Maximum handgrip strength test in long-lived elderly people from southeastern Brazil: definition of cutoff points

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Abstract

Objective: To define cut-off points for the values of the Maximum Handgrip Strength (MGS) test in long-lived elderly people. *Method*: Cross-sectional study with a sample of long-lived elderly people, octogenarians and nonagenarians, healthy and functionally independent (robust group) and frail (fragile group). The MHS test was performed in triplicate, with the highest value obtained being considered. Sensitivity, specificity and cut-off values were calculated using the Receiver Operating Characteristic Curve (ROC). The Brazilian cut-off points and those of the European Consensus on Sarcopenia were used for the comparison study. *Results*: 121 elderly people were evaluated, with a mean age of 84.5±5.3 years, 65 (53.7%) female, 46 (38%) from the frail group and 75 (62%) from the robust group. Cut-off points for MHS of 27 kgf for men and 19 kgf for women were found. Sensitivity and specificity values for men's cutoffs were 94.44 and 65.79, respectively. For woman, they were 85.71 and 67.57. Based on these cutoff points, 23 (38.3%) individuals from the robust group were classified as having competitive strength, and therefore with probable sarcopenia, while according to the Brazilian and European cutoff points, the number is 35 (44.3%) and 14 (33.3%). *Conclusion*: The study defined cut-off points for the oldest-old population and showed that the cut-off points defined so far for the Brazilian elderly population were not adequate for the oldest-old.

Keywords: Elderly Aged 80 Years or Older. Longevity. Hand Strength. Sarcopenia. Sensitivity and Specificity. ROC Curve.

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INTRODUCTION

The independence and autonomy necessary for a healthy longevity are inherently intertwined with an individual's well-being and functionality[1]. Muscular strength stands as a pivotal predictive parameter of functionality in the elderly[2]. Advancing age represents a risk factor for diminished muscular strength and the onset of sarcopenia, a condition associated with falls, functional decline, frailty, and mortality[3].

Sarcopenia is a progressive and pervasive muscular disorder characterized by the accelerated loss of muscular mass and functionality[4]. Initially, the primary diagnostic criterion for sarcopenia was the reduction in muscular mass. Nevertheless, the definition has evolved, and in the majority of consensuses, corroborated by allied research cohorts, the focal point has shifted towards the impairment of functionality, particularly in regard to muscular strength, concomitant with a diminished muscular mass[4-8]. This is presently the most widely acknowledged definition, as proposed and recently revised by the European Working Group on Sarcopenia in Older People (EWGSOP)[4].

In the current conceptualization of sarcopenia, three core elements are present: the reduction of strength, mass, and functionality[3]. Thus, it distinguishes itself from the physiological process of age-associated muscular mass decline and is regarded as a geriatric syndrome due to its associated morbidity and mortality[4]. This syndrome also bears resemblance to the phenotype of frailty[9], primarily due to their shared central component - the reduction of muscular mass. Consequently, older individuals afflicted with sarcopenia, whether considered as a syndrome or a process, find themselves at a heightened risk of becoming frail[1].

In Brazil, the prevalence of sarcopenia among individuals aged 60 or older ranges from 13.9% to 16%, as reported in the "COMO VAI?" study and the systematic review by Diz et al. (2017)[10,11]. Within this age bracket, the highest prevalence is observed in the more advanced age groups. This is attributed to the fact that muscular strength decreases by approximately 1.5% to 5% annually after the individual surpasses 50 years of age. This underscores the significance of delving more profoundly into the study of muscular strength in the aging population[12].

For the assessment and diagnosis of sarcopenia, various validated tests for strength, muscular mass, and performance can be employed[3,4,5]. Specifically, for the evaluation of muscular strength, the most recommended test is the Maximum Handgrip Strength (MGS) test. MGS offers the advantage of relatively low cost, ease of clinical application, and a demonstrated correlation with strength in other anatomical compartments[13]. Impaired performance in this test strongly indicates adverse hospital outcomes, significant functional limitations, and a diminished quality of life[3]. Muscle weakness, as evidenced by the handgrip test, has shown robust concordance with sarcopenia, as defined by the Sarcopenia Definition and Outcomes Consortium (SDOC)[7].

For the diagnosis of probable sarcopenia, which is confirmed when the muscular mass is also low[3], the test results should fall below the defined cutoff points in kilogram-force (kgf): 27 kgf for men and 16 kgf for women up to 80 years old[14]. These cutoff points are derived from a consensus that amalgamates data from 12 population-based studies conducted in the United Kingdom to establish normative grip strength values across the lifespan (from 4 to 90 years). Notably, within this study, only 10.5% of the sample consisted of individuals aged 80 years or older, thus representing the long-lived[14].

Yet, there exists substantial evidence that normative strength values vary between populations in developed and developing countries[15]. The EWGSOP underscores the pressing need for further investigations across diverse global regions to derive improved cutoff points[3].

In Brazil, two studies provide references for the test[16,17]. The first was conducted with participants from community centers for the elderly in the southern and southeastern regions, suggesting cutoff points of 30 kgf for men and 21.7 kgf for women based on a sample of elderly individuals, of whom

8% were considered long-lived[16]. The second study, carried out on a sample comprising individuals aged 18 to 102 years and residing in Rio Branco, a city in the Northern region of Brazil, offers percentile values stratified by age groups, albeit without sensitivity and specificity testing, and includes 10.7% of long-lived individuals within the sample[17].

The utilization of non-specific cutoff points for this age group can significantly impact the diagnosis of sarcopenia, as a value falling below these thresholds in the grip strength test may merely reflect physiological aging changes rather than indicating poor performance[17]. Consequently, positing the hypothesis that normal values for the grip strength test in long-lived older adults might be lower than the currently established values applicable to all age groups, the objective of the present study was to investigate the grip strength of this specific group and establish cutoff points for the test based on a sample of long-lived elderly individuals who are functionally independent and demonstrably healthy.

METHOD

This is a cross-sectional study that assessed grip strength in two distinct groups: long-lived elderly individuals demonstrating functional independence, who were attended to at the Healthy Aging Outpatient Clinic, and long-lived elderly individuals characterized as frail, who received care at the Nutritional Care Outpatient Clinic for the Elderly, both within the Jenny de Andrade Faria Institute at the Hospital das Clínicas of the Universidade Federal de Minas Gerais, Minas Gerais, Brazil. These clinics are part of the Geriatrics Reference Center (*Centro Referência de Geriatria*). Data collection took place between March 2016 and November 2021.

The elderly individuals in the study had their functionality assessed using the Visual Analogue Scale of Frailty, which performs the Clinical-Functional Classification of the Elderly (*Classificação Clínico-Funcional dos Idosos*)[1]. Functionally independent elderly individuals were those who exhibited independence in basic, instrumental, and advanced activities of daily living (ADLs), as determined from data collected during geriatric medical consultations. This group fell within Stages 1 to 3 of this scale[1]. Those considered frail were individuals with partial or total dependence in the performance of instrumental and/or basic ADLs, falling within Strata 6 to 8[1]. In the design of this study, it was presumed that functionally independent elderly individuals exhibited age-appropriate strength[1]. Conversely, frail individuals, who demonstrated dependency in the execution of certain activities of daily living, could potentially lack age-appropriate strength. The frail elderly individuals constituted the group referred to as 'frail', while the functionally independent elderly individuals formed the 'robust' group. Inclusion criteria encompassed individuals of 80 years or older, of both genders, with available handgrip strength test data in their multidisciplinary medical records. The strength evaluation conducted in the outpatient clinic follows a standardized procedure as part of the routine care, and all healthcare professionals receive training and guidance to adhere to this standard[13]. Centenarian elderly individuals were excluded. The participant selection process for the study is depicted in Figure 1.

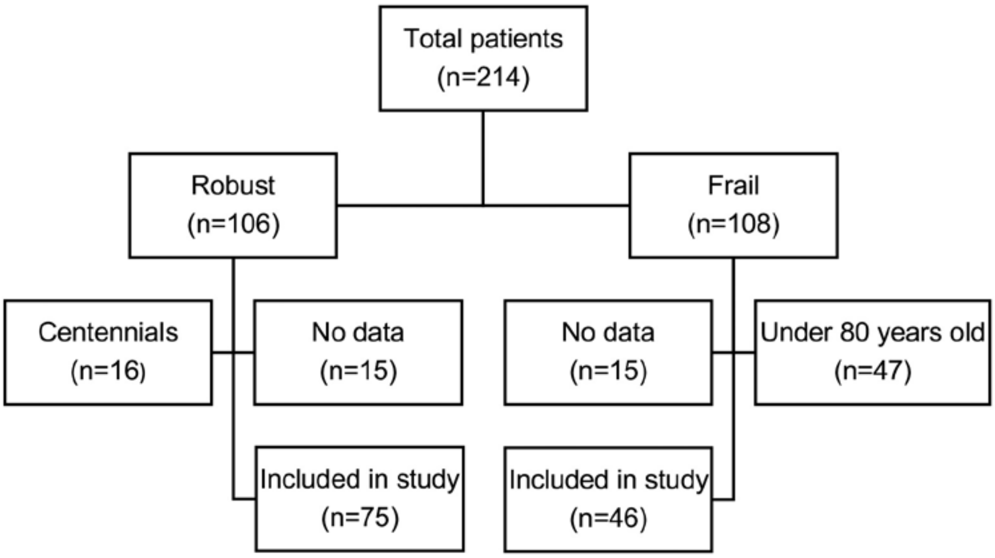

Figure 1. Participant Selection Process in the Study. Minas Gerais, 2018-2020.

All data were collected from the multidisciplinary medical records of geriatric and nutritional care, encompassing demographic information (gender and age), anthropometric measurements (weight, height, calf circumference, arm circumference, and triceps skinfold thickness), and Maximum Handgrip Strength data.

Below are described the methods employed by the professionals at the outpatient clinics to generate the collected data. It is worth emphasizing that all professionals and students within the team at these two clinics receive regular training to ensure the standardization of techniques.

Body mass was measured on a Filizola® scale (PL 200 LED, Filizola®, São Paulo, Brazil), with a precision of 100g, with the patient barefoot and without coats. Height was measured using a stadiometer incorporated into the same equipment, with the patient positioned facing away, the head in the Frankfurt Plane, and feet together[18].

Based on weight and height, the Body Mass Index (BMI) was calculated by dividing weight (in kilograms) by height squared (in meters). It was classified according to the recommended categorization for elderly individuals: underweight <23 kg/m², normal weight ≥23 kg/m² and <28 kg/m², overweight ≥28 kg/m² and <30 kg/m², and obesity ≥30 kg/m² [19].

The Maximum Handgrip Strength was measured using a Jamar® dynamometer (BL5001, Lafayette, Indiana, USA). To obtain this measurement, three readings were taken from the right hand and three from the left, alternating between hands, with the highest value achieved for each hand being recorded as the result of the test. The measurements were conducted with individuals seated, their backs and arms supported on the backrests, shoulders relaxed, and elbows flexed at 90°. Elderly individuals were instructed to exert their maximum squeezing force on the device's handle while the assessor encouraged them, observing the highest reading[13].

For comparative purposes, cutoff points for MGS adjusted for the Brazilian population[16] were employed, as well as those from the second European Sarcopenia Consensus (EWGSOP2)[3], based on the study by Dodds and colleagues[14]. The first set of cutoff points deem low strength as <30 kgf for men and <21.7 kgf for women[16]. In contrast, the second set defines low strength as results <27 kgf and <16 kgf for men and women, respectively[3]. Low strength was considered indicative of probable sarcopenia[3].

The values were presented descriptively using the mean and standard deviation for symmetric variables, and median along with the 25th and 75th percentiles for asymmetric variables. The normality test employed was the Kolmogorov-Smirnov test. Categorical values were expressed in terms of frequency.

To compare characteristics based on functional classification and gender, Student's t-tests were employed for symmetric variables, and the Mann-Whitney test for asymmetric variables. Categorical characteristics were compared using the chi-square test when more than 2 cells contained values greater than 5, and Fisher's Exact test when none of the cells had values exceeding 5.

In order to establish cutoff points in a series of continuous data values for MGS, a sensitivity and specificity study was conducted for each point, derived from Receiver Operating Characteristic (ROC) Curve based on data from robust and frail elderly individuals. This division is necessary as it entails a comparison between two groups with opposing clinical characteristics to construct the ROC Curve[20]. To assess the effectiveness of the ROC Curve in defining cutoff points in a diagnostic test, the area under the curve is employed. A value of 0.5 or less indicates a test's inability to discriminate the presence of the studied clinical condition, signifying an ineffective test[20].

The sensitivity of a statistical test corresponds to the quantity of positive results in relation to individuals who possess a certain clinical condition. Conversely, specificity corresponds to the quantity of negative results among individuals who do not have the studied clinical condition[21]. In this context, the chosen cutoff point was the one that yielded the highest value in the Youden's Index, which indicates the point with the lowest rate of false positives and false negatives simultaneously, based on sensitivity and specificity[22]. A significance level of 0.05 was adopted.

The positive predictive values (PPV) and negative predictive values (NPV), as well as the positive likelihood ratios (LR+) and negative likelihood ratios (LR-), along with other tests related to the ROC curve and cutoff points, were obtained using the MedCalc software[20,23].

The study was approved by the Research Ethics Committee of the Universidade Federal de Minas Gerais (CAAE: 80295616.1.0000.5149, Opinion Nº. 2,422,800, and CAAE 37058720.7.0000.5149, Opinion Nº. 4,329,040).

RESULTS

The sample consisted of 121 elderly individuals, comprising 46 (38%) from the frail group and 75 (62%) from the robust group. The demographic and anthropometric characteristics of the studied population are presented in Table 1. Seven individuals from the frail group were not assessed anthropometrically due to mobility issues; however, these individuals were not excluded as their strength was evaluated without any compromise in technique.

Regarding cutoff points, the analysis of sensitivities and specificities, based on the ROC Curve, identified a value of ≤27 kgf as the most suitable cutoff point for men and ≤19 kgf for women for the MGS test (Figure 2).

Table 1. Demographic and Anthropometric Characteristics of the Study Sample by Groups (N=121). Belo Horizonte, MG, 2018-2020.

Characteristics	Total (N=121)	Robust Group (n=75)	Frail Group (n=46)	*p*-Value
Sex n (%)				
Male	56 (46.3)	38 (50.7)	18 (39.1)	0.217#
Female	65 (53.7)	37 (49.3)	28 (60.9)	
Age in years Mean (SD)	85 (±4.3)	85 (±4.1)	85 (±4.6)	0.925 †
Octogenarians n (%)	101 (83.5)	63 (84.0)	38 (82.6)	0.841#
Nonagenarians n (%)	20 (16.5)	12 (16.0)	8 (17.4)	
Weight kg Mean (SD)	60.2 (±13.2)	64.4 (±11.3)	52.6 (±13.0)	<0.001†
Height cm Mean (SD)	153.6 (±8.1)	154.7 (±7.7)	151.5 (±8.4)	0.046*
BMI in kg/m² Mean (SD)	25.7 (±4.8)	26.9 (±4.0)	23.4 (±5.5)	0.001†
BMI Classification n (%)				
Underweight	31 (27.2)	12 (16.0)	19 (48.7)	<0.001#
Normal weight	50 (43.9)	37 (49.3)	13 (33.3)	
Overweight	30 (14.0)	13 (17.3)	3 (7.7)	
Obesity	17 (14.9)	13 (17.3)	4 (10.3)	
Missing data (n)	7	0	7	

kg: kilograms; p: percentile; cm: centimeters; BMI: Body Mass Index; m: meters; SD: standard deviation; CC: calf circumference; *Mann-Whitney test; †Independent samples t-test; £Fisher's exact test; #Pearson's chi-square test.

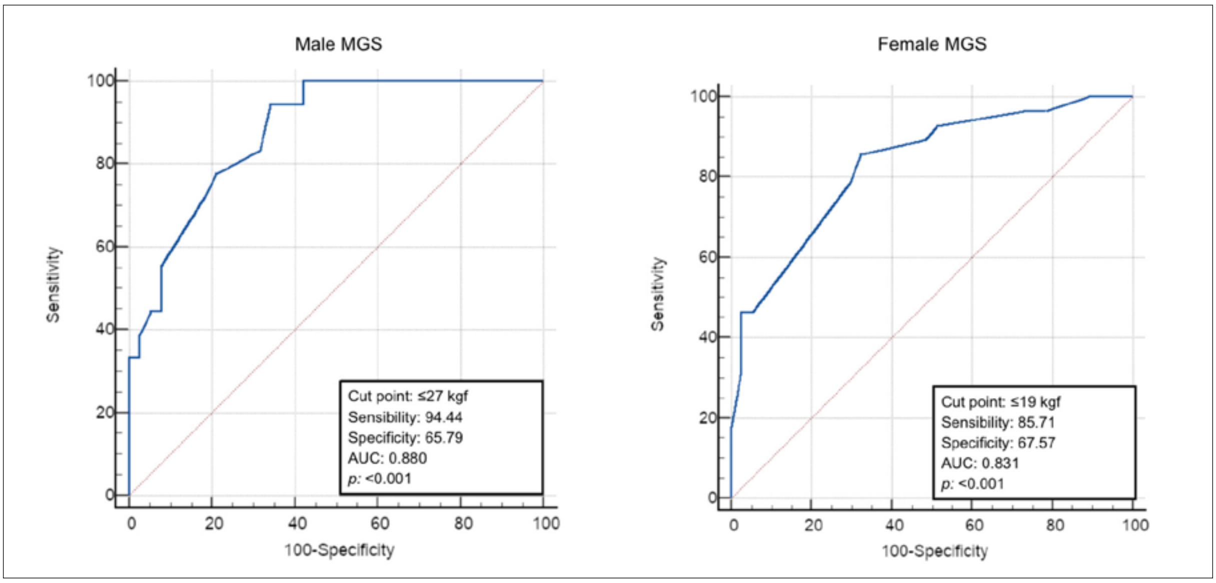

Figure 2. ROC Curves, cutoff points, and sensitivity and specificity values for males and females, respectively. Belo Horizonte, MG, 2018-2020.

The values obtained from the statistical indicators indicate that the defined cutoff points are considered effective in discriminating clinical conditions. As for the area under the curve, this characteristic is present when the values are above 0.8, and regarding the p-value, when it's <0.001, which was found in the study[20].

Furthermore, we have PPVs and NPVs of 32.8% and 98.5% for the male group and 31.8% and 96.4% for the female group, respectively. The PPV reflects the probability of an individual being frail when the MGS test value is equal to or below the established cutoff point and should be higher than the disease prevalence. The NPV reflects the probability of an individual being robust when the MGS test value is greater than the established point[23]. Thus, in practice, we see that the vast majority of individuals with a test result higher than the points found in the study will not be diagnosed with probable sarcopenia.

The RV+ and RV- were 2.76 and 0.08 for the male group and 2.64 and 0.21 for the female group, respectively. Considering that an RV+ value greater than 1.0 is more effective in indicating the presence of the disease based on a positive result, the values found reinforce the validity of the test[20]. For RV-, the closer the value is to 0, the lower the probability of disease from a negative result, and a value close to 1.0 reflects test inefficiency. In this regard, there are good RV- results, contributing to the test's effectiveness, with an emphasis on the male group.

As for the MGS test (Table 2), 65.3% of the elderly individuals in the sample showed low strength when considering the Brazilian cutoff points[16]. Among these, 44.3% were from the robust group, thus functionally independent. Regarding the EWGSOP[3] cutoff points, 34.7% of the sample was classified as having low strength, and 36.6% of these were from the robust group.

Using the cutoff points defined in this study, 60 (49.5%) individuals were classified as having inadequate strength, with 23 (38.3%) from the robust group and 37 (61.7%) from the frail group (p<0.001) (Table 2). In this classification, there is no difference between sexes (p=0.077). Applying these cutoff points, there is a 24% reduction in the classification of low muscle strength in functionally independent individuals compared to the Brazilian cutoff points.

Table 2. Maximum Handgrip Strength of the Study Sample, by Groups. Belo Horizonte, MG, 2018-2020.

Variables	Total (N=121)	Robust Group (N=75)	Frail Group (N=46)	*p*-Value
MGS (kgf) median (p25-p75)	22.0 (16.0-27.5)	26.0 (20.0-32.0)	16.0 (12.0-22.3)	<0.001*
Men	27 (24.0-32.0)	30 (26.0-34.5)	23 (14.8-25.3)	<0.001*
Women	18 (16.0-22.0)	21 (18.0-23.5)	16 (12.0-18.0)	
Strength Classification				
Inadequate Strength (Brazilian cutoff point) n (%)	79 (65.3)	35 (44.3)	44 (55.7)	0.003[£]
Men	34 (43.0)	16 (47.1)	18 (52.9)	0.326[#]
Women	45 (57.0)	19 (42.2)	26 (57.8)	
Inadequate Strength (EGWSOP2 cutoff point) n (%)	42 (34.7)	14 (33.3)	28 (66.6)	0.345[£]
Men	27 (64.3)	12 (44.4)	15 (55.56)	0.004[#]
Women	15 (35.7)	2 (13.3)	13 (86.7)	
Inadequate Strength (current study cutoff point)	60 (49.5)	23 (38.3)	37 (61.7)	<0.001[£]
Men	27 (45.0)	12 (44.4)	15 (55.6)	0.077[#]
Women	33 (55.0)	11 (33.3)	22 (77.7)	

EGWSOP2: Second European Consensus on Sarcopenia; MGS: Maximum Handgrip Strength; kgf: kilogram-force; P: Percentile; [£]Fisher's exact test; * Mann-Whitney test; [#]Pearson's chi-squared test.

DISCUSSION

The present study assessed the MGS of robust elderly individuals and proposed cutoff points of ≤27 kgf for men and ≤19 kgf for women as recommendations for clinical practice with long-lived elderly individuals. Furthermore, it was possible to conclude that these cutoff points are indeed lower than those currently used for the general Brazilian population, without age specification, indicating that normal values for long-lived elderly individuals may be lower.

The study assessed and defined cutoff points for the MGS test, exclusively focusing on a group of independent, long-lived Brazilian elderly individuals. In the statistical analysis, a group of the same age range with the opposite functional characteristic, in this case, the presence of frailty, was used. Until now, studies that analyzed MGS have used samples with different age groups, with long-lived elderly individuals being a minority among them[14,24-28].

Regional studies for defining cutoff points for the MGS test are necessary due to differences between the results in developed and developing countries[15]. In a study that compared the MGS of individuals from various regions around the world, it was clearly evident that grip strength values are significantly lower in developing countries compared to developed countries[15]. For example, in the male population at 30 years of age, the mean MGS in developed countries was 52.8 kgf, while in developing countries, it was 43.4 kgf.

Therefore, national studies to define more suitable cutoff points for our reality have been conducted. However, the design of each study is different and does not include a group with opposite clinical characteristics for comparison, a method recommended when studying sensitivity and specificity through a ROC curve[20], as presented here. In one of these studies, the comparison was made with participants' "fear of falling," while the other study only presented the test results according to age groups without evaluating sensitivity and specificity[17].

Regarding the cutoff points from our study, for men, the value of 27 kgf was lower than what was found in the Brazilian study, which was 30 kgf[16]. This result suggests that in long-lived older people studied, a lower absolute strength value does not qualify as low performance. A similar situation was found for women, with a cutoff point of 19 kgf, lower than the Brazilian study's 21.7 kgf. In practice, this shows that if the previously proposed Brazilian cutoff points were used, a long-lived older person who is known to be healthy and without functional impairment could be classified as having probable sarcopenia.

When we compare the cutoff points obtained in the present study with those established by EWGSOP2, we notice a closer match. For men, the value found of 27 kgf is exactly the same as the one established by the consensus. For women, the value of 19 kgf is higher than the consensus's 16 kgf[3]. Thus, the number of men classified as having low strength is exactly the same. However, the number of women classified as having low strength doubles when the cutoff point from our study is used.

These data reveal an important point to consider, which is the fact that the cutoff points generated from strength data of an octogenarian and nonagenarian population are very close to the points calculated in studies that included a wide age range (from 4 to 90 years)[14]. In the same study, the minimum strength percentiles (10th percentile) found in long-lived individuals were 16 kgf to 23 kgf in men and 9 kgf to 13 kgf in women[14], well below the cutoff point of our study. This suggests that perhaps the reduction in strength in older individuals with preserved functionality is not as intense, or that a plateau has been reached at a certain age, demonstrating the uniqueness of this group and emphasizing the need for more studies on the characteristics of this population. Here, we have a sparsely studied sample of functionally independent long-lived older individuals.

One limitation of our study is that it was conducted in a state capital in the southeastern region of Brazil, so the cutoff points for MGS found here cannot be considered a reference for long-lived older individuals throughout the country. Additionally, the studied group comes from a specialized healthcare service, which does not characterize a population-based study. However, as this study was exclusively developed with long-lived individuals, a minority group among the elderly, in the absence of other studies with this population, the findings can serve as a parameter for new research and potentially as a reference until studies with representative samples of the Brazilian population are published.

Therefore, the MGS cutoff values presented in our study are reference suggestions to be considered when working with long-lived older individuals in clinical and outpatient practice. In comparison to other Brazilian studies on the subject, this study managed to address identified limitations related to the lack of a comparative group with well-defined characteristics and provided a more focused approach to the long-lived population.

CONCLUSION

The present study defined cutoff points of ≤27 kgf for men and ≤19 kgf for women for a population of long-lived older individuals and observed that these values are indeed lower than those previously proposed in the country for MGS assessment and for the diagnosis of probable sarcopenia. This suggests that in current clinical practice, a long-lived older person, known to be healthy and without functional impairment, could be classified as having probable sarcopenia. Therefore, the proposed cutoff points aim to contribute to clinical practice by providing a more accurate diagnosis. However, it is still important to emphasize the need for further studies with representative groups of long-lived older individuals in Brazil to establish references that will fine-tune the clinical approach to the Brazilian elderly population.

AUTHORSHIP

- Lucca F. Machado (AUTHOR) – Conception, design, analysis and interpretation of data, writing of the article, approval of the version to be published, responsible for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
- Marcelle F. Saldanha (CO-AUTHOR) – Critical review and approval of the version to be published.
- Camila D. N. Rocha (CO-AUTHOR) - Critical review and approval of the version to be published.
- Rodrigo R. Santos (CO-AUTHOR) - Critical review and approval of the version to be published.
- Ann K. Jansen (AUTHOR) – Conception, design, analysis and interpretation of data, writing of the article, approval of the version to be published, responsible for all aspects of the work, ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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