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Original Article

Prevalence of sarcopenia: the impact of different diagnostic cut-off limits

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Abstract

Introduction: In the definition of the European Working Group on Sarcopenia in Older People (EWGSOP), different cut-off limits are proposed for appendicular lean mass, muscle strength and gait speed. Therefore we aimed to examine the variation in prevalence of sarcopenia obtained with these cut-off limits. **Materials and Methods:** Subjects aged 65 years and older were recruited in an outpatient clinic in Belgium and screened for sarcopenia using the EWGSOP definition. Appendicular lean mass was measured by Dual Energy X-Ray Absorptiometry, muscle strength by a hydraulic handgrip dynamometer and gait speed was measured on a 4-meter distance. Two different cut-off points proposed by the EWGSOP were examined for each variable and 8 diagnostic methods were thereby established. **Results:** 400 subjects were recruited for this study. Prevalence of sarcopenia varied from 9.25% to 18% depending on the cut-offs applied. When stratified by sex, it seems that the variation in prevalence of sarcopenia was mainly attributable to women. This prevalence ranged from 6.58% to 20.2% for women and only from 13.4% to 14.7% for men. **Conclusion:** Prevalence of sarcopenia varies widely depending on the EWGSOP cut-off points applied for women. This may limit clinical researches and development of therapeutic strategies in the field of sarcopenia.

Keywords: Sarcopenia, Prevalence, EWGSOP, Cut-off, Diagnosis

Introduction

One of the consequences of aging consists of decreases in muscle mass[1]. This phenomenon has been described for the first time in 1989 by Irwin Rosenberg as "sarcopenia"[2]. Over the last decade, definitions of sarcopenia, among researchers, have varied and have been conflicting[3,4]. In 2010, the European Working Group on Sarcopenia in Older People (EWGSOP) published their recommendations for a clinical definition and consensual diagnosis criteria of sarcopenia[5]. They defined sarcopenia as a progressive and generalized loss of skeletal muscle mass and strength, or physical performance, with a risk of adverse outcomes such as physical disability, poor quality of life and death[5-9].

Prevalence of sarcopenia is difficult to establish. Indeed, this prevalence can differ depending on the characteristics of the studied population. A higher prevalence is often observed in subjects living in nursing home, in elderly subjects, in subjects having a low body mass index but also in subjects having a low educational level[10,11-13]. The prevalence is also depending on the definition used for the diagnosis of sarcopenia. In 2013, Batsis et al.[14] compared eight definitions of sarcopenia and found a prevalence ranging from 4.4% to 94% across definitions. As expected, studies using muscle mass as single criterion of diagnosis came up with a higher prevalence of sarcopenia than studies based on the EWGSOP consensus algorithm. Interestingly, since 2010, most of the studies have used the EWGSOP consensus to define sarcopenia[5]. This is an epidemiological great step that allows a more meaningful comparison between studies. However, within this consensual definition, different cut-off points are recommended for the diagnosis of sarcopenia in regards of the measurement of muscle mass, muscle strength and gait speed[5]. Two options, for each variable (skeletal muscle mass index, muscle strength and physical performance including more specifically gait speed), are actually suggested to define sub-normal values.

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It is normal to expect that the use of different cut-off limits will lead to differences in the estimation of the prevalence of sarcopenia. To the best of our knowledge, no cross-sectional study has yet assessed the difference in prevalence of sarcopenia depending on the specific cut-off limits discussed by the EWGSOP[5]. In this cross-sectional study, our aim was to explore how the different cut-offs could affect the prevalence of sarcopenia in a population of subjects aged 65 years and older but also in this population stratified by age and by sex.

Muscle mass: cut-off 1	Muscle mass: cut-off 2
Men: 7.26 kg/m² **Women:** 5.5 kg/m²	**Men:** 7.25 kg/m² **Women:** 5.67 kg/m²
Muscle strength: cut-off 1	**Muscle strength: cut-off 2**
Men: <30 kg	**Men:** BMI ≤24: ≤29 kg BMI 24.1-26: ≤30 kg BMI 26.1-28: ≤30 kg BMI >28: ≤32 kg
Women: <20 kg	**Women:** BMI ≤23: ≤17 kg BMI 23.1-26: ≤17.3 kg BMI 26.1-29: ≤18 kg BMI >29: ≤21 kg
Gait speed: cut-off 1	**Gait speed: cut-off 2**
<0.8 m/s	**Men:** Height ≤173 cm: <0.65 m/s Height >173 cm: <0.76 m/s **Women:** Height ≤159 cm: <0.65 m/s Height >159 cm: <0.76 m/s

Table 1. Overview of cut-off criteria for the diagnosis of sarcopenia.

Materials and Methods

Study subjects

The present study was conducted on subjects aged 65 years or older, selected from July 2013 to June 2014, who were either consulting an outpatient clinic specialised in bone, cartilage and muscle in Liège, Belgium or recruited by press advertisements. These subjects were enrolled in the SarcoPhAge cohort, which is a Belgian 5-year prospective cohort.

Subjects had to read and sign an informed consent after being informed of the objectives and methods of the research. There were no selection criteria on health or demographic characteristics except for subjects with an amputated limb or with a BMI above 50 kg/m² who were excluded from this research.

The study was approved by the Ethics Committee of the University Teaching Hospital of Liège, Belgium.

Clinical characteristics

All subjects were interviewed by a clinical research assistant for a mean time of 45 minutes. The clinical research assistant collected sociodemographic, anamnestic and clinical data such as civil status, level of education, actual income, living at home or at another place, walking aids if any, comorbidities and drugs use. Anthropometric measures such as height, weight and calf, wrist and arm circumferences were also collected. The clinical research assistant also gathered information on the cognitive function (Mini-Mental State Examination), the limitation in instrumental activities of daily living (Lawton scale), the nutritional status (Mini Nutritional Assessment), the quality of life (Short-Form 36) and the depression (Geriatric Depression Scale).

Diagnosis of sarcopenia

We used the definition of the EWGSOP for the diagnosis of sarcopenia[5]. According to the experts of this working group, sarcopenia diagnosis is based on documentation of low muscle mass plus either low muscle strength or low physical performance. An overview of the different cut-off criteria for sarcopenia, which includes muscle mass, muscle strength and gait speed, is given in Table 1.

Muscle mass

Appendicular lean mass was measured by Dual-Energy X-Ray Absorptiometry (DXA) (Hologic Discovery A, USA). We used this technique, recommended by the EWGSOP, because computed tomography and magnetic resonance imaging, considered as the gold standards in this field, are limited in their use by high costs and concerns about radiation exposure. On the contrary, DXA, which is a method able to distinguish lean tissues from fat and bone mineral, has the advantage of exposing patients to minimal radiation. All whole-body scans were carried out by the same technician and the device was calibrated twice a week by scanning a spine phantom. Appendicular skeletal muscle mass (ASM) was obtained by adding skeletal muscle mass of both arms and legs. A skeletal muscle mass index (SMI), which is used for the diagnosis of sarcopenia, was calculated by dividing the ASM by the height squared. For the diagnosis of sarcopenia, two cut-offs were discussed in the EWGSOP report for this SMI. Based on reference groups derived from a population-based survey of 883 elderly Hispanic and non-Hispanic white men and women living in New Mexico, the first cut-off point raises at 7.26 kg/m² for men and 5.5 kg/m² for women[15]. This cut-off was defined by the EWGSOP at two standard deviations (SD) below the mean reference value, which was, in this case, healthy young adults living in Mexico. The second cut-off proposed is based on a group of 2976 subjects aged 70 to 79 years living in four districts of the United States and is defined as under the 20th percentile of the SMI of this population[16]. To be diagnosed sarcopenic, the SMI must be below 7.25 kg/m² for men and 5.67 kg/m² for women.

Muscle strength

As recommended by the EWGSOP, we measured subjects' handgrip strength to determine their muscle strength.Therefore,

Methods	Muscle mass	Muscle strength	Physical performance
A	Cut-off 1	Cut-off 1	Cut-off 1
B	Cut-off 1	Cut-off 1	Cut-off 2
C	Cut-off 1	Cut-off 2	Cut-off 1
D	Cut-off 1	Cut-off 2	Cut-off 2
E	Cut-off 2	Cut-off 1	Cut-off 1
F	Cut-off 2	Cut-off 1	Cut-off 2
G	Cut-off 2	Cut-off 2	Cut-off 1
H	Cut-off 2	Cut-off 2	Cut-off 2

Table 2. Eight methods of diagnosis of sarcopenia issued from the EWGSOP report.

we used a hydraulic dynamometer (Saehan Corporation, MSD Europe Bvba, Belgium) that subjects had to grip as hard as possible three times with each hand (dominant and non-dominant). For our analysis, we used the highest result out of the six measurements recorded[17]. For the diagnosis of sarcopenia, we also used the two different cut-offs discussed in the EWGSOP report. The first cut-off has been suggested by Lauretani et al.[7] based on a study of a cohort of 1030 Italian subjects aged 20-102 years and raises at 30 kg for men and 20 kg for women. The second cut-off depends on subjects' Body Mass Index (BMI). Four quartiles of grip strength depending on the subjects' BMI have been defined from of a cohort of 5317 subjects aged 65 years or older studied by Fried et al.[18]. Rationally, cut-off points issued from subjects presenting a lower BMI are below those issued from subjects with a higher BMI.

Physical performance

The third variable needed for the diagnosis of sarcopenia, physical performance, can be measured either by gait speed, expressed as meter/seconds, or by the Short Physical Performance Battery test, which is a composite test scored on 12 points. In the present study, we used the gait speed as criteria for the diagnosis of sarcopenia. Subjects had to walk a 4-meter course at their usual gait speed. Time taken to execute this walk was recorded and expressed as meter per second. Once again, two different cut-off points are discussed in the EWGSOP report for the gait speed. Also based on the results of Lauretani et al.[7], the first cut-off point for the diagnosis of sarcopenia raises at 0.8 m/s, both for women and men. The second cut-off is sex-and-height-dependent, which means it is different for men and women and it increases with their height. This second cut-off is based on the quartiles groups defined in the cohort of Fried et al.[18].

Diagnosis method

According to the EWGSOP[5], sarcopenia is defined as follow: (low muscle mass AND (low muscle strength OR low gait speed)). With 2 cut-off points available for each of the three components of sarcopenia, we defined 8 methods of diagnosis of sarcopenia, as given in Table 2.

Clinical characteristics	Men (n=157)	Women (n=243)
Age	74±6.4	73.8±6.2
Antropometric data		
Height (cm)	172±6.6	157.3±6.77
Weight (kg)	81.7±16.2	64.1±12.6
Body Mass Index (kg/m²)	27.6±4.88	25.9±4.57
Calf circumference (cm)	36.1±3.82	33.8±3.56
Waist circumference (cm)	101.7±12.1	89.1±12.9
Wrist circumference (cm)	18.1±1.54	16.1±1.69
Arm circumference (cm)	28.8±3.51	27.4±3.75
Number of diseases	4.23±2.55	4.54±6.27
Number of drugs	5.71±3.51	6.27±3.6
MMSE score (/30 points)	27.8±2.15	27.5±3.19
Lawton score (/5 points for men; /8 points for women)	4.76±0.70	7.29±1.35
Mini-Nutritional Assessment		
Well-nourished	136 (86.6)	193 (79.4)
Risk of malnutrition	19 (12.1)	44 (18.1)
Malnutrition	2 (1.27)	6 (2.47)
Quality of life SF-36 (%)	63.4±17.1	57.6±19.2
Depression (/15 points)	3.39±3.05	4.29±3.6
Total lean mass (kg)	55.6±9.33	37.9±5.69
Total fat mass (kg)	24.8±8.36	25.7±8.69
Diagnosis component of sarcopenia		
Gait speed (m/s)	1.02±0.29	0.93±0.28
Grip strength maximum (kg)	38.4±9.81	21.2±6.44
Skeletal Muscle Index kg/m²	7.91±1.17	6.06±1.02

Table 3. Clinical characteristics of subjects.

Statistical analysis

Continuous data are presented as mean ± SD. Categorical data were summarized as count and percentage.

Baseline differences between men and women were tested using a Student's t-test. Prevalence of sarcopenia was assessed according to each diagnosis method, as described in Table 2. After assigning the status of sarcopenic or not to each individual, the study population was stratified by sex and age (65-69 years, 70-74 years, 75-79 years and 80 years and older). The

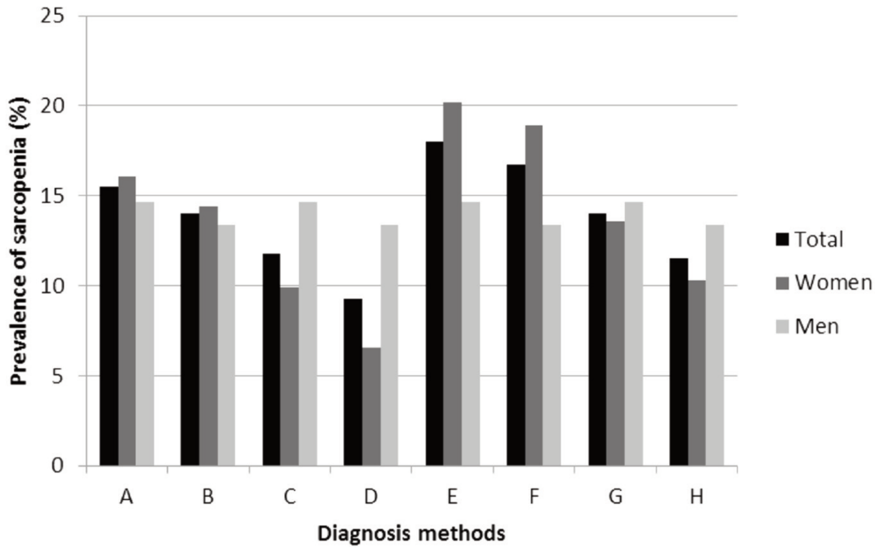

Figure 1. Prevalence of sarcopenia according to the eight diagnosis method, globally and stratified by sex.

difference in women characteristics dependant of the diagnosis method was tested with a Student's t-test.

All analyses were executed with the software Statistica 9.1. Results were considered statistically significant when 2-tailed p values were less than 0.05.

Results

A total of 400 subjects aged 65 years and older participated at this study. Out of them, 243 were women, which represent 60.7% of the population. Mean age was 73.8±6.2 years for women and 74±6.4 years for men. BMI was significantly higher in men than women (27.6 kg/m² versus 25.9 kg/m²) as well as arm circumference (28.8 cm versus 27.4 cm), wrist circumference (18.1 cm versus 16.1 cm) and calf circumference (36.1 cm versus 33.8 cm). Men also presented a higher global quality of life than women (63.4 % versus 57.6 %) and a lower level of depression (3.39 points versus 4.29 points). Regarding body composition, men subjects presented a mean of 24.8±8.36 kg of fat mass which was not significantly different than women (25.7±8.69 kg). Men presented significantly more lean mass than women (55.6 kg versus 37.9 kg) (Table 3).

Globally, total prevalence of sarcopenia, independently from sex, ranged from 9.25% to 18%, depending on the method used for the diagnosis (Figure 1). The lowest prevalence was found with the diagnosis method D and the highest prevalence was found with the diagnosis method E. When stratified by sex, it seems that the variation in prevalence of sarcopenia is mainly attributable to women. Indeed, this prevalence ranged from 6.58% to 20.2% for women and only from 13.4% to 14.7% for men.

When stratified by age (Table 4), there is no difference in prevalence of sarcopenia for men across the diagnosis methods except for men aged between 65 years and 69 years. Indeed, for these men, we found a difference of prevalence imputable to the cut-off used for gait speed. When using the first cut-off of 0.8 m/s, we found a prevalence of sarcopenia of 7.41% but, when using the height-dependant cut-offs, we found a lower prevalence of sarcopenia, reaching only 3.7%. Other cut-off criteria used for muscle mass and muscle strength did not cause differences in the measured prevalence of sarcopenia for men. For women, in the other side, it seems that the cut-off limits used led systematically to a difference in the prevalence of sarcopenia, and this observation is valid across all age strata. In the lowest age category, the prevalence of sarcopenia in women ranged from 1.18% to 4.71% and, in the highest age category, this prevalence ranged from 16.7% to 38.1%.

The strongest impact of the cut-off used for the estimation of the prevalence of sarcopenia is found for muscle strength in women aged 70-74 years. Indeed, the use of a unique cut-off for women's muscle strength leads to an estimation of the prevalence of about 15%, while the use of cut-offs dependent on BMI leads to an estimation of about 5%.

Given this variation in the number of subjects diagnosed with sarcopenia across the different methods, we checked for differences in the sarcopenic women's clinical characteristics between the eight methods used for the diagnosis. No significant difference was found between the different diagnosis criteria except for walk speed which was significantly higher in women diagnosed with method D versus method E (p=0.039) and method F (p=0.035).

Discussion

Different cut-off values are proposed for the diagnosis of sarcopenia, in regards of three measurements: muscle mass,

	65-69 years	70-74 years	75-79 years	≥ 80 years
Men N, (%)				
A	4 (7.41)	6 (16.7)	5 (13.2)	8 (27.6)
B	2 (3.70)	6 (16.7)	5 (13.2)	8 (27.6)
C	4 (7.41)	6 (16.7)	5 (13.2)	8 (27.6)
D	2 (3.70)	6 (16.7)	5 (13.2)	8 (27.6)
E	4 (7.41)	6 (16.7)	5 (13.2)	8 (27.6)
F	2 (3.70)	6 (16.7)	5 (13.2)	8 (27.6)
G	4 (7.41)	6 (16.7)	5 (13.2)	8 (27.6)
H	2 (3.70)	6 (16.7)	5 (13.2)	8 (27.6)
Women N, (%)				
A	4 (4.71)	9 (15.0)	14 (25.0)	12 (28.6)
B	3 (3.53)	9 (15.0)	12 (21.4)	11 (26.2)
C	2 (2.35)	3 (5.00)	11 (19.6)	8 (19.0)
D	1 (1.18)	2 (3.33)	6 (10.7)	7 (16.7)
E	6 (7.06)	10 (16.7)	17 (30.4)	16 (38.1)
F	5 (5.88)	10 (16.7)	16 (28.6)	15 (35.7)
G	4 (4.71)	3 (5.00)	14 (25.0)	12 (28.6)
H	3 (3.53)	2 (3.33)	9 (16.1)	11 (26.2)

Table 4. prevalence of sarcopenia stratified by age and sex.

muscle strength and physical performance. In this study, we assessed the impact of the use of different cut-off limits for the diagnosis of sarcopenia on its estimated prevalence. We found an important variation of the prevalence of sarcopenia depending on the cut-offs used for the diagnosis. The global prevalence of sarcopenia varied from 9.25% to 18% according to the cut-off used.

In men, the use of the different cut-offs does not seem to influence the estimation of the prevalence of sarcopenia. Contrariwise, for women, we found a huge variation of the estimated prevalence of sarcopenia. It is not surprising to see a larger difference in prevalence in women than in men. Indeed, first regarding the measurement of muscle mass, the difference between the two suggested cut-offs is much larger for women than for men. The first cut-off for men reaches 7.26 kg/m² for SMI and the second reaches 7.25 kg/m², which is a very little difference. This difference is obviously much larger for women since it varies from 5.5 kg/m² for the first cut-off to 5.67 kg/m² for the second.

In the same vein, the two cut-off criteria proposed for muscle strength are more likely to lead to a difference in the estimated prevalence of sarcopenia for women than for men. Indeed, for men, we can use a unique cut-off which rises at 30 kg or BMI-dependent cut-off. This BMI depend cut-off also raised at 30 kg, or even at 32 kg, at the exception for men presenting a BMI lower or equal to 24 kg/m² for whom this cut-off raised at 28 kg. Taking into account that the mean BMI for men in our population was 27.6 kg/m², the estimation of the prevalence in our study should not have been influenced by this measurement. For women, on the opposite, the unique cut-off equals 20 kg and the BMI-dependent cut-offs are systematically below this unique cut-off except for women who presented a BMI higher than 29 kg/m², which is the case of only 20% of the population of women in our study. Therefore, the estimation of the prevalence of sarcopenia in women, in our study, was noticeably influenced by the muscle strength criteria.

In the literature, one study also assessed the impact of the use of different cut-off criteria on the prevalence of sarcopenia. In 2013, Bijlsma[13] compared the two same cut-offs we used for the measurement of muscle mass and also found no difference in the estimated prevalence of sarcopenia in men but a difference ranging from 2.1% to 3% in women, in other words, by a factor of 1.43. In our analysis, global prevalence for women varied from 11.7% with the first SMI cut-off to 15.7% with the second SMI cut-off. Although the prevalence is higher in our population than in the study of Bijlsma et al.[13], the relative difference is quite the same and varies by a factor of 1.34.

In their study, they also found higher prevalence of sarcopenia with advancing age. This observation is valuable for every study that assesses the prevalence of sarcopenia. It seems that this geriatric syndrome increases with age, as stated in the definition itself. We also found that the older the groups of subjects were the higher the prevalence of sarcopenia was at the exception of the group of men aged 70-74 years which presented a higher prevalence of sarcopenia than the group of 74-79 years. This exception aside, prevalence of sarcopenia increases with age.

Regarding other subjects' characteristics, we did not find any clinical characteristics differences between women diagnosed with the method that leads to the highest prevalence of sarcopenia (20.2%) and women diagnosed with the method that leads to the lowest prevalence of sarcopenia (6.58%). So, even if we observed a large variation in the number of subjects diagnosed with sarcopenia, it is reassuring to note that subjects diagnosed with one method (set of cut-offs) presented the same clinical characteristics that those diagnosed with another method.

In this study, we sought to quantify the difference in prevalence of sarcopenia obtained with the different cut-off criteria. Because of the cross-sectional design of our study, we were not able to define the most appropriate cut-off for the diagnosis of sarcopenia. Even if the EWGSOP recommends using the normative (i.e. healthy young adults) rather than other predictive reference populations, with cut-off points at two standard deviations below the mean reference value, this group of experts notes that more research is urgently needed in order to obtain good reference values for populations around the world. Regarding the assessment of muscle mass, two cut-offs were suggested by the EWGSOP and used in our study, one defined by Baumgartner et al.[15] and the other defined by Newman et al.[4]. To establish their cut-off, Baumgartner et al.[15] developed a population-based survey of 883 elderly subjects and defined a SMI of two standard deviations below the mean SMI of young male and female reference groups as the gender-specific cut-off points for sarcopenia. In this way, sarcopenia was significantly associated with disability and was independent of ethnicity, age, comorbidity, health behaviours and fat mass. Newman et al.[4] performed an observational cohort of 2984 subjects aged 70-79 years. Newman used a different approach for the diagnosis and chose arbitrarily the gender specific 20th percentile as the cut-off point for the diagnosis of sarcopenia. Using this definition, sarcopenia was associated with poor health, lower activity and impaired lower extremity function in men and specifically with impaired lower extremity function in women.

One of the obvious limits of this study is the comparison of two cut-off points derived from two studies using two different populations. Even if the clinical characteristics of the subjects included in these populations are probably different from the clinical characteristics of our subjects, we note that both populations are composed of elderly subjects. Moreover, these two cut-off limits are suggested by the definition of the EWGSOP for the diagnosis of sarcopenia. So, our study is a first step to quantify the impact of the use of these cut-offs on the prevalence of sarcopenia. Currently, it is still a challenge for public health to establish a clear prevalence of sarcopenia. It seems obvious that the availability of different diagnosis criteria within a consensual definition remains an obstacle to this issue. We still need to establish one unique set of criteria to identify and diagnose subjects with sarcopenia. As second step, future studies should examine which cut-off criteria for muscle mass, muscle strength and gait speed are the most predictive for functional decline or hard clinical outcome such as death, hospitalization, falls, etc. and could therefore be used for the diagnosis of sarcopenia.

In conclusion, the prevalence of sarcopenia for women is depending on the applied cut-off criteria proposed by the EWGSOP. Depending on the cut-offs used for the diagnosis, the prevalence of sarcopenia can be doubled. This observation is true for women, but not for men. Even if the clinical characteristics of diagnosed subjects are not different across the cut-off method used, it is important to take this difference of prevalence into account to compare studies.

Author's contributions

CB, OB and JYR designed the study. CB, ML, JS and FB recruited the subjects and collected the data. CB performed statistical analyses. All authors commented on the drafts and approved the final draft. CB is the manuscript's guarantor.

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