OPEN ACCESS Freely available online

ISSN: 2329-8847
Journal of Aging Science

Research Article

Comparison of Diagnostic Criteria for Sarcopenia in Older People: Cross-Sectional Study

Luis Fernando Ferreira[1*], Cislaine Machado de Souza[2], Patrícia da Silva Klahr[2], Luis Henrique Telles da Rosa[2]

[1]Department of Medicine, Federal University of Health Sciences of Porto Alegre, Porto Alegre, Brazil; [2]Department of Physiotherapy, Federal University of Health Sciences, Porto Alegre, Brazil

ABSTRACT

Objective: To compare the methods for evaluating sarcopenia in older people, demonstrating the relationship of each test with its peers for the same criteria diagnostic.

Methods: Cross-sectional study. Older people assessed for muscle strength: handgrip and isokinetic dynamometers; body composition: BIA, skinfolds, mid-arm and calf circumferences; physical performance: six-minute walk test, Timed Up and Go [TUG] and Short-Physical-Performance-Battery [SPPB]. Qualitative variables expressed in absolute and relative frequency; quantitative in mean+SD, median and IQR. Correlations assessed by Spearman's Correlation Coefficient. p-value<0,05 was significant. Study approved by UFCSPA Research Ethics Committee; volunteer read and sign the ICF.

Results: 78.31% women, average age: 67,85+5,27 years. Strength assessments: moderate correlation between Handgrip and quadriceps PT; high with hamstrings PT. PT assessments showed high relation between them. SMM showed high correlation with FFM, and low with CC and MAC. FFM showed high correlation with all body composition assessments. Physical performance: UGS had moderate correlation with SPPB and high with TUG. TUG showed low correlation with SPPB.

Discussion: Strength: Handgrip showed best correlation, needing prospective studies. Chair stand test didn't show relationship with other techniques, maybe because of other variables than strength, as balance and power output. Body composition: BIA showed the best correlations. Skinfold, calf circumference and MAC could be a good choice for this criterion, for its good correlation, low cost, and fast to develop. Physical performance: UGS seems to be the best assessment, although SPPB and TUG showed correlations. Is important to note that, for these criteria, the choice of assessment method may affect the sarcopenia severity.

Keywords: Sarcopenia; Aged; Geriatric assessment; Anthropometry; Kinanthropometry

Abbreviations: AWGS: Asian Working Group on Sarcopenia Bioimpedance Analysis; BIA: Bioimpedance Analysis; BMI: Body Mass Index; CC: Calf Circumference; cm: centimetre; DXA: Dual Energy X-Ray Absorptiometry; EWGSOP: European Working Group on Sarcopenia in Older People; FFM: Free-fat Mass; GEReab: Grupo De Estudos Em Reabilitação; ICF: Informed Consent Form; IDC: International Statistical Classification of Diseases and Related Health Problems; IQR: Interquartile Range; Kg: Kilogram; m: Meter; m/s: Meter Per Second; MAC: Mid-Arm Circumference; MRI: Magnetic Resonance Imaging; n: Sample; NHANES: National Health And Nutrition Examination Survey; PT: Peak Torque; RCT: Randomized Clinical Trial; s: Seconds; SMM: Skeletal Muscle Mass; SPPB: Short Physical Performance Battery; SRF: Serum Response Factor; TUG: Timed-Up-and-Go Test; UFCSPA: Federal University of Health Sciences of Porto Alegre; UGS: Usual Gait Speed; UK: United Kingdom; USA: United States of America

BACKGROUND

Sarcopenia has been subject of large areas of study for some years, even having been included in the IDC, in 2016 [1]. Currently, there are some major consensuses that define the syndrome assessment and diagnosis, such as the European Working Group of Sarcopenia in Older People–EWGSOP, the Asian Working

Correspondence to: Luis Fernando Ferreira, Department of Medicine, Federal University of Health Sciences of Porto Alegre, Porto Alegre, Brazil, E-mail: proffernandof@gmail.com

Received: 11-Jul-2023, Manuscript No. JASC-23-22162; **Editor assigned:** 14-Jul-2023, Pre-QC No. JASC-23-22162 (PQ); **Reviewed:** 31-Jul-2023, QC No. JASC-23-22162; **Revised:** 07-Aug-2023, Manuscript No. JASC-23-22162 (R); **Published:** 15-Aug-2023, DOI:10.35248/2329-8847.23.11.326.

Citation: Ferreira LF, Souza CM, Klahr PS, da Rosa LHT (2023) Comparison of Diagnostic Criteria for Sarcopenia in Older People: Cross-Sectional Study. J Aging Sci.11:326.

Group on Sarcopenia-AWGS, the International Working Group on Sarcopenia-IWGS and the limited mobility consensus [2-6]. The main consensus, which has been at the forefront of studies on the subject, however, is the EWGSOP [3].

Most consensuses, nevertheless, are still under construction, as is the knowledge about sarcopenia itself [3,4]. Today the EWGSOP defines probable sarcopenia as low muscle strength (assessed by handgrip or chair stand test); sarcopenia as low strength combined with low skeletal muscle mass (assessed by DXA, CT, MRI or BIA); and the severe form of the syndrome with the combination of the two previous indicators, plus low physical performance (assessed by usual gait speed, SPPB, 400 m walk test or TUG). However, even those authors' highlights on their works that still lack more studies about the assessment and diagnosis of sarcopenia [3].

Due to the great variability of the possible assessments, there is also a difficulty in the literature in replicating the information, and even summarizing the epidemiological data of the disease. Several systematic reviews have reported difficulties running meta-analyses, given the variation in assessment models, cut-off points and diagnostic criteria adopted [7]

This study, therefore, aim to compare the methods for evaluating sarcopenia in older people, demonstrating the relationship of each test with its peers for the same diagnostic criteria.

MATERIALS AND METHODS

This study is part of the randomized clinical trial developed by the Rehabilitation Studies Group of the Federal University of Health Sciences (GEReab–UFCSPA), following all the methodological precepts listed in the original study from which it came. All assessments were done between March-2018-February-2021.

Study design

This is Cross-sectional observational study. Individuals included in this study were part of the RCT, as previously mentioned. For this study, however, only the evaluations of the volunteers were used, and they are demonstrated in a transversal way. In other words, there is no comparison on the evolution of patients in relation to the intervention to which they were submitted, nor are they divided into the groups to which they were originally randomized. This was used in the evaluations only, and each evaluation composes, in this study, an individual, counting for the final sample.

Research place

Federal University of Health Sciences of Porto Alegre (UFCSPA) with older volunteers from invitations made by various means, such as digital media, invitations delivered by mail, telephone calls and contacts with other research projects at UFCSPA that involved older people.

Ethical procedures

This study was submitted and approved by UFCSPA research ethics committee, registered under the number CAAE 66091417.5.0000.5345, with approval letter numbered 3.335.461.

In addition, all volunteers read and signed the free and informed consent form, in which all volunteer research subjects were presented to the risks and benefits of being included in a research project of this nature.

Inclusion criteria

To be included as a sample in this project, the individual must be considered older, that is, be 60 years of age or older, as established by Brazilian Law Nº 8.842/1994, being a resident of the city of Porto Alegre, Rio Grande do Sul, being aware of all the protocols to which they will be submitted and signing the Free and Informed Consent Form (ICF).

Exclusion criteria

Older people who did not want to participate in the project, and/or with physical, cognitive or metabolic disabilities were excluded from the study, as described below:

- People with physical, cognitive or sensory disabilities that make the individual unable to participate in the assessments proposed.
- Older people undergoing a postoperative process, of any nature, or who are undergoing physical therapy rehabilitation of any nature.
- Older people classified in the initial assessment as "high risk" for physical exercise, presenting cardiovascular, pulmonary or metabolic disorders, or one or more cardiovascular signs and symptoms were also excluded. Inclusion and exclusion criteria were identified through the first assessment, before the randomization process.

Procedure for data collection and evaluations

The evaluations were carried out at UFCSPA, by trained professionals. For the original project, participants underwent a series of assessments, including level of physical activity, sarcopenia, body composition, functional capacity, muscle quality, quality of life, and semi quantitative food frequency questionnaire and cytokine analysis.

The evaluators were blinded about the data treatment, as the statistical analysis was carried out by professional blinded about the assessments.

As it is a cross-sectional study, there were no lost of patients. It is, all patients assessed are included in the analysis. Is also important to notice that some assessments methods were not assessed in all sample, for many reasons, as discomfort with the test, fear of falling, or were stopped by the evaluator because the test represented some risk for the patient. The sample for each assessment can be found in Table 1.

For this study, however, the following assessments are presented:

Muscle strength: assessed by handgrip (Jamar hydraulic hand dynamometer-Sammons Preston Rolyan, IL, USA), which data are presented in Kg. The patients position and test realization followed the recommended by the American Society of Hand Therapy and; isokinetic dynamometry (Biodex System pro 4-Biodex Medical Systems Inc., NY, USA), which data are presented in Newton. meter (N.m) [8]. The patient positioning and protocol to assess were following Kannus, et al. [9]. Are presented only assessments of peak torque by isotonic eccentric contraction (PT) of quadriceps and hamstrings in movements of knee extension and flexion.

Skeletal muscle mass: Assessed by Bioimpedance Analysis-BIA (Maltron BF-906 Body Fat Analyser, Maltron International Ltd, Essex, UK). The patients preparation and positioning followed the recommended by the European Society for Clinical Nutrition and Metabolism [10]. The data collected was the impedance resistance, and the SMM was calculated using the formula proposed by Janssen, et al.; and skinfolds (Scientific Adipometer Top Tec II. Cescorf, Porto Alegre, Brazil). Triceps, suprailiac, subscapularis, midaxillary, thigh and calf skinfolds were collected, and the fat-free mass (FFM) was calculated using the formula proposed by Pereira, et al. [11,12].

Physical performance: Assessed by usual gait speed, through the 6-minute walk test, conducted following recommendation by Enright [13]. The data was reached dividing the meters walked by 360 seconds (six minutes); The timed-up-and-go test, following the recommended by Podsiadlo, et al., which data are presented in seconds to finish the test, and; The Short Physical Performance Battery, according to the Brazilian Portuguese version, which data are presented in points, been 0 the minimum, and 12 the maximum [14,15].

Also other variables are presented in this work, as the calf circumference and mid-arm circumference (MAC) [16].

Statistical analysis

The description of qualitative variables was expressed in absolute and relative frequency. The results of the quantitative variables are presented in mean and Standard Deviation (SD), median and Interquartile Range (IQR). Data were tested for normality by Shapiro-Wilk's test, and the correlations were assessed by Spearman's Correlation Coefficient. The correlation, presented with rs, was accepted as low when r>0,1; moderate when r>0,3, and; high when r>0,5, following the recommendations by Cohen [17]. The p-value<0,05 was adopted as significant. The analyzes were performed in the statistical software SPSS (IBM SPSS Statistics for Windows, Version 25.0. IBM Corp., Armonk, NY).

RESULTS

Table 1 demonstrates the characteristic of the sample evaluated. Of the 83 assessments, 78.31% were women (n=65). In addition, the average age verified was 67,85+5,27 years, which shows an average of young older people.

Regarding the diagnostic criteria for sarcopenia, according to the EWGSOP2, the sample presented, on average, assessments above the cut-off points proposed by EWGSOP2 for handgrip strength, SMM, usual gait speed, TUG and SPPB.

The following table present the correlations between the variables. As many data were returned in the analyses, only those recommended by EWGSOP2, or that showed some correlation with sarcopenia diagnostic criteria were included. The other data, those that did not show statistically significant results, can be seen in Appendix 1.

In Table 2, we can see the correlations between the evaluations for the same diagnostic criterion. In strength assessments all data showed correlation between themselves. Handgrip strength showed moderate correlation with quadriceps peak torque, and high with hamstrings peak torque. Both peak torque assessments showed good relation between them.

SMM showed a high positive correlation with FFM, and a low correlation with calf circumference and MAC. The FFM showed high correlation with all body composition assessments: MAC and calf circumference, showing that this data could be the most reliable to assess body composition.

In physical performance, all three assessments recommended by EWGSOP2 and presented here showed some correlation. UGS had moderate correlation with SPPB and high with TUG, while TUG showed low correlation with SPPB.

To understand those data are still needed some clarification about the results showed. In general, is expected that the individual has higher results. For example, to have more SMM is good, as is show more handgrip strength, or gait speed. However, the TUG test is expected to have lower results, when is measured the time to complete the track. So, to have completed in less time is a good outcome. In this way, is expected that good correlations with this assessment are negative.

Table 1: Descriptive data analysis.

	Variable	n	Mean+SD	Median	IQR
Sample Characteristics	Gender (female)		65 (78,31%)²		
	Age	81	67,82 ± 5,29	65,87	63,61-70,6
	BMI (Kg/m²)	81	29,01 ± 4,35	29,27	26,34-31,46
Strength	Handgrip strength (Kg)¹	79	31,29 ± 9,08	30	25-34
	PT Quadriceps	30	138,36 ± 47,12	128,5	110,1-166
	PT Hamstrings	30	110,17 ± 40,39	103,15	77,8-142,8
	Sit-to-stand test³	77	3,06 ± 1,02	3	2-4
Body Composition	SMM by BIA (Kg)¹	77	13,55 ± 2,8	12,75	11,82-14,92
	FFM by skinfolds (Kg)	63	49,82 ± 8,18	48,73	44,52-55,94
	Calf circumference (cm)	63	36,94 ± 3,25	37	35-39,5
	MAC	81	19,23 ± 10,62	23,41	20,81-25,92
Physical Performance	Usual gait speed (m/s)¹	81	1,26 ± 0,36	1,33	1,18-1,44
	TUG Time (s)¹	72	6,89 ± 1,39	6,7	6-7,67
	SPPB (points)¹	81	10,47 ± 2,61	11	10-12

Note: n: sample; SD: Standard Deviation; IQR: Interquartile Range; ¹Assessments recommended by EWGSOP2 to assess sarcopenia in older people; ²Data presented in absolute and relative frequency; ³Data extracted from SPPB test, been the third field of analysis in this instrument; SMM: Skeletal MUSCLE MASS; BIA: Bioimpedance analysis; Kg: Kilogram; FFM: Fat-Free Mass; BMI: Body MASS Index; m: meter; cm: centimetre; MAC: Mid-ARM Circumference; s: seconds; TUG: Timed-up-and-go test; SPPB: Short Physical Performance Battery; PT: Peak Torque of isotonic eccentric contraction.

Table 2: Correlations across the sarcopenia assessments.

Correlations	p-value	rs
Muscle Strength		
Handgrip Strength × Peak Torque# Quadriceps	0,008*	0,491²
Handgrip Strength × Peak Torque# Hamstrings	<0,00001*	0,711³
Handgrip Strength × Sit-to-stand test	0,587	0,063
Peak Torque# Quadriceps × Peak Torque# Hamstrings	<0,00001*	0.745³
Peak Torque# Quadriceps × Sit-to-stand test	0,580	0,109
Peak Torque# Hamstrings × Sit-to-stand test	0,757	0,061
Body Composition		
Skeletal Muscle Mass × Calf Circumference	0,035*	0,268¹
Skeletal Muscle Mass × Mid-arm Circumference	0,044*	0,231¹
Skeletal Muscle Mass × Free-fat Mass	<0,00001*	0,565³
Free-fat Mass × Mid-arm Circumference	<0,00001*	0,668³
Free-fat Mass × Calf Circumference	<0,00001*	0,801³
Physical Performance		
Usual Gait Speed × SPPB	0,003*	0,326²
Usual Gait Speed × TUG	<0,00001*	-0,631³
TUG X SPPB	0,046*	-0,236¹

Note: p-value and rs by Spearman Correlation; *statistically significant correlation; ¹low correlation; ²moderate correlation; ³high correlation; TUG: Timed-up-and-go test; #peak torque of isotonic eccentric contraction; SPPB: Short Physical Performance Battery.

DISCUSSION

Strength

All relationships between strength assessments were statistically significant, except for the sit-and-stand test, which showed no significant correlation with any test presented in this work.

According to some authors, handgrip tests have a good association, comparability and reliability when compared with the standard of strength assessment, the isokinetic dynamometry, particularly in older people groups [18,19]. This can explain why the isokinetic dynamometry is no longer recommended by the EWGSOP2, since the revised consensus [3]. If there is a faster and cheaper test, there would be no reason to use its standard, if not for method comparisons, like this work.

It is important to highlight that some authors have longitudinal studies. According to Ostolin, the handgrip test has a good comparability with isokinetic dynamometry in cross-sectional studies, but the same does not occur over time, in prospective studies. The hypothesis for this statement is that, when older people are trained, over time, have a more significant improvement in the musculature of the knee flexors and extensors, when compared to the palmar grip muscle groups. As in older people not undergoing interventions, over time the tendency is that more strength is lost in the muscles of the lower limbs than in upper limbs [19].

Meanwhile, the sit-to-stand test, although has a good relationship with the strength following some authors, and listed as one valid test for sarcopenia by the main consensuses, its relationship with muscle strength may depend of other factors, such as balance, familiarity with the test, impairment of the lower limbs, among others [3,4]. Also, this test is integrant part of the SPPB, one of the main tests to evaluate performance listed by EWGSOP and AWGS [3,4]. Thus, the sit-and-stand test could be better understood as a functional test, and not just a strength test. However, it did not present significant correlations with any test in this study, either strength or physical performance. This may be due to the excellent results in this test by most sample who performed it. We hypothesize that for this result, with generally high results in older dwelling people, a larger sample might be needed in order to demonstrate a significant correlation with other tests.

Body composition

In this work, SMM assessed by BIA showed low correlation with CC and MAC, while FFM measured by skinfolds showed high correlation with SMM, MAC and CC.

The SMM, assessed by BIA, showed a good correlation with the FFM, assessed by skinfolds. Although this second type of assessment was taken from the 2019 review of the European consensus for sarcopenia [3], this assessment appears to be valid for measuring this variable, although we did not have a standard to compare with both measures. According to Bruyere, et al., anthropometric assessments are the most used in clinical practice, representing about 57.5% of clinical assessments of body composition, as it is an instrument that is easy to apply, fast and inexpensive [20]. However, according to Beaudart, et al., with advancing age, skinfolds may lose their power to predict skeletal muscle mass, as better comparisons with dual-energy X-ray absorptiometry (DXA) are still needed a definition, in addition to more accurate cut-off points for this purpose [21].

Another interesting finding was the correlation, albeit low, of CC and MAC with SMM, and high correlation of those both variables with FFM. Calf circumference has been widely used in sarcopenia assessments for some time, and is even a valid screening measure for AWGS [4]. Kawakami, et al. compared the correlation of CC with BIA (presented in this work) and with the standard for evaluating this variable, DXA, finding a good correlation for both, concluding that this variable can be a simple, inexpensive, quick and reliable substitute for body composition assessments in sarcopenia [22].

The mid-arm circumference has lately been used as a predictor for several negative health outcomes, mainly by the National Health and Nutrition Examination Survey (NHANES), such as mortality, insulin resistance, arterial hypertension, among others, but this variable has been rarely used for risk assessment in sarcopenia [23-25]. As demonstrated in this work, there is a correlation between this measure and other assessments for body composition, such as BIA and skinfolds. Although the results were discreet, and with a not so expressive sample, evidence supports that this measure can be a better predictor for certain health outcomes, even better than widely used body composition assessments, such as BMI [26].

Performance

In this work, UGS presented moderate correlation with SPPB, and high correlation with TUG test. The TUG test also showed low correlation with SPPB.

According to EWGSOP2, the UGS is the simplest and most reliable measure to assess physical performance, in addition to being the most used measure in studies in sarcopenia field. SPPB and TUG are also recommended as being highly reliable for the assessment of physical performance [3,4]. However, in this part of the evaluation, the aim is to diagnose the severity of the syndrome, and this may depend on several factors, according to the characteristics of the patient.

For example, the UGS is a simple measure to obtain, and does not depend on a great understanding on the part of the patient, like the TUG and SPPB, thus favoring the patient with cognitive deficits or comprehension difficulties [3]. The TUG is a more complex test, which assesses the ability to sit and stand up from a chair, and to walk not only in a straight line, but also to make a 180º turn when walking, and a 180º turn when sitting [14]. This involves other parameters such as balance, cognition, fear of falling and mobility [27]. The SPPB, the most complex of the tests, is also the most complete, as it encompasses all the variables mentioned above, plus a variable of strength and power output, the sit-to-stand test [15]. Because it is so comprehensive, it is considered by some authors as the best predictor of negative outcomes for health, such as the risk of falls, immobility and mortality [28,29].

It is important to note that most consensuses, including EWGSOP2, determine gait, power, and endurance tests, together or alone, to assess older people physical performance, but do not recommend any isolated balance test, such as the Berg Balance Scale [3-6]. In this study, this instrument demonstrated a correlation with UGS (p=0,002; rs=0.347) and TUG (p=0,034; rs=-0.250), albeit modestly, and it can be explored more deeply by future studies as a valid instrument to assess physical performance in older people in suspicion of severe sarcopenia, since this test has good correlation with the same TUG and UGS outcomes, such as risk of immobility and falls, and even as an indicator of mortality [30].

This demonstrates that there are differences at the core of these assessments and, although they have a good correlation according to several authors [3-6], including the results found in this work, the literature needs to better define which of these tests is for which type of patient, in order to avoid using a test that does not correctly encompass the severity of the syndrome, overestimating the results, or that meets the specific deficits of the patients, underestimating the results.

CONCLUSION

For muscle strength in sarcopenia assessment, the most comparable test is the handgrip strength, having also the best cost-benefice among those available to assess this criterion. Also, the sit-to-stand test seems not have a good correlation with the standard, or even with the handgrip strength, for this sample. The isokinetic dynamometer, although have good relations with other tests, those relations are not as good as handgrip, and this test is very more expensive than its comparison.

For SMM assessment, the evaluation by BIA stands out as the most reliable assessment among those presented here. However, is important to highlight that cheaper and faster assessments as FFM with skinfolds, calf circumference and MAC have some good correlations with this technique, making those good options to population studies, with huge samples, or even to clinic assessments in public health, which tends to be in a short time and space, and with limited resources.

To assess the physical performance in sarcopenia, as is widely known in literature, the UGS is the one that showed most correlations with other techniques. Besides, this variable can be obtained with fast and cheap tests that can be made in any space or place. The TUG, however showed some correlations with the PP tests, presented best correlation with strength and body composition tests than with PP. The SPPB test showed moderate correlation with UGS, and low with TUG, and none significant correlation with any other test. This raises a question about the reliability of those two tests when compared with other PP assessment techniques.

Also is important to highlight that those correlations across diagnostic criteria showed good results, meaning that some techniques can be comparable between themselves to assess sarcopenia. For example, SMM and FFM showed high correlations with PP and strength tests; UGS and TUG showed the same when compared with body composition and strength tests, and; all three strength tests presented here showed the same with PP and body composition assessments.

LIMITATIONS

We did not have access to any test with higher accuracy and specificity for SMM assessment, as DXA, MRI or CT, making the comparisons to this criteria a less reliable evidence. Also, the fact of the sample be small can reduce the power of statistical tests presented here. We advise new wide studies, with higher samples, and using all the standards tests available to each variable, comparing them with other techniques.

CONFLICT OF INTERESTS

The authors of this article declare that there is no conflict of interest.

ACKNOWLODGEMENTS

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior–Brasil (CAPES).

REFERENCES

1. Feinstein A. Editorial: Icd-10. Int J Soc Psychiatry. 1993;39(3):157-8.
2. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, Boirie Y, Cederholm T, Landi F, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in older people. Age Ageing. 2010;39(4):412-23.
3. 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(1):16-31.
4. Chen LK, Woo J, Assantachai P, Auyeung TW, Chou MY, Iijima K, et al. Asian Working Group for Sarcopenia: 2019 Consensus Update on Sarcopenia Diagnosis and Treatment. J Am Med Dir Assoc. 2020;21(3):300-7 e2.
5. Cruz-Jentoft AJ, Landi F, Schneider SM, Zuniga C, Arai H, Boirie Y, et al. Prevalence of and interventions for sarcopenia in ageing adults: A systematic review. Report of the International Sarcopenia Initiative (EWGSOP and IWGS) [with consumer summary]. Age and Ageing 2014;43(6):748-759.
6. Morley JE, Abbatecola AM, Argiles JM, Baracos V, Bauer J, Bhasin S, et al. Sarcopenia with limited mobility: an international consensus. J Am Med Dir Assoc. 2011;12(6):403-9.
7. Ferreira LF, Scariot EL, da Rosa LHT. The effect of different exercise programs on sarcopenia criteria in older people: A systematic review of systematic reviews with meta-analysis. Arch Gerontol Geriatr. 2023;105:104868.

8. Fess EE. Grip Strength. In: Clinical assessment recommendations. Chicago, IL.: American Society of Hand Therapists; 1992.

9. Kannus P. Isokinetic evaluation of muscular performance: Implications for muscle testing and rehabilitation. Int J Sports Med. 1994;15(S1):S11-8.

10. Kyle UG, Bosaeus I, De Lorenzo AD, Deurenberg P, Elia M, Manuel Gomez J, et al. Bioelectrical impedance analysis-part II: Utilization in clinical practice. Clinical nutrition. 2004;23(6):1430-53.

11. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. J Appl Physiol. 2000;89(2):465-71.

12. Pereira PMG, da Silva GA, Santos GM, Petroski EL, Geraldes AA. Development and validation of anthropometric equations to estimate appendicular muscle mass in elderly women. Nutr J. 2013;12:92.

13. Enright PL. The six-minute walk test. Respir Care. 2003;48(8):783-5.

14. Podsiadlo D, Richardson S. The timed "Up and Go": A test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-8.

15. Nakano MM, Otonari TS, Takara KS, Carmo CM, Tanaka C. Physical performance, balance, mobility, and muscle strength decline at different rates in elderly people. J Phys Ther Sci. 2014;26(4):583-6.

16. Chumlea WC, Guo SS, Kuczmarski RJ, Flegal KM, Johnson CL, Heymsfield SB, et al. Body composition estimates from NHANES III bioelectrical impedance data. Int J Obes Relat Metab Disord. 2002;26(12):1596-609.

17. Cohen J. Statistical power analysis. Current directions in psychological science. 1992;1(3):98-101.

18. Bohannon RW. Muscle strength: Clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care. 2015;18(5):465-70.

19. Ostolin TLVDP, Gonze BdB, de Oliveira Vieira W, de Oliveira ALS, Nascimento MB, Arantes RL, et al. Association between the handgrip strength and the isokinetic muscle function of the elbow and the knee in asymptomatic adults. SAGE Open Med. 2021;9:2050312121993294.

20. Bruyère O, Beaudart C, Reginster JY, Buckinx F, Schoene D, Hirani V, et al. Assessment of muscle mass, muscle strength and physical performance in clinical practice: An international survey. Eur Geriatr Med. 2016;7(3):243-6.

21. Beaudart C, McCloskey E, Bruyère O, Cesari M, Rolland Y, Rizzoli R, et al. Sarcopenia in daily practice: assessment and management. BMC Geriatr. 2016;16(1):170.

22. Ito A, Ishizaka M, Kobayashi K, Sawaya Y, Hara T, Nagasaka Y, et al. Changes in the screening efficacy of lower calf circumference, SARC-F score, and SARC-CalF score following update from AWGS 2014 to 2019 sarcopenia diagnostic criteria in community-dwelling older adults. J Phys Ther Sci. 2021;33(3):241-5.

23. Nwankwo T, Ostchega Y, Zhang G, Hughes JP. Validating prediction equations for mid-arm circumference measurements in adults: National Health and Nutrition Examination Survey, 2001-2012. Blood Press Monit. 2015;20(3):157-63.

24. Chao YP, Lai YF, Kao TW, Peng TC, Lin YY, Shih MT, et al. Mid-arm muscle circumference as a surrogate in predicting insulin resistance in non-obese elderly individuals. Oncotarget. 2017;8(45):79775-84.

25. Ostchega Y, Hughes JP, Nwankwo T, Zhang G. Mean mid-arm circumference and blood pressure cuff sizes for US children, adolescents and adults: National Health and Nutrition Examination Survey, 2011-2016. Blood Press Monit. 2018;23(6):305-11.

26. Ho SC, Wang JY, Kuo HP, Huang CD, Lee KY, Chuang HC, et al. Mid-arm and calf circumferences are stronger mortality predictors than body mass index for patients with chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis. 2016;11:2075-80.

27. Tessier AJ, Wing SS, Rahme E, Morais JA, Chevalier S. Physical function-derived cut-points for the diagnosis of sarcopenia and dynapenia from the Canadian longitudinal study on aging. J Cachexia Sarcopenia Muscle. 2019;10(5):985-99.

28. Hoekstra T, Rojer AGM, van Schoor NM, Maier AB, Pijnappels M. Distinct trajectories of individual physical performance measures across 9 years in 60- to 70-year-old adults. J Gerontol A Biol Sci Med Sci. 2020;75(10):1951-9.

29. de Fátima Ribeiro Silva C, Ohara DG, Matos AP, Pinto A, Pegorari MS. Short physical performance battery as a measure of physical performance and mortality predictor in older adults: A comprehensive literature review. Int J Environ Res Public Health. 2021;18(20):10612.

30. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: Validation of an instrument. Can J Public Health. 1992;83(S2):S7-11.