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Cut-off points to determine muscle mass reduction by electrical bioimpedance analysis for the diagnosis of sarcopenia in older adults: a systematic review

Maria Camila PINEDA ZULUAGA[1], Clara Helena GONZÁLEZ CORREA[1], Angélica Guadalupe MARTÍNEZ DURÁN[2]

1 Department of Basic Sciences, Health Faculty, Universidad de Caldas.
2 Universidad de Guadalajara.

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ABSTRACT

Introduction: Sarcopenia is considered a muscular disease known in older adults, characterized by the reduction of muscle mass and physical performance. In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) established criteria to define sarcopenia based on muscle mass, grip strength, and gait speed. Bioelectrical Impedance Analysis (BIA) has become popular for estimating body composition in various populations, particularly for assessing sarcopenia in geriatrics.

Objective: To identify the cutoff points for Skeletal Muscle Mass Index (SMI) using BIA for the diagnosis of sarcopenia in men and women aged over 60 years within the period between January 1, 2010, and July 19, 2020.

Methodology: A literature search was conducted in the databases of PubMed, Science Direct, Springer, EBSCO, Scopus, OVID, and WOS. Studies in English and Spanish reporting cutoff points for skeletal muscle mass evaluated by BIA for the diagnosis of sarcopenia in adults > 60 years of both sexes were included. Results: Only 14 studies met the inclusion criteria. The cutoff points for the decrease in muscle mass varied in each study from 7 kg/m^2 to ≤ 10.75 kg/m^2 in men and from <5.7 kg/m^2 to <7.4 kg/m^2 in women, adjusted for height.

Conclusion: This systematic review enabled the recognition of distinct cutoff points for the diagnosis of sarcopenia in older adults worldwide. Furthermore, it demonstrated that the cutoff points for SMI vary from country to country. As a result, further studies encompassing diverse regions within each country are necessary to establish cutoff points that enhance the accurate diagnosis of sarcopenia in the elderly population.

KEYWORDS

Cut-off points, skeletal muscle mass index, sarcopenia, elderly, BIA.

ABBREVIATURES

EWGSOP: European Working Group on Sarcopenia in the Elderly.

BIA: Bioelectrical Impedance Analysis.

WHO: World Health Organization.

SD: Standard Deviations.

DEXA: double-energy X-ray.

INTRODUCTION

Sarcopenia is defined by the triad of loss of muscle mass, muscle strength, and physical function[1]. It is considered a muscle disease that is well known in older adults and can be detected in the fourth decade of life[2,3]. This reduction in muscle mass can also be accompanied by bone loss and cause fragility in addition to other clinical implications, which reduce physical performance and increase the risk of mortality[4-6].

Currently, the World Health Organization (WHO) estimates that sarcopenia affects more than 50 million people and will affect more than 200 million in the next 40 years. Between 5% and 13% of people between 60 and 70 years old and

Correspondencia:
Clara Helena González Correa
clara.gonzalez@ucaldas.edu.co

11% to 50% of people 80 years of age and older, among the normal population, have sarcopenia[7].

In Latin America, the aging process is accelerated and reaches figures of over 20%. Added to this situation are limitations in at least one basic activity of daily life, largely due to sarcopenia[8,9]. This is how the quantification of muscle mass arises as an increasingly important necessity in geriatric medicine[10,11].

In 2010, the European Working Group on Sarcopenia in the Elderly (EWGSOP) established criteria for defining sarcopenia based on the measurement of muscle mass, grip strength, and gait speed. For diagnosis, at least two of these criteria must be present, with the primary criterion being a skeletal muscle mass index (SMI) below 2 standard deviations (SD) from a reference population of young individuals. Reducing gait speed to less than 0.8 m/s and/or muscle strength below 20 kg/F in women and 30 kg/F in men would complete the syndrome[12,13]. However, there is a newer version of the working group's guidelines (EWGSOP2) published in 2018, which emphasizes recommendations to increase awareness of the risk associated with sarcopenia[2].

The AWGS (The Asian Working Group for Sarcopenia), defined sarcopenia as age-related loss of muscle mass, with low muscle strength and/or low physical performance and considered as a cut-off point for a determination as <7.0 kg/m2 in men and <5.7 kg/m2 [13]. The FNIH (Foundation for the National Institutes of Health)[11], through a comment article in 2014, agreed with the 2010 EWGSOP definition and considered sarcopenia with BMI-adjusted figures as <0.512 in women and <0.789 in men[14].

Furthermore, Bioelectrical Impedance Analysis (BIA) has become popular as a non-invasive, cost-effective, and rapid method for estimating body composition in different populations, particularly for assessing sarcopenia in geriatrics. However, some studies suggest that BIA might overestimate muscle mass in the elderly compared to Dual-Energy X-ray Absorptiometry (DXA)[15]. However, BIA is not only the technique available in low- and middle-income countries, but also a reliable, portable, simple, inexpensive, and non-invasive method that estimates body composition and is considered a valid substitute for total muscle mass with a high correlation to magnetic resonance imaging (MRI) results[16].

OBJECTIVE

To identify the cutoff points for Skeletal Muscle Mass Index (SMI) using BIA for the diagnosis of sarcopenia in men and women aged over 60 years within the period between January 1, 2010, and July 19, 2020.

METHODOLOGY

A literature search of electronic databases, including PubMed, ScienceDirect, Springer, EBSCO, Scopus, OVID, and WOS were performed. The PRISMA diagram shows the selection process for the items.

Search strategy

The following search strategy was used with Boolean operators: ("cut-off points" AND "sarcopenia" AND "elderly"), ("electrical bioimpedance" AND "Sarcopenia"), ("elderly" AND "muscle mass" AND "bioelectrical impedance").

Selection and exclusion criteria

Studies in English and Spanish available as a full publication were included, from January 1, 2010, to July 19, 2020, reporting the cut-off points of skeletal muscle mass estimated by electrical bioimpedance for the diagnosis of sarcopenia in adults from both sexes 60 years of age or older, who did not present any physical restriction or comorbidities. On the other hand, articles are written in another language, that were duplicated, that did not have the full text available, or that were not relevant to the study were excluded.

Data extraction

The references were exported from the electronic databases to the Mendeley Desktop bibliographic manager. Subsequently, the data was exported from the manager to an Excel sheet (Microsoft Excel 2010) to eliminate duplicate references and record the different findings. The selected articles contained information on the research objective, methodological design, population characteristics, description of the device used, and at least one cut-off point for the determination of low muscle mass.

To carry out this review, the evaluation standards of the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) were applied as shown in Figure 1[17].

RESULTS

429 records were identified, which were reduced to 63 selected by titles and abstracts, of which 19 duplicate articles were found, giving a total of 44 screened. Three that did not show the full text were excluded, to later assess the remaining 41 who did have the full text available; 12 studies matched the selection criteria and were included for analysis.

The studies reviewed were 10 original articles[9,14,15,18-24] and 2 manuscripts[11,25] approved by the journal, 10 were cross-sectional[9,11,14,15,18,20-24] and 2 from cohort[19,25] The publication date ranged from 2012 to 2020. 2 studies were developed in Spain[21,22], 1 in Turkey[18,22], 2 in Austria[11,15], 1 in Finland[24] and 1 in Netherlands[25]. Latin America contributed 2 studies, 1 in Brazil[23] and another in Colombia[9], the rest of the studies were conducted in Australia[18] and Japan[14,19].

Participants

A total of 7663 subjects participated in the different studies evaluated. The mean ages of the population ranged from 71.7 to 83.4 years, with a mean of 77.2 years across all studies and a standard deviation of + 1.5 years. Its Selection was mostly carried out in communities 7 studies)[14,18,19,24-26] in geriatric hospitals (3 studies)[11,15,23] in geriatric homes (1 study)[9], and a body composition laboratory (1 study)[20].

BIA measurements

8 of the studies were applied with a tetrapolar configuration, 1 study with an octopolar application and in 2 they were not reported. The most widely used model was the BIA-101Akern / RJL in four studies[11,15,21,22] Tanita BC 532 in 1 study[18], Tanita BC-418 in 1 study[9], Inbody 430 in 1 study[19], original ImpediMed SFB7 in a study[24], Tanita MC-780Ain 1 study[14] in another 3 different types of Inbody were included

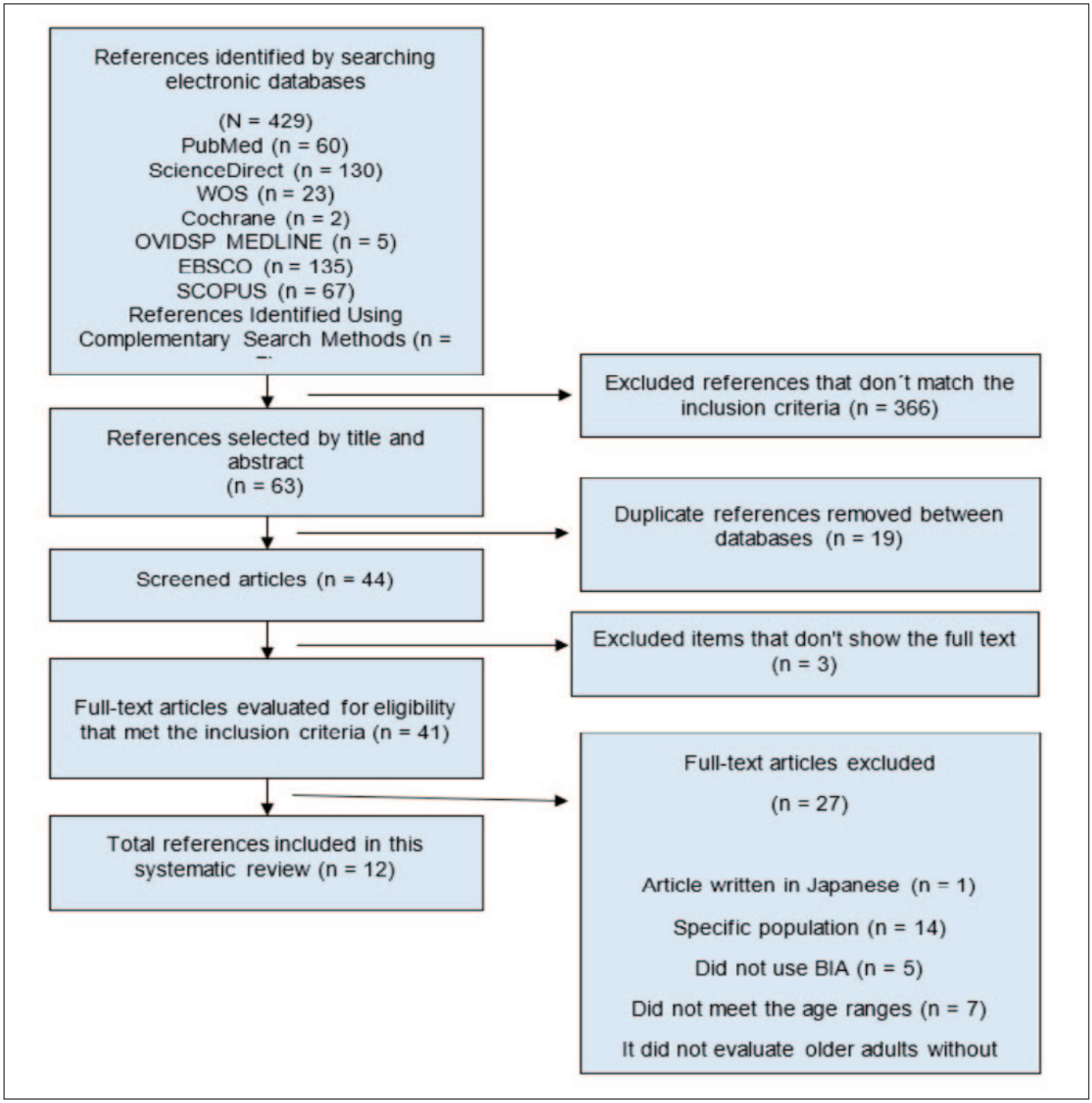

Figure 1. Flowchart on the identification of the eligibility of the systematic review in the study

(230, S10, 720)[25], 1 used the BF-450 model[23] and in 1 the ImpediMed DF50 model[20] was used. Regarding frequencies, 50 kHz was the most used in 7 studies[11,14,15,20-23], only 1 used 1000 kHz[24] and in 7 it was not described[9,18,19,23]. Table 1 better describes the characteristics of the studies.

Only 4 studies used dual-energy X-ray absorptiometry[11,15,20,23], compared to BIA, of which 2 used the GE Lunar model[20,25], 1 used the Hologic Inc., Marlborough, Mass[11] and the surplus did not report the model[15].

Equations

The most widely used equation was that of Janssen in 5 articles[15,20-22,24,26]. In 3 other studies, they chose to calculate the muscle mass index by dividing skeletal muscle mass in kilograms (kg) by height in meters squared[9,19,25], and in 1, the following formula was used: 0.566 × fat-free mass (kg)[18].

In a study that aimed to compare the single-frequency BIA equations to evaluate their precision, the formulas of Kyle, Sergi, Scafoglieri, and Rangel[15,29-32] were used. In another report designed to validate the BIA single frequency prediction, the Téngale, Janssen, and Kyle equations[20,21] was used. Finally, in 1 study the equation used was not reported[9]. Table 2 shows the breakdown of each formula used in the studies.

The cut-off points for SMMI for the diagnosis of sarcopenia varied varied in each study from 2.31 kg/m^2 to ≤10.75 kg/m^2 in men and <5.66 kg/m^2 to <7.4 kg/m^2 in women, adjusted for height (Tabla 3).

EWGSOP criteria were used to define sarcopenia in 8 studies (9, 11, 14, 18, 20-23), which considers sarcopenia if muscle mass is <7.26 kg/m^2 in men and <5.6 kg/m^2 in women. However, articles were identified in which they only used the cut-off points of the formula they used to define sarcopenia[17,19,22].

Table 1. Characteristics of the Selected Studies in the Present Review

Author, Year	Country	Population (%)	Sample size	Average age	SD	BIA model	Frequency (kHz)	Application (electrodes)
Bahat et al. 2019[18]	Turkey	M = 31.8 W = 68.1	1437	74.6	7	Tanita BC 532	N/A	N/A
Uemura et al. 2019[14]	Japan	M= 35.6W = 64.3	205	72.6	4.8	Tanita MC-780A	50	Octopolar
Reiter et al. 2018[11]	Austria	M = 40W = 60	144	80.7	5.6	AKERN BIA 101	50	Tetrapolar
Ishii et al. 2014[19]	Japan	M= 49.5W = 50.4	1971	78.4	5.5	Inbody 430 machine	N/A	N/A
Bosaeus et al. 2014[20]	Australia	M= 61.5W= 38.4	117	75	4	ImpediMed DF50	50	Tetrapolar
Reiss et al. 2016[15]	Austria	M= 30W= 70	60	81.6	5.28	AKERN BIA 101	50	Tetrapolar
Masanés et al. 2017[21]	Spain	M= 33.9W= 66	568	N / A	N / A	AKERN BIA 101	50	Tetrapolar
Masanés et al. 2012[22]	Spain	M = 55W = 45	200	74.4	3.2	AKERN BIA 101	50	Tetrapolar
Ferreira et al. 2017[23]	Brazil	M= 26.3W= 73.6	216	77	8	BF-450	50	Tetrapolar
Urazán et al. 2018[9]	Colombia	M= 50.9W= 49.1	61	80.4	7.9	Tanita BC-418	N/A	Tetrapolar
Björkman et al. 2019[24]	Finland	M= 33.5W= 66.5	428	83.4	4.6	ImpediMed SFB7	1000	Tetrapolar
Van et al. 2020[25]	Netherlands	M= 43.6W= 56.4	2256	71.7	4.6	In-Body S10	N/A	N/A

M, Man; W, Women; SD, Standard Deviation; N/A, Not Applicable.

Table 2. Formulas for estimating skeletal muscle mass

Equation name	Formula to calculate skeletal muscle mass (SMM) in kg
BIA Janssen[26]	SMM (kg) = (Ht² / R * 0.401) + (3.825 * sex) + (-0.071 * age) + 5.102
BIA Kyle[27]*	SMM (kg) = -4.211 + (Ht² / R * 0.267) + (0.095 * BW) + (1.909 * sex) + (- 0.012 * age) + (0.058 * Xc)
BIA Sergi[28]	SMM (kg) = -3.964 + (Ht² / R * 0.227) + (0.095 * BW) + (1.384 * sex) + (Xc)
BIA Scafoglieri[29]	SMM (kg) = 4.957 + (Ht² / R * 0.196) + (0.060 * BW) - (2.554 * sex)
BIA Rangel[30]	SMM (kg) = -0.05376 + (Ht² / R * 0.2394) + (2.708 * sex) + (0.065 * BW).
BIA Tengvall[31]	SMM (kg) = -24.021 + (0.33 * Ht²) + (-0.0.31 * R) + (0.083 * Xc) + 1.58 * sex)

Table 3. Cut-off points for SMMI for the diagnosis of sarcopenia reported by the studies included in this review that used BIA

Author,Year	SMMI	
	Men (Kg/m²)	Women (Kg/m²)
Bahat et al. 2019[18]	9.2	7.4
Uemura et al. 2019[14]	7.0	5.7
Ishii et al. 2014[19]	7.0	5.8
Bosaeus et al. 2014[20]	8.9	7.0
Reiss et al. 2016[15]	10.75	6.75
Masanés et al. 2017[21]	7.5	5.45
Masanés et al. 2012[22]	8.31	6.68
Ferreira et al. 2017[23]	10.76	6.76
Urazán et al. 2018[9]	8.87	6.42
Björkman et al. 2019[24]	9.31	6.90
Van et al. 2020[25]	10.75	6.75

DISCUSSION

Despite the clinical significance of sarcopenia, which was previously only defined by a progressive loss of muscle mass and is now known to involve a reduction in function[33], an operational definition is still lacking, as are standardized intervention programs, so much so that appropriate diagnostic cut-off values must be selected for all measurements in Latin American populations[34]. The present study shows that there are multiple variables according to the use of a tool, in our case of BIA which, as expected, differs between each population from the choice of the BIA model or the formula to be used up to the cut-off point or the diagnostic criteria.

While the use of BIA is the most widely used body composition technique in published studies[35], it has a very little boom in the elderly since scientific evidence was found quite scarce in Latin America. There are, however, several studies in young patients, such as the case of Colombia, which recently established cut-off points for the Andean region in a population of Caldas in healthy young people[15].

To show how different cut-off points for the muscle mass index affected the prevalence of sarcopenia according to the EWGSOP criteria, one study reported that their findings were similar to the FNIH[20]. However, this study was more focused on the impact of the muscle mass index.

It should be added that only one study conducted in nursing homes was obtained, taking into account that according to a study, subjects living in nursing homes have a higher prevalence[36]. There is no more literary information on the comparison of different types of cuts in the adult population, so research on this syndrome in the aging population must continue to be carried out to give it a greater impact in terms of prevalence and produce more figures. reliable, with specific cut-off points.

Among the main limitations derived from the analysis of the literature on BIA cut-off points for muscle mass reduction are: 1) the scarcity of scientific information related to the use of BIA in the elderly without comorbidities; 2) the limited scientific evidence of related documents in Latin America that allows us to compare the various cut-off points; 3) The variability of devices and frequency of IAB that can give a different result and that in many articles was not specified. Likewise, a review of information bias was not carried out by another person, so there may be a high bias.

CONCLUSION

This systematic review enabled the recognition of distinct cutoff points for the diagnosis of sarcopenia in older adults worldwide. Furthermore, it demonstrated that the cutoff points for SMI vary from country to country. As a result, fur-

ther studies encompassing diverse regions within each country are necessary to establish cutoff points that enhance the accurate diagnosis of sarcopenia in the elderly population.

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