


Prevalence of sarcopenia among the elderly: findings from broad cross-sectional studies in a range of countries



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Abstract

Sarcopenia is characterized by the generalized and progressive loss of skeletal muscle mass and strength with age. Due to the rapid growth of the global elderly population, it has become necessary to better understand the factors associated with the aging process. Therefore, to describe the frequency and distribution of such factors, including sarcopenia, it is essential to understand the issues connected with its occurrence and provide health care to the elderly. The aim of this review was to show the summary findings of epidemiological population-based studies on sarcopenia prevalence among community-dwelling elderly people, including the socio-demographic characteristics of the populations studied and the difference in outcomes between genders. The findings of six cross-sectional studies performed between 2002 and 2014 in the United States, United Kingdom, Brazil, Japan, South Korea and Taiwan were described. It was found from assessment of these six studies that sarcopenia is highly prevalent in the population aged over 60 and in both genders. Prevalence was higher among women in five of the six studies. Japan had the highest prevalence, followed by Brazil. Sarcopenia increased with age in all the studies and was associated with several health problems. It was difficult to establish a standardized assessment of sarcopenia, mainly due to the particularities of each population, an essential feature to be considered when reading studies about the prevalence of this syndrome.

Key words: Sarcopenia;
Elderly; Prevalence.

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INTRODUCTION

Sarcopenia has been described as a geriatric syndrome that is characterized by the global and progressive decrease of muscle mass and strength, severely limiting the functionality of elderly individuals.¹ Multiple mechanisms are involved in its etiology and progression, including alterations to the synthesis of proteins, proteolysis, decreases in neuromuscular function, inflammation, oxidative stress, hormonal alterations and metabolic and nutritional abnormalities. In addition, risk factors, such as gender, lifestyle habits, comorbidities and genetic factors may also predispose an individual to the onset of sarcopenia.¹⁻³ The decline of the muscle system involves modifications of the muscle fiber, with decreased innervation, vascularization and contractility, as well as impairment of the tendon units. Significant alterations can also occur in the metabolism of glucose.^{2,3} In elderly individuals, these losses can be reflected in weakness and generalized fatigue.¹⁻³

Studies of the frequency of sarcopenia among the elderly in order to describe and monitor its occurrence are currently in progress in several regions. A high prevalence of sarcopenia has been observed in an age-dependent proportion of the population (over 60 years), among whom this syndrome and its adverse effects begin to manifest in a more accentuated manner, although its onset and progression are correlated with a multifactorial contingent.⁴⁻⁷

Therefore, the aim of this literature review was to present a synthesis of the results from six epidemiological, population-based studies, conducted in six different countries, on the prevalence of sarcopenia in community-dwelling elderly individuals, while also addressing the sociodemographic characteristics of the

populations studied and the differences in the results for men and women.

METHODOLOGY

This is a narrative literature review that involved a systematic search for studies of the occurrence of sarcopenia, based on ample cross-sectional studies. The following inclusion criteria were established: studies with samples of more than 1000 individuals; studies of community residents; studies of men and women aged 60 years or more.

The PubMed, Embase, SciELO, LILACS, MedCarib and IBECs databases were searched, with no date restrictions, for articles in English, Spanish and Portuguese. The following search terms were used: sarcopenia; sarcopenia and prevalence; sarcopenia and epidemiology; sarcopenia and prevalence or epidemiology; prevalence of sarcopenia and community-dwelling elderly people; sarcopenia and aging; age-associated reductions in muscle mass. The same terms were used for the three languages (English, Spanish and Portuguese).

In total, 502 articles on this subject were identified, all of which were conducted between 1998 and 2014. Of these, 416 were excluded for one or more of the following reasons: they did not contain an abstract; they were not in one of the three search languages used; they were not adequately linked to the theme proposed in this review. Thus, 86 articles were analyzed by three researchers. Based on the abovementioned inclusion criteria, six cross-sectional studies were selected, which had been published between 2002 and 2014 and fulfilled the referred criteria. These cross-sectional studies came from six different countries: the USA; the UK; Brazil; Japan; South Korea and Taiwan.

RESULTS

Prevalence of sarcopenia in the elderly

Janssen et al.⁸ conducted a cross-sectional study on sarcopenia in the USA using data from The Third National Health and Nutrition Examination Survey (NHANES III). The NAHANES III was a national health survey that used probabilistic cluster sampling in multiple and stratified stages. This study assessed 4504 individuals aged 60 years or more (mean age of 70.5 ± 7.0 years), of whom 2224 were men and 2278 were women. Potential confounding factors, such as age, race, lifestyle habits, comorbidities and body composition, were appropriately adjusted according to the needs of the study.

Sarcopenia was diagnosed using anthropometry and bioelectrical impedance analysis (BIA) to determine the muscle mass. The calculation muscle mass/body weight $\times 100$ provided the skeletal muscle index (SMI). The BIA technique that was used in this study is strongly correlated ($r=0.93$) with magnetic resonance imaging, which is recognized for high reliability and accuracy in the analysis of the muscular system. The standard error for the estimated skeletal muscle mass (using BIA) was 9%. Individuals from ethnic groups whose BIA for muscle mass had not been validated were excluded from the final analysis. This study also used questionnaires that addressed functional aspects of impairment and physical capacity tests, such as: the walking speed test over 2.4 meters; the sit-to-stand test (SST), performed five times consecutively and the 10-second tandem test to assess static balance.⁸

Data from 6414 healthy adults (aged between 18 and 39 years) were used as reference values to define the cut-off points for normal skeletal muscle mass and sarcopenia. Elderly individuals were considered normal if their SMI was at least

one standard deviation (SD) above the gender-specific mean of the young adults. The presence of sarcopenia was confirmed if the SMI was 2 SD below the values of the young adults (Class II sarcopenia). The total prevalence of sarcopenia in elderly individuals ≥ 60 years was 7.0% among men and 10.0% among women. The results confirmed that sarcopenia increases from the third decade of life, is relatively common among individuals aged 60 years or more, and is more common among women than men (Figure 1). Sarcopenia was also correlated with functional impairment and disability.⁸

Patel et al.,⁹ based on the diagnosis algorithm proposed by the European Working Group on Sarcopenia in Older People (EWGSOP) (Figure 2), examined 1787 elderly individuals in the United Kingdom, of which 765 were men and 1022 were women. All of the participants were aged 60 years or more (67 ± 2.6 years) and had been involved in the Hertfordshire Cohort Study (HCS), a set of several cohort studies conducted in the English county of Hertfordshire. The assessments were conducted using anthropometry, adipometry (to obtain the fat-free mass index) and the following tests of physical capacity: handgrip strength (HS), with a Jamar[®] dynamometer; the walking speed (WS) test over three meters at normal speed; the SST and the timed up and go (TUG) test. WS values ≤ 0.8 m/s and HS values < 30 kg for men and < 20 kg for women were used as reference values for the detection of sarcopenia, as per the EWGSOP. Quality of life was also assessed using the SF-36 questionnaire.

Elderly individuals of both genders who were diagnosed with sarcopenia were generally shorter and lighter, with a smaller waist, hip and thigh (meso femoral) circumference. They were also slower in the execution of the TUG and SST tests and obtained lower scores in the SF-36 for “general state of health” and “functional capacity”.⁹

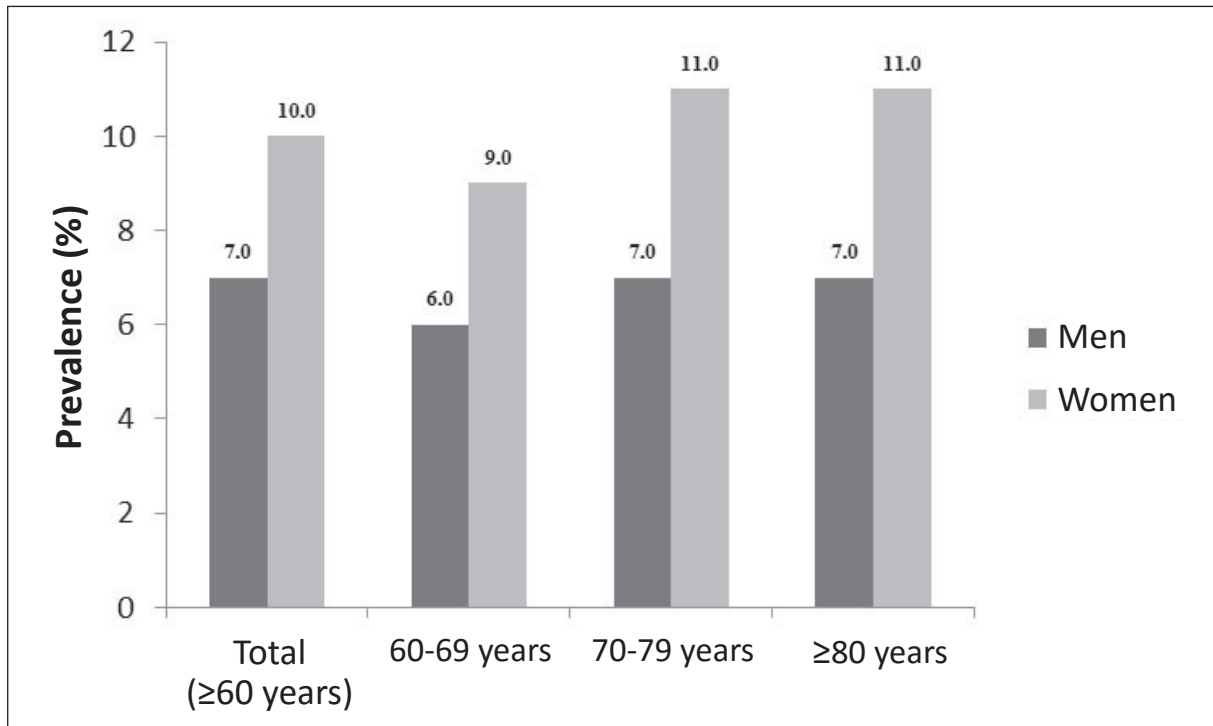


Figure 1. Prevalence of sarcopenia among men and women according to age group (USA).⁸

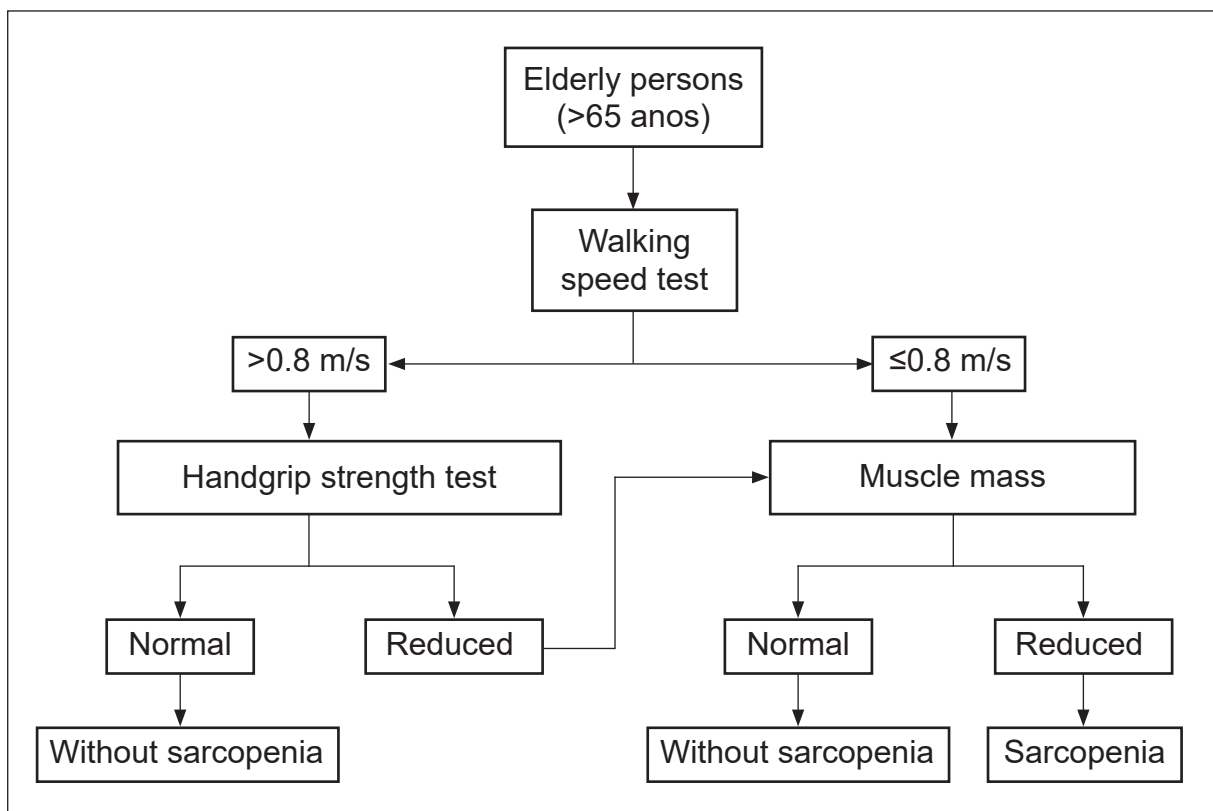


Figure 2. Diagram of the algorithm of diagnosis for sarcopenia, suggested by the EWGSOP.¹

According to the algorithm proposed by EWGSOP, the prevalence of sarcopenia was 4.6% in men and 7.9% in women. This prevalence was based on the lower third of the gender-specific distribution of the fat-free mass index, which was used as an indicator of losses in muscle mass. It is significant that the adipometry used to estimate the fat-free mass index in this study was strongly correlated ($r=0.91$) with the technique of dual energy x-ray absorptiometry (DEXA), which is used to estimate muscle mass and is considered the gold standard for this type of assessment. DEXA was used in a sub-study of the HCS with a similar, although smaller, sample.⁹ In conclusion, the authors highlighted the use of the diagnostic algorithm proposed by the EWGSOP as a practical resource in the detection of sarcopenia in community-dwelling elderly individuals.⁹ Figure 2 displays a model of the complete algorithm.

In Brazil, Alexandre et al.¹⁰ studied 1149 healthy individuals (437 men and 712 women) aged 60 years or more (69.6 ± 0.6 years) who resided in an urban area of the municipality of São Paulo. This sample was provided by the SABE (*Saúde, Bem-Estar e Envelhecimento* – Health, Wellbeing and Aging) project, which involved a population-based, multicentric study in several Latin American and Caribbean countries. Sarcopenia was again defined according to the algorithm proposed by the EWGSOP. Muscle mass was estimated by measuring appendicular skeletal muscle mass (ASMM), using the equation proposed by Lee.¹¹ Subsequently, the ASMM was adjusted for height² in order to obtain the SMI. This equation was validated for the Brazilian population using DEXA as a reference. A strong correlation was found between DEXA and the referred equation for both genders ($r=0.86$ for men and $r=0.90$ for women).¹¹ The cut-off point used to identify the

loss in muscle mass was the lowest 20% of the distribution of the population (8.90 kg/m^2 for men and 6.37 kg/m^2 for women). This study also measured the HS using a Takei[®] dynamometer and the WS for 2.4 meters at normal speed. The parameters recommended by the EWGSOP for the identification of sarcopenia were adopted (HS $<30\text{ kg}$ for men and $<20\text{ kg}$ for women; WS $\leq 0.8\text{ m/s}$). Furthermore, anthropometric, sociodemographic and behavioral data was collected from the sample, including: body composition; health status; lifestyle habits; marital status; income and education. This data was gathered using interviews and validated questionnaires.¹⁰

The results of this Brazilian study confirmed that sarcopenia in the elderly was significantly correlated with the following: advancing age; unmarried individuals; low income; infrequent physical activity (only women); decreased cognitive status; low body mass index (BMI) and SMI; malnutrition or risk of malnutrition; low prevalence of diabetes (only women) and osteoarthritis (only men). The total prevalence of sarcopenia in the sample studied, using the assessment proposed by the EWGSOP, was 15.4%. Sarcopenia was prevalent in 14.4% of the men and in 16.1% of the women. The sample was split into three age groups (60-69, 70-79 and ≥ 80 years) and prevalence increased with age, with no significant differences recorded for gender in all groups (Figure 3). However, several factors were significant: age group from 70 to 79 years (OR=2.00; CI95%=1.01-3.95); age group ≥ 80 years (OR=7.53; CI95%=3.79-14.97); cognitive impairment (OR=2.68; CI95%=1.23-5.84); low income (OR=2.57; CI95%=1.06-6.20); smokers (OR=2.00; CI95%=1.11-3.63); risk of malnutrition (OR=3.15; CI95%=2.03-4.89) and malnutrition (OR=11.54; CI95%=3.45-38.59).¹⁰

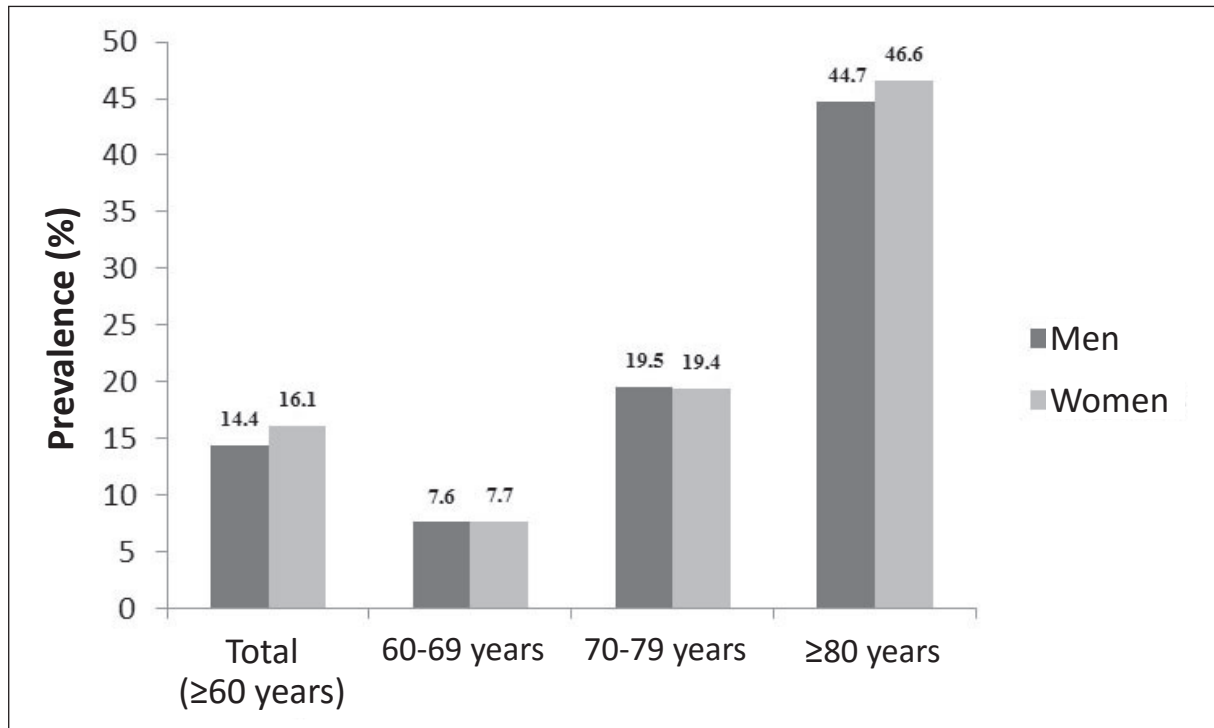
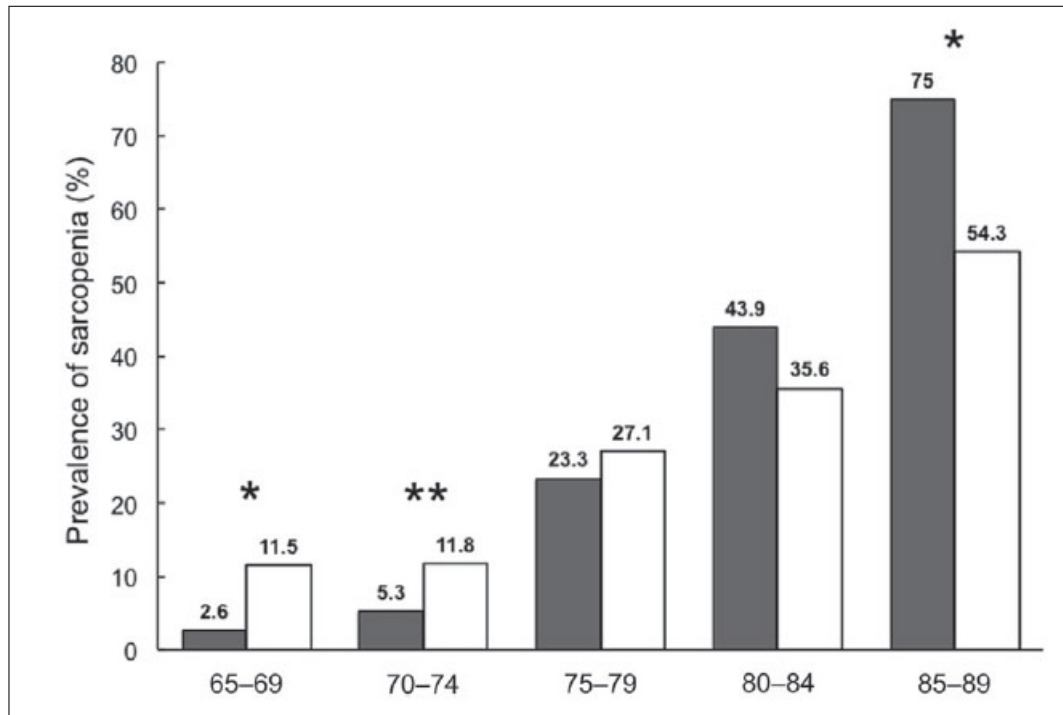


Figure 3. Prevalence of sarcopenia among men and women according to age group (Brazil).¹⁰

A cross-sectional study in Japan examined 1882 healthy elderly community-dwellers aged between 65 and 89 years (74.9 ± 5.5 years), of which 568 were men and 1314 were women. The participants were separated by gender and stratified in five groups based on age: 65-69, 70-74, 75-79, 80-84 and 85-89 years. The BIA was used to assess muscle mass. The calculation muscle mass/height² provided the SMI. Physical capacity tests were also performed (WS for 10 meters at normal speed and the HS, with a dynamometer). Sarcopenia was confirmed when the SMI was 2 SD below the gender-specific mean value of the reference data, obtained from 38,099 healthy adults aged between 18 and 40 years.¹² The same classification parameters as previously described in the two abovementioned studies were used in the WS and HS tests. Sarcopenia was also diagnosed using the algorithm suggested by the EWGSOP.¹²

The prevalence of sarcopenia among the elderly Japanese participants (65-89 years) was 21.8% for men and 22.1% for women.

Prevalence increased with age among both men and women (Figure 4). This increase was greater among women up to the age group of 75-79 years (w=27.1% vs m=23.3%) but was greater among men in the age groups from 80-84 years (m=43.9% vs w=35.6%) and 85-89 years (m=75.0% vs w=54.3%). Among individuals aged under 75 years, the prevalence of sarcopenia was higher for women than for men (OR 65-69 years=4.81; CI95%=1.2-20.55; OR 70-74 years=2.41; CI95%=1.18-4.91). Among individuals aged between 85-89 years, the prevalence was lower for women than for men (OR=0.39; CI95%=0.17-0.88). Sarcopenia was significantly correlated with falls and a fear of falling (OR falls=3.16; CI95%=2.04-4.89; OR fear of falling=6.23; CI95%=4.04-9.60). The authors highlighted that, although obtaining the SMI using the BIA is not recommended by the EWGSOP, it is a practical method when seeking to assess large samples, particularly in studies conducted in a community where no interventions occur.¹²



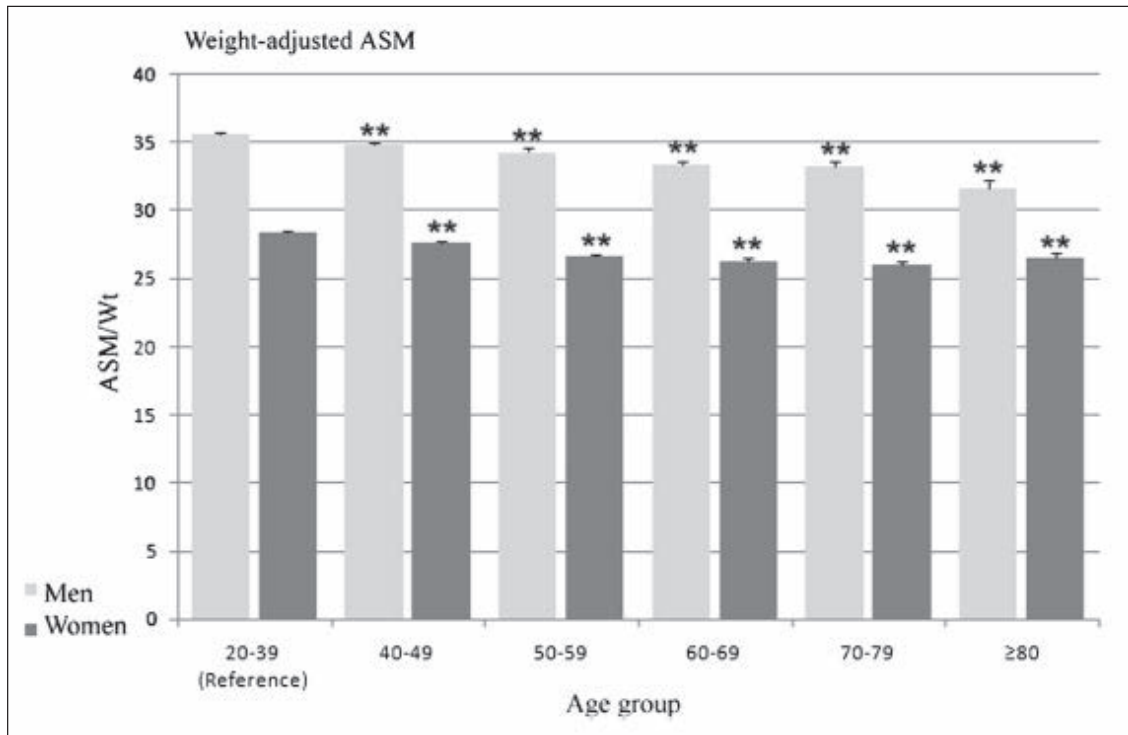
Prevalence of sarcopenia according to age group; black column= men; white column= women; * $p < 0.05$; ** $p < 0.01$ (Reproduced from: "Prevalence of sarcopenia in community-dwelling Japanese older adults", by Yamada M. et al., 2013, J Am Med Dir Assoc (USA); 14, p.913. Copyright © 2013 by American Medical Directors Association, Inc. Published by Elsevier Inc. All rights reserved. Reproduced with permission).

Figure 4. Prevalence of sarcopenia among men and women according to age group (Japan).¹²

The Fourth Korean National Health and Nutritional Examination Survey (KNHANES IV) was a national health survey in South Korea which also used a probabilistic, stratified, multistage sample design. Kim et al.¹³ analyzed 10,485 people (4486 men and 5999 women) aged 20 years or more. In this sample, 2332 of the participants were aged 65 years or more, of which 962 were men and 1370 were women. The mean age of the elderly individuals was not provided. DEXA was used to assess muscle mass and thus, the ASMM, which was adjusted for body weight (ASMM/weight $\times 100$) in order to obtain the SMI. The cut-off point for sarcopenia was established based on the gender-specific mean and standard deviation of the SMI of healthy adults aged between 20 and 39 years, the data of whom were used as reference values.¹³ The presence of sarcopenia was confirmed when the

SMI was 2 SD below the values of the young adults (Class II sarcopenia), similar to the study conducted by Janssen et al.⁸

In this South Korean study, the prevalence of sarcopenia was 9.7% for men and 11.8% for women. A significant decrease in the ASMM was correlated with age for both men and women. Among men, this decline was progressive throughout all age groups (Figure 5). Among women, the ASMM was effectively stable after 70 years of age. The prevalence of sarcopenia increased to 25.6% among those aged ≥ 80 years. In addition, the ASMM estimated in this study exhibited a strong correlation with body weight for men ($r=0.84$) and women ($r=0.78$). However, it is important to note that physical capacity tests, such as the WS and the HS,¹³ were not conducted in this study.



Modifications of the ASMM adjusted for body weight, according to gender and age group; p for tendency <0.001 (among men and women); **means there was no significant difference based on the mean of the reference group ($p < 0.01$); ASMM= appendicular skeletal muscle mass; Wt= body weight (Reproduced from: "Prevalence of sarcopenia and sarcopenic obesity in the Korean population based on the Fourth Korean National Health and Nutritional Examination Surveys", by Kim Y-S. et al., 2012, *J Gerontol A Biol Sci Med Sci* (UK); 67, p.1.110. Copyright © 2012 by Oxford University Press on behalf of The Gerontological Society of America. All rights reserved. Reproduced with permission).

Figure 5. ASMM values (adjusted for weight) among men and women according to age group (South Korea).¹³

In Taiwan, Wu et al.,¹⁴ based on the data from five cohort studies that integrated the Sarcopenia and Translational Aging Research in Taiwan (START) project, assessed 2867 individuals aged 65 years or more (74 ± 6 years), of whom 50% were women. The authors used anthropometry and the BIA to estimate the SMI ($ASMM/height^2$). The presence of sarcopenia was confirmed when the SMI was 2 SD below the reference values, which were estimated from 998 healthy adults aged between 20 and 40 years (cut-off points: 6.76 kg/m^2 for men and 5.28 kg/m^2 for women).¹⁴ WS was also assessed based on a walk of between three and five meters (depending on the cohort study analyzed) at normal speed. The authors analyzed the distribution of the stratified WS based on the gender-specific median height. A decreased WS was confirmed for individuals who

were in the portion below 20% of the gender and height-specific distributions. HS was assessed with a Jamar[®] dynamometer. The distribution of stratified force was analyzed according to the gender-specific quartiles of the BMI, and individuals in the portion below 20% of the BMI and gender-specific distributions were classified with decreased HS. Again, sarcopenia was defined using the algorithm proposed by the EWGSOP. Functional assessments were also performed using appropriate tools and interviews to gather data for co-variables, such as age, gender, education level, smoking, body composition and comorbidities.¹⁴

Based on the EWGSOP definition, the total prevalence of sarcopenia in the samples assessed was 5.4% for men and 2.5% for women. As

in the other studies, the prevalence increased significantly with advancing age among both men and women (Figure 6). The presence of sarcopenia in the elderly individuals assessed was significantly

correlated with an increase in age, low weight and chronic diseases. Sarcopenia was correlated with functional limitations and disabilities, regardless of the potential confusion factors.¹⁴

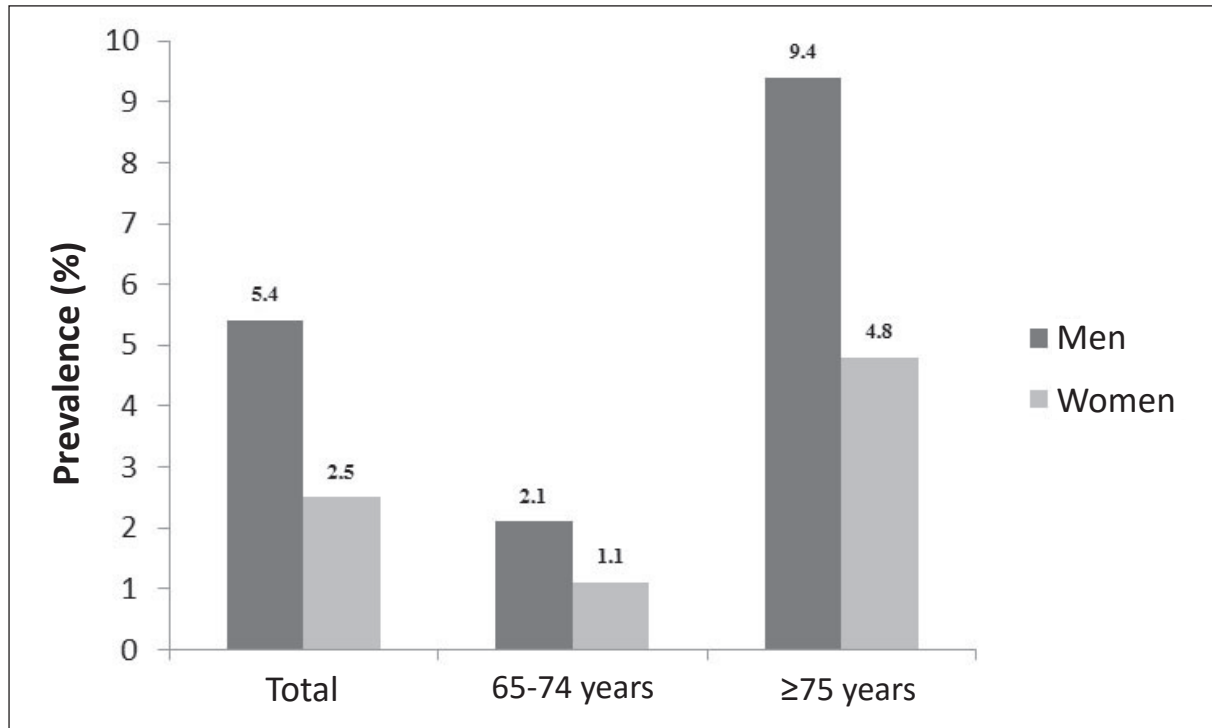


Figure 6. Prevalence of sarcopenia among men and women according to age (Taiwan).¹⁴

Upon analysis of the six studies in this literature review, the total prevalence of sarcopenia among individuals aged 60 years or more ranged from 4.6% (United Kingdom) to 21.8% (Japan) for men and from 2.5% (Taiwan) to 22.1% (Japan) for women. Therefore, the highest prevalence values for sarcopenia were recorded in the Japanese study, followed by the Brazilian study (m=14.4%; w=16.1%). The prevalence among women was higher than among men in five of the six studies assessed. The lowest prevalence values were recorded in the United Kingdom (men) and Taiwan (women), with the lowest difference between both for men. The countries that provided the closest prevalence rates (smallest range) were the USA and Taiwan for men and the USA and South Korea for women. The Brazilian study recorded

the greatest prevalence of sarcopenia among the Western countries (Brazil, USA and UK). The Japanese study recorded the greatest prevalence of sarcopenia among the Eastern countries (Japan, South Korea and Taiwan) (Figure 7).

In the age group of 80 years or more, the highest prevalence values for sarcopenia were recorded in Japan, reaching 75% in men and 54.3% in women, while the lowest values were recorded in Taiwan (m=9.4%; w=4.8%). In all of the studies, the prevalence of sarcopenia increased with age, although this phenomenon was more subtle in the USA and more accentuated in Japan and Brazil. The mean age in the prevalence studies used in this review ranged between 67 ± 2.6 (United Kingdom) and 74.9 ± 5.5 years (Japan).

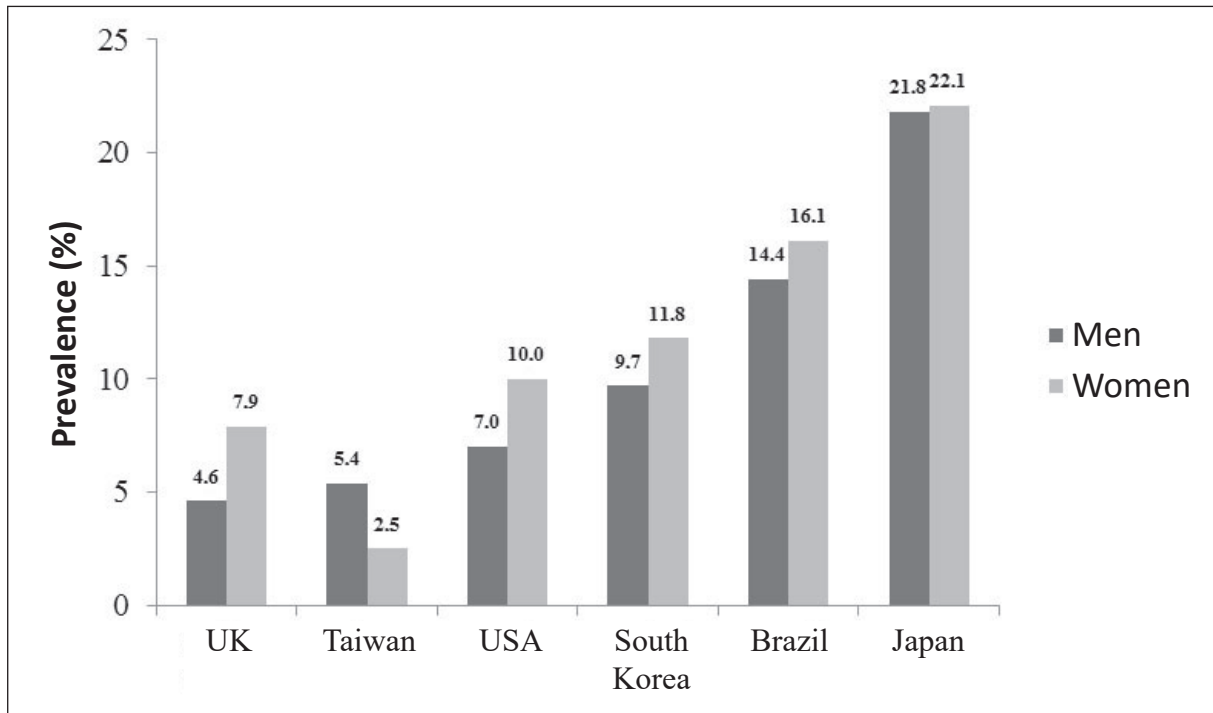


Figure 7. Prevalence of sarcopenia among men and women for the six countries included in the literature review.^{8-10,12-14}

DISCUSSION

The presence of sarcopenia is strongly influenced by a number of factors that directly affect the quality and quantity of muscle mass or act as risk factors that can affect physiological body functions, with a parallel alteration in body composition, resulting in a decline of the muscular system and the musculoskeletal system as a whole.^{2,7,15,16}

Cross-sectional studies tend to provide different prevalence rates due to the difficulty of establishing a specific standard definition for sarcopenia in the elderly population. This is due to the peculiarities of each population assessed and the multiple factors that affect mass and muscle strength.^{7,15,17,18} Consequently, the inclusion criteria for the articles in this literature review were based on a search for

greater sample representability, which led to the search for population-based studies with large samples. The age group 60 years or more was selected due to the need to use chronological age as a reference, despite the fact that the WHO has stated that classifications used to identify elderly individuals differ in developed and developing countries.¹⁹ This review also sought an identification between the studies in relation to the diagnostic methods used, prioritizing the most reliable, and the descriptive characteristics of the populations studied, without seeking more detailed comparisons.

Despite the fact that confounding factors are identified and adjusted correctly in many studies, they can create difficulties in studies of sarcopenia, particularly in terms of planning and implementing an adequate study design that enables a consistent methodological development

at all stages of the scientific investigation.^{7,15} Confounding factors can be negative or positive, in that they interfere in favor of (negative) or against (positive) muscular decline.¹⁵ The negatives, such as age, gender, race, smoking and comorbidities, were addressed in several of the studies in this review, although the positives were not mentioned.

Concerning negative confounding factors, Janssen et al.,⁸ Alexandre et al.¹⁰ and Wu et al.¹⁴ addressed the presence of comorbidities in their studies. Alexandre et al.¹⁰ and Wu et al.¹⁴ dealt with the prevalence of sarcopenia in specific conditions (*i.e.*, sub-groups), such as: diabetes; cardio/pulmonary diseases; arthritis and strokes. Although these conditions are quite common among the elderly population, and may have been present in the samples of the other studies assessed, thereby affecting the prevalence of sarcopenia in some way, a complex bidirectional mechanism should be considered, in which the loss of mass and muscle strength can either precede, occur simultaneously, or succeed these conditions.¹⁵ In light of etiological and temporal distinctions, other terms have been proposed to define these muscle losses more clearly, particularly those caused by specific health conditions that are not strictly associated with the elderly, such as myopenia.^{7,15,20} Therefore, since this literature review clearly defined the population and conditions of the study, greater discussions of these confounding factors would clarify the aim in question and should be accessed in the literature available on this subject.^{1-4,7,8,10,14,15,20}

The following techniques were used to assess muscle mass in the studies selected for this literature review: bioelectrical impedance analysis (BIA) (in three); dual-energy x-ray absorptiometry (DEXA) (in one) and adipometry (in one). All of the studies used anthropometric measurements such as height, weight and BMI. The algorithm proposed by the EWGSOP to determine the presence of sarcopenia was used

in four of the six studies. The following physical capacity tests were used to detect sarcopenia in four of the six studies: assessment of handgrip strength using a dynamometer (HS) and the walking speed test (WS). These functionality measurements are often used in studies that intend to assess sarcopenia. The only instrument used to measure muscle strength in the articles assessed was the handgrip dynamometer, which has been used in research and in clinical practice to assess HS. Previous studies have reported a correlation between HS and global strength.^{21,22} However, in a recent cross-sectional study of 221 elderly community dwellers (71.07±4.93 years), Felicio et al.²³ compared the muscle strength assessed using an isokinetic dynamometer, which is considered the gold standard for assessments of muscle strength, and found no correlation between most of the variables assessed and the manual dynamometer. This suggests that caution is required when interpreting the data provided by this instrument and inferring such correlations.

Since 1989, when the term sarcopenia was proposed as a reduction of mass and muscle strength in old age, it has been widely stated that the conduction should be clinically measured based on mass and muscle strength.^{1,4,9,10,12,14,15,24} In recent years, however, muscle strength has been addressed independently of muscle mass, since longitudinal studies have demonstrated that the loss of muscle mass (sarcopenia) has little influence on the loss of strength (dynapenia) and the mechanisms implicated in the onset of these phenomena in old age are different.^{20,25}

All of the previously mentioned techniques used to assess muscle mass have been widely used in cross-sectional studies of sarcopenia and are considered reliable in terms of its identification among the elderly. The DEXA technique is considered the gold standard for muscular assessments. However, this technique is expensive and requires qualified personnel to execute and interpret the results in a laboratory environment.

The BIA has been indicated as a practical and inexpensive method, enabling the performance of studies with community-dwelling elderly individuals.^{8-10,12-14} The different techniques of muscular assessment, as well as the different adjustment formulae and cut-off points used to classify sarcopenia in distinct populations, have led to a variety of results.^{13,15,17,18,25} This can be considered a limitation of this literature review.

CONCLUSION

Sarcopenia is highly prevalent among the population aged 60 years or more. An increase of sarcopenia in association with advancing age was referred to in all studies and for both genders. Although Japan is a developed country, with a health system that is considered excellent, the Japanese study contained the highest prevalence rates for both genders, followed by Brazil. The

studies from the United Kingdom and Taiwan recorded the lowest prevalence rates. Sarcopenia correlated with low physical capacity, functional limitations and disabilities, as well as other factors such as: comorbidities; social conditions; lifestyle habits and falls. Further studies of this theme should be encouraged, bearing in mind the technique used to diagnose sarcopenia, as well as other individual factors that could affect this outcome.

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REFERENCES

1. 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.
2. Narici MV, Maffulli N. Sarcopenia: characteristics, mechanisms and functional significance. *Br Med Bull* 2010;95(1):139-59.
3. Kim TN, Choi KM. Sarcopenia: definition, epidemiology, and pathophysiology. *J Bone Metab* 2013;20(1):1-10.
4. Cruz-Jentoft AJ, Landi F, Topinková E, Michel JP. Understanding sarcopenia as a geriatric syndrome. *Curr Opin Clin Nutr Metab Care* 2010;13(1):1-7.

5. Fielding RA, Vellas B, Evans WJ, Bhasin S, Morley JE, Newman AB, et al. Sarcopenia: an undiagnosed condition in older adults. Current consensus definition: prevalence, etiology and consequences. *J Am Med Dir Assoc* 2012;12(4):249-56.
6. Wang C, Bai L. Sarcopenia in the elderly: basic and clinical issues. *Geriatr Gerontol Int* 2012;12(3):388-96.
7. Scott D, Blizzard L, Fell J, Jones G. The epidemiology of sarcopenia in community living older adults: what role does lifestyle play? *J Cachexia Sarcopenia Muscle* 2011;2(3):125-34.
8. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *J Am Geriatr Soc* 2002;50(5):889-96.
9. Patel HP, Syddall HE, Jameson K, Robinson S, Denison H, Roberts HC, et al. Prevalence of sarcopenia in community-dwelling older people in the UK using the European Working Group on Sarcopenia in Older People (EWGSOP) definition: findings from the Hertfordshire Cohort Study (HCS). *Age Ageing* 2013;42(3):378-84.
10. Alexandre TS, Duarte YA, Santos JL, Wong R, Lebrão ML. Prevalence and associated factors of sarcopenia among elderly in Brazil: findings from the SABE Study. *J Nutr Health Aging* 2014;18(3):284-90.
11. Rech CR, Dellagrana RA, Marucci MF, Petroski EL. Validity of anthropometric equations for the estimation of muscle mass in the elderly. *Rev Bras Cineantropom Desempenho Hum* 2012;14(1):23-31.
12. Yamada M, Nishiguchi S, Fukutani N, Tanigawa T, Yukutake T, Kayama H, et al. Prevalence of sarcopenia in community-dwelling Japanese older adults. *J Am Med Dir Assoc* 2013;14(12):911-15.
13. Kim YS, Lee Y, Chung YS, Lee DJ, Joo NS, Hong D, et al. Prevalence of sarcopenia and sarcopenic obesity in the Korean population based on the Fourth Korean National Health and Nutritional Examination Surveys. *J Gerontol Ser A Biol Sci Med Sci* 2012;67(10):1107-13.
14. Wu IC, Lin CC, Hsiung CA, Wang CY, Wu CH, Chan DC, et al. Epidemiology of sarcopenia among community-dwelling older adults in Taiwan: a pooled analysis for a broader adoption of sarcopenia assessments. *Geriatr Gerontol Int* 2014;14(Suppl 1):52-60.
15. Cesari M, Ferrini A, Zamboni V, Pahor M. Sarcopenia: current clinical and research issues. *Open Geriatr Med J* 2008;1(1):14-23.
16. Jones TE, Stephenson KW, King JG, Knight KR, Marshall TL, Scott WB. Sarcopenia: mechanisms and treatments. *J Geriatr Phys Ther* 2009;32(2):39-45.
17. Van Kan GA. Epidemiology and consequences of sarcopenia. *J Nutr Health Aging* 2009;13(8):708-12.
18. Bijlsma AY, Meskers CG, Ling CH, Narici M, Kurlle SE, Cameron ID, et al. Defining sarcopenia: the impact of different diagnostic criteria on the prevalence of sarcopenia in a large middle aged cohort. *Age* 2013;35(3):871-81.
19. World Health Organization. Active ageing: a policy framework. Madrid: WHO; 2002.
20. Morley JE. Sarcopenia in the elderly. *Fam Pract* 2012;29(Suppl 1):144-48.
21. Bohannon RW. Dynamometer measurements of grip and knee extension strength: are they indicative of overall limb and trunk muscle strength? *Percept Mot Skills* 2009;108(2):339-42.
22. Bohannon RW. Are hand-grip and knee extension strength reflective of a common construct? *Percept Mot Skills* 2012;114(2):514-18.

23. Felício DC, Pereira DS, Assumpção AM, De Jesus-Moraleida FR, De Queiroz BZ, Da Silva JP, et al. Poor correlation between handgrip strength and isokinetic performance of knee flexor and extensor muscles in community dwelling elderly women. *Geriatr Gerontol Int* 2014;14(1):185-89.
24. Cooper C, Fielding R, Visser M, Van Loon LJ, Rolland Y, Orwoll E, et al. Tools in the assessment of sarcopenia. *Calcif Tissue Int* 2013;93(3):201-10.
25. Janssen I. The epidemiology of sarcopenia. *Clin Geriatr Med* 2011;27(3):355-63.

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