Consequences of applying the different criteria of the EWGSOP2 guideline for sarcopenia case-finding in Spanish community-dwelling older adults

Alessio Montemurro [a,*], Juan D. Ruiz-Cárdenas [a], María del Mar Martínez-García [a,b], Juan J. Rodríguez-Juan [c]

[a] Physiotherapy Department, Faculty of Physiotherapy, Podiatry and Occupational Therapy, Universidad Católica de Murcia, Murcia, Spain
[b] Cystic Fibrosis Association of Murcia, Av. de las Palmeras, 37, 30120 Murcia, Spain
[c] Physiotherapy Department, Facultad de Medicina, Universidad de Murcia, Campus de Ciencias de la Salud, 30120, Murcia, Spain

ARTICLE INFO

Keywords:
Sarcopenia
Older adults
Agreement
Prevalence
Ewgsop2

ABSTRACT

Introduction: Sarcopenia prevalence varies according to differences in diagnostic criteria used. In order to overcome this issue, the European Working Group on Sarcopenia in Older People-2 (EWGSOP2) published a consensus to increase harmonization for sarcopenia diagnosis. This study aimed to determine the prevalence and risk factors across the different sarcopenia diagnosis criteria recommended by EWGSOP2 and to analyze its agreement.

Methods: A total of 699 community-dwelling older adults (median-age: 72, 60% female) were recruited in this cross-sectional study. Sarcopenia prevalence was obtained by different combinations of muscle strength (handgrip strength or 5-times sit-to-stand) and muscle quantity (appendicular skeletal mass or skeletal muscle index) as recommended by the EWGSOP2. Cohen's Kappa coefficient was calculated to analyze agreement among the four sarcopenia diagnostic criteria and logistic regressions were performed to identify risks associated to health-related outcomes for each diagnostic criterion.

Results: Sarcopenia prevalence varied from 2.1% to 11.6%, depending on the diagnostic criteria used. Weak-to-moderate agreements (κ-range: 0.13–0.66) were observed among the four sarcopenia diagnosis criteria. There was scarce overlap in sarcopenic people when different diagnostic criteria were used leading to up to 10.4% of underdiagnosis. Sarcopenia defined by 5-times sit-to-stand was more associated with health-related outcomes compared to handgrip strength.

Conclusions: Sarcopenia prevalence rates vary considerably depending on the diagnostic criteria used. These criteria should not be used in an interchangeable way due to their weak agreement. Sarcopenia diagnosis criteria defined by 5-times sit-to-stand could be more suitable in Spanish community-dwelling older adults due their associations with health-related outcomes.

1. Introduction

Sarcopenia is formally recognized as a disease of the musculoskeletal system and connective tissue (ICD code: M62.84) characterized by a progressive and generalized loss of muscle mass, strength, and physical function associated with aging process (Cruz-Jentoft et al., 2019). This disease is related with a wide spectrum of health-related adverse outcomes like falls, fractures, physical disability, and mortality (Cruz-Jentoft et al., 2019). Despite the importance of this disease, a single diagnostic criterion has not yet been established. Actually, sarcopenia prevalence in Europe varies between 1% and 33% according to differences in diagnostic criteria and cut-off points used (Petermann-Rocha et al., 2022). In order to provide a systematic and consistent identification of people with sarcopenia or its risk, the European Working Group on Sarcopenia in Older People 2 (EWGSOP2) published a consensus to facilitate early detection and better treatment of sarcopenia in clinical practice. Concretely, probable sarcopenia is defined as low levels of muscle strength and is confirmed when both low strength and low muscle quantity are present. Finally, physical performance is measured as an indicator of severity (Cruz-Jentoft et al., 2019).

* Corresponding author at: Physiotherapy Department, Faculty of Physiotherapy, Podiatry and Occupational Therapy Universidad Católica de Murcia, Av. de los Jerónimos, 135, 30107 Guadalupe de Maciascoque, Murcia, Tel: (+34) 968 27 88 00.
E-mail address: amontemurro@ucam.edu (A. Montemurro).

The European consensus (EWGSOP2) provides a list of validated tools, including cut-off values, for the measurement of muscle strength and muscle quantity to increase harmonization for sarcopenia diagnosis in clinical practice and research studies. Muscle strength can be assessed through handgrip strength or 5-times sit-to-stand test (5STS) and muscle quantity can be measured as appendicular skeletal mass either absolute (ASM) or adjusted for height also named skeletal muscle index (SMI). However, although different options for muscle strength assessment could facilitate sarcopenia diagnosis in clinical practice in those cases where a handgrip dynamometer is not available, the use of a specific parameter instead of another could greatly affect the prevalence of the disease and some people could be underdiagnosed (Johansson et al., 2020). A recent study showed that when muscle strength was assessed by 5STS test, sarcopenia was twice as prevalent than when muscle strength was determined by handgrip strength in community-dwelling older adults (Johansson et al., 2020). Moreover, only 10% of participants manifested sarcopenia when both diagnostic criteria overlapped, showing a very weak agreement ($\kappa = 0.18$) between muscle strength assessment parameters. Therefore, there is a need to analyze the impact of sarcopenia prevalence and health-related risk factors according to the recommendations provided by the EWGSOP2 guidelines, as well as the agreement between sarcopenia diagnosis criteria in Spanish community-dwelling older adults.

The aim of this study was to determine the prevalence of sarcopenia with the different parameters recommended by the EWGSOP2 for both muscle strength and muscle quantity, to analyze the agreement among sarcopenia diagnosis criteria, as well as to analyze the association for each diagnostic criterion with socioeconomic status, education level, smoking habit, polypharmacy, self-perceived health and health-related adverse outcomes, such as comorbidities, depression, falls and hospitalization in Spanish community-dwelling older adults.

2. Methods

2.1. Design and protocol registration

This cross-sectional study was designed according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (von Elm et al., 2008) and registered on ClinicalTrial.gov (NCT05148351). The study was approved by the Ethical Committee of the Catholic University of Murcia (CE022108) and was in accordance with the principles of the Declaration of Helsinki.

2.2. Participants recruitment and setting

This study is a secondary analysis from a previous published protocol carried out from February to October 2022 (Montemurro et al., 2022). Community-dwelling adults aged 60 or more were recruited from elderly social centers of the Region of Murcia. Participants were contacted either via telephone or face-to-face and were instructed about the study development. After being provided with the detailed information about the assessment procedure and its related risk, their written informed consent was obtained. Participants were informed that they could withdraw at any time from the study.

Participants who reported severe cardiovascular problems (such as heart valve disease, uncontrolled heart rhythm problems, automatic defibrillator, and pacemakers), moderate dependency (less than 90 in Barthel score), likelihood of dementia or cognitive impairment (less than 3 points in the Mini-Cog test), inability of standing without assistance or any health condition that affects the performance of the functional tests such as stroke sequelae, neuropathy, low back pain or osteoarthritis were excluded.

2.3. Data collection

Participants were systematically asked about sex, age, presence of depressive symptoms (Geriatric Depression Scale 5-items; cut-off point: ≥2), socioeconomic status (low income cut-off point: net salary <10,000 €/year), education level (low education level cut-off point: primary or less), presence of comorbidity (two or more chronic conditions), polypharmacy (five or more drugs/day), self-perceived health (low self-perceived health cut-off point: very bad, bad or fair), presence of two or more falls in the last year, hospitalizations in the last year, current smoking habit, and physical activity levels with the Spanish Short Version Minnesota leisure time Physical Activity Questionnaire (Ruiz-Comellas et al., 2012). Further information of the registered socioeconomic and health-related outcomes can be found in the study protocol (Montemurro et al., 2022).

2.4. Sarcopenia assessment

Prevalence of sarcopenia was determined according to the recommendations proposed by the EWGSOP2 (Cruz-Jentoft et al., 2019). Muscle strength was measured by using either handgrip strength or 5STS test. Handgrip strength test was carried out using a handgrip digital dynamometer (Takei 5401, Takei Scientific Instruments Co., Ltd., Tokyo, Japan). Participants were instructed to maximally squeeze the device two times with each hand alternatively for a total of four trials while sitting on a chair with their elbow flexed at 90°, wrist on a neutral position and thumb facing upwards. Maximal score was registered to determine low levels of muscle strength (cut-off points in men <27 kg and women <16 kg). For the 5STS test, participants were instructed to fully rise from a chair five times as fast as possible with arms crossed on their chest. Time taken to sit down on the chair at the fifth repetition was recorded with a stopwatch. A time longer than 15 s was used as cut-off point for low levels of muscle strength.

For sarcopenia diagnosis confirmation, muscle quantity was assessed as absolute ASM (kg) or adjusted for squared height, also named SMI (kg/m^2), through bioelectrical impedance analysis (BIA) (TANITA MC-580, Tanita Corp., Tokyo, Japan). Following the EWGSOP2 recommendations, resistance index and reactance values from BIA were introduced in the Sergi's validated equation (Sergi et al., 2015) to calculate ASM and SMI. Cut-off points for low ASM were <20 kg for men and <15 kg for women, while cut-off points for low SMI were <7 kg/m^2 for men and <5.5 kg/m^2 for women. Therefore, following these recommendations a total of four diagnostic criteria can be obtained (Table 1).

2.5. Statistical analysis

A database was created in Microsoft Excel© (Microsoft Corp., Redmond, WA, USA) and the software IBM SPSS Statistics 26.0 (SPSS Inc., Chicago, Ill, USA) was used for data analysis. Continuous variables were reported as median and interquartile range due to non-normal distribution, while frequencies and percentages were used for categorical data.

Prevalence of sarcopenia was calculated using four different combinations of sarcopenia determinants according to the EWGSOP2

Table 1
Sarcopenia definitions according to the EWGSOP2.

Sarcopenia diagnostic criteria	Low muscle strength	Low muscle quantity
Sarcopenia$_{HG+ASM}$	Handgrip Strength	Appendicular Skeletal Mass
Sarcopenia$_{HG+SMI}$	Handgrip Strength	Skeletal Muscle Index
Sarcopenia$_{5STS+ASM}$	5-times Sit-to-Stand	Appendicular Skeletal Mass
Sarcopenia$_{5STS+SMI}$	5-times Sit-to-Stand	Skeletal Muscle Index

Cut-off points: Handgrip (men <27 kg; women <16 kg); Appendicular Skeletal Mass (men <20 kg; women <15 kg); Skeletal Muscle Index (men <7 kg/m^2; women <5.5 kg/m^2); 5-times Sit-to-Stand (>15 s for men and women).

guidelines (see Table 1). Cohen's Kappa coefficient (κ) was used for agreement analysis among sarcopenia definitions and 95% confidence intervals (CI) were reported. Values lower than 0.4 were considered as weak, 0.4 and 0.79 as moderate, and higher than 0.8 as strong. Unadjusted and adjusted logistic regression analyses for age, sex, and body mass index were carried to identify associations between each sarcopenia diagnostic criterion with the risk of develop health-related adverse outcomes. Therefore, each sarcopenia diagnostic criterion was used as the dependent variable and socioeconomic status, education level, comorbidities, smoking habit, self-perceived health, depression, polypharmacy, falls, and hospitalization were used as independent variables. Odds ratios (ORs) with 95% CI were calculated and statistical significance was fixed at $p < 0.05$. An observed OR value less than 1 indicates that the odds of exposure among sarcopenic participants are lower than the odds of exposure among apparently healthy participants, whereas an observed OR value greater than 1 indicates that the odds of exposure among sarcopenic participants are greater compared the odds of exposure among apparently healthy participants which could be interpreted with caution as a risk factor of the disease. The Haldane-Anscombe correction was used to avoid infinity values in the calculation of the ORs.

3. Results

3.1. Participant characteristics

A total of 775 older adults from elderly social centers of the Region of Murcia were screened for eligibility. Seventy-six participants reported at least one of the exclusion criteria ($n = 59$ Mini-Cog test positive; $n = 17$ implanted electronic devices), therefore a total of 699 community-dwelling older adults (418 women and 281 men) with age ranges between 60 and 92 years were finally included in the analysis. Detailed information is available in Table 2.

3.2. Sarcopenia prevalence according to EWGSOP2 definitions

Prevalence of sarcopenia ranged from 2.1% to 11.6% depending on the diagnostic criteria used. Concretely, sarcopenia prevalence was highest when both 5STS and ASM values were combined (Sarcopenia$_{5STS+ASM}$). In contrast, the lowest prevalence of sarcopenia was found when both handgrip and SMI were considered (Sarcopenia$_{HG+SMI}$). In fact, a prevalence gradient in sarcopenia diagnosis was found showing greater prevalence when low muscle strength was defined as 5STS rather than handgrip strength test as well as when low muscle quantity was defined as ASM rather than SMI (Table 2).

Low muscle strength determined by 5STS was present 119 participants (17.1%) whereas low handgrip strength was present in 43 participants (6.2%). Low muscle quantity determined by ASM was present 387 participants (55.4%) whereas low SMI was detected in 206 participants (29.5%).

3.3. Agreement among sarcopenia definitions

The overall results showed weak to moderate agreements among EWGSOP2 sarcopenia definitions. As expected, the highest agreements were found when low muscle strength diagnostic criteria concurred and low muscle quantity was exchanged, Sarcopenia$_{5STS+ASM}$ *vs.* Sarcopenia$_{5STS+SMI}$ (κ= 0.66; 95% CI: 0.56 to 0.76) and Sarcopenia$_{HG+ASM}$ *vs.* Sarcopenia$_{HG+SMI}$ (κ= 0.63; 95% CI: 0.46 to 0.80). However, when low muscle quantity concurred as diagnostic criteria and low muscle strength was exchanged the results shown weak agreements between sarcopenia definitions, Sarcopenia$_{5STS+ASM}$ *vs.* Sarcopenia$_{HG+ASM}$ (κ= 0.21; 95% CI: 0.11 to 0.32) and Sarcopenia$_{5STS+SMI}$ *vs.* Sarcopenia$_{HG+SMI}$ (κ= 0.25; 95% CI: 0.10 to 0.40). Finally, the lowest agreements were found when neither low muscle strength and low muscle quantity concurred as diagnostic criteria, Sarcopenia$_{5STS+SMI}$ *vs.* Sarcopenia$_{HG+ASM}$ (κ= 0.17; 95% CI: 0.04 to 0.29) and Sarcopenia$_{5STS+ASM}$ *vs.* Sarcopenia$_{HG+SMI}$ (κ= 0.13; 95% CI: 0.04 to 0.23).

Table 2
Characteristics of participants ($n = 699$).

Outcome	Women	Men
Number of participants (%)	418 (60)	281 (40)
Age (years)	72 (68–76)	72 (68–76)
Height (m)	1.55 (1.51–1.59)	1.69 (1.64–1.72)
Weight (kg)	66.4 (59.8–73.3)	79.3 (71.6–88.6)
BMI (kg/m^2)	27.4 (24.5–30.2)	28.1 (25.8–31.3)
ASM (kg)	14.4 (13.2–15.7)	20.2 (18.7–22.3)
SMI (kg/m^2)	5.9 (5.5–6.4)	7.2 (6.7–7.7)
Handgrip Strength (kg)	22.5 (19.7–25.4)	37.9 (32.5–41.5)
5STS (s)	12.1 (10.6–14.1)	12.2 (10.7–14.2)
Physical activity levels (%)		
Sedentary	26 (6.2)	42 (14.9)
Physically active	392 (93.8)	239 (85.1)
Smokers	32 (7.6)	42 (14.9)
Comorbidities	244 (58.3)	137 (48.7)
Polypharmacy	80 (19.1)	71 (25.2)
Self-perceived Health (%)		
Very Bad	0 (0)	0 (0)
Bad	6 (1.4)	1 (0.3)
Fair	85 (20.3)	45 (16.0)
Good	268 (64.1)	198 (70.4)
Very Good	59 (14.1)	37 (13.1)
Education level (%)		
None	78 (18.6)	55 (19.5)
Primary	116 (27.7)	77 (2.5)
Lower secondary	14 (3.3)	18 (6.4)
Upper secondary	46 (11)	45 (16.0)
Qualified profession	68 (16.2)	34 (12.1)
Degree	63 (15.0)	25 (8.9)
Licensed	22 (5.2)	22 (7.8)
PhD	1 (0.2)	4 (1.4)
Socioeconomical status (%)		
0–10k €	63 (15)	37 (13.1)
10–20k €	139 (33.2)	83 (29.5)
20–30k €	111 (26.5)	85 (30.2)
30–40k €	44 (10.5)	48 (17.1)
>40k €	29 (6.9)	16 (5.7)
Falls (2 or more) (%)	66 (15.6)	24 (8.3)
Hospitalization (%)	46 (10.9)	48 (16.6)
Depression (GDS $\geq$ 2) (%)	40 (9.5)	13 (4.5)
Sarcopenia prevalence (%)		
Sarcopenia$_{HG+ASM}$	21 (5)	11 (3.9)
Sarcopenia$_{HG+SMI}$	8 (1.9)	7 (2.5)
Sarcopenia$_{5STS+ASM}$	51 (12.2)	30 (10.7)
Sarcopenia$_{5STS+SMI}$	20 (4.8)	24 (8.5)

BMI: Body Mass Index; ASM: Appendicular Skeletal Mass; SMI: Skeletal Muscle Index; 5STS: 5-times sit-to-stand; GDS: Geriatric Depression Scale. Continuous variables are shown as median and interquartile range due to non-normal distribution, while categorical variables are shown as absolute frequencies and percentages.

Additionally, overlapped participants between diagnostic criteria were analyzed looking for those who could be potentially underdiagnosed, *i.e.,* when a sarcopenic participant was categorized as apparently healthy using another criterion proposed by the EWGSOP2 guideline. In the worst scenario, a total of 73 participants (10.4%) were underdiagnosed using our lowest prevalence criterion (Sarcopenia$_{HG+SMI}$) compared to the highest prevalence criterion (Sarcopenia$_{5STS+ASM}$) as could be expected due to weak agreement. However, despite of moderate level of agreement between Sarcopenia$_{5STS+ASM}$ and Sarcopenia$_{5STS+SMI}$, a total of 38 participants (5.4%) were underdiagnosed when SMI was used as muscle quantity instead of ASM, likewise 66 participants (9.4%) were underdiagnosed when ASM concurred as criteria and 5STS was exchanged by handgrip strength. Only when Sarcopenia$_{HG+ASM}$ was used as diagnosis criteria sarcopenic participants categorized by Sarcopenia$_{HG+SMI}$ were overlapped. Detailed information about underdiagnosed participants is provided in Fig. 1.

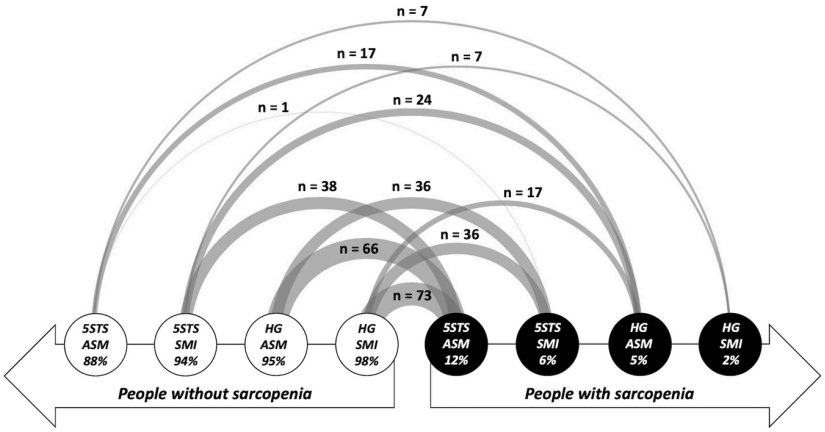

Fig. 1. Agreement between sarcopenia diagnostic criteria (n = 699). White circles represent the proportion of non-sarcopenic people whereas black circles represent sarcopenia prevalence according to the four diagnostic criteria proposed in the EWGSOP2. Arc lines represent the flow of people moving across disease to non-disease (or *vice versa*) according to the four diagnostic criteria. For example, a total of 66 participants were classified as apparently healthy using Sarcopenia$_{HG+ASM}$ criterion whereas they were classified as sarcopenic using Sarcopenia$_{5STS+ASM}$ criterion. 5STS: 5-times sit-to-stand test; HG: Handgrip; ASM: Appendicular Skeletal Mass; SMI: Skeletal Muscle Index.

3.4. Risk factors for sarcopenia diagnosis criteria

In our adjusted analyses, Sarcopenia$_{5STS+ASM}$ and Sarcopenia$_{5STS+SMI}$ were the diagnostic criteria most associated with health-related adverse outcomes. Sarcopenia$_{5STS+ASM}$ was associated with education level (OR: 2.26; 95% CI: 1.39 to 3.68), comorbidities (OR: 2.12; 95% CI: 1.28 to 3.50), polypharmacy (OR: 3.69; 95% CI: 2.18 to 6.21), self-perceived health (OR: 2.81; 95% CI: 1.66 to 4.76), depression (OR: 2.33; 95% CI: 1.37 to 3.96), and hospitalization (OR: 2.10; 95% CI: 1.16 to 3.79). Similar associations were reported for Sarcopenia$_{5STS+SMI}$, but with the exception of comorbidities (OR: 1.79; 95% CI: 0.93 to 3.46) and the addition of previous falls (OR: 2.50; 95% CI: 1.07 to 5.81). Sarcopenia$_{HG+ASM}$ and Sarcopenia$_{HG+SMI}$ only showed associations with polypharmacy (OR: 2.43; 95% CI: 1.11 to 5.31; OR: 4.14; 95% CI: 1.30 to 13.15; respectively) and self-perceived health (OR: 2.98; 95% CI: 1.39 to 6.35; OR: 3.12; 95% CI: 1.01 to 9.75; respectively) (Table 3).

4. Discussion

This study was originally designed to provide readers with a reflection on different ways to estimate sarcopenia prevalence using the EWGSOP2 guidelines, as well as to determine its agreement and the risk associated with sarcopenia diagnostic criteria in community-dwelling older adults.

Overall prevalence of sarcopenia in our study ranged from 2.1% to 11.6%, depending on the EWGSOP2 criteria used. These results are in line with the global prevalence estimated at 10% (95% CI: 2.0 to 17) in a recent meta-analysis in 5720 older adults using the EWGSOP2 criteria defined as low handgrip strength and low SMI (Petermann-Rocha et al., 2022). However, few studies have analyzed differences in sarcopenia prevalence among the recommended criteria developed in the EWGSOP2 (Chew et al., 2020; Johansson et al., 2020; Kim & Won, 2019). To the best of our knowledge, only three studies (Chew et al., 2020; Johansson et al., 2020; Kim & Won, 2019) aimed to analyze differences in sarcopenia prevalence using upper limb (handgrip) or lower limb (5STS) muscle strength criteria when low muscle quantity was defined as SMI in community-dwelling older adults. Whereas two studies (Chew et al., 2020; Kim & Won, 2019) showed 1.3 and 3.5 times more prevalence using handgrip strength instead of 5STS in Asian community-dwelling older adults, the study of Johansson et al., (Johansson et al., 2020) reported a prevalence more than twofold using 5STS instead of handgrip strength in European community-dwelling older adults. One possible reason for the inconsistent findings could be the differences in sociodemographic characteristics between studies as the optimal 5STS cut-off point to predict disability in Japanese community-dwelling older adults is ≥9 s (Makizako et al., 2017), whereas the cut-off point proposed in the EWGSOP2 is >15 s (Cruz-Jentoft et al., 2019). These results highlight the need of using population-specific cut-off points for determining low muscle strength, especially in those parameters that depend upon body size (height, weight or body mass index). In our study, sarcopenia prevalence was more than threefold using 5STS instead of handgrip criterion when low muscle quantity was defined as SMI, and more than twofold when low muscle quantity was defined as ASM. This issue may be due to the fact that during aging process loss of muscle strength is greater in lower limb than upper limb leading to greater prevalence rates (Ditroilo et al., 2010; Hughes et al., 2001).

Therefore, considering this circumstance and given the higher sarcopenia prevalence obtained when assessing lower limb muscle strength, one could think that using 5STS as diagnostic criterion would lead to an earlier detection of the disease compared to when low handgrip strength is used. This hypothesis would be confirmed if positive case-findings using handgrip strength are overlapped using 5STS as diagnostic criterion. However, the results from our study did not shown overlap between lower limb and upper limb diagnostic criteria. In fact, a total of 17 participants would be underdiagnosed using Sarcopenia$_{5STS+ASM}$ compared to Sarcopenia$_{HG+ASM}$. The scenario worsens when Sarcopenia$_{HG+SMI}$ is used instead of our criterion with the highest prevalence rate (Sarcopenia$_{5STS+ASM}$), a total of 73 participants (10.4%) were underdiagnosed. This is remarkable, since it seems that Sarcopenia$_{HG+SMI}$ is the most used criterion among studies (Petermann-Rocha et al., 2022) which could lead to an underdiagnosis and undertreatment of this disease, especially in populations in which underweight or malnutrition is uncommon. Several studies have found negligible prevalence (< 0.3%) in overweight and obese community-dwelling older adults using Sarcopenia$_{HG+SMI}$ as diagnostic criteria. However, when muscle quantity was adjusted for body mass index using a reference population, a prevalence from 4 to ~15% was found (Bahat et al., 2021; Maïmoun et al., 2022). These results emphasize the need of using specific cut-off point in overweight and obese population in order to not underestimate sarcopenia prevalence and potential undertreatment. However, from our knowledge, there is no specific cut-off point to adjust muscle quantity for body mass index in Spanish community-dwelling older adults. These issues could explain the low prevalence rate in our study when muscle quantity was adjusted by squared height (SMI).

Our results showed moderate agreements between sarcopenia definitions only when the criteria for low muscle strength concurred and low muscle quantity was exchanged, otherwise agreements between sarcopenia definitions were weak ($\kappa < 0.26$). Similar to our results, Johansson et al. (Johansson et al., 2020) observed low level of agreement when low muscle quantity concurred and low muscle strength was defined by 5STS or handgrip strength ($\kappa = 0.18$). These results could be due to the low construct validity between 5STS and handgrip testing (Harris-Love et al., 2018; Yee et al., 2021). This is of notable importance since some studies

Table 3
Associations between sarcopenia diagnostic criteria with health-related risk factors ($n = 699$).

Risk factors		n	Sarcopenia $_{5STS+ASM}$ OR (95% CI)	Sarcopenia $_{5STS+ASM}$ Adjusted	Sarcopenia $_{5STS+SMI}$ OR (95% CI)	Sarcopenia $_{5STS+SMI}$ Adjusted	Sarcopenia $_{HG+ASM}$ OR (95% CI)	Sarcopenia $_{HG+ASM}$ Adjusted	Sarcopenia $_{HG+SMI}$ OR (95% CI)	Sarcopenia $_{HG+SMI}$ Adjusted
Education level	*High level*	373								
	Low level	326	**1.88 (1.17–3.02)**	**2.26 (1.39–3.68)**	1.71 (0.92–3.18)	**2.46 (1.26–4.80)**	1.71 (0.83–3.52)	1.96 (0.94–4.07)	1.31 (0.47–3.67)	1.75 (0.61–5.01)
Socioeconomic level	*High level*	100								
	Low level	566	1.55 (0.85–2.80)	1.75 (0.95–3.23)	0.92 (0.38–2.25)	1.19 (0.45–3.12)	1.41 (0.56–3.55)	1.55 (0.61–3.94)	0.17 (0.01–2.93)[a]	N/A
Comorbidities	*<2 pathologies*	318								
	≥ 2 pathologies	381	**1.78 (1.09–2.9)**	**2.12 (1.28–3.50)**	1.22 (0.65–2.27)	1.79 (0.93–3.46)	1.41 (0.68–2.93)	1.58 (0.75–3.32)	1.69 (0.57–4.99)	2.27 (0.75–6.85)
Smoking habit	*Not Smoking*	624								
	Smoking	74	1.08 (0.51–2.26)	0.98 (0.46–2.08)	1.66 (0.71–3.86)	1.09 (0.44–2.70)	0.12 (0.01–2.02)[a]	N/A	0.26 (0.02–4.46)[a]	N/A
Polypharmacy	*<5 drugs*	545								
	≥5 drugs	151	**2.72 (1.67–4.44)**	**3.69 (2.18–6.21)**	**2.43 (1.29–4.60)**	**4.30 (2.05–9.03)**	1.96 (0.92–4.16)	**2.43 (1.11–5.31)**	2.46 (0.86–7.03)	**4.14 (1.30–13.15)**
Self-perceived Health	*High level*	137								
	Low level	562	**2.31 (1.39–3.83)**	**2.81 (1.66–4.76)**	1.59 (0.79–3.17)	**2.58 (1.20–5.53)**	**2.60 (1.24–5.46)**	**2.98 (1.39–6.35)**	2.09 (0.70–6.22)	**3.12 (1.01–9.75)**
Depression	*Not Depressed*	565								
	Depressed	134	**2.08 (1.25–3.49)**	**2.33 (1.37–3.96)**	1.64 (0.82–3.27)	**2.30 (1.08–4.87)**	1.99 (0.92–4.31)	2.21 (0.97–4.64)	1.55 (0.49–4.94)	2.03 (0.61–6.69)
Falls last year	*<2 falls*	608								
	≥2 falls	89	1.66 (0.90–3.07)	1.74 (0.93–3.26)	1.84 (0.85–3.97)	**2.50 (1.07–5.81)**	1.62 (0.65–4.05)	1.63 (0.64–4.13)	1.05 (0.23–4.74)	1.22 (0.26–5.68)
Hospitalization	*Not Hospitalized*	605								
	Hospitalized	92	**2.13 (1.19–3.80)**	**2.10 (1.16–3.79)**	**3.44 (1.75–6.77)**	**2.90 (1.38–6.06)**	1.55 (0.62–3.88)	1.55 (0.61–3.90)	1.01 (0.22–4.56)	0.76 (0.16–3.56)

HG: Handgrip strength; 5STS: 5-times sit-to-stand tests; ASM: Appendicular Skeletal Mass; SMI: Skeletal Muscle Index; CI: Confidence Interval. Adjusted odds ratio (OR) for age, sex and body mass index. Statistical significance at an alpha level 0.05 is represented by bold numbers. [(a)] Haldane-Anscombe correction. N/A: Not assessed due to zero cases.

have used 5STS for diagnosing sarcopenia when missing data on handgrip testing occurred (Swan et al., 2022; Trevisan et al., 2022). This could be not surprising since the EWGSOP2 guidelines states that probable sarcopenia (*i.e.,* low muscle strength) can be determined by handgrip strength test or 5STS test, suggesting interchangeability of these measures. However, our results did not support the use of any of the combinations proposed in the EWGSOP2 in an interchangeable way. Lack of agreement between sarcopenia diagnostic criteria using the EWGSOP2 for detecting probable sarcopenia has been also recently reported in geriatric rehabilitation inpatients ($\kappa = 0.08$) (Verstraeten et al., 2022). Therefore, the aforementioned evidence suggests that both handgrip strength and 5STS should be used for detecting probable sarcopenia in clinical practice in order to avoid missing sarcopenia case-findings and possible undertreated older adults.

Furthermore, confirmed sarcopenia determined by 5STS showed more relationships with health-related adverse events when compared to handgrip strength as diagnostic criterion. Similar results were observed by Chew et al. (Chew et al., 2020) who aimed to compare the predictive validity of probable sarcopenia defined as 5STS or handgrip strength for two years health-related outcomes. Their results showed that muscle strength determined by 5STS was more associated with poor physical performance compared to handgrip strength in community-dwelling older adults. However, contrary findings were reported by Verstraeten et al. (Verstraeten et al., 2022) who concluded that probable sarcopenia defined by 5STS was not useful to predict adverse outcomes in geriatric rehabilitation inpatients. In fact, probable sarcopenia defined by handgrip strength was associated to institutionalization at three months and mortality at three months and one year whereas no association were observed for probable sarcopenia defined by 5STS. Inconsistent findings could be due to differences in sample characteristics across studies, since only few geriatric rehabilitation inpatients scored above the cut-off points proposed by the EWGSOP2 guideline leading to an important floor effect (Verstraeten et al., 2022). Taken together, these results suggest that probable and confirmed sarcopenia defined by 5STS could be potentially more useful in well-functioning older adults while handgrip strength could be more suitable for older adults with poor physical function to predict health-related adverse events using the cut-off proposed by the EWGSOP2 guideline. Therefore, particular attention is needed when decision about diagnostic criteria has to be taken.

The recommendations proposed by the EWGSOP2 are aimed at facilitating early detection and better treatment of sarcopenia in clinical practice. Thus, to assess for evidence of sarcopenia, EWGSOP2 recommends use of grip strength or 5STS test with specific cut-off-points for each test. However, in order to avoid underdiagnosis cases it would be recommended to evaluate handgrip strength together with 5STS test whenever possible, since there is a large difference in prevalence rate and weak agreement among the different tools proposed to diagnose sarcopenia. As EWGSOP2 recommends, there is a high priority for research studies for developing validated cut-off points based on normative data and their predictive value for hard end-points for each population (Cruz-Jentoft et al., 2019). Thus, longitudinal studies are needed to elucidate whether differences in diagnosis criteria have an impact on health-related adverse outcomes.

This study is not without limitations. First, participants of this study were recruited in elderly social centers where movement-based activities are encouraged. In fact, only 9.7% of participants were sedentary while most of the participants were moderately actives. Physical activity has a protective role against sarcopenia reducing till 55% the odds of its development later in life (Steffl et al., 2017). This could explain the low prevalence of sarcopenia observed in our sample, as well as the associations observed between sarcopenia diagnostic criteria and socioeconomic and health-related adverse outcomes. Additionally, these outcomes were self-reported in a cross-sectional time point, therefore the information provided depended on subject's comprehension and perception and cross-sectional data do not allow causal relationship

between measures. Moreover, muscle quantity was assessed by BIA which is not recognized as the gold standard for the assessment of this variable. In order to overcome this limitation, a cross-validated equation in a sample with similar characteristics was used as previously recommended (Beaudart et al., 2020; Cruz-Jentoft et al., 2019; Sergi et al., 2015). Additionally, muscle quantity was only adjusted for height squared and not for body mass index. However, from our knowledge, there is no reference values of muscle quantity adjusted for body mass index in young Spanish population. Further studies are needed to elaborate specific cut-off point for assessing sarcopenia in overweight and obese Spanish community-dwelling older adults.

5. Conclusion

The present study showed that sarcopenia prevalence rates vary considerably using the different combinations for sarcopenia diagnosis proposed in the EWGSOP2. These combinations have weak to moderate level of agreement and should not be used in an interchangeable way. Sarcopenia diagnosis criteria defined by 5STS could be more suitable in Spanish community-dwelling older adults due to their associations with health-related outcomes. Further studies should analyze the consequences of using different diagnosis criterion during follow-up period for better understand the risk associated to this disease in community-dwelling older adults.

Role of the funding source

This work was supported by Universidad Católica de Murcia [grant number PMAFI-07/19] and by the Comunidad Autónoma de la Región de Murcia grants for projects for the development of scientific and technical research by competitive groups included in the Programa Regional de Fomento de la Investigación Científica y Técnica de la Fundación Séneca-Agencia de Ciencia y Tecnología de la Región de Murcia (21639/PDC/21).

Ethics approval

The study was approved by the Ethical Committee of the Catholic University of Murcia (CE022108).

CRediT authorship contribution statement

Alessio Montemurro: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **Juan D. Ruiz-Cárdenas:** Conceptualization, Formal analysis, Funding acquisition, Supervision, Writing – review & editing. **María del Mar Martínez-García:** Conceptualization, Writing – review & editing. **Juan J. Rodríguez-Juan:** Funding acquisition, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

Acknowledgments

The authors thank to the elderly social centers and their team for your kind reception and facilitating the spaces for the development of this study.

References

Bahat, G., Kilic, C., Ozkok, S., Ozturk, S., & Karan, M. A. (2021). Associations of sarcopenic obesity *versus* sarcopenia alone with functionality. *Clinical Nutrition (Edinburgh, Scotland), 40*(5), 2851–2859. https://doi.org/10.1016/j.clnu.2021.04.002

Beaudart, C., Bruyère, O., Geerinck, A., Hajaoui, M., Scafoglieri, A., Perkisas, S., et al. (2020). Equation models developed with bioelectric impedance analysis tools to assess muscle mass: A systematic review. *Clinical Nutrition ESPEN, 35*, 47–62. https://doi.org/10.1016/j.clnesp.2019.09.012

Chew, J., Yeo, A., Yew, S., Lim, J. P., Tay, L., Ding, Y. Y., et al. (2020). Muscle strength definitions matter: Prevalence of sarcopenia and predictive validity for adverse outcomes using the European Working Group on Sarcopenia in older people 2 (EWGSOP2) criteria. *The Journal of Nutrition, Health & Aging, 24*(6), 614–618. https://doi.org/10.1007/s12603-020-1371-y

Cruz-Jentoft, A. J., Bahat, G., Bauer, J., Boirie, Y., Bruyère, O., Cederholm, T., et al. (2019). Sarcopenia: Revised European consensus on definition and diagnosis. *Age and Ageing, 48*(1), 16–31. https://doi.org/10.1093/ageing/afy169

Ditroilo, M., Forte, R., Benelli, P., Gambarara, D., & De vito, G. (2010). Effects of age and limb dominance on upper and lower limb muscle function in healthy males and females aged 40–80 years. *Journal of Sports Sciences, 28*(6), 667–677. https://doi.org/10.1080/02640411003642098

Harris-Love, M. O., Benson, K., Leasure, E., Adams, B., & McIntosh, V. (2018). The influence of upper and lower extremity strength on performance-based sarcopenia assessment tests. *Journal of Functional Morphology and Kinesiology, 3*(4), 53. https://doi.org/10.3390/jfmk3040053

Hughes, V. A., Frontera, W. R., Wood, M., Evans, W. J., Dallal, G. E., Roubenoff, R., et al. (2001). Longitudinal muscle strength changes in older adults: influence of muscle mass, physical activity, and health. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(5), B209–B217. https://doi.org/10.1093/gerona/56.5.B209

Johansson, J., Strand, B. H., Morseth, B., Hopstock, L. A., & Grimsgaard, S. (2020). Differences in sarcopenia prevalence between upper-body and lower-body based EWGSOP2 muscle strength criteria: The Tromsø study 2015–2016. *BMC Geriatrics, 20*(1), 461. https://doi.org/10.1186/s12877-020-01860-w

Kim, M., & Won, C. W. (2019). Prevalence of sarcopenia in community-dwelling older adults using the definition of the European Working Group on Sarcopenia in Older People 2: Findings from the Korean Frailty and Aging Cohort Study. *Age and Ageing, 48*(6), 910–916. https://doi.org/10.1093/ageing/afz091

Maïmoun, L., Serrand, C., Mura, T., Renard, E., Nocca, D., Lefebvre, P., et al. (2022). Definition of an adapted cut-off for determining low lean tissue mass in older women with obesity: A comparison to current cut-offs. *Scientific Reports, 12*(1), 16905. https://doi.org/10.1038/s41598-022-21258-5

Makizako, H., Shimada, H., Doi, T., Tsutsumimoto, K., Nakakubo, S., Hotta, R., et al. (2017). Predictive cutoff values of the five-times sit-to-stand test and the timed "Up & Go" test for disability incidence in older people dwelling in the community. *Physical Therapy, 97*(4), 417–424. https://doi.org/10.2522/ptj.20150665

Montemurro, A., Ruiz-Cárdenas, J. D., Martínez-García, M.del M., & Rodríguez-Juan, J. J. (2022). Validity of an iPhone app to detect prefrailty and sarcopenia syndromes in community-dwelling older adults: the protocol for a diagnostic accuracy study. *Sensors, 22*(16), 16. https://doi.org/10.3390/s22166010. Article.

Petermann-Rocha, F., Balntzi, V., Gray, S. R., Lara, J., Ho, F. K., Pell, J. P., et al. (2022). Global prevalence of sarcopenia and severe sarcopenia: A systematic review and meta-analysis. *Journal of Cachexia, Sarcopenia and Muscle, 13*(1), 86–99. https://doi.org/10.1002/jcsm.12783

Ruiz-Comellas, A., Pera, G., Baena Díez, J. M., Mundet Tudurí, X., Alzamora Sas, T., Elosua, R., et al. (2012). [Validation of a Spanish short version of the Minnesota leisure time physical activity questionnaire (VREM)]. *Revista Espanola De Salud Publica, 86*(5), 495–508. https://doi.org/10.4321/S1135-57272012000500004

Sergi, G., De Rui, M., Veronese, N., Bolzetta, F., Berton, L., Carraro, S., et al. (2015). Assessing appendicular skeletal muscle mass with bioelectrical impedance analysis in free-living Caucasian older adults. *Clinical Nutrition (Edinburgh, Scotland), 34*(4), 667–673. https://doi.org/10.1016/j.clnu.2014.07.010

Steffl, M., Bohannon, R. W., Sontakova, L., Tufano, J. J., Shiells, K., & Holmerova, I. (2017). Relationship between sarcopenia and physical activity in older people: A systematic review and meta-analysis. *Clinical Interventions in Aging, 12*, 835–845. https://doi.org/10.2147/CIA.S132940

Swan, L., Warters, A., & O'Sullivan, M (2022). Socioeconomic disadvantage is associated with probable sarcopenia in community-dwelling older adults: findings from the English Longitudinal Study of Ageing. *The Journal of Frailty & Aging, 11*(4), 398–406. https://doi.org/10.14283/jfa.2022.32

Trevisan, C., Vetrano, D. L., Calvani, R., Picca, A., & Welmer, A.-. K. (2022). Twelve-year sarcopenia trajectories in older adults: Results from a population-based study. *Journal of Cachexia, Sarcopenia and Muscle, 13*(1), 254–263. https://doi.org/10.1002/jcsm.12875

Verstraeten, L. M. G., de Haan, N. J., Verbeet, E., van Wijngaarden, J. P., Meskers, C. G. M., & Maier, A. B. (2022). Handgrip strength rather than chair stand test should be used to diagnose sarcopenia in geriatric rehabilitation inpatients: REStORing health of acutely unwell adulTs (RESORT). *Age and Ageing, 51*(11). https://doi.org/10.1093/ageing/afac242. afac242.

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2008). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *Journal of Clinical Epidemiology, 61*(4), 344–349. https://doi.org/10.1016/j.jclinepi.2007.11.008

Yee, X. S., Ng, Y. S., Allen, J. C., Latib, A., Tay, E. L., Abu Bakar, H. M., et al. (2021). Performance on sit-to-stand tests in relation to measures of functional fitness and sarcopenia diagnosis in community-dwelling older adults. *European Review of Aging and Physical Activity, 18*(1), 1. https://doi.org/10.1186/s11556-020-00255-5