The Impact of Different Diagnostic Criteria on the Prevalence of Sarcopenia in Healthy Elderly Participants and Geriatric Outpatients

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Abstract

Background: A consensus on the diagnostic criteria for sarcopenia, a common syndrome in the elderly, has not been reached yet. Prevalence rates vary between studies due to the use of different criteria encompassing different measures, correction factors and cutoff points. **Objective:** This study compared prevalence rates of sarcopenia using nine sets of diagnostic criteria applied in two different elderly populations. **Methods:** The study population encompassed 308 healthy elderly participants (152 males, 156 females; mean age 74 years) and 123 geriatric outpatients (54 males, 69 females; mean age 81 years). Diagnostic criteria included relative muscle mass, absolute muscle mass, muscle strength and physical performance. **Results:** Prevalence rates of sarcopenia varied between 0 and 15% in healthy elderly participants and between 2 and 34% in geriatric outpatients. **Conclusion:** This study clearly demonstrates the dependency of sarcopenia prevalence rates on the applied diagnostic criteria.

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Introduction

Sarcopenia is a frequent syndrome in the elderly [1] and is associated with physical disability, impaired standing balance, a lower quality of life, cognitive impairment and mortality [2–6]. Previous diagnostic criteria for sarcopenia incorporated measures of muscle mass [2, 7–10].

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Recent consensus working groups proposed to include measures of muscle strength [11, 12] and physical performance [11–13]. In the context of the ageing population, consensus on a single set of diagnostic criteria for sarcopenia, including the appropriate measures, correction factors and cutoff points, is essential to refine for medical, social and financial reasons, but has not been reached yet. As a consequence, prevalence rates between studies may vary, which prevents valid comparison across studies.

Prevalence rates of sarcopenia were found to vary substantially when applying different criteria to a single middle-aged cohort [14]. Applying different diagnostic criteria in a clinically relevant population of geriatric outpatients is the next step to further demonstrate the impact of diagnostic criteria on sarcopenia prevalence rates. This study aimed to compare prevalence rates of sarcopenia using nine sets of diagnostic criteria in both a healthy elderly population and a geriatric outpatient population.

Materials and Methods

Study Design

This cross-sectional study included two different populations. The first was a group of 308 healthy elderly participants who were physically active and in whom comorbidity was minimized with regard to the criteria of the European MyoAge study [15]. The MyoAge study included 322 old participants recruited via advertisements and at universities and associations of emeriti from five research centers located in the UK, France, the Netherlands, Estonia and Finland [15]. The MyoAge study only included healthy participants, thereby minimizing the impact of disease, medication and level of physical activity on sarcopenia. Each center used the same equipment whenever possible. A detailed description of the MyoAge study design is reported elsewhere [15]. For the present analysis, 308 participants were included due to missing data on diagnostic criteria for sarcopenia in 14 cases.

The second population was a group of 123 community-dwelling elderly who were consecutively referred to a geriatric outpatient clinic in a middle-sized teaching hospital (Bronovo Hospital, The Hague, The Netherlands) for a comprehensive geriatric assessment due to mobility problems (e.g. falls, impaired standing balance). Geriatric outpatients were included within an inception cohort based on referral. Comorbidity was defined as the presence of two or more chronic diseases.

Diagnostic Criteria for Sarcopenia

Muscle mass, discerned in both relative and absolute muscle mass, was measured using dual-energy X-ray absorptiometry (DXA) in healthy elderly participants [15] and using a direct segmental multifrequency bioelectrical impedance analysis (DSM-BIA) in geriatric outpatients [6]. Muscle strength was assessed using maximal handgrip strength in kilograms by hand dynamometry (JAMAR hand dynamometer; Sammons Preston, Inc., Bolingbrook, Ill., USA) [6, 15]. Physical performance was assessed by gait speed measured during a 6-minute walking test in healthy

Table 1. Participant characteristics stratified by population

	Geriatric outpatients (n = 123)	Healthy elderly participants (n = 308)
Male	54 (43.9)	152 (49.4)
Age, years	80.5±7.0	74.4±3.2
BMI	25.8±4.6	25.6±3.3
Comorbidity[a]	52 (43.7)	54 (17.5)

All variables are presented as n (%) or mean ± standard deviation. [a] ≥2 diseases.

elderly participants performed as fast as possible in Finland, Estonia, France and the UK and at normal pace in the Netherlands [15]. The 6-minute walking test measures the distance over a total of 6 min, from which gait speed can be derived. In geriatric outpatients, gait speed was measured over a distance of 4 m at normal pace from a standing start [6].

To both populations, nine sets of diagnostic criteria for sarcopenia were applied. Six single diagnostic criteria to diagnose sarcopenia, which have previously been applied to cohorts [14], were selected based on measurements of muscle mass by DXA (diagnostic criteria A, B, C) [2, 7, 8] or BIA (diagnostic criteria D, E) [9, 10] and muscle strength by handgrip strength (diagnostic criterion F) [16]. In addition to these single diagnostic criteria, three sets of diagnostic criteria proposed by recent consensus working groups for sarcopenia were selected for the present analysis (diagnostic criteria G, H, I) [11–13].

Statistical Analysis

Descriptive statistics were performed to determine the prevalence of sarcopenia according to each of the nine applied sets of diagnostic criteria, stratified by study population. Due to differences in measuring gait speed in the Netherlands, data were reanalyzed excluding data from Dutch participants. Exclusion of Dutch data did not change the results significantly. Statistical analyses were performed using the Statistical Package for the Social Sciences (version 20). For visualization purposes, the agreement between the different sets of diagnostic criteria was assessed using Venn diagrams.

Results

Participant Characteristics

The study populations included 308 healthy elderly participants and 123 geriatric outpatients with a mean age of 74 (standard deviation 7.0) and 81 (standard deviation 3.2) years, respectively. Table 1 shows the characteristics of the participants, stratified by study population. There were no significant differences in gender and body mass index (BMI) distribution between the two studied populations. Comorbidity was more present in geriatric outpatients than in healthy elderly participants.

Table 2. Prevalence of sarcopenia in geriatric outpatients (Bronovo hospital) and healthy elderly participants (MyoAge cohort)

Code	First author or study	Diagnostic criteria	Cutoff point males	Cutoff point females	Prevalence, n (%) geriatric outpatients (n = 123)	Prevalence, n (%) healthy elderly participants (n = 308)
A	Baumgartner, 1998 [2]	ALM/height^2	≤7.26 kg/m^2	≤5.45 kg/m^2	27 (22.0)	35 (11.4)
B	Delmonico, 2007 [7]	ALM/height^2	≤7.25 kg/m^2	≤5.67 kg/m^2	28 (22.8)	46 (14.9)
C	Kelly, 2009 [8]	ALM/height^2	≤6.19 kg/m^2	≤4.73 kg/m^2	3 (2.4)	1 (0.3)
D	Janssen, 2002 [10] – Class I – Class II	(SM/body mass) × 100%	 <37% <31%	 <28% <22%	 23 (18.7) 1 (0.8)	 0 0
E	Janssen, 2004 [9] – Moderate – Severe	SMI (SM/height^2)	 ≤10.75 kg/m^2 ≤8.50 kg/m^2	 ≤6.75 kg/m^2 ≤5.75 kg/m^2	 42 (34.1) 5 (4.1)	 0 0
F	Lauretani, 2003 [16]	Handgrip strength	<30.3 kg	<19.3 kg	41 (33.3)	20 (6.5)
G	EWGSOP, 2010 [11]	Total sarcopenic Subtotal sarcopenic based on gait speed ≤0.8 m/s – Gait speed – DXA: ALM/height^2 – BIA: SMI (SM/height^2) Subtotal sarcopenic based on gait speed >0.8 m/s – Gait speed – Handgrip strength – DXA: ALM/height^2 – BIA: SMI (SM/height^2)	 ≤0.8 m/s ≤7.23 kg/m^2 ≤10.75 kg/m^2 >0.8 m/s <30 kg ≤7.23 kg/m^2 ≤10.75 kg/m^2	 ≤0.8 m/s ≤5.67 kg/m^2 ≤6.75 kg/m^2 >0.8 m/s <20 kg ≤5.67 kg/m^2 ≤6.75 kg/m^2	31 (25.2)[a] 23 (18.7) 72 NA 23 8 (6.5) 51 12[d] NA 8	9 (2.9)[b] 0 0 0 NA 9 (2.9) 308 23[d] 9[e] NA
H	IWGS, 2011 [13]	Total sarcopenic based on gait speed <1.0 m/s – Gait speed – ALM/height^2	 <1.0 m/s ≤7.23 kg/m^2	 <1.0 m/s ≤5.67 kg/m^2	26 (21.1) 99 (80.5) 26 (26.3)[f]	0 3 (1.0) 0
I	FNIH, 2014 [12]	1. Weakness and low lean mass – Handgrip strength – ALM/BMI 2. Slowness with weakness and low lean mass – Gait speed – Handgrip strength – ALM/BMI	 <26 kg <0.789 ≤0.8 m/s <26 kg <0.789	 <16 kg <0.512 ≤0.8 m/s <16 kg <0.512	5 (4.1) 16 (13.0) 13 (10.6) 3 (2.4) 72 (58.5) 16 (13.0) 13 (10.6)	2 (0.6) 5 (1.6) 32 (10.4) 0 0 5 (1.6) 32 (10.4)

ALM = Appendicular lean mass; SMI = skeletal muscle mass index; SM = skeletal muscle mass; NA = not applicable.
[a] Prevalence of total sarcopenic is based on BIA measurements which were performed in the geriatric outpatients. [b] Prevalence of total sarcopenic is based on DXA measurements which were performed in the healthy elderly participants from the MyoAge study. [c] Proportion of the number of cases with a gait speed ≤0.8 m/s. [d] Proportion of the number of cases with a gait speed >0.8 m/s. [e] Proportion of the number of cases with low handgrip strength. [f] Proportion of the number of cases with a gait speed <1.0 m/s.

Diagnostic Criteria for Sarcopenia

Table 2 shows the prevalence rates of sarcopenia according to the applied diagnostic criteria. Geriatric outpatients had lower muscle mass, muscle strength and gait speed compared to healthy elderly participants. None of the healthy elderly participants had a gait speed ≤0.8 m/s, and in 1%, it was <1.0 m/s. Fifty-nine percent of the geriatric outpatients had a gait speed ≤0.8 m/s, and in 81%, it was <1.0 m/s.

The prevalence of sarcopenia in healthy elderly participants ranged from 0 to 15% and in geriatric outpatients from 2 to 34%, dependent on the applied set of di-
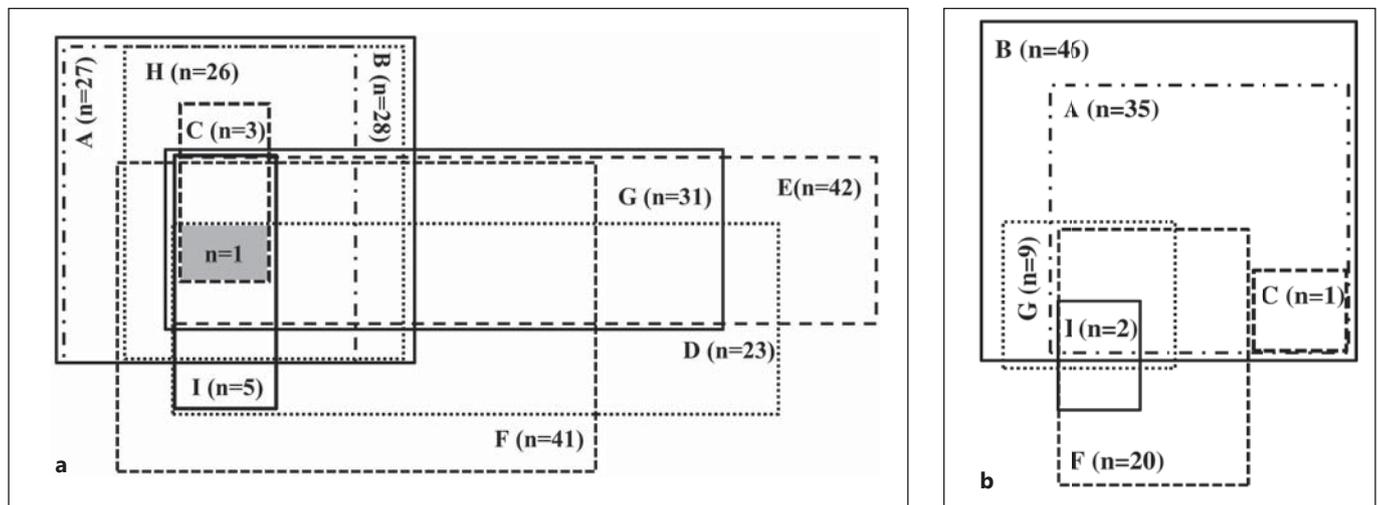
Fig. 1. Number of participants identified as having sarcopenia according to various diagnostic criteria. **a** Geriatric outpatients (Bronovo hospital, n = 123; percent of total: A: 22.0%, B: 22.8%, C: 2.4%, D: 18.7%, E: 34.1%, F: 33.3%, G: 25.2%, H: 21.1%, I: 4.1%).

b Healthy elderly participants (MyoAge study, n = 308; percent of total: A: 11.4%, B: 14.9%, C: 0.3%, F: 6.5%, G: 2.9%, I: 0.6%). See table 2 for the studies represented by codes A–I.

agnostic criteria. Out of the 308 healthy elderly participants, 250 did not have sarcopenia according to any of the applied sets of diagnostic criteria; among the 123 geriatric outpatients, this number was 44. Fifty-eight healthy elderly participants and 79 geriatric outpatients were classified as having sarcopenia, dependent on the applied set of diagnostic criteria.

Figure 1 visualizes the distribution of the prevalence rates according to the applied set of diagnostic criteria for sarcopenia. The diagnostic criteria (D, E, H) with a 0% prevalence of sarcopenia were omitted in figure 1b. There was very little agreement between the applied sets of criteria: only one of the geriatric outpatients was classified as sarcopenic according to all applied sets of diagnostic criteria; this was true for none of the healthy elderly participants.

Discussion

The purpose of this study was to compare prevalence rates of sarcopenia using nine different sets of diagnostic criteria in two clinically relevant elderly populations. In both elderly populations, the prevalence of sarcopenia was highly dependent on the applied set of diagnostic criteria. In fact, agreement between the criteria was minimal. Only one of the geriatric outpatients was classified as sarcopenic according to all applied diagnostic criteria.

Prevalence of Sarcopenia

Overall, and in line with the expectations, the prevalence of sarcopenia was higher in geriatric outpatients than in healthy elderly participants. However, the prevalence of sarcopenia is dependent on the used measure, correction factor and cutoff point. Geriatric outpatients had lower muscle mass, muscle strength and gait speed than healthy elderly participants. This higher prevalence of sarcopenia was expected, since geriatric outpatients are more vulnerable, and comorbidity is common in this population [17].

The prevalence of sarcopenia in healthy elderly participants was 0% according to diagnostic criteria D and E [9, 10] and the diagnostic criteria of the International Working Group on Sarcopenia (IWGS) [13]. Diagnostic criteria D and E are based on BIA results [9, 10], while DXA results were used in our study of healthy elderly participants. However, previously, we showed excellent agreement between DSM-BIA and DXA in middle-aged adults [18]. The IWGS criteria are based on an algorithm in which the sequence is to first measure gait speed and then to measure muscle mass when gait speed is low [13]. There were only two healthy elderly participants with a gait speed <1.0 m/s, and neither of these two was classified as sarcopenic based on the subsequent measurement of muscle mass. Within the IWGS criteria, it is possible to classify participants as not having sarcopenia in spite of having low muscle mass. The same holds for the diagnos-

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tic criteria of the European Working Group on Sarcopenia in Older Persons (EWGSOP), which also includes an algorithm with the sequence to first determine gait speed, then to measure handgrip strength when gait speed is normal and to measure muscle mass when the handgrip strength is low, or to measure muscle mass when gait speed is low [11]. Within the EWGSOP algorithm, it is also possible to classify participants as not having sarcopenia in spite of having low muscle mass but normal gait speed and handgrip strength.

Lack of Agreement

The lack of agreement between the nine sets of diagnostic criteria for sarcopenia can be explained by the use of different measures, i.e. muscle mass, muscle strength and physical performance. These measures are apparently based on different constructs. In geriatric outpatients, the prevalence rate of sarcopenia assessed by handgrip strength only [16] was higher than the prevalence rates based on the single factor muscle mass [2, 7–10]; this was not true in healthy elderly participants, where the prevalence rate of sarcopenia assessed by handgrip strength was lower. Apart from the differences in muscle characteristics, this is also due to the fact that the lower limbs are more affected by muscle loss and weakness with ageing than the upper limbs [15, 19].

Another explanation for the lack of agreement is the use of correction factors. Measures of muscle mass are corrected for height [2, 7–9, 11, 13], body mass [10] and BMI [12]. Height squared is a commonly used correction factor for muscle mass. However, this factor and also the correction factor BMI are questionable because of the influence of frequent collapsed vertebra on height in the elderly. Diagnostic criteria for sarcopenia are difficult to compare due to the use of these correction factors. In addition, the use of different cutoff points could also explain the lack of agreement. Cutoff points are based on reference populations and are used interchangeably in different populations.

Methodological issues should also be taken into account while explaining the lack of agreement. Different cutoff points for BIA and DXA are applied to determine low muscle mass. The EWGSOP algorithm suggests several cutoff points for BIA and DXA validated in different target populations [11]. Therefore, prevalence rates may vary within this algorithm due to the use of different cutoff points and depending on the chosen measurement [11]. Gait speed can be measured using different procedures; some require walking at normal pace, others request participants to cover as much distance as possible

in a specific time, while others require walking as fast as possible over a short distance. The 4-meter walking test includes a straight walking space, while the 6-minute walking test includes walking around a track and therefore a turning direction point. These different procedures can influence the gait speed [20], which can also explain the lack of agreement between the diagnostic criteria for sarcopenia.

Prevalence rates of sarcopenia differed between the diagnostic criteria of the consensus working groups, EWGSOP, IWGS and the Foundation for the National Institutes of Health (FNIH) [11–13]. This result is in line with a previous study that has found good negative but poor positive percent agreements in a community-dwelling elderly population between the diagnostic criteria of the EWGSOP, IWGS and FNIH [21]. Both the EWGSOP and the IWGS include algorithms to define sarcopenia. In contrast, the FNIH includes combinations of low muscle mass, low muscle strength and low physical performance. The lack of agreement between the EWGSOP, IWGS and FNIH can be explained by the use of different measures of muscle mass (appendicular lean mass/height^2 and appendicular lean mass/BMI), but also by the use of different cutoff points for muscle strength and physical performance.

Consensus on the diagnostic criteria for sarcopenia should be based on evidence of the relation between different diagnostic measures of sarcopenia and clinically relevant muscle-related outcomes, such as physical performance [22], standing balance [6], insulin resistance [23] and bone mineral density [24]. Furthermore, the terminology should be clearly defined. Skeletal lean mass and total lean mass are used interchangeably without a clear explanation of the difference between both terms. This also applies to the terms appendicular skeletal muscle mass and appendicular lean mass. Consensus on the diagnostic criteria for sarcopenia should also be based on useful correction factors and valid cutoff points. Cutoff points need to be derived from different elderly reference populations. However, without a consensus on the diagnostic measure, it is difficult to determine valid cutoff points.

Conclusion

Prevalence rates of sarcopenia vary within the same elderly population, depending on the applied set of diagnostic criteria, and there is very little agreement between the diagnostic criteria for sarcopenia. These findings in-

dicate the importance of defining sarcopenia and the need to reach a consensus on the diagnostic criteria encompassing measures, correction factors and cutoff values. Further research should focus on the association between diagnostic measures of sarcopenia and clinically relevant muscle-related outcomes, including functional mobility. This understanding is essential for the development of a consensus definition of sarcopenia.

Disclosure Statement

The authors declare no conflicts of interest.

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