European Journal of Clinical Nutrition
https://doi.org/10.1038/s41430-019-0508-8

ARTICLE

Clinical nutrition

Sarcopenia as a mortality predictor in community-dwelling older adults: a comparison of the diagnostic criteria of the European Working Group on Sarcopenia in Older People

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Received: 26 June 2019 / Revised: 16 September 2019 / Accepted: 19 September 2019

Abstract

Background/objectives The definition of sarcopenia remains a matter of discussion and there is no globally accepted consensus for its diagnosis. The aim of this study was to assess the effect of sarcopenia diagnostic components on mortality, as well as to compare the associations between sarcopenia diagnosed via the 2010 and 2018 Consensuses of the European Working Group on Sarcopenia in Older People (EWGSOP) and mortality.

Methods Prospective cohort study involving noninstitutionalized older adults aged ≥ 60 years. For the diagnosis of sarcopenia, the definitions proposed by the 2010 (EWGSOP) and 2018 (EWGSOP2) Consensuses were used. The diagnostic components corresponded to muscle mass, muscular strength, and physical performance. The associations of sarcopenia and its components with mortality were investigated using Cox proportional hazard regression models.

Results The sample consisted of 1291 older adults. After an average of 2.6 years of follow-up, 88 (6.8%) participants had died. The diagnosis of severe sarcopenia by both Consensuses was associated with an increased risk of mortality. Severe sarcopenia was associated with an increased risk of death compared with that in people without sarcopenia when using EWGSOP (hazard ratio (HR) 3.15, 95% confidence interval (CI) 1.44–6.90) and EWGSOP2 (HR 4.11, 95% CI 1.88–9.00). Older adults with decreased gait speed had a 76% higher risk of dying ($p = 0.033$). There was no statistically significant association between the other sarcopenia components and mortality risk.

Conclusions Older adults with severe sarcopenia and those with changes in physical performance had an increased risk of death in the short term.

Introduction

The aging process is responsible for numerous changes in body composition [1]. Age-related sarcopenia (primary sarcopenia) was first described by Rosenberg in 1989 [2] and was initially related to a reduction of muscle mass in the older subjects [3]. More recently, primary sarcopenia has been considered to represent both loss of muscle mass and function [4].

There is still no universally accepted definition for sarcopenia. In particular, studies on sarcopenia have tended to use different definitions that diverge in terms of the diagnostic components and methods as well as the cutoff points used to measure each component [5–7]. Thus, a comparison of the epidemiology, etiology, and consequences of sarcopenia in different settings is challenging.

The most frequently adopted definition of sarcopenia is the one proposed by the European Working Group on

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Published online: 04 October 2019

Sarcopenia in Older People (EWGSOP) in 2010. Sarcopenia was, then, described as a geriatric syndrome characterized by the progressive and generalized loss of skeletal muscle mass and functionality (either through loss of strength and/or physical performance) [8]. The EWGSOP consensus introduced muscle mass and function into the concept of sarcopenia [8]. The concept of "pre-sarcopenia" was introduced to express the presence of low muscularity without identifiable loss of muscle function. The operational definition for sarcopenia included low muscle mass and low muscle strength or performance, and, in the presence of the three conditions, sarcopenia was considered "severe".

Due to the increasing epidemiological and clinical knowledge on sarcopenia in addition to the complexity in the evaluation of muscle mass and low clinical applicability of the previous consensus, an updated consensus paper was developed by the Group—now, self-entitled EWGSOP2 in 2018 [9]. In this new version, the reduction of muscle strength was considered the main diagnostic determinant, assuming the role previously attributed to muscle mass. According to the updated consensus statement, older people with decreased muscle strength should be considered as having probable sarcopenia and therapeutic intervention should be initiated, without the need for muscle mass evaluation [9].

In order to establish a universal consensus for sarcopenia, it is important to validate the diagnostic methods in different settings, including the observation of the association between the diagnostic components and health outcomes of interest. The most researched outcomes for a possible association with sarcopenia among the older subjects in the community are falls, fractures, physical incapacity, hospitalizations, quality of life, and mortality [10].

Therefore, the aim of this study was to: (a) assess the relationship between the individual components of sarcopenia (muscle mass, strength, and performance) and the risk of 3-year mortality, (b) classify sarcopenia according to the consensus of the EWGSOP and EWGSOP2 and compare their associations with mortality in a sample of non-institutionalized older subjects.

Methods

Sample assessments

This is a cohort study of noninstitutionalized older adults aged 60 years or older living in the urban area of the city of Pelotas, a medium-sized city located in southern Brazil. The sample was constituted by the participants of the cross-sectional population-based study entitled COMO VAI? (Master's Consortium for Valuation of Older subjects Care —*Consórcio de Mestrado Orientado para a Valorização da Atenção ao Idoso*, in Portuguese).

Baseline data was obtained between January and August 2014 from the household assessments conducted by trained personnel. More detail on both the sampling process has been thoroughly described in previous publications and can be found elsewhere [11, 12].

The follow-up assessment of selected health outcomes (including mortality) was carried out through telephone interviews by trained volunteers between November 2016 and April 2017. Repeated failed attempts to reach the participants by phone contact led to home visits. Telephone interviews were registered online using the Research Electronic Data Capture method (REDCap, available at https://projectredcap.org/), whereas home interviews were registered on tablets offline, and, once a week, updated onto the server.

Sarcopenia: definitions and diagnostic tests

Baseline data on muscle performance, strength, and mass were assessed using, respectively, 4 m gait-speed test, hand dynamometry and calf circumference (CC) measurements for the diagnosis of sarcopenia, the definitions proposed by EWGSOP and EWGSOP2 were used [8, 9].

The CC was measured using a nondistensible measuring tape. Four measurements were performed in the region of greatest circumference (two in each leg, alternately), with the participants standing and their legs exposed. Measurements were recorded in centimeters, and the older subjects were considered to have reduced muscle mass if CC was ≤34 cm for men and ≤33 cm for women, according to cutoff values established from the same population, previously reported elsewhere [11].

Handgrip strength was measured using manual digital dynamometers (Jamar Digital Plus + Hand Dynamometer; Simmons Preston, Canada). Six measurements were obtained for each participant (three in each hand, alternately) while sitting with the arms supported. The measurements were recorded in kilogram (kg), and the highest value reached by the participant in the six attempts was considered. Muscle strength was considered low in the presence of handgrip values <30 kg or <20 kg (men and women, respectively) for the EWGSOP definition [8, 13], and, for EWGSOP2, <29.7 kg of <16.2 kg. As recommended in the latter, regional normative cutoffs were adopted: they came from a previous study conducted in a younger population from the same city [14], using the also suggested 2.5 standard deviations below the mean "conservative" approach [9, 15].

Gait speed was based on the time taken by the participants to walk a 4-m distance marked on the ground as a straight line. The test was conducted twice, and the best

performance (that is, the fastest) was chosen to identify low gait speed (<0.8 m/s) [8, 13].

In line with the EWGSOP, older subjects with normal muscle mass were considered as not having sarcopenia; those with isolated muscle mass reduction, as having pre-sarcopenia; individuals with reduced muscle mass and muscle strength or physical performance, as having sarcopenia; and with reduced muscle mass, muscle strength, and physical performance, as having severe sarcopenia [8].

Per the EWGSOP2 consensus, individuals with normal muscle strength were considered as not having sarcopenia; with reduced muscle strength alone, as having probable sarcopenia; with reduced muscle strength and muscle mass, as having confirmed sarcopenia; and with reduced muscle strength, muscle mass, and physical performance, as having severe sarcopenia [9].

Covariates

Data on independent variables of the study were collected using a standardized questionnaire. The sociodemographic data obtained were sex, age, color, level of schooling, and marital status. The economic profile of the participants was evaluated through the Brazilian Association of Research Companies classification, a questionnaire composed of questions related to consumer goods, use of services, and schooling of the head of the family. According to this assessment, individuals can be stratified into five economic classifications, in descending order from A to E, where A refers to the highest classification and E, the lowest [16]. Smoking; comorbidities (from self-reported medical diagnosis of 14 diseases); body mass index (BMI) using the formula: weight (kg)/height^2 (m^2) [17]; physical activity in leisure (International Physical Activity Questionnaire—IPAQ) [18, 19]; and functional capacity (Katz Scale) were also evaluated [20].

Mortality

Information on all-cause death was obtained from a close family member or neighbor in the 2016–2017 follow-up and subsequently confirmed through the Mortality Information System, with permission from the Department of Epidemiological Surveillance of the Pelotas Municipal Health Secretariat. In addition to the finding of death, the following were recorded: cause and date of death of the participant and name and relationship of the informant with the participant.

Data analysis and ethical concerns

Data analysis was performed using Stata 14.2 program (StataCorp, College Station, TX). The characteristics of the sample were described as absolute and relative frequencies and Pearson's Chi-square test was used to identify the factors associated with mortality.

The follow-up time of the individuals was defined as the time interval between the date of the first interview of the patient and the date of death, second interview, or estimated loss to follow-up. It was assumed that they occurred in a uniform way, in the average period between first and second contact with the participants. Cox regression was used to determine the effect of the diagnosis of sarcopenia and its components on the risk of death, after controlling for the confounding factors identified in the bivariate analysis. Cox survival curves were used to depict the death rates by category according to the EWGSOP and EWGSOP2 classifications. For all tests, a p-value < 0.05 was considered statistically significant.

The COMO VAI study was approved by the Research Ethics Committee of the Medical School of the Federal University of Pelotas (UFPel) (register CAAE-24538513.1.0000.5317), as well as the follow-up assessment (register 472.357). Participation was voluntary, and informed consent was obtained prior to data collection.

Results

There were 1844 older adults, among whom 1451 (78.7%) were interviewed in 2014 (total sample). Of these, 1291 performed the three tests required for the diagnosis of sarcopenia (CC, handgrip strength and gait test), and comprised the final study sample. After 2.6 years of follow-up, 145 (9.9%) older adults died. Of the study participants who completed the complete measurements, 88 (6.8%) died.

Table 1 shows the general characteristics of the sample included in this study and the original sample. The majority of the participants were female (62.6%), aged 60–69 years (55.3%) and Caucasians (83.9%). About 54.8% of the participants lived with a partner, 54.4% had less than 8 years of schooling, the majority were not working (78.9%) and more than half were in the economic classification C (52, 8%). Regarding lifestyle and morbidities, most participants had never smoked (53.7%), 47.9% had four or more diseases, and 14.3% had depressive symptoms. More than half of the older adults were physically independent (68.7%), but almost 60% were classified as insufficiently active in leisure activities. As per their BMI, the majority of the participants were overweight (42.4%) and only 1.6% were underweight. Considering only the sample with the three tests for diagnosis of sarcopenia, mortality was not associated with skin color, education, socioeconomic class, smoking, comorbidities, and functional capacity.

In relation to the three diagnostic components of sarcopenia (strength, muscle mass, and gait speed), the percentage

Table 1 Description of the sample ($N = 1.451$) and the percentage of deaths of community-dwelling older adults and those with complete information on the components of sarcopenia ($N = 1.291$), according to socioeconomic, behavioral, and health characteristics

Characteristics	*N* (%) 1.451 (100)	Deaths (%) 145 (9.9)	*N* (%) 1.291 (100)	Deaths (%) 88 (6.8)
Sex				$p = 0.001$
Male	537 (37.0)	69 (12.8)	483 (37.4)	47 (9.7)
Female	914 (63.0)	76 (8.3)	808 (62.6)	41 (5.1)
Age				$p < 0.001$
60–69 years	756 (52.3)	41 (5.4)	712 (55.3)	32 (4.5)
70–79 years	460 (31.8)	46 (10.0)	415 (32.2)	30 (7.2)
≥80 years	230 (15.9)	58 (25.2)	161 (12.5)	26 (16.1)
Skin color				$p = 0.388$
Caucasian	1.211 (83.7)	118 (9.7)	1.082 (83.9)	71 (6.6)
Non-Caucasian	236 (16.3)	27 (11.4)	207 (16.1)	17 (8.2)
Marital status				$p = 0.002$
With companion	763 (52.7)	59 (7.7)	707 (54.8)	37 (5.2)
Without companion	225 (15.6)	17 (7.6)	210 (16.3)	11 (5.2)
Widower	459 (31.7)	69 (15.0)	372 (28.9)	40 (10.7)
Schooling				$p = 0.34$
None	196 (13.6)	27 (13.8)	156 (12.2)	14 (9.0)
<8 years	782 (54.4)	83 (10.6)	697 (54.4)	49 (7.0)
≥8 years	459 (32.0)	34 (7.4)	427 (33.4)	24 (5.6)
Working				$p = 0.05$
Yes	264 (19.6)	12 (4.5)	255 (21.1)	10 (3.9)
No	1.084 (80.4)	114 (10.5)	952 (78.9)	70 (7.3)
Socioeconomic status				$p = 0.082$
A/B	483 (35.2)	44 (9.1)	429 (34.9)	23 (5.4)
C	720 (52.5)	73 (10.1)	648 (52.8)	46 (7.1)
D/E	169 (12.3)	20 (11.8)	149 (12.1)	16 (10.7)
Smoking				$p = 0.06$
Never	781 (54.0)	71 (9.1)	692 (53.7)	39 (5.6)
Previous smoker	483 (33.4)	50 (10.4)	429 (33.3)	31 (7.2)
Yes	182 (12.6)	23 (12.6)	168 (13.0)	18 (10.7)
Comorbidities				$p = 0.104$
≤1	221 (16.4)	9 (4.1)	218 (17.2)	8 (3.6)
2 or 3	461 (35.3)	32 (6.9)	443 (34.9)	31 (7.0)
≥4	664 (49.3)	65 (9.8)	607 (47.9)	48 (7.9)
Depressive symptoms				$p = 0.016$
Yes	212 (15.2)	31 (14.6)	182 (14.3)	20 (11.0)
No	1.182 (84.8)	91 (7.7)	1.094 (85.7)	67 (6.1)
Functional capacity				$p = 0.197$
Independent	920 (63.9)	58 (6.3)	885 (68.7)	55 (6.2)
Dependent	520 (36.1)	85 (16.4)	404 (31.3)	33 (8.2)
Physical activity at leisure				$p = 0.001$
Active (≥150 min/week)	522 (38.1)	21 (4.0)	509 (40.4)	20 (3.9)
Not active (<150 min/week)	850 (61.9)	95 (11.2)	750 (59.6)	66 (8.8)
BMI				$p < 0.001$
<18.5 kg/m^2	25 (1.8)	7 (28.0)	21 (1.6)	5 (23.8)
18.5–24.9 kg/m^2	360 (26.4)	40 (11.1)	334 (26.0)	35 (10.5)
25–29.9 kg/m^2	571 (41.9)	32 (5.6)	543 (42.4)	26 (4.8)
≥30 kg/m^2	408 (29.9)	29 (7.1)	385 (30.0)	22 (5.7)

Study "COMO VAI?" (2014–2017). *p*–Pearson's Chi-square test

BMI body mass index

of deaths was significantly higher (all $p < 0.001$) among the older subjects with a reduction in strength (15.3 × 5.1%), muscle mass (11.7 × 5.3%), and performance (12.8 × 5.0%), as described in Table 2. Mortality was higher among the older adults diagnosed with sarcopenia by EWGSOP2 than among those without sarcopenia, and an increase in the frequency of deaths among older subjects patients classified as having severe sarcopenia was also observed.

Table 2 Description of the sample ($N = 1.291$) and percentage of deaths according to the components and diagnoses of sarcopenia, and association between the diagnostic components, sarcopenia by the EWGSOP and EWGSOP2 criteria and mortality

Characteristics	*N* (%)	Deaths (%)	HR[a] (IC95%)	HR[b] (IC95%)
Low strength[c]			$p < 0.001$	$p = 0.136$
No	1076 (83.4)	55 (5.1)	1.0	1.0
Yes	215 (16.6)	33 (15.3)	3.22 (2.07–5.00)	1.51 (0.88–2.61)
Low muscle mass[d]			$p < 0.001$	$p = 0.389$
No	982 (76.1)	52 (5.3)	1.0	1.0
Yes	309 (23.9)	36 (11.7)	2.40 (1.55–3.70)	1.32 (0.69–2.51)
Low gait speed[e]			$p < 0.001$	$p = 0.033$
No	986 (76.4)	49 (5.0)	1.0	1.0
Yes	305 (23.6)	39 (12.8)	2.80 (1.82–4.31)	1.76 (1.04–2.96)
EWGSOP[f]			$p < 0.001$	$p = 0.005$
No sarcopenia	982 (76.1)	52 (5.3)	1.0	1.0
Pre sarcopenia	130 (10.1)	4 (3.1)	0.58 (0.21–1.62)	0.52 (0.17–1.58)
Sarcopenia	114 (8.8)	14 (12.3)	2.52 (1.39–4.58)	1.18 (0.53–2.65)
Severe sarcopenia	65 (5.0)	18 (27.7)	6.87(3.99–11.82)	3.15 (1.44–6.90)
EWGSOP2			$p < 0.001$	$p < 0.001$
No sarcopenia	1076 (83.4)	55 (5.1)	1.0	1.0
Sarcopenia probable	130 (10.1)	12 (9.2)	1.77 (0.92–3.39)	0.92 (0.42–2.04)
Sarcopenia confirmed	44 (3.4)	8 (18.2)	3.76 (1.79–7.92)	1.36 (0.52–3.57)
Severe sarcopenia	41 (3.2)	13 (31.7)	8.13 (4.42–14.95)	4.11 (1.88–9.00)

Study "COMO VAI?" (2014–2017)

EWGSOP European Working Group on Sarcopenia in Older People criteria 2010, *EWGSOP2* European Working Group on Sarcopenia in Older People criteria 2018

[a]Cox regression

[b]Multivariable Cox model adjusted for sex, age, marital status, working, smoking, physical activity at leisure, body mass index, comorbidities, and depressive symptoms

[c]Low handgrip strength <29.7 kg for men and <16.2 kg for women (local normative references, as suggested by EWGSOP2)

[d]Calf circumference ≤34 cm for men and ≤33 cm for women

[e]Gait speed <0.8 m/s

[f]Low handgrip strength: <30 kg for men and <20 kg for women by EWGSOP; low muscle mass and gait speed as defined previously

In the multivariable Cox model, only the low physical performance remained significantly associated with an increased risk of mortality ($p = 0.033$). Older adults with a decrease in gait speed showed a 76% higher mortality risk (hazard ratio (HR) 1.76, 95% CI 1.04–2.96). There was no statistically significant association between the other sarcopenia components and mortality risk.

We further assessed the relationship between sarcopenia diagnosed by EWGSOP and EWGSOP2 and the risk of mortality. However, as per the multivariable Cox model, only severe sarcopenia was significantly associated with an increase in the risk of death when diagnosed either according to the EWGSOP (HR 3.15, 95% CI 1.44–6.90) or EWGSOP2 (HR 4.11, 95% CI 1.88–9.00) criteria.

Figure 1 shows the Cox proportional survival curves of the older adults according to the categories of sarcopenia by the EWGSOP and EWGSOP2 consensuses. According to the EWGSOP criterion ($p = 0.005$), it can be observed that the percentage of survival among pre-sarcopenic individuals was higher than that among those without sarcopenia. With the EWGSOP2 criteria ($p < 0.001$), the survival rate of participants without sarcopenia and those with probable sarcopenia overlapped. It is also observed that the survival curves diverge after the first year of follow-up, with lower survival observed among older subjects classified with severe sarcopenia by both consensuses.

Discussion

To our knowledge, this was the first study to compare the two EWGSOP consensus definitions of sarcopenia and the relationship with mortality in noninstitutionalized older adults in Latin America. The results showed that over a 2.6-

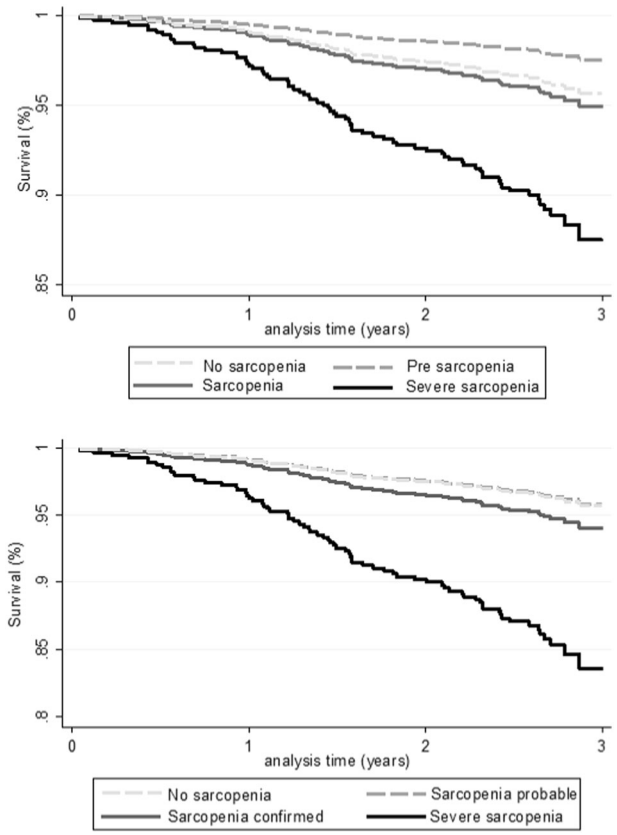

Fig. 1 Cumulative hazard survival probability in older adults according to criteria EWGSOP (first graph) and EWGSOP2 (second graph)

year follow-up older adults with severe sarcopenia diagnosed using both EWGSOP and EWGSOP2 criteria had a significantly increased risk of mortality.

People with severe sarcopenia were found to have an almost four times increased risk of death in this study, in agreement with the results of prior meta-analyses [21, 22], which found that sarcopenia diagnosed by the EWGSOP criteria was associated with an increased risk of mortality (HR 3.6, 95% CI 2.9–4.3). However, it should be noted that even studies that used the EWGSOP criteria did not present results according to the severity of sarcopenia.

Our finding that only severe sarcopenia was associated with mortality is in line with the findings from individual analysis of the diagnostic components, wherein only physical performance, assessed by walking speed, was found to be independently related to mortality. This finding may be related to a follow-up time of 2.6 years, which may be relatively short so only the sign of worse prognosis, as gait speed, consists of a factor more proximal of mortality, thus representing the severity of sarcopenia.

The results of the present study are also in line with that presented by Landi et al. [23] and Kim et al. [24], who found that a reduction in physical performance increased the mortality rates in noninstitutionalized older subjects. As for muscle mass, in accordance with the study of Bianchi et al. [25], we showed that only a low amount of muscle mass did not increase the risk of mortality. This corroborates the current idea that only the evaluation of isolated muscle mass is unable to predict mortality [26, 27].

However, our results differ from those reported by some authors [27, 28] as we did not identify an association between strength reduction and mortality both in the individual-component analysis and in the classification of probable sarcopenia by EWGSOP2. Thus, it is worth asking whether the recommendations of the current consensuses for the diagnosis of sarcopenia are adequate for classifying risk in older adults, as it is possible to observe changes in the pattern of associations according to the diagnostic criteria and methods used in each study [5, 29–31].

It was found that 352 individuals with altered muscle functionality (strength or physical performance) did not have sarcopenia according to the EWGSOP criteria. Per the criteria, older subjects with preserved muscular mass were considered as not having sarcopenia even if they had reduced strength or physical performance. On the basis of the recommended classification in the new EWGSOP2 consensus, older adults with loss of muscle mass and reduction in gait speed, but with unchanged strength, were classified as normal. Per this criterion, a diagnosis is made only through evaluation of muscular strength. When handgrip strength is preserved, sarcopenia is excluded without evaluation of the other components. However, in both classifications, older adults with changes in muscle mass or function are classified as not having sarcopenia, depending on the consensus chosen. Thus, some studies may be unable to demonstrate reality because of inadequate classification of the studied population.

The importance of the clinical applicability of the diagnostic criteria is known. However, 160 older subjects were excluded from our study as they were unable to perform any of the three diagnostic tests for sarcopenia. Of these 160 older subjects, 57 died during the follow-up period, accounting for more than a third of deaths (39.3%). In view of this, it is pointed out that the inability of older adults to complete the diagnostic tests represents an important risk factor for mortality and is probably highly predictive of a diagnosis of sarcopenia.

Our study has some limitations, and one of them is related to our sample age. As elderly is defined as “older than 60 years old” in our country, and this is a population-based study, most of the subjects (55.3%) was <70 years. This fact may have influenced our results. We also determined muscular mass through an anthropometric measure, CC. This method is less accurate than those recommended by the Consensuses (magnetic resonance imaging, tomography, and X-ray absorptiometry (DXA)), but is extremely relevant in population studies because it is accessible,

inexpensive, and appropriately related to the standard-gold [32, 33]. In addition, the exclusion of one-third of deaths, due to the inability to perform any of the three diagnostic evaluations, may have resulted in a lower statistical power to establish the associations studied, besides a possible reduction in the magnitude of the association between sarcopenia and mortality. Regardless, this study has some key strengths, such as the fact that it is a population-based study that evaluated a solid outcome and used specific cutoff points for the local population, both for mass and muscle strength assessment.

Conclusions

Our study showed that older subjects with severe sarcopenia and those with altered physical performance had an increased risk of death in the short term, requiring immediate intervention and frequent follow-up. The results reiterate the need to further discuss the applicability of the diagnostic criteria for sarcopenia and its components in order to create a diagnostic flowchart for sarcopenia with a more complete, more sensitive, and less exclusive initial evaluation.

Acknowledgements The authors thank the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and the the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support, and all the colleagues who collaborated on the COMO VAI? study.

Funding First phase (2014) was funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) from Brazil and also by individual financial resources of the students. The second phase was partially funded by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Authors' contributions NPB and MCG planned the study. RMB and MCG performed the statistical analyses. NPB, RMB, AMBM, ET, TGBS and MCG wrote the paper. All authors approved the final version of the paper.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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