Clinical Nutrition Open Science 43 (2022) 20–27

Contents lists available at ScienceDirect

Clinical Nutrition Open Science

journal homepage: www.clinicalnutritionopenscience.com

Original Article

# Calf circumference as a predictor of skeletal muscle mass in postmenopausal women

Patrícia Paula da Fonseca Grili [a], Melyna Freire Ribeiro Marim [b], Ana Carolina Ceolin Comério [b], Glenda Blaser Petarli [c], Geise Ferreira da Cruz [b], José Luiz Marques-Rocha [a, b], Valdete Regina Guandalini [a, b, *]

[a] *Postgraduate Program in Nutrition and Health, Health Sciences Center, Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil*
[b] *Department of Integrated Education, Health Sciences Center, Federal University of Espírito Santo, Vitória, Espírito Santo, Brazil*
[c] *University Cassiano Antonio Moraes Hospital, Vitória, Espírito Santo, Brazil, Marechal Campos Avenue, 1355 – Santa Cecília, Vitória, Espírito Santo, Brazil CEP: 29043-260*

A R T I C L E I N F O

*Article history:*
Received 14 December 2021
Accepted 6 April 2022
Available online 30 April 2022

*Keywords:*
Menopause
Body Composition
Anthropometric Measurement
Muscle Strength
Muscle Mass
Sarcopenia

S U M M A R Y

*Background & Aims:* Menopause causes significant changes in the quantity of female muscle mass. Reduced muscle mass is associated with lower quality of life, increased risk of fractures, and decline in functional capacity. Therefore, the use of simple and affordable measures to detect decreased skeletal muscle mass is important for an efficient clinical practice**.** This study analyzed the correlation between skeletal muscle mass (SMM) with calf circumference (CC) and handgrip strength (HGS) in postmenopausal women.
*Methods:* This cross-sectional study was conducted on postmenopausal women ≥ 60 years old (n = 120) recruited in an outpatient clinic of a Brazilian university. Sociodemographic, clinical, and anthropometric data (height, body mass, body mass index - BMI, CC), HGS, and SMM using BIA were collected according to standardized protocols. Correlation between variables (SMM, CC, HGS, and BMI) were analyzed using Pearson and Spearman correlation tests. Multivariate linear regression was applied to determine the influence of CC, HGS and BMI on SMM. Statistical tests were performed at 95% confidence level.

* Corresponding author. Department of Integrated Education, Health Sciences Center, Federal University of Espírito Santo, Marechal Campos avenue, 1468, Maruípe, Vitória, Espírito Santo, CEP: 29040-090, Brazil.
*E-mail address:* valdete.guandalini@ufes.br (V.R. Guandalini).

https://doi.org/10.1016/j.nutos.2022.04.002
2667-2685/

*Results:* Significant and moderate correlation were found between SMM and BMI ($r = 0.54$; $P < 0.001$), low correlations with SMM and dominant handgrip strength ($r = 0.35$; $P < 0.001$) and non-dominant handgrip strength ($r = 0.33$; $P < 0.001$). CC was high correlated to SMM ($r = 0.71$; $P < 0.001$). CC was the only variable associated with SMM after adjusting for sociodemographic and lifestyle variable ($P < 0.005$), meaning that for every centimeter increase in CC there was an increase of 0.53 kg in SMM.
*Conclusions:* CC was associated to SMM in postmenopausal women, expanding the possibilities of using simple measures in clinical practice for tracking sarcopenia.


## Introduction

During female aging, the menopausal transition causes several hormonal changes, mainly a decrease in estrogen serum levels [1]. Such changes interfere with a woman's body - *e.g.*, fat mass gain, increased central adiposity, and joint loss of qualitative and quantitative parameters of skeletal muscle mass (SMM) [2,3] - and increase the risk of developing sarcopenia by 20% [4]. Since this disorder leads to accelerated loss of both muscle mass and function, it is important to preserve lean mass in post-menopausal women to prevent negative developments in this phase of women's lives [5].

Among the different methods for estimating SMM, bioelectrical impedance analysis (BIA) is a practical alternative [6] that has high validity and can be portable and less expensive than gold standards exams for the diagnosis of sarcopenia, such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT), or the reference method Dual Energy X-ray Absorptiometry (DXA), [7]. These characteristics make the assessment of this body compartment more available at both outpatient and hospital levels, especially in public health services.

Another alternative that has been recognized as effective, accessible, low-cost, and viable in clinical practice to measure muscle mass is the calf circumference (CC) [8]. CC is a sensitive measure to identify low muscle mass in the elderly [9] indicated by the European Working Group on Sarcopenia in Older People (EWGSOP) as an alternative for assessing the risk of sarcopenia [5]. In previous studies, CC was positively correlated with appendicular skeletal muscle mass (ASM) and skeletal muscle mass index (SMI) [10,11], measures used to diagnose sarcopenia [5].

The handgrip strength (HGS) test stands out as an efficient method to assess muscle functionality. HGS is used as an indicator of muscle strength and can predict the individual's physical function [12,13]. Its main advantages are related to its simplicity, low cost and application time [5].

Although CC and HGS can be used as prognostic and monitoring measures to assess muscle status at this stage of life [13], these measures are still not routinely included in screening and assessment protocols for the elderly, which evidences an important gap in serving this population. Investigating simple, low-cost measures to predict SMM can contribute to early screening for sarcopenia, especially in elderly postmenopausal women who are exposed to changes in body composition earlier inf life than men. In this sense, the present study analyzed the association between SMM with CC and HGS in elderly postmenopausal women.

## Methods

### *Study design and population*

This cross-sectional study was carried out in the climacteric outpatient clinic of a university hospital in Vitória/ES, from June 2019 to March 2020. The sample was calculated based on the number of consultations performed by the clinic in the previous 12 months (n = 527), excluding duplicate visits and women under the age of 50 (n = 185), totaling 342 women. A confidence interval (CI) of 95%, a margin of error of 5% and a prevalence of osteoporosis in women of 21.3% were considered [14]. After this step, the final sample size was 147 women, who were selected by random drawing, contacted by telephone, informed about the objectives of the study, and invited to participate. In case of refusal, failure to answer the phone call or non-compliance with the inclusion criteria, a new draw was carried out to replace the sample. Due to the pandemic of COVID-19 and the start of quarantine, 140 women were evaluated.

*Data collection*

All assessments were carried out by professionals properly trained and qualified for this purpose. A semi-structured questionnaire containing sociodemographic, clinical and lifestyle information was applied. The color/race (white, yellow, brown, black) [15] information was collected on self-reported and categorized as white and non-white. Level of education in years was categorized as < 4 years, from 4 to 8 years, and > 8 years. Menopause time was calculated, in years, from 12 months after the last menstrual period to the date of participation in the study. As for lifestyle, cigarette use (non-smokers, former smokers and smokers) and alcohol consumption (do not consume, consumed in the past or consume) were evaluated. An anthropometric assessment including the measurement of handgrip strength of the dominant hand (DHGS) and non-dominant hand (NDHGS) and the BIA exam was performed.

*Physical activity level and anthropometric variables*

The participants' physical activity level was determined through the International Physical Activity Questionnaire (IPAQ) [16]. According to the World Health Organization (WHO), adults between 18 and 65 years and elderly individuals over 65 years of age must perform at least 150 minutes of moderate aerobic physical activity per week or 75 minutes of rigorous activity in sessions of at least 10 minutes in duration [17]. Insufficiently active were those who performed physical activity below the recommended level, while those who reached the target recommended by the WHO guideline were considered sufficiently active [17].

The anthropometric variables evaluated were height (m), body mass (kg) and calf circumference (CC) (cm). The Body Mass Index (BMI) was obtained from the ratio between body mass (kg) and height squared ($m^2$). For classification of nutritional status, we used the reference standard proposed by the Pan American Health Organization (PAHO), which considers the following ranges: underweight ($\leq$ 23.0 $kg/m^2$), normal weight (>23.0 and < 28.0 $kg/m^2$), overweight ($\geq$ 28.0 and < 30.0 $kg/m^2$) and obesity ($\geq$ 30.0 $kg/m^2$) [18].

The CC was measured in the greatest prominence of the calf muscles according to a standardized technique, with the participant seated, with the spine erect, and the knees flexed 90º, with values below 33 cm being considered as markers of muscle depletion [8].

*Assessment of skeletal muscle mass and handgrip strength*

To identify SMM, a standard tetrapolar Inbody model 230® bioelectrical impedance device was used. Before the exam, the women received the following instructions: to not drink alcoholic beverages 48 hours before the exam; fast for 4 hours before the exam; do not consume diuretic drinks in the week before the exam; do not practice intense physical exercise 24 hours before the exam; go to the bathroom at least 20 minutes before the exam.

The evaluation of HGS was carried out according to the method recommended by the American Society of Hand Therapist (ASHT) [19]. The participant remained seated, with the spine erect, knees flexed at 90º, with the shoulder positioned in adduction, the forearm supported and the elbow flexed at 90º. The procedure was performed 3 times in the dominant hand and 3 times in the non-dominant hand, with maximum effort for about 5 seconds and a 1-minute interval between assessments [19]. The cutoff point defined by the Revised European Consensus on Sarcopenia was considered, for women, <16.0 kg [5].

### *Ethical aspects*

Participation was voluntarily and consent was given in writing by signing the Free and Informed Consent Term (FICT). This research complied with CNS Resolution 466/2012 and was approved by the Research Ethics Committee for human beings at the Federal University of Espírito Santo, under opinion No. 2.621.794. This study was developed in accordance with the Declaration of Helsinki.

### *Statistical analysis*

A descriptive analysis was performed, expressed as means and standard deviations and minimum and maximum values to describe continuous variables and percentages for categorical variables. The *Kolmogorov-Smirnov* test was used to verify the normality of quantitative variables. Correlation between SMM and continuous variables was analyzed by *Pearson's* Correlation (CC and BMI) and *Spearman's* Correlation (DHGS and NDHGS) according to the normality of the data. To classify the degree of correlation between the variables, the proposal by Mukaka *et al.* (2012) was considered [20]. Multivariate linear regression analysis was applied to determine the influence of predictor variables - *i.e.*, CC, HGS, and BMI on SMM. All variables that showed significance in the correlation test and in the univariate analysis were included. Data were analyzed using SPSS® software version 22.0. The significance level adopted for all tests was $P < 0.05$.

## Results

Of 140 women were recruited, 4 of whom did not meet the BIA application criteria and 16 were less than 60 years old, thus yielding a total of 120 valid research subjects. The main sample included women between 60 and 80 years old (mean age 67.4 ± 4.5 years), which most participants being up to 69 years old (n = 84), non-white (n = 75), sufficiently active (n= 66), do not consume alcohol (n = 72) or cigarettes (n = 84), and are classified as normal weight according to the BMI (n = 51). Detailed information can be seen in Table 1.

Table 2 presents the means, medians, standard deviations, and minimum and maximum values of the dependent (SMM) and independent (BMI, CC, DHGS and NDHGS) variables.

Significant and moderate correlation were found between SMM and BMI ($r = 0.54$; $P < 0.001$), and low correlation between SMM and DHGS ($r = 0.35$; $P < 0.001$) and NDHGS ($r = 0.33$; $P < 0.001$) (Figure 1: A, B and C). CC showed a high and significant correlation with SMM ($r = 0.713$; $P < 0.001$) (Figure 1:D).

Multivariate linear regression results indicate that when controlling for sociodemographic, lifestyle, and nutritional status - *i.e.*, age, ethnicity, level of physical activity, alcohol and cigarette consumption, only CC remained as a significant predictor of SMM (Table 3). The final model has a high effect size ($\beta = 0.53$) and explanation power ($r^2 = 0.56$), meaning that for each centimeter of CC gained there was an increase of 0.53 kilograms in SMM.

## Discussion

The results of the present study show that CC, a low-cost and easy-to-apply anthropometric measure, is related to the SMM in postmenopausal women. On the other hand, both HGS and BMI lost association when adjusted for potentially confounding variables.

Similar results regarding the strong association between CC and SMM have been previously reported [10,11,21]. Kawakami *et al.* (2014), in a study involving 526 Japanese individuals, of whom 416 were women with a mean age of 63 years, observed that CC showed a positive correlation between appendicular skeletal mass (ASM) ($r = 0.73$, $P < 0.001$) and skeletal muscle index (SMI) ($r = 0.69$, $P < 0.001$), when evaluating SMM by DXA in these women [11]. In another study by Kawakami *et al.* (2020), who evaluated 412 Japanese women with a mean age of 52 years, CC was positively related to ASM/height$^2$ measured by BIA ($r = 0.73$) and DXA ($r = 0.76$) [10].

Gonzáles-Correa *et al.* (2020), when evaluating 124 Colombian women with a mean age of 69.9 years, mean CC of 33.3 cm, SMM of 16.7 kg, and SMI of 7.2 kg/m$^2$ evaluated by BIA, found a positive

**Table 1**
Sociodemographic, lifestyle and nutritional status characterization of postmenopausal women

| Variables (n=120) | Total n (%) |
|---|---|
| Age group (years) | |
| 60.0–69.9 | 84 (70.0) |
| 70.0–80.0 | 36 (30.0) |
| Race/Color | |
| White | 45 (37.5) |
| Non-White | 75 (62.5) |
| Physical Activity Level | |
| Insufficiently active | 54 (45.0) |
| Sufficiently active | 66 (55.0) |
| Alcohol Consume | |
| Never drank | 72 (60.0) |
| Used to Drink | 29 (24.2) |
| Drinks | 19 (15.8) |
| Smoking | |
| Never smoked | 84 (70.0) |
| Used to smoke | 31 (25.8) |
| Smokes | 5 (4.2) |
| Nutritional Status | |
| Underweight | 21 (17.5) |
| Normal weight | 51 (42.5) |
| Overweight | 21 (17.5) |
| Obesity | 27 (22.5) |

correlation between CC and SMI ($r = 0.57$, $P < 0.001$) [21]. In the same line of investigation, other studies have also shown that CC is an easy and cheap measure to accurately assess the risk of sarcopenia in the elderly [6,22].

Esteves *et al.* (2020), in a study involving 411 elderly people from the North of Brazil aged in average 70.0 years, observed an association between anthropometric variables (BMI, arm circumference, waist circumference and CC) and sarcopenia, and demonstrated that an increase of 1 (one) unit of these nutritional status indicators reduced the probability of the occurrence of sarcopenia among the elderly [23].

In the present study, HGS was weakly correlated with SMM. Likewise, in a study by Kwon *et al.* (2019) with 28 elderly women (mean age 69.9 years), SMM measured by BIA was weakly associated with HGS ($r = 0.49$, $P = 0.008$) [24]. In addition to the weak correlation, the association between HGS and SMM in our study was not maintained when adjusted for age, race/color, level of physical activity, and consumption of alcohol and cigarettes.

The loss of association between HGS and SMM may be due to the amount of muscle, which only partially explains the loss of muscle strength [25]. Considering that the population evaluated is elderly, muscle strength seems to be more associated with deficiencies in neuromotor control, which delays muscle activation and reduces the ability of the skeletal muscle to generate force because of a decrease in the amount of motor units, which decreases functionality [26].

**Table 2**
Summary measures of dependent and independent variables assessed in postmenopausal women

| Variables | Mean or median | SD or Min-Max |
|---|---|---|
| SMM (kg) | 20.7 | 3.1 |
| BMI (kg/m$^2$) | 27.2 | 4.0 |
| CC (cm) | 36.5 | 3.6 |
| DHGS (kg) | 24.0 | 8.0–34.0 |
| NDHGS (kg) | 22.0 | 4.0–36.0 |

SMM: Skeletal Muscle Mass; BMI: Body Mass Index; CC: Calf Circumference; DHGS: Dominant Handgrip Strength; NDHGS: Non-Dominant Handgrip Strength. *Pearson* correlation; *Spearman's* correlation. p<0.001.

Although the loss of muscle mass is associated with a decline in strength in elderly individuals, studies show that such decline is faster than the loss of muscle mass, pointing to a decline in muscle quality in this population [27], which was not evaluated in this study. In a study by Alexandre *et al.* (2018) with the elderly population of a southeastern Brazilian state, advancing age was associated with dynapenia and sarcopenia. Cognitive impairment, education level, and being a former smoker were associated with dynapenia. Low education level, smoking, and not having a marital life were associated with sarcopenia [28].

Assessing and identifying SMM in the elderly becomes relevant particularly from the sixth decade of life onwards, when structural changes in skeletal muscle begin and are followed by progressive

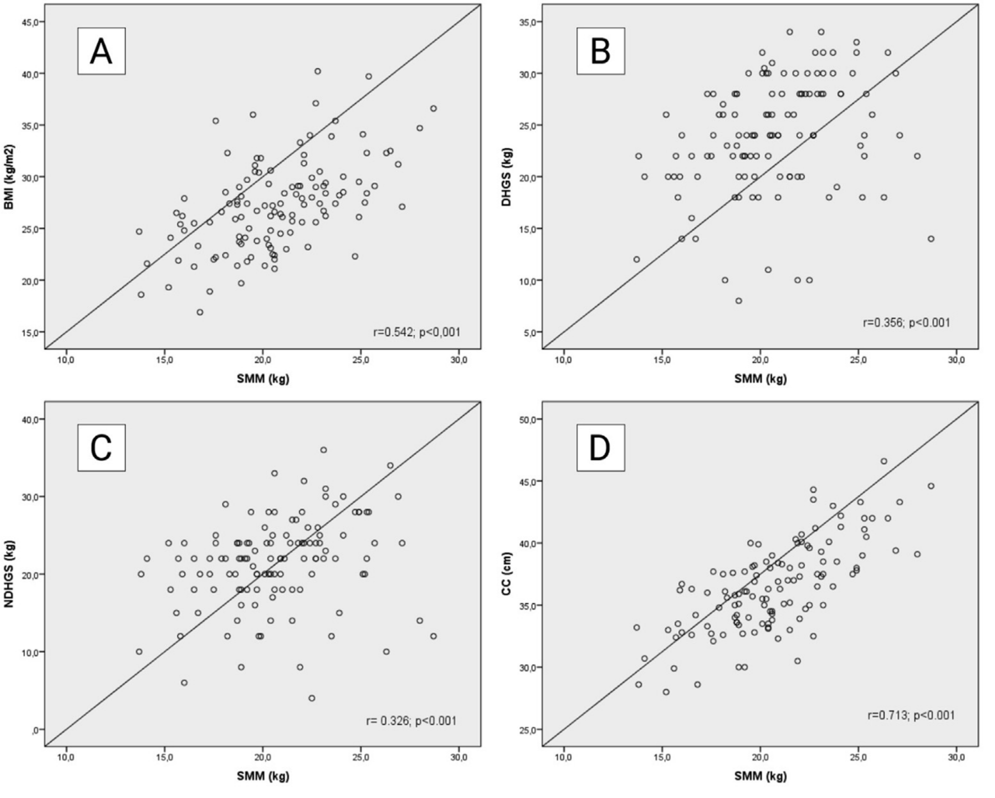


**Figure 1.** Correlation between skeletal muscle mass and Body Mass Index, Handgrip Strength and Calf Circumference in postmenopausal women. SMM: Skeletal Muscle Mass; CC: Calf Circumference; DHGS: Dominant Handgrip Strength; NDHGS: Non-Dominant Handgrip Strength. *Pearson* correlation; *Spearman's* correlation. p<0.001.

**Table 3**
Variables associated with skeletal muscle mass in postmenopausal women after multivariate linear regression analysis

| | Univariate | | Model 1 | | Model 2 | |
|---|---|---|---|---|---|---|
| | β | 95% CI | β | 95% CI | β | 95% CI |
| BMI | **0.38** | **0.274–0.490** | 0.05 | -0.084–0.184 | 0.05 | -0.085–0.193 |
| CC | **0.61** | **0.501–0.719** | **0.53** | **0.366–0.694** | **0.53** | **0.362–0.695** |
| DHGS | **0.16** | **0.069–0.264** | 0.08 | -0.047–0.212 | 0.09 | -0.044–0.221 |
| NDHGS | **0.14** | **0.044–0.232** | 0.04 | -0.080–0.169 | 0.04 | -0.085–0.170 |

BMI: Body Mass Index; CC: Calf Circumference; DHGS: Dominant Handgrip Strength; NDHGS: Non-Dominant Handgrip Strength. Model 1: adjusted for age, race/color. Model 2: adjusted for age, race/color, level of physical activity, alcohol and cigarette consumption. Values in bold indicate $P<0.05$. Model 2: $R^2 = 56.0\%$.

declines [29], especially among women. Due to the high predisposition of this group to reduced SMM [3,4], an early diagnosis would allow for more rapid interventions, enabling the prevention of clinical complications of sarcopenia, such as loss of functional capacity and independence and an increased risk of falls [24,30].

Given the various evidences presented, it appears that CC can be an integral part of nutritional assessment in clinical practice to assess SMM and track the risk of sarcopenia in postmenopausal women and other populations [31]. This method carriers advantages and facilities, added to the feasibility of training health professionals and the possibility of using it on a large scale due to the low cost and speed of obtaining results [5].

In spite of being a practical and cheaper method to assess SMM, the limitations of BIA for the diagnosis of sarcopenia must be considered. Firstly, it is an indirect evaluation method, in which muscle mass is predicted from an equation and to do so it is necessary to consider the population evaluated, as the cut-off points may vary according to ethnicity. Furthermore, the assessment may be affected by hydration status and the presence of severe obesity [5,6].

Among the limitations, it is worth mentioning that this is a population undergoing periodic outpatient follow-up, a condition that may reflect established and practiced care and treatment. Another limitation refers to the cross-sectional design of this investigation, which allows the establishment of a causal relationship between variables. However, it should be noted that this study involved a homogeneous population of postmenopausal women without hormone replacement therapy. There are few studies on this subject, which highlights the importance of working with this population.

## Conclusion

Calf circumference was positively associated with SMM in the postmenopausal women evaluated even after adjustment with confounding variables, with an increase of 0.53 kg in SMM for each centimeter of CC. The application and availability of this measure in the care and health care of the elderly is a great possibility for tracking sarcopenia and preventing frailty and worsening of health and nutritional conditions.

## Ethical standard clearance

This study was conducted according to the guidelines laid down in the declaration of Helsinki and all procedures involving human subjects were approved by the Research Ethics Committee for human beings at the Federal University of Espírito Santo, Brazil.

## Funding

This work did not received funding from any donor or agency or research funding body.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## References

[1] Davis SR, Lambrinoudaki I, Lumsden M, Mishra GD, Pal L, Rees M, et al. Menopause. Nat Rev Dis Prim 2015;1:15004. https://doi.org/10.1038/nrdp.2015.4.
[2] Leeners B, Geary N, Tobler PN, Asarian L. Ovarian hormones and obesity. Hum Reprod Update 2017;23:300–21. https://doi.org/10.1093/humupd/dmw045.
[3] Ikeda K, Horie-Inoue K, Inoue S. Functions of estrogen and estrogen receptor signaling on skeletal muscle. J Steroid Biochem Mol Biol 2019;191:105375. https://doi.org/10.1016/j.jsbmb.2019.105375.
[4] Yang L, Smith L, Hamer M. Gender-specific risk factors for incident sarcopenia: 8-year follow-up of the English longitudinal study of ageing. J Epidemiol Community Health 2019;73:86–8. https://doi.org/10.1136/jech-2018-211258.

[5] Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing 2019;48:16–31. https://doi.org/10.1093/ageing/afy169.
[6] Gonzalez MC, Barbosa-Silva TG, Heymsfield SB. Bioelectrical impedance analysis in the assessment of sarcopenia. Curr Opin Clin Nutr Metab Care 2019;21:366–74. https://doi.org/10.1097/MCO.0000000000000496.
[7] Lustgarten MS, Fielding RA. Assessment of analytical methods used to measure changes in body composition in the elderly and recommendations for their use in phase II clinical trials. J Nutr Health Aging 2011;15:368–75. https://doi.org/10.1007/s12603-011-0049-x.
[8] Pagotto V, Santos KF dos, Malaquias SG, Bachion MM, Silveira EA. Calf circumference: clinical validation for evaluation of muscle mass in the elderly. Rev Bras Enferm 2018;71:322–8. https://doi.org/10.1590/0034-7167-2017-0121.
[9] WHO. Physical status: the use and interpretation of anthropometry. 1995. Geneva.
[10] Kawakami R, Miyachi M, Sawada SS, Torii S, Midorikawa T, Tanisawa K, et al. Cut-offs for calf circumference as a screening tool for low muscle mass: WASEDA'S Health Study. Geriatr Gerontol Int 2020;20:943–50. https://doi.org/10.1111/ggi.14025.
[11] Kawakami R, Murakami H, Sanada K, Tanaka N, Sawada SS, Tabata I, et al. Calf circumference as a surrogate marker of muscle mass for diagnosing sarcopenia in Japanese men and women. Geriatr Gerontol Int 2014;15:969–76. https://doi.org/10.1111/ggi.12377.
[12] Bohannon RW. Muscle strength: clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care 2015;18:465–70. https://doi.org/10.1097/MCO.0000000000000202.
[13] Lopes AJ, Santos Neves R. Hand grip strength in healthy young and older Brazilian adults. Kinesiology 2017;49:208–16. https://doi.org/10.26582/k.49.2.5.
[14] Baccaro LF, de Souza Santos Machado V, Costa-Paiva L, Sousa MH, Osis MJ, Pinto-Neto AM. Factors associated with osteoporosis in Brazilian women: a population-based household survey. Arch Osteoporos 2013;8:138. https://doi.org/10.1007/s11657-013-0138-z.
[15] Instituto Brasileiro de Geograifa e Estatítica (IBGE), Petruccelli JL, Saboia AL. Autoidentificação, identidade étnico-racial e heteroclassificação. Rio de Janeiro, Brasil: Instituto Brasileiro de Geografia e Estatística (IBGE); 2013.
[16] Matsudo S, Araújo T, Matsudo V, Andrade D, Andrade E, Oliveira LC, et al. International Physical Activity Questionnaire (IPAQ): Study of validity and reliability in Brazil. Atividade Física & Saúde 2001;6:5–18. https://doi.org/10.12820/rbafs.v.6n2p5-18.
[17] Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med 2020;54:1451–62. https://doi.org/10.1136/bjsports-2020-102955.
[18] XXXI OPAS. Reunión del Comité Asesor de Investigaciones en Salud. Rev Panam Salud Pública 2002;1:471–5. https://doi.org/10.1590/S1020-49891997000600016.
[19] MacDermid J, Solomon G, Valdes K, Society A of HT. Clinical assessment recommendations. 3rd ed. N.J.: American Society of Hand Therapists; 2015. ount Laurel.
[20] Mukaka MM. Statistics corner: A guide to appropriate use of correlation coefficient in medical research. Malawi Med J 2012;24:69–71.
[21] González-Correa CH, Pineda-Zuluaga MC, Marulanda-Mejía F. Skeletal muscle mass by bioelectrical impedance analysis and calf circumference for sarcopenia diagnosis. J Electr Bioimpedance 2020;11:57–61. https://doi.org/10.2478/JOEB-2020-0009.
[22] Chen C-Y, Tseng W-C, Yang Y-H, Chen C-L, Lin L-L, Chen F-P, et al. Calf Circumference as an Optimal Choice of Four Screening Tools for Sarcopenia Among Ethnic Chinese Older Adults in Assisted Living. Clin Interv Aging 2020;15:2415–22. https://doi.org/10.2147/CIA.S287207.
[23] Esteves CL, Ohara DG, Matos AP, Ferreira VTK, Iosimuta NCR, Pegorari MS. Anthropometric indicators as a discriminator of sarcopenia in community-dwelling older adults of the Amazon region: a cross-sectional study. BMC Geriatr 2020;20:1–10. https://doi.org/10.1186/s12877-020-01923-y.
[24] Kwon I, Kim J-S, Shin C-H, Park Y, Kim J-H. Associations Between Skeletal Muscle Mass, Grip Strength, and Physical and Cognitive Functions in Elderly Women: Effect of Exercise with Resistive Theraband. J Exerc Nutr Biochem 2019;23:50–5. https://doi.org/10.20463/jenb.2019.0023.
[25] Manini TM, Clark BC. Dynapenia and aging: An update. Journals Gerontol - Ser A Biol Sci Med Sci 2012;67:28–40. https://doi.org/10.1093/gerona/glr010.
[26] Kaya RD, Nakazawa M, Hoffman RL, Clark BC. Interrelationship between muscle strength, motor units, and aging. Exp Gerontol 2013;48:920–5. https://doi.org/10.1016/j.exger.2013.06.008.
[27] Mitchell WK, Williams J, Atherton P, Larvin M, Lund J, Narici M. Sarcopenia, Dynapenia, and the Impact of Advancing Age on Human Skeletal Muscle Size and Strength; a Quantitative Review. Front Physiol 2012;3:1–18. https://doi.org/10.3389/fphys.2012.00260.
[28] Alexandre T da S, Duarte YA de O, Santos JLF, Lebrão ML. Prevalence and associated factors of sarcopenia, dynapenia, and sarcodynapenia in community- dwelling elderly in São Paulo – SABE Study. Rev Bras Epidemiol 2018;21:1–13. https://doi.org/10.1590/1980-549720180009.supl.2.
[29] Larsson L, Degens H, Li M, Salviati L, Lee Y il, Thompson W, et al. Sarcopenia: Aging-Related Loss of Muscle Mass and Function. Physiol Rev 2019;99:427. https://doi.org/10.1152/PHYSREV.00061.2017.
[30] Bravo-José P, Moreno E, Espert M, Romeu M, Martínez P, Navarro C. Prevalence of sarcopenia and associated factors in institutionalised older adult patients. Clin Nutr ESPEN 2018;27:113–9. https://doi.org/10.1016/j.clnesp.2018.05.008.
[31] Trussardi Fayh AP, de Sousa IM. Comparison of revised EWGSOP2 criteria of sarcopenia in patients with cancer using different parameters of muscle mass. PLoS One 2021;16:e0257446. https://doi.org/10.1371/journal.pone.0257446.