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Original Article

Can EWGSOP2 and SDOC Definitions of Sarcopenia Identify Functional Muscle Quality?

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Abstract

Objectives: To compare the European Working Group on Sarcopenia in Older People (EWGSOP2) and the Sarcopenia Definition and Outcomes Consortium (SDOC) in identifying muscle quality indexes (MQI) and lower limb muscle performance in older women aged ≥ 65. **Methods**: Participants meeting EWGSOP2 and SDOC criteria were classified into the sarcopenia group (GS); others were placed in the non-sarcopenia group (GNS). Using an isokinetic dynamometer, we assessed peak torque (PT), maximal work (MW), and power (POW) of lower limbs. MQI was calculated as the ratio of muscle performance to appendicular lean mass, adjusted for body mass index (BMI) and lean tissue mass of the right lower limb (LTM). **Results**: We included 96 older women. In both SDOC (n=37) and EWGSOP2 (n=48) sarcopenia groups, muscle performance and BMI-adjusted MQI were significantly lower. Sarcopenia (SDOC) was significantly associated with all lower limb muscle performance and MQI variables [adjusted model by age and race: $MQI_{POW/LTM}$ OR = 0.67 (95% CI 0.52; 0.85); $MQI_{PT/LTM}$ OR = 0.76 (95% CI 0.64; 0.89)]. **Conclusions**: Older women diagnosed with sarcopenia by EWGSOP2 and SDOC criteria showed significant declines in muscle function and quality. The SDOC definition discriminated muscle contraction quality components in older individuals with and without sarcopenia.

Keywords: Aged, Functional Muscle Quality, Muscle Strength, Physical Functional Performance, Sarcopenia

Introduction

Sarcopenia is a muscular disorder officially recognized in the International Classification of Diseases (ICD-10)[1]. It exhibits a high prevalence among community-dwelling older adults (1% to 29%) and carries substantial clinical and functional implications[2–6]. However, a widely accepted criterion for identifying sarcopenia is still lacking, especially in clinical practice. The consensus of the European Working Group on Sarcopenia in Older People (EWGSOP) to define sarcopenia has been widely accepted in epidemiological studies[2,3]. In 2019, the EWGSOP2 proposed a primary criterion for diagnosing sarcopenia as the reduction in muscle strength, evaluated through handgrip strength (HGS) or the sit-to-stand test[3]. Muscle quantity or quality within the EWGSOP2 framework validates the sarcopenia diagnosis, and the functional assessment further categorizes its severity. Moreover, muscle mass (MM) must be determined according to cut-off points obtained from the

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sum of appendicular skeletal muscle mass (ASM), acquired using dual-energy X-ray absorptiometry (DXA), adjusted or not by height squared[3]. The DXA is accessible, correlates with gold-standard instruments for MM assessment (e.g., nuclear magnetic resonance or computed tomography)[6], and presents reduced radiation exposure[3,7]. Although there is no consensus on whether muscle mass alone, measured by DXA, predicts muscle strength or physical performance, it significantly correlates with these parameters and contributes to disability frailty, and mortality in older individuals[8-12]. This highlights the importance of understanding the multifactorial nature of sarcopenia assessment in aging research.

Aging alters primary muscle function through changes in the quantity and size of type II muscle fibers, shifts in fiber orientation, increased intramuscular and intermuscular fat infiltration, and the onset of neuromuscular deficits[13,14]. Systemic alterations caused by immune senescence also affect muscle homeostasis[15–18]. Augmented systemic pro-inflammatory cytokine levels (interleukin 6 [IL-6] and tumoral necrosis factor-alpha [TNF-α])[16,17] and reduced anti-inflammatory cytokine levels (interleukin 15 [IL-15]) are associated with decline in muscle strength, mass, and function[15,16]. Adiposity, comorbidities, and a sedentary lifestyle may also increase the pro-inflammatory profile and potentiate the deleterious effects on skeletal muscles[15,16,19]. The aging-associated network of changes influences the functional and structural aspects of muscle quality, subsequently affecting the onset of sarcopenia[20,21].

Critics have recently called into question the term 'muscle quality'. Given its broad and non-specific nature, it encompasses functional, histological, metabolic, and thermoregulatory aspects[20,22,23]. In this context, the classification of muscle quality into two domains — functional and morphological — has been endorsed[20-22]. The functional domain concerns muscle-specific force, as described in muscle quality indices (MQI). MQI, on the other hand, represents the ratio between muscular performance measures, such as peak torque (PT), maximal work (MW), and muscle power (POW), to MM[20,23]. PT, MW, and POW are relevant to functional demands and compose a complex network related to muscle quality[14,24]. PT refers to the maximal muscle torque, MW indicates the force produced during the entire movement, and POW reflects the force produced by time; the latter is strongly associated with functional tasks and mobility limitation in older adults[14,24].

These MQI demonstrate a more pronounced association with functional limitations compared to muscle mass alone[9,12,25,26], and they exhibit superior predictive capacity for mobility tests than isolated parameters[25]. Moreover, the decline in the functional quality of muscle contraction is linked to the deterioration of dynamic balance and the increased incidence of falls in older individuals[27,28]. Therefore, this reinforces the evidence that specific muscle strength (MQI) is distinct from muscle quantity[29], and it is suggested that its monitoring complements the prognosis of community-dwelling older individuals with and without sarcopenia[3,30,31].

The Sarcopenia Definition and Outcomes Consortium (SDOC) recently established operational criteria and cut-off points for sarcopenia based on a large database of the American and European populations[32]. Manini et al. showed that absolute HGS (< 35.5 kg for men and < 20 kg for women) and weight-adjusted HGS were able to discriminate a reduction in gait speed of 18,767 community-dwelling older adults (5,115 women), contrary to MM measures (assessed using DXA) that were not significant[8]. These findings were also significant in older adults with specific conditions and increased risk of mobility limitation[33]. In longitudinal analyses, older adults with reduced HGS and gait speed presented a high incidence and more chances of self-reported mobility limitation, falls, hip fractures, and mortality[9]. Therefore, SDOC proposes the identification of sarcopenia using HGS (absolute and adjusted) and gait speed. The SDOC highlights that the accuracy of diagnostic parameters may vary according to age, race, clinical condition, and population and encourages the development of studies in this direction[32-34].

The SDOC proposal identifies sarcopenia in a single moment using accessible and clinically relevant instruments[32]. However, the ability of the SDOC proposal to distinguish muscle quality in older adults with and without sarcopenia is unknown. Therefore, this study aims to compare the European Working Group on Sarcopenia in Older People (EWGSOP2) with the Sarcopenia Definition and Outcomes Consortium (SDOC) for identifying muscle quality indexes (MQI) and lower limb muscle performance in older women with and without sarcopenia.

Materials and Methods

We conducted a cross-sectional study with older women enrolled at an outpatient facility in Belo Horizonte (Minas Gerais, Brazil) between 2014 and 2015. We included community-dwelling women aged 65 or older, with a sedentary lifestyle (i.e., three months or more without regular physical activity), able to walk with or without assistance, and experiencing impaired muscle strength (HGS < 20 kg) or walking speed ≤ 0.8 m/s, or both[2]. Therefore, all women enrolled in the study exhibited diminished muscle function identified during the initial screening. We excluded participants with cognitive impairment (Mini-Mental State Examination)[35], acute or chronic pain, neurological or rheumatologic diseases, hip or knee arthroplasty, cancer diagnosis in the last five years, and use of corticoids. All participants answered a questionnaire containing sociodemographic, clinical, and functional data. Blood samples, muscle strength (isokinetic dynamometer), and body composition (DXA) were collected less than 15 days after the first interview[17].

Measures

We recorded sociodemographic and clinical data the groups with and without sarcopenia (GS and GNS) based on

Table 1. Descriptive data of the total sample and comparisons between groups with or without sarcopenia.

		Total (*N* = 96)	EWGSOP2			SDOC		
			No (*N* = 48)	Yes (*N* = 48)	*p*-value	No (*N* = 59)	Yes (*N* = 37)	*p*-value
Age (years)		75.5 (71; 81)	75 (69; 79)	76 (71.5; 81.5)	0.08	74(72; 81)	77 (72; 81)	0.16
Race (%)	White	27.08	14.58	39.58	0.02	30.51	21.62	0.51
	Black	18.75	27.08	10.42		16.95	21.62	
	Mixed-race	50.00	54.17	45.83		50.85	48.65	
	Others	4.16	4.16	4.17		1.69	8.1	
Educational level (%)	Illiterate	25.00	29.17	20.83	0.34	27.12	21.62	0.25
	1-4 years	54.17	50.00	58.33		49.15	62.16	
	5-8 years	15.62	12.50	18.75		15.25	16.22	
	9 years or more	5.21	8.33	2.08		8.47	0	
Marital status (%)	Married	21.88	25.00	18.75	0.55	28.81	10.81	0.16
	Single	19.79	22.92	16.67		16.95	24.32	
	Divorced	9.38	6.25	12.50		6.78	13.51	
	Widow	48.96	45.83	52.08		47.46	51.35	
Living alone (%)		23.96	25	22.92	0.81	25.42	21.62	0.67
Comorbidities (%)		76.04	83.33	68.75	0.09	77.97	72.97	0.58
BMI (kg/m²)		26.44 (±5.91)	30.33 (±5.42)	22.54 (±3.19)	< 0.01	25.82 (22.5; 32.41)	24.52 (22.5; 32.41)	0.08
HGS (kg)		17.59 (14.09; 19.33)	18.33 (14.09; 22.17)	16.79 (14.17; 18.59))	0.04	18.33 (14.67; 20.17)	16.33 (13.33; 18.33)	0.01
ASM/H² (kg/m²)		5.9 (5.19; 6.66)	6.66 (6.26;7.32)	5.25 (4.90; 5.58)	< 0.01	5.72 (5.11; 6.42)	6.18 (5.36; 7.31)	0.05
ASM/BMI		0.53 (±0.08)	0.52 (±0.08)	0.54 (±0.07)	0.41	0.53 (±0.76)	0.52 (0.75)	0.41
LTM (kg)		5.16 (4.41; 5.95)	5.95 (5.23; 6.65)	4.41 (4.13; 4.91)	< 0.01	4.82 (4.42; 5.61)	5.39 (4.41; 6.47)	0.13
GS (m/s)		0.78 (±0.16)	0.72 (±0.13)	0.83 (±0.17)	< 0.01	0.85 (0.77; 0.93)	0.67 (0.58; 0.73)	< 0.01
Inflammatory biomarkers (Med; ITR)	IL-6 (pg/ml)	1.80 (0.99; 3.82)	2.23 (1.43; 3.96)	1.51 (0.63; 3.82)	0.04	1.75 (1.10; 4.16)	1.95 (0.99; 3.13)	0.95
	sTNFR1, pg/ml	1892 (1457; 2439)	1916 (1504; 2344)	1868 (1457; 2581)	0.77	1884 (1377; 2439)	1916 (1773; 2344)	0.40
	IL-15, pg/ml	8 (5; 15)	10 (4; 15)	8 (5; 15)	0.95	7 (4; 12)	10 (8; 18)	0.02

Race: individualized race declaration. The participant self-declared her perception regarding her race ("White," "Black," "Mulatto or Mixed-race," or others). Comorbidities: prevalence of two or more self-reported chronic diseases; BMI: body mass index; HGS: handgrip strength; ASM/H²: appendicular skeletal muscle mass adjusted to height squared; ASM/BMI: appendicular skeletal muscle mass adjusted to BMI; LTM: lean tissue mass of the right lower limb; GS: gait speed; IL-6: interleukin 6; sTNFR1: soluble tumor necrosis factor receptor 1. Med: median; ITR: interquartile range.

the diagnostic criteria of EWGSOP2 and SDOC. Presence of comorbidities was defined as the presence of two or more chronic diseases[36]. Body mass index (BMI) was calculated according to weight divided by height squared. We used high-sensitivity ELISA (enzyme-linked immunosorbent assay) to assess IL-6 (Quantikine®HS, R&D Systems Minneapolis, USA), sTNFR1 (R&D Systems, 86 Minnesota), and IL-15 biomarkers (Quantikine®ELISA, R&D Systems, Human IL-15), according to standardized instructions of the manufacturer[17].

Sarcopenia

We assess muscle strength through HGS measurement using a Jamar® dynamometer. The study identified reduced HGS using a cutoff point of < 21 kg. This cutoff is based on the psychometric properties of HGS as a clinical marker of mobility limitation in a representative sample of individuals from Brazil and England[37]. HGS of the dominant upper limb was assessed three times (Jamar® dynamometer) with an interval of one minute in between, and the mean value was ascertained[17,38]. We evaluated habitual gait speed over an 8.6-m path. The initial and final two meters were not considered (i.e., acceleration and deceleration, respectively), and the time to cover the central 4.6 m was registered. Three trials were conducted with a one-minute interval in between; and the mean value (in m/s) was registered[17].

Body composition was measured using DXA (Hologic Discovery W, model, software version 3.3.01). The ASM (i.e., sum of appendicular skeletal muscle mass of upper and lower limbs) was obtained and normalized by height squared[2,3] and BMI[10] (ASM/H^2 and ASM/BMI, respectively). Lean tissue mass of the right lower limb (LTM) was also registered (kg) to calculate MQI.

The diagnosis of sarcopenia was determined based on the criteria established by EWGSOP2 and SDOC to categorize two groups of study participants (GS and GNS). Sarcopenia identification according to EWGSOP2 involved the assessment of reduced muscle strength (HGS < 21 kg) and MM[3]. Due to the absence of specific MM cutoff points (assessed via DXA) for the Brazilian population, we utilized ASM/H^2 < 6 kg/m^2 as a reference for MM assessment[3]. Sarcopenia identification based on SDOC criteria involved using HGS < 20 kg and gait speed < 0.8 m/s[32].

Performance and Muscle quality indexes

We assessed muscle performance using an isokinetic dynamometer (Biodex Systems, Shirley, NY, USA). PT, MW, and POW adjusted by body weight were measured in the right lower limb during five repetitions at an angular velocity of 60°/s. All positioning and proceedings were conducted according to previous protocols[17].

MQI extracted for analysis were calculated by the ratio of muscle performance (PT, MW, POW) and LTM ($MQI_{PT/LTM}$, $MQI_{MW/LTM}$, and $MQI_{POW/LTM}$) and ASM/BMI ($MQI_{PT/ASM/BMI}$, $MQI_{MW/ASM/BMI}$, and $MQI_{POW/ASM/BMI}$). The variables used for diagnosing sarcopenia were not used for calculating MQI. Outcomes of interest comprise the mentioned Performance and Muscle quality indexes.

Statistical analysis

Descriptive analysis was used to characterize the sample, and the Shapiro-Wilk test verified data normality. Data normally distributed were expressed as mean and standard deviation, whereas data with non-normal distribution were expressed as median and 25% - 75% interquartile range (IQR). GNS and GS (EWGSOP2 and SDOC) were compared using unpaired t-test or Wilcoxon-Mann-Whitney test. The chi-square test compared categorical variables. Uni- and multivariate logistic regression verified the associations of independent variables of muscle performance (TP, MW, POW) and MQI ($MQI_{PT/LTM}$, $MQI_{MW/LTM}$, $MQI_{POW/LTM}$, $MQI_{PT/ASM/BMI}$, $MQI_{MW/ASM/BMI}$, $MQI_{POW/ASM/BMI}$) with sarcopenia defined according to EWGSOP2 and SDOC (dependent variable). Significant associations in the raw model ($p \leq 0.20$) were included in the regression analysis adjusted by age and race; findings were expressed as odds ratio (OR), 95% confidence intervals (95%CI), and p-value ($\alpha < 0.05$). The Stata software (version 14.0; StataCorp LLC, College Station, TX) was used for statistical analyses.

Results

A total of 389 women underwent screening. Of these, 293 were excluded from the study for various reasons: cognitive deficit during the Mini-Mental State Exam (n = 50), age < 65 years[1], refusal to participate[83], failure to meet muscle function deficit criteria[89], engagement in regular physical activity[15], presence of neurological and rheumatic diseases[7], corticosteroid use[22], incomplete data[19], and other reasons including recent surgery, cancer, or chemotherapy[7]. We included 96 older women with median age of 75.5 years (IQR 71 to 81). According to the criteria proposed by EWGSOP2, 48 individuals met the criteria for sarcopenia (GNS = 48), whereas, based on the SDOC definition, 37 women were identified with sarcopenia (GNS = 59).

Table 1 provides descriptive data of the total sample and compares the GS and GNS groups based on the sarcopenia diagnostic criteria outlined by EWGSOP2 and SDOC. No differences were observed between the GS and GNS groups in terms of age, marital status, living arrangements, and the presence of comorbidities for both sarcopenia definitions. Sarcopenic women (according to EWGSOP2 criteria) exhibited lower MM adjusted for height, HGS, and BMI compared to those without sarcopenia ($p < 0.05$). Additionally, gait speed was higher in the GS (EWGSOP 2) compared to the GNS (mean 0.83 m/s ± 0.17 and 0.72 ± 0.13, respectively). According to the criteria proposed by SDOC, sarcopenic women demonstrated reduced functionality compared to those without sarcopenia (median gait speed - GS of 0.67 m/s and GNS of 0.85; $p < 0.01$), with no differences in BMI between the groups.

Table 2. Comparison of lower limb muscle performance and muscle quality indexes in older women with and without sarcopenia according to the EWGSOP2 and SDOC definitions.

		Total (*N* = 96)	EWGSOP2			SDOC		
			No	Yes	*p*-value	No	Yes	*p*-value
Muscle performance (Mean ± SD)	PT (J)	52.35 (± 17.61)	56.91 (± 17.06)	47.80 (± 17.14)	0.01	56.11 (± 16.70)	46.37 (± 17.58)	< 0.01
	MW (%)	259.80 (± 87.61)	282.31 (± 85.5)	237.28 (± 84.68)	0.01	279.30 (± 80.35)	228.68 (± 90.75)	< 0.01
	POW (W)	32.31 (± 11.60)	35.05 (± 11.11)	29.56 (± 11.53)	0.02	34.71 (± 10.99)	28.46 (± 11.65)	< 0.01
MQI (Mean ± SD)	$MQI_{PT/LTM}$	10.12 (± 3.44)	9.61 (± 3.03)	10.64 (± 3.76)	0.14	11.11 (± 3.25)	8.54 (± 3.16)	< 0.01
	$MQI_{MW/LTM}$	50.17 (± 16.63)	47.61 (± 14.55)	52.74 (± 18.27)	0.13	55.34 (± 15.02)	41.94 (± 15.89)	< 0.01
	$MQI_{POW/LTM}$	6.25 (± 2.27)	5.91 (± 1.93)	6.58 (± 2.55)	0.15	6.89 (± 2.19)	5.22 (± 2.03)	< 0.01
	$MQI_{PT/ASM/BMI}$	101.03 (± 37.28)	110.60 (± 35.35)	91.45 (± 37.04)	0.01	107.61 (± 34.64)	90.53 (± 9.36)	0.03
	MQIMW/ ASM/BMI	501.18 (± 184.46)	547.86 (± 172.82)	454.50 (± 185.63)	0.01	534.74 (±163.77)	447.67 (± 204.43)	0.02
	MQIPOW/ ASM/BMI	62.44 (± 24.56)	68.16 (± 23.13)	56.73 (± 24.85)	0.02	66.64 (± 22.71)	55.75 (± 26.19)	0.03

PT: peak torque; MW: maximal work; POW: muscle power; LTM: lean tissue mass of the right lower limb; BMI: body mass index; ASM: appendicular skeletal muscle mass; PT, MW, and POW measures are adjusted by body weight. MQI: muscle quality index; $MQI_{PT/LTM}$: ratio of PT and LTM of the right lower limb; $MQI_{MW/LTM}$: ratio of MW and LTM of the right lower limb; $MQI_{POW/LTM}$: ratio of POW and LTM of the right lower limb; $MQI_{PT/ASM/BMI}$: ratio of PT and ASM of the right lower limb adjusted by BMI; $MQI_{MW/ASM/BMI}$: ratio of MW and ASM of the right lower limb adjusted by BMI; $MQI_{POW/ASM/BMI}$: ratio of POW and ASM of the right lower limb adjusted by BMI. SD: standard deviation; Med: median; ITR: interquartile range.

The detailed comparison of lower limb muscle performance, MQI, and inflammatory biomarkers in older women with and without sarcopenia according to the EWGSOP2 and SDOC definitions is presented in Table 2. Women diagnosed with sarcopenia according to EWGSOP2 exhibited lower muscular performance (PT, MW, and POW) and a lower MQI formed by MM adjusted for BMI ($MQI_{PT/ASM/BMI}$, $MQI_{MW/ASM/BMI}$, $MQI_{POW/ASM/BMI}$) compared to those without sarcopenia. Muscle performance (PT, MW, POW) and all MQI were significantly lower in the GS than GNS, according to SDOC (Table 2).

The raw logistic regression model demonstrated significant associations of muscle performance (PT, MW, and POW) and $MQI_{PT/ASM/BMI}$, $MQI_{MW/ASM/BMI}$, and $MQI_{POW/ASM/BMI}$ with sarcopenia according to EWGSOP2. However, only MW was significant (OR = 0.99, 95%CI 0.99 to 1.00, p = 0.04) after adjusting the model for age and race. In contrast, all muscle performance and MQI variables studied were associated (raw and adjusted models) with sarcopenia according to the SDOC. A stronger association between muscular quality and SDOC definition has been reported as $MQI_{POW/LTM}$ (OR 0.67; 95%IC 0.52; 0.85) and $MQI_{PT/LTM}$ (OR = 0.76; 95% CI 0.64; 0.89). Table 3 presents the results of logistic regression analyses between lower limb muscle performance and MQI and sarcopenia according to EWGSOP2 and SDOC proposals.

Discussion

The EWGSOP2 and SDOC proposals identified lower functional muscle quality in older women with sarcopenia than without sarcopenia. The SDOC proposal to identify sarcopenia differentiated older women with and without sarcopenia according to all muscle performance and MQI variables. Results did not change after adjusting the logistic regression model for age and race, the ratio of POW and PT by LTM showed a stronger association between muscle quality and sarcopenia (SDOC). This study also showed that the SDOC proposal was valid for identifying sarcopenia using simple and viable measures in clinical practice, such as HGS and gait speed. Furthermore, the SDOC proposal discriminated important components of functional muscle quality

Table 3. Logistic regression analysis between sarcopenia (EWGSOP2 e SDOC) and lower limb muscle performance and muscle quality indexes.

		EWGSOP2				SDOC			
		Raw model		Adjusted model		Raw model		Adjusted model	
		OR (95%IC)	*p*-value	OR (95%IC)	*p*-value	OR (95%IC)	p-value	OR (95%IC)	*p*-value
Muscle performance	PT (J)	0.97 (0.94; 0.99)	0.01	0.97 (0.95; 1.00)	0.05	0.97 (0.94; 0.99)	0.01	0.96 (0.94; 0.99)	0.01
	MW (%)	0.99 (0.99; 1.00)	0.02	0.99 (0.99; 1.00)	0.04	0.99 (0.99; 1.00)	<0.01	0.99 (0.99; 1.00)	< 0.01
	POW (W)	0.96 (0.92; 0.99)	0.02	0.96 (0.93; 1.00)	0.08	0.95 (0.91; 0.99)	0.01	0.95 (0.91; 0.99)	0.01
MQI	$MQI_{PT/LTM}$	1.09 (0.97; 1.24)	0.15	1.14 (1.00; 1.30)	0.05	0.77 (0.65; 0.90)	< 0.01	0.76 (0.64; 0.89)	< 0.01
	$MQI_{MW/LTM}$	1.02 (0.99; 1.05)	1.13	1.03 (1.00; 1.05)	0.06	0.94 (0.91; 0.97)	< 0.01	0.94 (0.91; 0.97)	< 0.01
	$MQI_{POW/LTM}$	1.14 (0.95; 1.37)	0.15	1.22 (1.00; 1.48)	0.05	0.68 (0.53; 0.85)	< 0.01	0.67 (0.52; 0.85)	< 0.01
	$MQI_{PT/ASM/BMI}$	0.99 (0.97; 1.00)	0.02	0.99 (0.98; 1.00)	0.05	0.99 (0.97; 1.00)	0.03	0.99 (0.97; 1.00)	0.03
	$MQI_{MW/ASM/BMI}$	1.00 (0.99;1.00)	0.02	1.00 (0.99; 1.00)	0.05	1.00 (0.99; 1.00)	0.03	1.00 (0.99; 1.00)	0.03
	$MQI_{POW/ASM/BMI}$	0.98 (0.96; 0.99)	0.03	0.98 (0.97; 1.00)	0.09	0.98 (0.96; 1.00)	0.04	0.98 (0.96; 1.00)	0.04

PT: peak torque; MW: maximal work; POW: muscle power; LTM: lean tissue mass of the right lower limb; BMI: body mass index; ASM: appendicular skeletal muscle mass; PT, MW, and POW measures are adjusted by body weight. MQI: muscle quality index; $MQI_{PT/LTM}$: ratio of PT and LTM of the right lower limb; $MQI_{MW/LTM}$: ratio of MW and LTM of the right lower limb; $MQI_{POW/LTM}$: ratio of POW and LTM of the right lower limb; $MQI_{PT/ASM/BMI}$: ratio of PT and ASM of the right lower limb adjusted by BMI; $MQI_{MW/ASM/BMI}$: ratio of MW and ASM of the right lower limb adjusted by BMI; $MQI_{POW/ASM/BMI}$: ratio of POW and ASM of the right lower limb adjusted by BMI.

between older adults with and without sarcopenia.

Regarding the EWGSOP2 proposal, BMI and ASM/H^2 were significantly low in the GS. This might be justified by the parameter used to assess MM (ASM/H^2) according to the EWGSOP2, which predisposes the identification of sarcopenia in older adults with reduced BMI[39–41]. In contrast, the SDOC proposal did not differentiate BMI and ASM/H^2 between GNS and GS groups. Adipose tissue may be directly associated with MM but inversely associated with muscle quality[10,25,31,42]. Longitudinal studies are needed to understand the influence of MM, muscle quality, and adipose tissue in the diagnosis and prognosis of sarcopenia.

Our findings demonstrated a significant reduction of PT, MW, and POW in older women with sarcopenia classified either using EWGSOP2 or SDOC. A previous study of our group, demonstrated that sarcopenia, according to EWGSOP[2], presented worse muscle performance (POW and MW of lower limbs) than those without sarcopenia[17]. Seo et al. compared muscle quality in Korean older women with and without sarcopenia, identified by reduced gait speed (< 1.0 m/s), muscle strength (HGS < 20 kg), and MM (< 5.67 kg/m^2) or low gait speed and MM[2,31]. Functional muscle quality was investigated using absolute and relative lower limb isometric muscle strength, assessed using an isokinetic dynamometer, whereas computed tomography measured MM and thigh inter- and intramuscular adipose tissue. This study demonstrated that women with sarcopenia presented reduced lower limb muscle strength in both measurements, reduced muscle volume, and increased infiltration of intermuscular adipose tissue compared with those without sarcopenia[31]. A significant association was reported between absolute and relative lower limb muscle strength and sarcopenia (OR 0.97, 95%CI 0.95 to 0.99; OR = 0.99, 95%CI 0.98 to 1.00, respectively)[31]. Despite the barrier of accessibility and complexity, accurate instruments for assessing muscle quality, such as computed tomography, demonstrated discriminative ability for factors

relevant to muscle performance (e.g., muscle fat infiltration).

The deterioration of quality of contraction compromises muscle function in older adults. Straight, Brady, and Evans[43] observed that lower limb PT (isokinetic dynamometer) accompanied the decline of gait speed in a four-year longitudinal study, regardless of MM and fat mass. Individuals with low POW showed to be more than twice as likely to have functional limitation - basic (OR 2.4, 95% CI 1.4 to 4.0) and instrumental activities (OR 2.4 95%CI 1.4 to 4.1) - and six-fold more likely to have walking speed below 0.8 m/s in 392 community-dwelling outpatient older (OR 6.6, 95% CI 3.6 to 11.0)[44]. A systematic review, including 44 studies, investigated the relationship between muscle performance measures, muscle strength and POW, and functional status in the older persons[24]. The authors reported an overlap in the ability of POW in relation to muscle strength to predict functional outcomes (self-reported questionnaires and standardized physical tests[24]. In the present study, the ratio of POW and PT by LTM ($MQI_{POW/LTM}$ and $MQI_{PT/LTM}$) showed the strongest association with sarcopenia, according to the SDOC (OR 0.67; 95% CI 0.52 to 0.85 and OR 0.76; 95%CI 0.64 to 0.89 respectively). Therefore, the interaction between morphological properties, contractile velocity, nerve conduction, and connective tissue arrangement reflects the magnitude of motor response during daily tasks[14]. We reinforce the use of MQI measures to verify the quality of contraction in different groups (BMI, age and ethnicity) and the response of physical interventions[27,28,45–48], especially for older persons with sarcopenia.

Our findings suggest that SDOC criteria for identifying sarcopenia present a discriminative validity for muscle quality in community-dwelling older women. SDOC criteria is more applicable in clinical practice since the measures are more practical and accessible[32]. The inclusion of absolute or adjusted HGS to identify sarcopenia was based on its significant discriminative ability to identify the profile of older adults with reduced gait speed[8]. Regardless gait speed reduction, HGS predicts relevant outcomes for older adults with sarcopenia[9]. Absolute and relative MM assessed using DXA were excluded from the SDOC proposal due to the lack of association with gait speed and functional outcomes (self-reported mobility limitation, falls, hip fractures, and mortality)[8,32]. The SDOC also highlights the clinical relevance of habitual gait speed for diagnosing sarcopenia compared to MM parameters assessed using DXA[32]. The authors indicate that muscle strength (HGS) is one of the several contributors to gait speed, and the decline of habitual gait speed is associated with adverse outcomes related to sarcopenia. Despite controversial findings regarding relationships between HGS and lower limb muscle strength, the present study demonstrated the association between sarcopenia according to SDOC (reduced HGS and gait speed) and MQI, PT, MW, and POW (lower limb muscle quality), reinforcing the indication of SDOC. Thus, SDOC criteria enable clinical practitioners to identify older people at risk of sarcopenia, monitor its clinical pathway, and use it as an outcome for physical interventions.

The analyses of pro- and anti-inflammatory profiles demonstrated distinct behaviors for identifying sarcopenia using the EWGSOP2 and the SDOC criteria. Considering the EWGSOP2, only IL-6 was able to discriminate the group with and without sarcopenia; however, an enhanced pro-inflammatory profile was observed in the GNS, likely due to increased adiposity[17]. An enhanced pro-inflammatory profile (IL-6 and sTNFR1) was observed in the GS classified according to SDOC, but without significant differences between groups. The GS presented IL-15 levels significantly higher than GNS, suggesting compensatory anti-inflammatory mechanisms. Furthermore, the classification proposed by SDOC did not find between-group differences in BMI, which partially excludes the interference of fat mass in this analysis. We included sedentary older women, and no differences in age and comorbidities were observed between groups identified using SDOC and EWGSOP2. Future longitudinal studies with larger samples are needed to better understand the inflammatory status, fat mass and the recent definition of sarcopenia according to SDOC.

Ethnical differences and sociocultural and specific health conditions may also interfere with psychometric properties to diagnose sarcopenia[37,38]. In this study, sarcopenia identified according to reduced HGS and gait speed distinguished the quality of lower limb muscle contraction between Brazilian community-dwelling older women. To enhance clarity regarding the associations between functional muscle quality and sarcopenia, we excluded HGS and appendicular skeletal muscle mass divided by height squared (ASM/H^2) from the proposed MQI. This study has limitations. Our findings do not infer causality of the interaction between muscle quality and sarcopenia. The sample size may have influenced the analyses of IL-6, sTNFR1, and IL-15. While we controlled for characteristics of the participants (inclusion criteria; e.g., sedentary lifestyle and muscle function deficit) and observed no statistically significant differences in variables such as age, education level, marital status, living arrangements, and comorbidities[49-52].

Conclusion

The EWGSOP2 and SDOC criteria for identifying sarcopenia distinguished lower limb functional muscle quality and performance between Brazilian older women with and without sarcopenia. The SDOC classification excludes MM and highlights the reduced HGS and habitual gait speed. Our findings demonstrated that the SDOC discriminated all components of quality of muscle contraction analyzed, and these measures were significantly associated with the diagnosis of sarcopenia. The SDOC proposal allows a rapid disease diagnosis and facilitates an early identification, management, and monitoring of sarcopenia using simple instruments.

Ethics approval

Approval was obtained from the research ethics committee of Universidade Federal de Minas Gerais (CAAE 39702014.2.0000.5149). The procedures used followed the Declaration of Helsinki (The Code of Ethics of the World Medical Association).

Consent to participate

Informed consent was obtained from all individual participants included in the study, along with guidance on whether to withdraw from the study.

Authors' contributions

Patricia Parreira Batista: Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. Monica Rodrigues Perracini: Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation, Supervision, Project administration. Daniele Sirineu Pereira: Methodology, Visualization, Writing – original draft, Writing – review & editing. Juleimar Soares Coelho de Amorim: Formal analysis, Visualization, Writing – original draft, Writing – review & editing. Leani Souza Máximo Pereira: Conceptualization, Formal analysis, Methodology, Visualization, Writing – original draft, Writing – review & editing, Supervision, Project administration. All authors read and approved the final version of the manuscript and reserved public responsibility for its content.

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