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Assessment of Skeletal Muscle Mass in Older People: Comparison Between 2 Anthropometry-Based Methods and Dual-Energy X-ray Absorptiometry

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A B S T R A C T

Objectives: Sarcopenia is a common geriatric syndrome, whose diagnosis implies the assessment of muscle mass. Dual-energy x-ray absorptiometry (DXA) is the reference method for clinical practice, but it is not universally available. We compared DXA with 2 anthropometry-based methods to assess muscle mass in older adults.
Design: Cross-sectional.
Setting: Ambulatory patients.
Participants: 148 (87 female and 61 male) white older adults.
Measurements: Mid-arm muscle circumference (MAMC), whole skeletal muscle mass estimated by the Lee's formula (eTSMM), and relative skeletal muscle index (RSMI).
Results: Men and women did not differ for MAMC and RSMI, whereas eTSMM was higher ($P < .001$) in men. MAMC and eTSMM correlated with RSMI, in the whole sample as in men and women separately ($P < .001$). According to the McNemar test, the frequencies of older men and women with low muscle mass identified by eTSMM did not differ from those detected by RSMI ($P = .066$) at variance with MAMC. Using EWGSOP (European Working Group on Sarcopenia in Older People) criteria for RSMI as standard reference, the receiver operating characteristic (ROC) curves provided redefined cut-offs of reduced muscle mass: 18.6 cm in women and 22.3 cm in men for MAMC, and 17.7 kg in women and 28.3 kg in men for eTSMM. The areas under the ROC curves (AUCs) for MAMC were 0.882 in women (sensitivity 89%, specificity 84%) and 0.826 in men (sensitivity 94%, specificity 67%). The AUCs for eTSMM were 0.8913 in women (sensitivity 95%, specificity 81%) and 0.878 in men (sensitivity 97%, specificity 67%). No significant difference was found between the ROC curves of MAMC and eTSMM in both sexes.
Conclusion: Two simple anthropometric methods, possibly used in every clinical setting, could be valuable screening tools for low muscle mass in older subjects.

Sarcopenia is defined as a low skeletal muscle mass, associated with poor muscle strength and/or physical performance.[1] It is associated with limited mobility,[2] increased risk of fall,[3] decreased quality of life,[4] and higher risk of hospitalization[5] and mortality.[6]

The current diagnostic criteria for sarcopenia[1] consist of low muscle mass, associated with low muscle strength and/or low physical performance. Low muscle mass alone is defined as pre-sarcopenia by EWGSOP (European Working Group on Sarcopenia in Older People) criteria,[1] and it is not sufficient for the diagnosis of sarcopenia because muscle mass and strength do not decrease proportionally with age and muscle mass measurement does not fully capture functionality.

The authors declare no conflicts of interest.

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However, according to current criteria, the estimate of muscle mass is an essential part of the diagnostic workup.

Because of the high prevalence of sarcopenia among older adults, growing attention is paid to simple and cheap methods to estimate muscle mass. Among the imaging technologies, both computed tomography and magnetic resonance imaging (MRI) are currently considered the gold standard in research settings, being capable to distinguish different tissue, and fat infiltration into the muscle. However, both techniques are expensive and not universally available, determine high radiation exposure (eg, computed tomography), and require a long time for total body scan (eg, MRI). These characteristics limit their widespread use in clinical practice, particularly in older people. Dual-energy x-ray absorptiometry (DXA), although unable to assess intramuscular fat infiltration, is a low-radiation, accurate, and reproducible technique,[7] and has become the imaging procedure of choice to assess appendicular muscle mass in clinical research and practice.[1]

However, many clinicians have no access to DXA devices, and as a result, anthropometric measurements are still widely used to assess skeletal muscle.[8] Among such measurements, mid-arm muscle circumference (MAMC) has been widely used to assess muscle mass in large samples of older people.[9] An alternative approach comes from the accurate measurement of total skeletal muscle mass by MRI and the setting up of a predictive equation to estimate muscle mass from anthropometric parameters.[10] Our study was aimed to investigate whether such anthropometric measurements may identify low skeletal muscle mass, and their possible use as diagnostic or screening tools, in older men and women. For this purpose, we compared MAMC and an equation-based estimate of muscle mass with the results of DXA assessment in a sample of older adults.

Methods

We investigated 148 (87 female and 61 male) white older adults (aged ≥65 years) consecutively enrolled in an ongoing study from our group. Subjects reporting rapid weight gain or loss in the last 6 months or with acute illnesses and endocrine, water and electrolyte, or neoplastic disorders were excluded. In particular, we excluded patients with severe heart failure, liver cirrhosis, or renal failure, whose body weight and composition could be affected by fluid retention. A total of 103 (52 female and 51 male) healthy subjects, aged 18 to 54 years (mean ± standard deviation 35.8 ± ±9.5 years), were used as a reference sample only to derive normative data for anthropometric parameters. The study was approved by the local ethics committee, and subjects gave written informed consent. Height was measured by a standard stadiometer and weight by a calibrated bathroom scale. Body mass index was calculated as weight (in kilograms) divided by squared height (in meters).

Anthropometry-Based Parameters

To calculate MAMC, the mid-arm circumference of the dominant arm was measured by a nonstretch plastic tape. Triceps skinfold thickness was measured using a conventional skinfold calliper. MAMC was then calculated by the formula[9]:

$$\text{MAMC (cm)} = \text{mid} - \text{arm circumference(cm)} - (3.14 \times \text{triceps skinfold thickness})$$

The estimated total body skeletal muscle mass (eTSMM) was calculated through the Lee formula, derived from whole-body MRI scans of subjects aged 20 to 81 years[10]:

$$\text{eTSMM(kg)} = 0.244 \times \text{body weight (kg)} + 7.80 \times \text{height (m)} + 6.6 \times \text{sex (female} = 0,\ \text{male} = 1) - 0.098 \times \text{age (years)} + \text{race (Asian} = -2.0,\ \text{African Americans} = 1.1,\ \text{white or Hispanics} = 0) - 3.3$$

DXA Measurements

In older adults only, a whole-body scan was performed using a new-generation DXA device (Lunar iDXA, GE Healthcare, Madison, WI; enCORE 2011 software, v.13.6), as reported,[11] to measure the relative skeletal muscle index (RSMI) (obtained by dividing the nonbone and nonfat mass of the limbs for squared height). Low appendicular muscle mass was defined on the basis of RSMI values lower than 7.26 in men and 5.5 in women, according to the EWGSOP criteria.

Statistical Analysis

Descriptive statistics of quantitative variables are expressed as mean ± standard deviation and qualitative variables (low muscle mass yes/no) as absolute and relative (%) frequencies. After normality testing by the test of Kolmogorov-Smirnov, mean comparisons were made using unpaired *t* test or Mann-Whitney test, as appropriate. Associations between variables were tested by Spearman correlation, and Fisher transform was used to compare correlation coefficients. For MAMC and eTSMM, cut-offs for low muscle mass were calculated using young adults data and were equal to 2 standard deviations below the reference mean for the young. For DXA-obtained RSMI values, the cut-off points fixed by EWGSOP for men and women were used (see above).[1] The frequencies of low muscle mass cases identified through MAMC, eTSMM, and RSMI were compared using the McNemar test. Thereafter, the cut-off thresholds for low skeletal muscle mass estimated by MAMC and eTSMM in older men and women were redefined using the EWGSOP criteria for RSMI as reference standard. The redefined cut-offs for MAMC and eTSMM were obtained from the highest sensitivity + specificity values in the receiver operating characteristic (ROC) curve. The areas under the ROC curve, indicating the probability of discriminating low muscle mass, were compared using the DeLong test. The level of significance was set at $P < .05$.

Results

The descriptive statistics of the main parameters of older people are presented in Table 1. Men and women did not significantly differ for age and weight, whereas body mass index was significantly higher in older women, men being significantly taller. Women also had higher fat mass and lower lean mass than men (data not shown). No

Table 1
Main Parameters of the Investigated Subjects

	Old Subjects (n = 148)	Old Men (n = 61)	Old Women (n = 87)
Age, y	76.0 ± 6.7	76.2 ± 6.6	75.9 ± 6.8
Weight, kg	72.5 ± 18.8	73.4 ± 20.2	71.9 ± 17.9
Height, m	1.60 ± 8.5	1.67 ± 6.5	1.56 ± 6.6*
BMI	28.6 ± 6.5	27.3 ± 6.7	29.6 ± 6.3†
MAMC, cm	20.7 ± 4.3	20.3 ± 4.5	21.1 ± 4.1
eTSMM, kg	22.2 ± 6.3	26.7 ± 5.3	19.0 ± 4.7*
RSMI	6.9 ± 1.5	7.2 ± 1.7	6.8 ± 1.3

BMI, body mass index.
RSMI was measured by DXA only in older subjects.
*$P < .001$ vs age-matched male subjects.
†$P < .05$ vs age-matched male subjects.