	<0.001***	-14.963	<0.001***	0.285	0.685	-0.05	0.184	-0.075	0.36	0.059	0.713
BMI	0.157	<0.001***	0.233	0.118	0.176	0.147	-0.008	0.217	-0.012	0.388	-0.044	0.111
Depression score	0.004	0.684	-0.174	0.092	0.325	<0.001***	-0.009	0.041*	-0.24	0.016*	-0.061	0.002**

Adjustment for age, gender and BMI; β standardised coefficient.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ indicate a statistically significant difference.

BMI, body mass index; SMI, appendicular skeletal muscle mass index; SPPB, Short Physical Performance Battery.

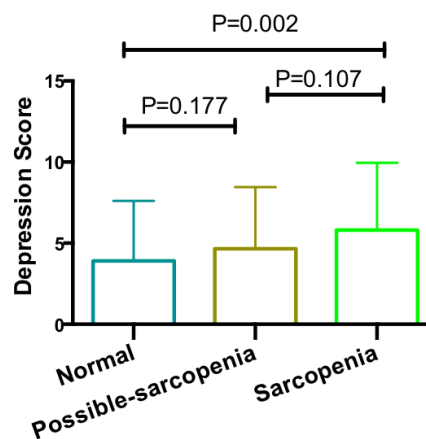


Figure 4 Depression score in different stages of sarcopenia. Normal: n=121; possible-sarcopenia: n=74; sarcopenia: n=55. $p < 0.05$ indicates a statistically significant difference.

terms of gait speed, standing balance test performance and strength of leg muscles, but not with muscle mass. Together, our findings highlight the significance of muscle function in relation to mental health and suggest that exercise-enhanced muscle function may be an effective intervention for depression.

Contributors LC wrote the manuscript. HQ conducted handgrip strength and physical function assessments. YS conducted the DXA. TT performed the statistical analysis. JY did depression assessment for all participants. SL designed the experiments and revised the manuscript. All authors gave final approval of the version to be published.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

Ethics approval The clinical study was approved by the Ethics Committee of the First Affiliated Hospital of Nanjing Medical University, Jiangsu, China, in accordance with the Declaration of Helsinki.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. No additional data are available.

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