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ORIGINAL RESEARCH

The Optimal Cut-off Value of Upper Arm Circumference and Calf Circumference for Assessing Sarcopenia Among Chinese Community-Dwelling Older Adults

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Objective: To explore the cut-off values and health evaluations of upper arm circumference (AC) and calf circumference (CC) on sarcopenia in Chinese community-dwelling older people.

Methods: In this cross-sectional study, AC, CC, handgrip strength, muscle mass and gait speed were measured in 1537 Chinese community-dwelling older people in *Sub-study 1*. Correlation analysis, receiver operator characteristic curve (ROC curve) analysis, and consistency analysis were used for determination of AC and CC cut-off values for sarcopenia diagnosis (sarcopenia-AC and CC). Thereafter, 269 participants accepted additional assessments on physical function, body composition and muscle strength in *Sub-study 2*. *T*-test or Mann-Whitney *U*-test was used to explore the differential effects of sarcopenia-AC and CC on health indicators between sarcopenic and non-sarcopenic participants.

Results: In *Sub-study 1*, the Area Under ROC (AUC) of AC and CC for sarcopenia screening were greater than 0.700 ($P<0.05$). The cut-off values, sensitivity and specificity of AC and CC on sarcopenia in males were 25.9 cm (86.0%, 83.6%) and 33.7 cm (90.7%, 81.4%) whereas in females were 26.5 cm (70.8%, 69.7%) and 33.0 cm (86.5%, 69.4%), respectively. In *Sub-study 2*, the participants with sarcopenia-AC or sarcopenia-CC showed lower muscle strength and lower fat and muscle mass than the ones without ($P<0.05$). Additionally, males instead of females with sarcopenia-AC or sarcopenia-CC showed worse performance in time-up and go test and 6-Minute Walk Test ($P<0.05$). However, the 30-second chair stand test was not different between participants with and without sarcopenia-AC or sarcopenia-CC in both sexes.

Conclusion: We found accurate and Chinese population targeted cut-off values of AC and CC on sarcopenia diagnosis (25.9 cm and 33.7 cm in males; 26.5 cm and 33.0 cm in females) and a good evaluation effect of AC and CC on fat and muscle mass, muscle strength and physical functions in males, not females.

Keywords: sarcopenia, upper arm circumference, calf circumference, health assessment

Introduction

Sarcopenia is becoming increasingly common in older adults due to rapid aging. Globally, more than 120 million older adults are diagnosed with sarcopenia, and the number is expected to double by 2050.[1] Sarcopenia is characterized by declined muscle mass, muscle strength and physical function,[2] which has been classified by WHO as an independent disease with the code ICD-10-CM (M62.84).[3] Sarcopenia significantly increases the risks of health adverse events, including fracture,[4] hospitalization,[5] and all-cause mortality,[6] greatly increasing the healthcare costs and the need for medical resources.[7]

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However, it is almost impossible for sarcopenic older adults to realize their conditions due to no obvious symptoms in the early stages.[8] The common situation is that when they realize their conditions, they are already physically and functionally dependent.[8] Thus, it is imperative to diagnose sarcopenia in the early stages to provide timely interventions. However, certain limitations exist in the equipment diagnosed for sarcopenia (ie computed tomography, magnetic resonance imaging), such as radiation, high costs, and requirement for highly trained personnel.[9] More importantly, the above equipment is not available in many Chinese primary and community hospitals, which are supposed to provide early screening and initial treatment for older adults. Consequently, it is highly important to find a simple, rapid and accurate screening approach for early identification of patients with sarcopenia, especially for countries like China with large population and limited medical resources.

Calf circumference (CC), an inexpensive, non-invasive and easy to be measured indicator,[10] has been used in sarcopenia screening.[10–12] Although CC is widely used in screening for sarcopenia, limited studies are conducted in Chinese community-dwelling older adults, according to a recent scoping review.[13] The screening ability and cut-off values of CC on sarcopenia screening interfere with geographic variations and ethnic differences.[14,15] Thus, accurate and Chinese tailor-made cut-off values of CC on the screening for sarcopenia are essential to identify potential patients with sarcopenia. Although the Asian Working Group for Sarcopenia 2019 (AWGS 2019) has recommended the cut-off values of CC on sarcopenia screening (males: 34 cm; females: 33 cm),[16] some limitations exist in the recommendations[16] and above studies.[10–12] First, many studies, including those referred in the AWGS 2019, did not have the "gold standard" for the diagnosis of sarcopenia, only focusing on low muscle mass,[17,18] which is different from sarcopenia. Second, these studies included middle-aged adults (age 40 years or older), not targeting older adults,[17,18] which leads to the recommended cut-off values that may not be suitable for older adults. Third, these studies were from Canada,[19] Japan,[17] and Korea.[14] Only one study explored the evaluation effect of calf circumference on reduced muscle mass in community-dwelling elderly adults in China.[20] The study found that calf circumference has a good evaluation effect on reduced skeletal muscle index (SMI) in elderly adults in Shanghai. However, the study did not explore its role in screening and diagnosing sarcopenia. In addition, it also pointed out that the evaluation effect of calf circumference on reduced SMI can be influenced by factors such as geography. Overall, the cut-off values of CC screening for sarcopenia in Chinese community-dwelling older adults are still unclear.

In addition to CC, upper arm circumference (AC) is another anthropometric index associated with muscle mass[13] and has good screening performance on sarcopenia in Brazilian older adults[21] and Japanese patients with chronic liver disease.[22] Similar to CC, the screening ability and cut-off values of AC on sarcopenia are influenced by age, gender, region and race.[14] To our best known, there is no study exploring the screening ability of AC on sarcopenia in Chinese community-dwelling older adults.

AC and CC have been used as indicators for nutritional assessment,[23,24] and nutrition plays a crucial role in the development and progression of sarcopenia,[2] thereby affecting the health status of older adults, such as physical function. Therefore, in addition to the early detection of patients with sarcopenia, it is also pivotal to explore the evaluation effects of CC and AC on health assessments among older adults with sarcopenia. This can provide easy and rapid approaches for health evaluations and expand the use of AC and CC in this field.

The objectives of this study were 1) to explore the screening ability and cut-off values of CC and AC on sarcopenia in Chinese community-dwelling older adults and 2) to explore the evaluation effects of AC and CC on health indicators.

Materials and Methods

Overall Trial Design

This is a cross-sectional project, including sub-study 1 being diagnostic research and sub-study 2 correlational research. Firstly, we included a larger population to explore the screening abilities and cut-off values of AC and CC on sarcopenia diagnosis (sarcopenia-AC and sarcopenia-CC) in Chinese community-dwelling older adults (*Sub-study 1*). Thereafter, a portion of participants were invited to have additional health assessments to explore the differential effects of sarcopenia-AC and sarcopenia-CC on health indicators (*Sub-study 2*). Sarcopenia-CC or sarcopenia-AC was defined if the CC or AC of participant was lower than the cut-off value of CC or AC on sarcopenia obtained from *Sub-study 1*.

Sub-Study 1

Participants and Groups

This cross-sectional *sub-study* was conducted from November 2019 to October 2020. A total of 1537 participants were included. The participants were aged 60 years or older, able to stand and willing to participate in this *sub-study*. The exclusion criteria were 1) unable to have BIA measurement due to any reason, including but not limited to the presence of cardiac stents, pacemakers, steel plates, steel nails within the body; 2) unable to communicate; 3) having clinically visible edema.

The participants were randomly divided into the experimental group (EG) or the validation group (VG) at the ratio of 7:3. To avoid data contamination, the characteristics and correlation between muscle indicators and CC or AC were analyzed from the data in the EG.

Sample Sizes

The sensitivity (S_N) of CC screening for sarcopenia in the study of Kawakami et al[17] was referred to calculate the sample size of participants in the EG. The S_N was 88% in males and 76% in females. The permissible Error (d) was 10%, and statistical significance (α) was 0.05. According to the following equation,[25] the required sample size for the EG was 239 males and 413 females.

$$n = \frac{Z^2{}_{\propto/2} \times S_N\ (1 - S_N)}{d^2 \times P}$$

Based on the ratio of 7:3 between the EG and the VG, the required sample size for the VG was 103 males and 177 females. Considering an attribution rate of 20% (eg dropping out during the tests), the total required sample size was 428 males and 738 females.

Measurements

In addition to the demographic data, body composition was measured by bioelectrical impedance analysis (BIA) (Tanita, MC-180, Japan).[26] The included indicators were body mass index (BMI), fat mass, body fat percentage (BFP), fat-free mass (FFM), appendix skeletal muscle mass (ASM) and SMI, which was calculated by ASM (kg)/ Height^2 (m^2).

Handgrip strength was assessed by a hydraulic dynamometer (Jamar, 563213, America).[27] After resting for 5 minutes, the subjects sat in front of the instrument with their torso upright, shoulder joint in a neutral position, and elbow joint at 90 degrees, with the forearm and hip joint in a neutral position. Each hand was tested three times with a 30-second interval between tests and a 1-minute rest between sets. If the coefficient of variation (CV%) across the three sets exceeded 10%, the test was repeated after a 20-minute rest. In this study, the maximum handgrip strength of the dominant hand was adopted.

The 6-m gait was measured by instructing participants to walk a straight line of 10 meters at their usual gait speed, and the time to walk the middle 6 meters was recorded to minimize the bias. CC and AC were both measured by inelastic but flexible measuring tapes without compressing the skin. CC measurement was performed at the largest part of the calf with participants in the seated position and the calf at 90° to the thigh. AC measurement was performed at the midpoint of the acromion and olecranon. CC and AC were both measured twice, and the average results were used.

Diagnosis of Sarcopenia

The AWGS 2019 criteria[16] was the gold standard for sarcopenia as our participants were Chinese older adults. Specifically, sarcopenia was defined as the presence of low SMI (male: <7.0 kg/m^2, female: <5.7 kg/m^2) and low handgrip strength (male: <28 kg, female: <18 kg) or/and low gait speed (<1.0/s).

Sub-Study 2

Participants

Due to better screening ability of CC on sarcopenia than AC, participants with and without sarcopenia-CC were included in *Sub-study 2* at the ratio of 1:1. The exclusion criteria were having severe osteoarthritis or surgeries or other conditions that cannot perform the physical function tests, besides the exclusion criteria of *Sub-study 1*.

Sample Size

With the aim to evaluate the differences between participants with and without sarcopenia-CC or sarcopenia-AC on health indicators, the following equation of comparison between two sample sizes was used in *Sub-study 2*:

$$n_1 = n_2 = 2\left[\frac{(z_\alpha + z_\beta)\sigma}{\delta}\right]^2 + \frac{1}{4}z_\propto{}^2(\alpha = 0.05, \beta = 0.05, Z_{0.05} = 1.645)$$

Handgrip strength was the primary indicator in *Sub-study 2* and the specific values were referred to *Sub-study 1*. In males, the handgrip strengths were 32.23 kg and 25.07 kg for older adults without and with sarcopenia, respectively. Thus, $\delta = 7.16$, $\sigma = 6.41$ and the sample size for males was 24 per group considering 20% drop-out rate. In females, the handgrip strengths were 20.30 kg and 16.96 kg for older adults without and with sarcopenia, respectively. Thus, $\delta = 3.34$, $\sigma = 4.41$ and the sample size for females was 48 per group considering 20% drop-out rate.

Measurements

Regarding demographic data, the following aspects were added to the demographic questionnaire of *Sub-study 1*: living alone, sleep quality, exercise habit, walking with assistant, clinical treatment, weight loss, history of hypertension, diabetes, hyperlipidemia, cardiovascular disease, and sedentary hours. Additionally, nutritional status was assessed using the mini nutritional assessment (MNA).[28]

Based on the definition and diagnostic criteria of sarcopenia, fat and muscle mass, muscle strength, and physical function were assessed. Besides the Measurements in *Sub-study 1*, the additional indicators and measurements were as follows.

Senior fitness tests (SFTs) including the back scratch test (BST), the chair sit and reach test (CSRT), the biceps curl test (BCT), time-up and go test (TUGT), 30-second chair stand test (30 CST), 6-Minute Walk Test (6MWT) were tested based on the standard procedures recommended by Rikli and Jones.[29]

Digital muscle strengths, including hip flexion strength (HFS), knee extension strength (KES), knee flexion strength (KFS), ankle dorsiflexion strength (ADS), elbow flexion strength (EFS) and elbow extension strength (EES), were assessed by MicroFET3 muscle strength tester (FET3, Hoggan, USA). The detailed information about limb position, MicroFET3 placement and required movements for each group of muscle testing are presented in Table S1.[30,31] Before the test, participants were instructed to practice each test with mild effort 1–2 times. During the test, participants were instructed to perform the corresponding movement for each test quickly and with maximum effort. Each test lasted for 3–5 seconds and ended when the dynamometer reading stabilizes. Each group of muscles were tested twice, and the maximum value was recorded.

Statistical Analysis

T-test or Mann-Whitney *U*-test was used for normal or skewedly distributed continuous data, respectively and x^2 or Fisher test was used for categorical data. The correlation between muscle indicators and CC or AC was analyzed by Pearson (for normal distributed data) or Spearman analysis (for skewedly distributed data).

Receiver operating characteristic (ROC) analysis was used to explore the screening ability and cut-off values of CC and AC on sarcopenia. The indicators included sensitivity (S_n), specificity (S_p), AUC with 95% confidence interval, and Youden index (YI). AUC values of 0.5–0.7, 0.7–0.8, 0.8–0.9 and >0.9 were considered presenting low, acceptable, excellent and outstanding accuracy of screening ability.[32] The difference between AUCs was compared by x^2 test. The cut-off values of CC and AC for screening sarcopenia were determined by YI. Positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (LR+), and negative likelihood ratio (LR-) were also calculated.

Statistical analyses were performed with SPSS 23.0 (IBM, Chicago) and Stata 16.0 (Stata Corp, College Station, USA). Two-sided P values <0.05 were considered statistically significant.

Results

Sub-Study 1

Characteristic of Participants

A total of 1537 participants were included with 690 males (44.89%) and 847 females (55.11%) after screening 1681 community-dwelling older people. The prevalence of sarcopenia was 11.58% (males: 8.41%; females: 14.17%, P<0.001). When compared with non-sarcopenic older adults, sarcopenic older adults were older, had less muscle mass (eg ASM, SMI) and fat mass (eg total fat mass, BFP), lower gait speed, lower handgrip strength, smaller AC and CC (P<0.05, Table 1).

Screening Ability and Cut-off Values of AC and CC on Sarcopenia

Shown in Table 2, the AUCs of AC and CC on screening of sarcopenia were statistically significant in males and females and all greater than 0.7 (0.7–0.9, P<0.05). In males, there was no significant difference between the AUCs of AC and the AUCs of CC ($x^2 = 0.56, P = 0.455$) Figure 1A. In females, the AUC of CC was greater than that of AC ($x^2 = 13.78, P<0.001$) Figure 1B. The cut-off values of sarcopenia-CC were 33.7 cm in males ($S_n:\ 90.7\%, S_p:\ 81.4\%$) and 33.0 cm in females ($S_n:\ 86.5\%, S_p:\ 69.4\%$). The cut-off values of sarcopenia-AC were 25.9 cm in males ($S_n:\ 86.0\%, S_p:\ 83.6\%$) and 26.5 cm in females ($S_n:\ 70.8\%, S_p:\ 69.7\%$) Table 2. The PPVs of AC and CC on screening of sarcopenia ranged from 0.283 to 0.343, while the NPVs were all greater than 0.9. The LR+s of AC and CC were greater than 2.0 and the LR- were less than 0.5. The conformity rate of sarcopenia-AC and sarcopenia-CC were all greater than 60% and the Kappa values ranged from 0.241 to 0.416 (P<0.001, Table S2).

The Results of the VG

A total of 461 participants aged 65–90 years (72.30 ± 5.44) with 44.90% (207 males) were included in the VG. The prevalence of sarcopenia-AC and sarcopenia-CC were 17.87% and 31.88% in males, respectively, with the conformity rate with the AWGS 2019 all greater than 60%. In females, the prevalence of sarcopenia-AC and sarcopenia-CC were 35.43% and 42.52%, respectively, with the conformity rate with the AWGS 2019 all greater than 60%. The kappa values in male and female participants were statistically significant (P<0.05, Table S3).

Sub-Study 2

Demographics

A total of 269 participants were included in *Sub-study 2*. In males, participants with sarcopenia-CC were older, had higher rate of living alone, higher prevalence of hypertension and lower score of MNA, compared to participants with non-sarcopenia-CC (P<0.05). In females, participants with sarcopenia-CC had a higher prevalence rate of hypertension and a lower score of MNA (P<0.05, Table 3).

The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Muscle and Fat Mass

As shown in Table 4, participants with sarcopenia-AC or sarcopenia-CC had lower fat and muscle mass indicated by all of 11 indicators included in *Sub-study 2* (eg BMI, total muscle mass), compared to participants without sarcopenia-AC or sarcopenia-CC, respectively (P<0.05). The differentiation effects of sarcopenia-AC and sarcopenia-CC on fat and muscle mass were all consistent with the assessments of sarcopenia-AWGS.

The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Muscle Strength

There were 9 indicators of muscle strength (eg handgrip strength, BCT, HFS), Table 5. Based on the sarcopenia criteria of AC and CC, the muscle strength of sarcopenic older people was significantly lower than their counterparts without sarcopenia indicated by handgrip strength, BCT, EFS, EES, ADS, HFS, KES, and KFS (P<0.05), in both sexes. However, 30 CST showed no difference in either males (P=0.123 and 0.805, respectively) or females (P=0.913 and 0.681, respectively), details in Table 5. The evaluation effects of sarcopenia-AC and sarcopenia-CC on muscle strength were consistent with the assessments of sarcopenia-AWGS in both males and females, except for the evaluation of 30

Table 1 Characteristics of Participants Using the AWGS 2019 Sarcopenia Criteria

Characteristics	Total Population (*n*=1076)		*t*/Z	*P*	Male (*n*=483)		*t*/Z	*P*	Female (*n*=593)		*t*/Z	*P*
	Sarcopenia (*n*=132)	Non-sarcopenia (*n*=944)			Sarcopenia (*n*=43)	Non-sarcopenia (*n*=440)			Sarcopenia (*n*=89)	Non-sarcopenia (*n*=504)		
Age (year)	75.6±6.3	72.0±5.5	−7.017	<0.001	75.4±6.2	71.9±5.4	−4.031	<0.001	75.7±6.3	72.0±5.6	−5.633	<0.001
BMI (kg/m^2)	20.2±2.1	24.2±3.1	18.962	<0.001	19.2±2.0	24.1±2.7	11.641	<0.001	20.7±2.0	24.2±3.4	13.532	<0.001
FFM (kg)	37.2±5.2	44.8±7.9	14.714	<0.001	42.6±4.1	51.9±5.2	11.443	<0.001	34.6±3.3	38.6±3.5	10.068	<0.001
Total fat mass (kg)	12.6±4.8	17.6±6.6	10.679	<0.001	9.7±4.0	15.2±5.4	8.404	<0.001	14.0 (11.2, 16.6)	18.9 (15.0, 23.4)	−7.814	<0.001
Appendicular fat mass (kg)	7.3±3.1	10.1±4.0	9.143	<0.001	5.9±2.6	8.8±3.4	5.579	<0.001	8.0±3.1	11.1±4.2	8.274	<0.001
BFP (%)	24.8±7.8	27.9±8.4	3.887	<0.001	18.0±5.9	22.1±5.7	4.555	<0.001	28.1±6.3	32.8±7.2	5.804	<0.001
Visceral fat content (kg)	1.8 (1.3, 2.5)	2.9 (2.0, 3.9)	−8.884	<0.001	1.7 (1.0, 2.2)	2.9 (2.0, 4.0)	−6.091	<0.001	1.9 (1.3, 2.5)	2.8 (1.9, 3.9)	−6.429	<0.001
Subcutaneous fat content (kg)	10.6±3.9	14.4±5.2	10.174	<0.001	7.9±3.0	12.1±3.9	6.794	<0.001	12.0 (9.8, 14.1)	16.1 (12.9, 19.5)	−8.127	<0.001
Total muscle mass (kg)	35.2±4.9	42.4±7.6	14.619	<0.001	40.3±3.9	49.2±4.9	11.430	<0.001	32.7±3.0	36.4±3.2	10.071	<0.001
Trunk muscle mass (kg)	21.3±2.5	23.9±3.7	10.255	<0.001	23.4±2.1	26.9±2.6	8.213	<0.001	20.2±2.0	21.2±2.0	4.245	<0.001
LUEMM (kg)	1.7±0.4	2.2±0.5	14.415	<0.001	2.1±0.3	2.6±0.3	10.215	<0.001	1.5±0.2	1.8±0.3	11.361	<0.001
LLEMM (kg)	5.3±1.0	7.0±1.6	17.031	<0.001	6.4±0.7	8.4±1.1	16.003	<0.001	4.8±0.5	5.8±0.7	16.065	<0.001
RUEMM (kg)	1.8±0.4	2.5±0.9	15.071	<0.001	2.2±0.4	3.0±0.9	10.446	<0.001	1.6±0.2	2.0±0.6	13.414	<0.001
RLEMM (kg)	5.4±1.0	6.9±1.6	15.556	<0.001	6.5±0.8	8.4±1.2	13.780	<0.001	4.8±0.5	5.7±0.7	13.992	<0.001
ASM (kg)	14.1±2.6	18.6±4.3	16.704	<0.001	17.2±2.0	22.4±3.0	15.600	<0.001	12.7±1.3	15.3±1.8	16.924	<0.001
SMI (kg/m^2)	5.7±0.6	7.2±1.1	23.884	<0.001	6.3±0.5	8.1±0.9	20.444	<0.001	5.4±0.2	6.4±0.6	25.840	<0.001
Waist-to-hip ratio	0.9±0.1	0.9±0.1	7.078	<0.001	0.9±0.1	0.9±0.1	5.888	<0.001	0.9±0.1	0.9±0.0	3.776	<0.001
Handgrip strength (kg)	20.0±6.4	25.8±8.2	9.436	<0.001	25.1±7.2	32.0±7.0	6.201	<0.001	17.5±4.1	20.4±4.5	5.724	<0.001
Gait speed (m/s)	0.9±0.2	1.0±0.2	7.380	<0.001	0.9±0.2	1.1±0.2	4.728	<0.001	0.9±0.2	1.0±0.2	5.522	<0.001
AC (cm)	24.8±2.5	27.7±2.5	12.648	<0.001	23.9±2.6	27.8±2.1	11.290	<0.001	25.2±2.4	27.7±2.8	7.754	<0.001
CC (cm)	31.1±2.0	34.9±2.6	19.365	<0.001	31.2±2.2	35.6±2.3	12.090	<0.001	31.1±1.9	34.2±2.6	13.275	<0.001

Note: Values are presented as mean ± SD/median (interquartile range).

Abbreviations: AWGS, Asian Working Group for Sarcopenia; BMI, body mass index; FFM, fat-free mass; BFP, body fat percentage; LUEMM, left upper extremity muscle mass; LLEMM, left lower extremity muscle mass; RUEMM, right upper extremity muscle mass; RLEMM, right lower extremity muscle mass; ASM, appendix skeletal muscle mass; SMI, skeletal muscle mass index; AC: arm circumference; CC, calf circumference.

Table 2 Screening Ability and Cut-off Values of AC and CC on Sarcopenia in the Experimental Group

Sex	Variable	AUC value	AUC SD	*P*	AUC 95% *CI*		Cut-off value (cm)	S_n (%)	S_p (%)	YI	PPV	NPV	LR+	LR-
					Upper	Lower								
Male	AC	0.906	0.027	<0.001	0.854	0.958	25.9	86.0	83.6	0.697	0.343	0.984	5.224	0.167
	CC	0.930	0.020	<0.001	0.892	0.969	33.7	90.7	81.4	0.721	0.322	0.986	4.188	0.114
Female	AC	0.747	0.027	<0.001	0.694	0.801	26.5	70.8	69.7	0.385	0.283	0.930	2.337	0.419
	CC	0.840	0.020	<0.001	0.801	0.879	33.0	86.5	69.4	0.560	0.332	0.964	2.828	0.195

Abbreviations: AC, arm circumference; CC, calf circumference; AUC, area under curve; SD, standard deviation; CI, confidence interval; S_n, sensitivity; S_p, specificity; YI, Youden index. PPV, positive predictive value; NPV, negative predictive value; LR+, positive likelihood ratio; LR-, negative likelihood ratio.

CST in females. Specifically, female participants with sarcopenia-AC or CC had similar Results on 30 CST to participants without sarcopenia-AC or CC (P=0.913 and 0.681, respectively), which was different from the results that female participants with sarcopenia-AWGS had significantly less 30 CST than those without sarcopenia-AWGS ($P < 0.05$), details in Table 5.

The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Physical Function

A total of five indicators of physical function were included in *Sub-study 2*, Table 6. In males, older adults with sarcopenia-AC had a longer time cost of TUGT and less meters of 6MWT than those without sarcopenia-AC ($P < 0.05$). In addition to the similar results of TUGT and 6MWT, older males with sarcopenia-CC had greater gait speed than those without sarcopenia-CC (P<0.05). The evaluation effects of sarcopenia-CC on physical functions were consistent with the assessments of sarcopenia-AWGS in male participants, while not the evaluation of gait speed based on sarcopenia-AC. In females, none of the five indicators of physical function had statistically significant (P>0.05) based on either sarcopenia-AC or sarcopenia-CC, which was different from the evaluation on CSRT and 6MWT based on sarcopenia-AWGS. The female participants with sarcopenia-AWGS had longer CSRT and less distance of 6MWT than those without sarcopenia-AWGS (P<0.05).

Discussion

This study provided the accurate and Chinese population targeted cut-off values of AC and CC on screening for sarcopenia (25.9 cm and 33.7 cm in males; 26.5 cm and 33.0 cm in females, respectively). In addition, we found that

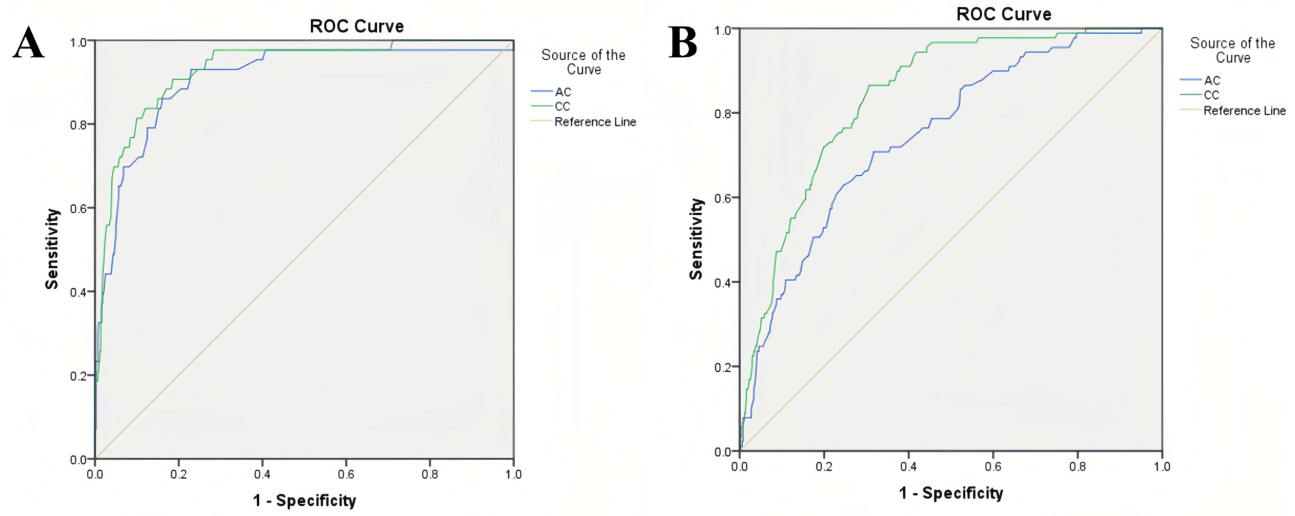

Figure 1 ROC Curves of AC and CC on the Screening of Sarcopenia in the Older People (**A**) Male; (**B**)Female. The areas under the green and blue curves presented the screening abilities of AC and CC screening for sarcopenia in older males, respectively. The yellow line was the reference line and the area under the yellow line was 0.5. The green and blue line were above the yellow line, which mean that areas under the curves of AC and CC in older males and females were greater than 0.5.
Abbreviations: AC, arm circumference; CC, calf circumference; ROC, receiver operating characteristic.

Table 3 Demographic Data of Participant in Sub-Study 2

Variables	Male		t/x^2	*P*	Female		t/x^2	*P*
	Sarcopenia-CC	Non-sarcopenia-CC			Sarcopenia-CC	Non-sarcopenia-CC		
Age (year)	75.7±6.5*	72.3±5.6	2.818	0.006	73.5±6.4	71.6±5.8	1.946	0.053
Education level								
Primary school and below	11(27.50)	13(22.41)	0.817	0.665	50(53.19)	32(50.79)	1.439	0.487
Middle school	17(42.50)	30(51.72)			35(37.23)	21(33.33)		
High school and above	12(30.00)	15(25.87)			9(9.58)	10(15.88)		
Living alone								
Yes	9(22.50)*	3(5.20)	5.100	0.010	29(30.21)	12(18.18)	2.993	0.084
No	31(77.50)	55(94.80)			67(69.79)	54(81.82)		
Sleep quality								
Good	20(50.00)	38(65.52)	2.463	0.292	52(54.17)	30(45.45)	2.828	0.243
Average	11(27.50)	10(17.24)			17(17.71)	19(28.79)		
Bad	9(22.50)	10(17.24)			27(28.12)	17(25.76)		
Regular exercise								
Yes	27(67.50)	44(75.86)	0.829	0.362	63(65.63)	51(77.27)	2.545	0.111
No	13(32.50)	14(24.14)			33(34.37)	15(22.73)		
Walking with assistant								
Yes	0(0.00)	2(3.40)	1.408	0.235	4(4.21)	3(4.55)	0.702	0.704
No	40(100.00)	56(96.60)			91(95.79)	63(95.45)		
Injury								
Yes	9(22.50)	6(10.34)	2.698	0.100	17(17.71)	12(18.18)	0.006	0.938
No	31(77.50)	52(89.66)			79(82.29)	54(81.82)		
Clinical treatment								
Yes	8(20.00)	13(22.81)	0.109	0.741	12(12.77)	10(15.38)	0.221	0.638
No	32(80.00)	44(77.19)			82(87.23)	55(84.62)		
Weight loss								
Yes	10(25.00)	8(13.79)	1.983	0.159	21(21.88)	12(18.18)	0.329	0.566
No	30(75.00)	50(86.21)			75(78.12)	54(81.82)		
Hypertension								
Yes	17(42.50)*	39(67.24)	5.917	0.015	43(45.26)#	40(61.54)	4.095	0.043
No	23(57.50)	19(32.76)			52(54.74)	25(38.46)		
Diabetes								
Yes	6(15.38)	16(27.59)	1.980	0.159	18(19.15)	7(10.77)	2.036	0.154
No	33(84.62)	42(72.41)			76(80.85)	58(89.23)		
Hyperlipidemia								
Yes	6(15.00)	9(15.79)	0.011	0.916	12(12.63)	12(18.75)	1.117	0.291
No	34(85.00)	48(84.21)			83(87.37)	52(81.25)		
CVD history								
Yes	16(40.00)	20(33.90)	0.384	0.536	31(31.63)	26(38.81)	0.906	0.341
No	24(60.00)	39(66.10)			67(68.37)	41(61.19)		
Sedentary hours per day (h)	3.3±2.0	3.4±1.5	−0.211	0.833	3.6±1.5	3.5±1.4	0.407	0.685
MNA score	23.9±3.2**	26.8±2.4	−5.213	<0.001	24.3±2.5##	25.9±2.8	−3.576	<0.001

Notes: Values are presented as mean ± SD or number (percentage %). *P<0.05 in males; **P<0.01 in males; #P<0.05 in females; ##P<0.01 in females.
Abbreviations: CC, calf circumference; CVD, cardiovascular disease; MNA, mini nutritional assessment.

AC and CC were able to distinguish the differences in muscle mass, fat mass, and physical function between males with and without sarcopenia-AC or sarcopenia-CC, but not the physical function of females. Our study provides efficient and population-tailored evidence on the use of AC and CC in the screening and health evaluation of sarcopenia in Chinese community-dwelling older people.

This study has demonstrated that AC and CC both have excellent screening abilities on sarcopenia (AUC≥0.7) in Chinese community-dwelling older people, which has been further confirmed by the data in the VG with the conformity rates between sarcopenia-AC/CC and sarcopenia-AWGS all greater than 60%. AC and CC are noninvasive, inexpensive and easily assessed,[33] which are feasible to use in facilities and community health service centers, especially for countries

Table 4 The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Fat and Muscle Masses

Sex	Variable	AC Criteria		t	P	CC Criteria		t	P	AWGS Criteria		t	P
		Sarcopenia	Non-Sarcopenia			Sarcopenia	Non-Sarcopenia			Sarcopenia	Non-Sarcopenia		
Male	BMI (kg/m^2)	19.8±2.3	24.6±2.8	−8.989	<0.001	19.7±2.1	24.9±2.5	−10.880	<0.001	19.5±2.0	24.7±2.6	−10.475	<0.001
	FFM (kg)	43.7±5.3	52.5±5.4	−8.041	<0.001	43.8±5.4	52.7±5.0	−8.709	<0.001	43.4±5.1	52.5±5.3	−8.411	<0.001
	Total fat mass (kg)	9.6±3.6	16.0±5.9	−6.798	<0.001	8.9±3.5	16.9±5.1	−9.311	<0.001	8.7±3.5	16.5±5.2	−8.089	<0.001
	Total muscle mass (kg)	41.4±5.0	49.7±5.1	−8.031	<0.001	41.5±5.1	50.1±4.8	−8.702	<0.001	41.1±4.9	49.8±5.0	−8.392	<0.001
	BFP (%)	17.7±5.0	22.8±6.1	−4.324	<0.001	16.6±5.4	23.8±4.9	−6.929	<0.001	16.4±5.6	23.5±4.9	−6.578	<0.001
	ASM (kg)	17.5±2.9	22.6±3.1	−8.204	<0.001	17.1±2.1	23.1±2.9	−12.106	<0.001	16.9±2.0	22.9±3.0	−11.885	<0.001
	SMI (kg/m^2)	6.5±0.8	8.1±1.0	−8.902	<0.001	6.4±0.6	8.3±0.9	−12.640	<0.001	6.3±0.5	8.2±0.9	−11.283	<0.001
	LUEMM (kg)	2.1±0.3	2.6±0.4	−7.852	<0.001	2.1±0.3	2.7±0.3	−9.011	<0.001	2.1±0.3	2.6±0.4	−8.513	<0.001
	LLEMM (kg)	6.6±1.2	8.6±1.2	−7.962	<0.001	6.4±0.9	8.8±1.2	−11.154	<0.001	6.3±0.8	8.7±1.2	−11.712	<0.001
	RUEMM (kg)	2.2±0.4	2.7±0.4	−6.155	<0.001	2.2±0.3	2.8±0.4	−8.797	<0.001	2.1±0.3	2.8±0.4	−8.902	<0.001
	RLEMM (kg)	6.6±1.2	8.7±1.3	−8.145	<0.001	6.4±0.8	8.9±1.2	−12.180	<0.001	6.4±0.8	8.7±1.3	−11.556	<0.001
Female	BMI (kg/m^2)	20.5±2.0	24.7±3.0	−10.328	<0.001	20.8±2.2	24.6±3.2	−8.550	<0.001	20.6±2.1	23.8±3.4	−7.408	<0.001
	FFM (kg)	35.5±3.7	39.0±4.1	−5.959	<0.001	35.2±3.7	39.8±3.4	−8.144	<0.001	34.7±3.1	39.0±4.1	−7.608	<0.001
	Total fat mass (kg)	12.6±3.9	21.0±5.7	−10.905	<0.001	13.3±4.4	20.8±6.2	−8.653	<0.001	14.0±5.0	18.2±6.7	−4.646	<0.001
	Total muscle mass (kg)	33.5±3.4	36.8±3.7	−5.954	<0.001	33.3±3.4	37.5±3.2	−8.131	<0.001	32.8±2.8	36.7±3.7	−7.590	<0.001
	BFP (%)	25.8±6.5	34.5±5.8	−9.048	<0.001	27.0±6.9	33.7±6.6	−6.364	<0.001	28.2±7.2	31.0±7.6	−2.504	0.013
	ASM (kg)	13.2±1.6	15.4±2.3	−6.994	<0.001	13.1±1.5	15.9±2.1	−10.070	<0.001	12.6±1.2	15.5±2.1	−10.963	<0.001
	SMI (kg/m^2)	5.6±0.5	6.3±0.8	−6.484	<0.001	5.6±0.5	6.5±0.8	−7.790	<0.001	5.4±0.3	6.4±0.7	−13.705	<0.001
	LUEMM (kg)	1.5±0.2	1.8±0.4	−6.667	<0.001	1.5±0.2	1.9±0.3	−8.586	<0.001	1.5±0.2	1.8±0.3	−7.596	<0.001
	LLEMM (kg)	5.0±0.7	5.7±0.8	−6.308	<0.001	4.9±0.6	5.9±0.7	−9.686	<0.001	4.8±0.5	5.8±0.7	−10.602	<0.001
	RUEMM (kg)	1.6±0.2	2.1±1.0	−3.807	<0.001	1.7±0.5	2.0±0.9	−3.501	<0.001	1.6±0.2	2.0±0.9	−3.811	<0.001
	RLEMM (kg)	5.1±0.7	5.8±0.9	−6.181	<0.001	5.0±0.6	6.0±0.7	−10.307	<0.001	4.8±0.47	5.9±0.8	−10.820	<0.001

Note: Values are presented as mean ± SD.

Abbreviations: AC, arm circumference; CC, calf circumference; AWGS, Asian Working Group for Sarcopenia; BMI, body mass index; FFM, fat-free mass; BFP, body fat percentage; ASM, appendix skeletal muscle mass; SMI, skeletal muscle mass index; LUEMM, left upper extremity muscle mass; LLEMM, left lower extremity muscle mass; RUEMM, right upper extremity muscle mass; RLEMM, right lower extremity muscle mass.

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Table 5 The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Muscle Strength

Sex	Variable	AC criteria		*t*	*P*	CC criteria		*t*	*P*	AWGS criteria		*t*	*P*
		Sarcopenia	Non-sarcopenia			Sarcopenia	Non-sarcopenia			Sarcopenia	Non-sarcopenia		
Male	Handgrip strength (kg)	26.4±7.0	32.3±5.9	−4.532	<0.001	27.4±6.7	32.0±6.4	−3.452	0.001	26.1±6.6	32.5±6.0	−4.970	<0.001
	BCT (n)	16.9±4.0	21.4±5.2	−4.477	<0.001	17.2±4.0	21.5±5.3	−4.639	<0.001	16.7±3.5	21.5±5.3	−5.410	<0.001
	30CST (n)	14.5±3.8	15.8±4.5	−1.555	0.123	15.2±4.4	15.4±4.3	−0.248	0.805	14.7±4.3	15.7±4.3	−1.160	0.249
	EFS (kg)	16.5±3.0	21.1±4.9	−5.788	<0.001	16.5±3.1	21.4±4.7	−6.354	<0.001	15.9±2.8	21.5±4.5	−7.600	<0.001
	EES (kg)	12.6±2.2	16.7±3.2	−7.593	<0.001	12.9±2.5	16.8±3.3	−6.613	<0.001	12.5±2.1	16.7±3.3	−6.980	<0.001
	ADS (kg)	13.1±3.3	17.5±3.3	−6.416	<0.001	13.4±3.1	17.6±3.5	−6.111	<0.001	13.0±3.0	17.6±3.3	−7.040	<0.001
	HFS (kg)	16.5±4.8	23.5±6.3	−5.793	<0.001	16.9±4.9	23.7±6.4	−5.758	<0.001	16.0±4.4	23.8±6.1	−6.830	<0.001
	KES (kg)	19.3±4.5	25.6±6.0	−5.528	<0.001	19.5±4.7	25.9±5.8	−5.874	<0.001	18.9±4.2	25.9±5.8	−6.420	<0.001
	KFS (kg)	13.3±2.8	17.8±3.4	−6.720	<0.001	13.5±3.0	17.9±3.3	−6.800	<0.001	13.1±2.9	17.9±3.2	−7.390	<0.001
Female	Handgrip strength (kg)	18.7±4.4	20.5±4.7	−2.482	0.014	18.7±4.1	20.8±4.9	−2.977	0.003	17.9±3.9	20.9±4.7	−4.396	<0.001
	BCT (n)	16.7±3.7	18.0±4.0	−2.114	0.036	16.7±3.6	18.1±4.2	−2.246	0.026	16.2±3.1	18.1±4.3	−3.285	0.001
	30 CST (n)	14.5±3.7	14.4±3.9	0.109	0.913	14.4±3.3	14.6±4.3	−0.413	0.681	13.8±2.8	15.0±4.3	−2.042	0.043
	EFS (kg)	12.1±3.0	14.0±4.1	−3.262	0.001	12.1±3.1	14.1±4.1	−3.324	0.001	11.4±2.5	14.2±4.0	−5.339	<0.001
	EES (kg)	9.6±2.5	11.4±3.1	−4.176	<0.001	9.6±2.3	11.5±3.3	−3.952	<0.001	9.3±1.9	11.3±3.2	−5.023	<0.001
	ADS (kg)	11.6±2.3	13.5±3.5	−3.979	<0.001	11.8±2.3	13.4±3.7	−3.197	0.002	11.7±1.9	13.1±3.7	−2.982	0.003
	HFS (kg)	12.1±3.6	14.8±4.6	−4.019	<0.001	12.1±3.3	15.0±4.9	−4.131	<0.001	11.8±2.5	14.6±5.0	−4.430	<0.001
	KES (kg)	16.0±4.1	18.4±5.0	−3.373	0.001	15.9±4.2	18.7±4.8	−3.936	<0.001	15.4±3.3	18.4±5.1	−4.467	<0.001
	KFS (kg)	10.6±2.8	12.6±3.2	−4.182	<0.001	10.6±2.9	12.8±3.1	−4.586	<0.001	10.5±2.4	12.4±3.5	−4.045	<0.001

Note: Values are presented as mean ± SD.

Abbreviations: AC, arm circumference; CC, calf circumference; AWGS, Asian Working Group for Sarcopenia; BCT, the Biceps Curl Test; 30CST, 30-second Chair Stand Test; EFS, Elbow flexion strength; EES, Elbow extension strength; ADS, Ankle dorsiflexion strength; HFS, Hip flexion strength; KES, Knee extension strength; KFS, Knee flexion strength.

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Table 6 The Evaluation Effects of Sarcopenia-AC and Sarcopenia-CC on Physical Function

Sex	Variable	AC Criteria		t	P	CC Criteria		t	P	AWGS Criteria		t	P
		Sarcopenia	Non-Sarcopenia			Sarcopenia	Non-Sarcopenia			Sarcopenia	Non-Sarcopenia		
Male	Gait speed (m/s)	1.0±0.2	1.0±0.2	−1.116	0.269	1.0±0.2	1.1±0.2	−2.560	0.012	0.9±0.2	1.1±0.2	−3.080	0.003
	TUGT (s)	8.0±2.4	7.0±1.4	2.335	0.023	7.9±2.3	7.0±1.5	2.219	0.029	8.0±2.3	7.0±1.5	2.590	0.011
	BST (cm)	−6.6±7.9	−9.9±10.1	1.689	0.094	−6.5±8.1	−10.2±10.0	1.981	0.050	−6.5±8.2	−10.0±9.9	1.800	0.074
	CSRT (cm)	−7.3±7.0	−5.5±8.4	−1.074	0.285	−7.1±6.8	−5.6±8.6	−0.942	0.349	−7.2±7.0	−5.6±8.4	−0.990	0.323
	6MWT (m)	449.3±85.7	485.7±71.3	−2.279	0.025	449.7±86.6	487.9±68.8	−2.442	0.016	433.8±79.0	495.0±69.4	−4.030	<0.001
Female	Gait speed (m/s)	0.9±0.2	0.9±0.2	−1.070	0.286	0.9±0.2	0.9±0.2	−1.776	0.078	0.9±0.2	0.9±0.2	−0.730	0.466
	TUGT (s)	7.9±2.6	8.2±2.7	−0.742	0.459	8.1±2.7	8.0±2.5	0.302	0.763	8.0±2.7	8.1±2.6	−0.170	0.865
	BST (cm)	−4.5±7.3	−6.8±8.4	1.853	0.066	−5.2±7.2	−6.1±8.8	0.703	0.483	−4.8±7.5	−6.2±8.2	1.129	0.261
	CSRT (cm)	−2.9±7.1	−2.3±5.2	−0.618	0.537	−2.9±6.9	−2.3±5.5	−0.594	0.553	−3.8±6.0	−1.6±6.4	−2.187	0.030
	6MWT (m)	449.2±74.7	440.3±77.1	0.727	0.468	441.7±67.3	450.1±86.3	−0.657	0.513	432.0±57.9	456.4±86.8	−2.090	0.038

Note: Values are presented as mean ± SD.

Abbreviations: AC, arm circumference; CC, calf circumference; AWGS, Asian Working Group for Sarcopenia; TUGT, Time-Up and Go Test; BST, the Back Scratch Test; CSRT, the Chair Sit and Reach Test; 6MWT, 6-Minute Walk Test.

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with large population and limited medical resource in primary or community hospitals, like China. Similarly, Esteves et al[21] investigating Brazilian community of older people and Nishikawa et al[22] including Japanese patients with chronic liver disease, have found that AC has a good screening ability on sarcopenia with AUCs greater than 0.7 in both sexes. However, the cut-off values of AC screening for sarcopenia are different from ours. These studies have indicated that the cut-off values were 27 cm both for males and females,[21,22] which is higher than our study (25.9 cm for males, 26.5 cm for females). Currently, there are few studies related to AC in sarcopenia screening, and to our best knowledge, no studies have been found in the Chinese community-dwelling older adults. However, one study has found that the cut-off value of AC for the diagnosis of malnutrition is 24 cm in Chinese inpatients.[24] Malnutrition is closely associated with the development of sarcopenia,[2] which indirectly proves the value of the application of AC in the screening of sarcopenia. However, more studies are needed to find the optimal cut-off values of AC on sarcopenia screening, especially in different regions.

Similar to this study, these studies investigating community older adults in Indonesia[34] and Brazil,[21] older adults with walking dysfunction in Taiwan[35] and middle-aged and older Japanese men and women[17] have found that CC has good screening ability for sarcopenia with AUCs greater than 0.7. However, the optimal cut-off values of CC screening for sarcopenia vary in different populations, with a greater variation in cut-off values in women (29–33 cm) and a smaller variation in men (33–34 cm). The different cut-off values further demonstrated that the use of CC screening for sarcopenia interferes with populations and regions[14,15] and it is necessary to explore the accurate and Chinese population-targeted cut-off values due to limited studies in Chinese community-dwelling older people. We also explored the screening abilities of multiple factors (ie BMI, age, gait speed, handgrip strength) and found that the AUCs of multiple factors were similar to those of CC in both sexes while higher than that of AC in females, details in Table S4.

Sex differences in the screening abilities and variations in the cut-off values of AC and CC for sarcopenia may be related to higher adiposity (especially the subcutaneous fat) and greater individual variability in women compared to men.[36] This further underscores the need to determine optimal cut-off values for different populations, especially for females. Regarding the better screening ability of CC compared to AC in females, the reason may be that the screening ability of AC for sarcopenia is more likely influenced by subcutaneous fat than CC, as the muscle mass of the upper arm is less than that of the calf.[37]

Based on the results of *Sub-study* 1, which have shown that AC and CC have excellent screening abilities on sarcopenia, we further explored the evaluation effects of sarcopenia-AC and sarcopenia-CC on health outcomes in Chinese community-dwelling older people. We have found that sarcopenia-AC and sarcopenia-CC are able to distinguish the differences in fat mass, muscle mass and physical function between males with and without sarcopenia but not physical function of females. In line with our study, studies also have found that physical function was significantly associated with sarcopenia-CC and sarcopenia-AWGS in males but not in females.[33,38] One explanation is that physical function of females may be more related to fat mass (especially the intramuscular fat mass)[39] and muscle quality,[40] instead of muscle mass. For example, one study[39] has reported that physical function of females was significantly associated with intramuscular fat, whereas in males, it was associated with muscle mass. These results suggest that we should pay special attention to obesity or fat mass in older females to prevent the further decline of their physical function. Besides, we also found that limited studies evaluate the body flexibility, which is crucial to maintain the body postures and mobility and are associated with muscle mass and muscle endurance.[41] A comprehensive assessment of physical function, including flexibility, in patients with sarcopenia is important to maintain their holistic physical health.

Regarding muscle strength, we have found that sarcopenia-AC and sarcopenia-CC had good differentiation effects on muscle strength indicators except for the number of 30 CST in both males and females. The reason may be that although the 30 CST is a simple method for assessing muscle strength, study has shown that its test results can be influenced by a variety of factors, such as co-morbidities, cognitive impairment, and physical inactivity.[42] The relationship between these factors and sarcopenia is not clear, thus leading to the poor assessment of sarcopenia-AC and sarcopenia-CC on 30 CST in this population.

Limitation

First, although the relatively large number of participants, the specific targeted population and the "gold standard" guarantee the accuracy of results of this study, we did not explore the effect of obesity on the screening abilities and cut-off values of AC and CC on sarcopenia as the prevalence of obesity (BMI $\geq$ 28.0kg/m^2, 8.72%) was relatively low in our study. Second, despite that the validation in the VG ensures the reliability and robustness of results of this study, the generalization of the cut-off values needs to be validated in other regions, populations or ethnic groups. Third, our study is a cross-sectional study and the predictive effects of sarcopenia-AC and sarcopenia-CC on health outcomes still need to be explored. Lastly, as older adults with edema were excluded from our study, the usage of AC and CC on the screening of sarcopenia in such population needs further explanation.

Conclusions

Our study has provided the accurate and population-targeted cut-off values of AC and CC screening for sarcopenia in Chinese community-dwelling older people (25.9 cm and 33.7 cm in males; 26.5 cm and 33.0 cm in females) and found that sarcopenia-AC and sarcopenia-CC have good evaluation effects on health assessments in older males. The results of this study provide clinical professions, especially these in Chinese primary or community hospitals, the precise and tailor-made tools for screening of sarcopenia and simple approaches to health assessments of sarcopenia on older adults of the community.

Abbreviations

AC, arm circumference; ADS, Ankle dorsiflexion strength; ASM, appendix skeletal muscle mass; AUC, area under curve; AWGS, Asian Working Group for Sarcopenia; BCT, the Biceps Curl Test; BMI, body mass index; BFP, body fat percentage; BST, the Back Scratch Test; CC, calf circumference; CI, confidence interval; CSRT, the Chair Sit and Reach Test; EES, Elbow extension strength; EFS, Elbow flexion strength; FFM, fat-free mass; HFS, Hip flexion strength; KES, Knee extension strength; KFS, Knee flexion strength; LLEMM, left lower extremity muscle mass; LUEMM, left upper extremity muscle mass; LR+, positive likelihood ratio; LR-, negative likelihood ratio; LUEMM, left upper extremity muscle mass; MNA, mini nutritional assessment; NPV, negative predictive value; PPV, positive predictive value; RLEMM, right lower extremity muscle mass; ROC, receiver-operating characteristic; RUEMM, right upper extremity muscle mass; SD, standard deviation; SMI, skeletal muscle mass index; TUGT, Time-Up and Go Test; YI, Youden index; 30CST, 30-second Chair Stand Test; 6MWT, 6-Minute Walk Test.

Data Sharing Statement

In an attempt to preserve the privacy of individuals, clinical data will not be shared; the data can be available from the corresponding author on reasonable request authors upon request.

Ethics Approval and Consent to Participate

All participants were fully informed about the research purpose and characteristics before they provided signed consent. Ethical approval was granted from the Ethics Committee of Soochow University (ECSU-2019000161). This study conformed to the standards of the Declaration of Helsinki and was registered with Chinese Clinical Trial Registry (ChiCTR1900027960).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically

reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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