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Prevalence of sarcopenia in community-dwelling older people in the UK using the European Working Group on Sarcopenia in Older People (EWGSOP) definition: findings from the Hertfordshire Cohort Study (HCS)

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Abstract

Introduction: sarcopenia is associated with adverse health outcomes. The aim of this study was to describe the prevalence of sarcopenia in community-dwelling older people in the UK using the European Working Group on Sarcopenia in Older People (EWGSOP) consensus definition.
Methods: we applied the EWGSOP definition to 103 community-dwelling men participating in the Hertfordshire Sarcopenia Study (HSS) using both the lowest third of dual-energy X-ray absorptiometry (DXA) lean mass (LM) and the lowest third of skin-fold-based fat-free mass (FFM) as markers of low muscle mass. We also used the FFM approach among 765 male and 1,022 female participants in the Hertfordshire Cohort Study (HCS). Body size, physical performance and self-reported health were compared in participants with and without sarcopenia.
Results: the prevalence of sarcopenia in HSS men (mean age 73 years) was 6.8% and 7.8% when using the lowest third of DXA LM and FFM, respectively. DXA LM and FFM were highly correlated (0.91, $P < 0.001$). The prevalence of sarcopenia among the HCS men and women (mean age 67 years) was 4.6% and 7.9%, respectively. HSS and HCS participants with sarcopenia were shorter, weighed less and had worse physical performance. HCS men and women with sarcopenia had poorer self-reported general health and physical functioning scores.
Conclusions: this is one of the first studies to describe the prevalence of sarcopenia in UK community-dwelling older people. The EWGSOP consensus definition was of practical use for sarcopenia case finding. The next step is to use this consensus definition in other ageing cohorts and among older people in a range of health-care settings.

Keywords: *sarcopenia, prevalence, EWGSOP consensus definition, muscle mass, fat-free mass, grip strength, gait speed, older people*

Introduction

Sarcopenia, the loss of skeletal muscle mass and function with age [1], is associated with disability, morbidity and mortality [2–5]. Estimates for the total decline in the muscle mass between the ages of 40 and 80 years range from 30% to 50% [6, 7] and the annual decline in functional capacity is reported to be ∼1–2% after the age of 50 increasing to as much as 3% after the age of 60 [8]. Well-recognised lifecourse influences on muscle mass and strength include age, gender, heritability, adult body size, physical activity, nutrition and co-morbid disease [9–11]. In

addition, there is consistent evidence for a relationship between poor growth in early life and sarcopenia [12].

Estimates of the prevalence of sarcopenia in older men and women worldwide vary from 3% to 30% according to the operational definition implemented [8, 13–17]. There has recently been progress in the field with convergence in the approaches used to define sarcopenia. The European Working Group on Sarcopenia in Older People (EWGSOP) [1] has published a consensus definition based on the ascertainment of lean mass (LM), grip strength and gait speed that provides a clear, structured and understandable method for sarcopenia case finding (See Figure 1 and supplementary data available in *Age and Ageing* online). The guidelines recommend the measurement of muscle mass by dual-energy X-ray absorptiometry (DXA), bioelectrical impedance (BIA), computerised tomography (CT), magnetic resonance imaging (MRI) or simple anthropometry; choice depending on local availability. Handheld dynamometry is recommended for the measurement of muscle strength and gait speed to characterise physical performance. The EWGSOP also conceptualised a grading for sarcopenia such that those with pre-sarcopenia have a decrease in muscle mass without disturbance in strength or function, those with sarcopenia have decreased mass and strength or function, and those with severe sarcopenia have decreased mass, strength and function [1].

Previous cross-sectional studies in North America and Europe have described a sarcopenia index (muscle mass/height^2) and used a cut-off that is two standard deviations (SD) or more lower than a mean derived from a healthy young reference sample [1, 18]. This approach has been endorsed by the EWGSOP but its application requires reference values from relevant young, healthy, gender and ethnicity-matched populations; data that may not always be available in all settings. Pragmatic approaches to the identification of sarcopenia, which do not rely on resource intensive scanning or scarce reference data are required to characterise the burden of sarcopenia in a wide range of populations. For example, one US study used an index of fat-free mass (FFM) as well as the lowest third of FFM as approaches to define sarcopenia [14]. In the present study, we evaluate an anthropometric estimation of LM and use it in the EWGSOP definition of sarcopenia to determine the prevalence of sarcopenia in a UK population of community-dwelling older men and women from the Hertfordshire Cohort Study (HCS).

Methods

The HCS has been described in detail previously [19]. The current study utilises two samples of community-dwelling HCS participants. First, 103 men, average age 73 years, who participated in the Hertfordshire Sarcopenia Study (HSS) substudy of HCS who had detailed data collected on anthropometry, DXA, grip strength and physical performance measures [20]. Secondly, 765 men and 1,022 women mean age 67 years, who participated in HCS who had anthropometry, grip strength and physical performance measures, but not DXA (HCS PP). Ethical approval was obtained from the Hertfordshire Research Ethics Committee. All participants gave written informed consent.

Measurements

Body composition in the HSS was assessed by DXA (Hologic Discovery, software version 12.5) and multisite skin-fold thickness (SFT) measurement. In the HCS PP sample, body composition was assessed by SFT only [21]. Weight was measured once to the nearest 0.1 kg with floor scales (SECA, Hamburg, Germany). Height was measured to the nearest 0.1 cm. Physical performance was assessed by a battery comprising chair rises, a timed 6-m up and go test (TUG) and a 3-m customary paced walk; used to calculate walking speed in metres per second (m/s) [22]. A walking speed of ≤0.8 m/s identified subjects with poorer physical performance [1]. A standardised protocol [23] was used to measure isometric grip strength with a Jamar dynamometer (Promedics, Blackburn, UK). Low muscle strength was classified as grip strength <20 kg in women and <30 kg in men [1]. All participants completed the SF-36 health-related quality of life (HRQoL) questionnaire at both HCS baseline and HSS follow-up from which self-reported general health (GH) and physical functioning (PF) domain scores were derived.

Statistical analysis

Percentage body fat was derived from the average SFT [24]. Fat mass was derived by multiplying body weight by percentage body fat. FFM, a proxy for lean muscle mass, was estimated by subtracting fat mass from body weight [24]. The maximum values of six grip measures were used. Variables were summarised using means and SD or medians and inter-quartile ranges (IQRs) for continuously distributed variables. Pearson's correlation coefficient was used to describe the relationship between skin-fold-based FFM and DXA LM in the HSS sample. In the absence of young reference values for DXA-derived LM or reliable FFM cut-off points, the bottom thirds of the sex-specific distributions of DXA LM or skin-fold-based FFM were used to identify participants with low LM. The EWGSOP algorithm was then used to estimate the prevalence of sarcopenia in both study samples using DXA LM or skin-fold-based FFM as available. Body composition, physical performance and SF-36 domain scores were contrasted between individuals with and without sarcopenia using ANOVA, *t*-tests, Kruskal–Wallis and Wilcoxon tests as appropriate. All analyses were carried out for men and women separately using STATA, release 11 (Stata Corp, College Station, TX, USA).

Results

Summary characteristics of the HSS and the HCS PP samples of men and women are presented in Table 1. The implementation of the EWGSOP algorithm among HSS

Table 1. Characteristics of HSS and HCS PP participants

	HSS men ($n = 103$)		HCS PP men ($n = 765$)		HCS PP women ($n = 1022$)	
	n	Mean (SD)	*n*	Mean (SD)	*n*	Mean (SD)
Age (years)	103	72.5 (2.5)	765	67.0 (2.6)	1022	67.1 (2.6)
Height (cm)	103	174.3 (6.7)	765	174.1 (6.4)	1022	160.8 (5.8)
Weight (kg)	103	82.7 (12.6)	765	82.7 (13.1)	1022	71.5 (13.2)
BMI (kg/m^2)	103	27.2 (3.5)	765	27.2 (3.8)	1022	27.7 (4.9)
Lean mass $_{DXA}$	103	56.4 (6.7)	—	—	—	—
Fat % $_{DXA}$	103	26.8 (4.9)	—	—	—	—
Fat mass (kg) $_{DXA}$	103	22.2 (6.5)	—	—	—	—
Body fat % anthro	103	26.9 (5.0)	765	28.4 (5.2)	1022	39.7 (4.9)
Fat-free mass (kg) anthro	103	60.0 (7.2)	765	58.8 (7.2)	1022	42.7 (5.9)
Waist circumference (cm)	103	101.7 (10.4)	764	100.9 (10.5)	1018	92.4 (12.4)
Hip circumference (cm)	103	105.2 (6.8)	765	103.9 (7.2)	1021	107.9 (10.7)
Mid-thigh circumference (cm)	103	51.7 (4.2)	762	52.2 (4.3)	1013	53.3 (5.8)
Physical performance						
Grip strength (kg)	103	38.7 (8.3)	765	43.9 (7.6)	1022	26.3 (5.8)
TUG (s)	103	10.6 (2.1)	765	10.8 (2.7)	1022	11.1 (3.0)
Chair rise time (s)	103	17.2 (4.2)	333	15.5 (3.4)	642	18.5 (5.3)
Walking speed (m/s)	103	1.1 (0.2)	765	0.9 (0.1)	1022	0.9 (0.2)
SF-36 domain score		Median (IQR)		Median (IQR)		Median (IQR)
General health	103	77 (72–87)	764	72 (62–82)	1022	72 (62–87)
Physical functioning	103	95 (90–100)	764	90 (80–95)	1022	85 (65–95)

DXA, dual-energy X-ray absorptiometry; anthro, anthropometry; TUG, 6-m timed up and go.

Table 2. Anthropometry and functional characteristics of HSS men according to EWGSOP sarcopenia status

	HSS men			
	No sarcopenia ($n = 96$), mean (SD)	Sarcopenia ($n = 7$), mean (SD)	*P*-value*	*P*-value**
Age (years)	72.4 (2.4)	74.4 (2.9)	0.04	0.02
Height (cm)	174.9 (6.3)	165.8 (5.6)	<0.001	<0.001
Weight (kg)	83.6 (12.5)	70.1 (7.2)	0.006	0.01
BMI (kg/m^2)	27.3 (3.6)	25.5 (1.6)	0.20	0.27
Waist circumference (cm)	102.2 (10.4)	95.6 (8.9)	0.11	0.11
Hip circumference (cm)	105.5 (6.9)	100.0 (4.0)	0.09	0.07
Mid-thigh circumference (cm)	52.0 (4.2)	48.1 (2.8)	0.02	0.02
Physical performance				
TUG (s)	10.5 (1.8)	12.5 (4.3)	0.01	0.05
Chair rise time (s)	17.1 (4.2)	18.7 (4.2)	0.37	0.79
Self-report	Median (IQR)	Median (IQR)	*P*-value***	*P*-value****
SF-36 General health	77 (72–87)	67 (57–82)	0.21	0.31
SF-36 Physical functioning	95 (90–100)	95 (70–100)	0.21	0.19

DXA, dual-energy X-ray absorptiometry; anthro, anthropometry; TUG, 6-m timed up and go.

*P-value for differences between those without sarcopenia (no sarcopenia + pre-sarcopenia, $n = 96$) and those with sarcopenia (sarcopenia + severe sarcopenia, $n = 7$) described by DXA lean mass.

**P-value for differences between those without sarcopenia ($n = 95$) and those with sarcopenia ($n = 8$) described by FFM.

***P-value for the Wilcoxon two-sample test between those without sarcopenia ($n = 96$) and those with sarcopenia ($n = 7$) described by DXA lean mass.

****P-value for the Wilcoxon two-sample test between those without sarcopenia ($n = 95$) and those with sarcopenia ($n = 8$) described by FFM.

men revealed a prevalence of sarcopenia of 6.8% when the lowest third of the distribution of DXA LM was used as the marker of the low muscle mass and of 7.8% when the lowest third of the distribution of skin-fold-based FFM was used (See Figures 2a, b, Table A1 and supplementary data available in *Age and Ageing* online). The high correlation ($r = 0.91$, $P < 0.001$) between DXA LM and skin-fold-based FFM justified the use of skin-fold-based FFM as a marker of muscle mass.

The implementation of the EWGSOP algorithm for men and women in the HCS PP sample using the sex-specific lowest third of the distribution of skin-fold-based FFM as a marker of low muscle mass revealed a prevalence of sarcopenia of 4.6% among men and 7.9% among women (See Figures 3, 4, Table A1 and supplementary data available in *Age and Ageing* online). The prevalence of the extended definition of sarcopenia among HSS men and HCS PP men and women is also presented in Table A1 available as supplementary data in *Age and Ageing* online.

HSS men with sarcopenia were on average older, shorter, weighed less, had lower mid-thigh circumferences, and as expected recorded slower TUG times than men

without sarcopenia, although analyses were limited by the small sample size. Results were consistent between the DXA LM and skin-fold FFM implementations of the EWGSOP definition (Table 2).

Both HCS PP men and women with sarcopenia were on average shorter, weighed less, had lower waist, hip and mid-thigh circumferences, and also recorded slower TUG and chair rise test times than their counterparts without sarcopenia (Table 3). HCS PP men and women with sarcopenia also reported poorer (i.e. lower) SF-36 GH and PF scores (Table 3).

Discussion

In this present study, we describe the prevalence of sarcopenia among community-dwelling older people in the UK using the EWGSOP recommended diagnostic algorithm. Among 103 community-dwelling older men who participated in the HSS, the prevalence of sarcopenia was 6.8% when the lowest third of DXA LM was used as a marker of low muscle mass and was 7.8% when the lowest third of skin-fold-based FFM was used. Using the lowest third of skin-fold-based FFM to denote low muscle mass, the prevalence of sarcopenia among community-dwelling older men ($n = 765$) and women ($n = 1022$) of the HCS PP group was 4.6% and 7.9%, respectively.

Our results suggest that the EWGSOP algorithm is useful to define cases with and without sarcopenia. Furthermore, the algorithm can be implemented in the absence of reference values for muscle mass by using muscle mass thirds as we have shown. This model can easily be applied to muscle measurements obtained from DXA, BIA, CT or MRI.

Studies of the prevalence of sarcopenia in North America have primarily used muscle mass derived from DXA or BIA as a skeletal muscle mass index and defined sarcopenia as two SDs below the mean for relevant young healthy reference populations. For example, in 883 participants of the New Mexico Elder Study, prevalence increased from 13% to 24% in people under 70 years of age to >50% in persons over 80 years and differed by ethnicity [13]. In a US cross-sectional survey by Melton *et al.*, [16] age- and sex-adjusted prevalence rates varied from 6% to 15% in participants who were 65 years or older and depended on the muscle parameter used to define sarcopenia. This was similar to findings from a study of 237 men and women aged 64–92 years by Iannuzzi-Sucich *et al.* [25] where the prevalence was reported to be 27% in men and 23% in women and increased in those over 80 years to 53% and 31%, respectively. There are also some European studies. For example, in a sample of Spanish community-dwelling older people, prevalence rates were reported to be 10% in men (mean age: 74.6) and 33% in women (mean age: 75.3 years) [8] and in a French population aged 60–78 years, the reported prevalence was 3.6% in men and 2.8% in women [17]. In the Leiden Longevity Study by Bijlsma *et al.* [26], the prevalence of sarcopenia was 4.6% in men and 2.1% in women.

Other investigators have used anthropometry to characterise muscle mass. For example, Landi *et al.* [27] used thirds of mid-arm muscle circumference (MAMC) as a marker of muscle mass in the absence of a reference population. Physical performance and function including handgrip improved significantly as MAMC increased. Furthermore, those in the highest third of MAMC had a lower risk of death. FFM has also been used to define sarcopenia in previous studies. For example, in a study of 1700 community-dwelling older adults by Castillo *et al.* [14],

Table 3. Anthropometry and functional characteristics of HCS PP men and women according to EWGSOP sarcopenia status

	HCS men			HCS women		
	No sarcopenia ($n = 730$) Mean (SD)	Sarcopenia ($n = 35$) Mean (SD)	*P*-value*	No sarcopenia ($n = 941$) Mean (SD)	Sarcopenia ($n = 81$) Mean (SD)	*P*-value*
Age (yrs)	67.0 (2.6)	67.4 (2.6)	0.400	67.1 (2.6)	67.5 (2.7)	0.140
Height (cm)	174.5 (6.1)	166.1 (6.1)	<0.001	161.2 (5.7)	155.8 (4.9)	<0.001
Weight (kg)	83.4 (12.9)	68.2 (9.5)	<0.001	72.6 (13.1)	58.9 (6.5)	<0.001
BMI (kg/m^2)	27.4 (3.8)	24.7 (3.5)	<0.001	27.9 (4.9)	24.3 (3.1)	<0.001
Waist circumference (cm)	101.2 (10.5)	93.9 (9.2)	<0.001	93.1 (12.4)	83.5 (7.7)	<0.001
Hip circumference (cm)	104.2 (7.1)	97.5 (5.9)	<0.001	108.6 (10.7)	99.5 (6.6)	<0.001
Mid-thigh circumference (cm)	52.4 (4.2)	48.2 (4.1)	<0.001	53.6 (5.8)	49.7 (5.2)	<0.001
Physical performance						
TUG (s)	10.6 (2.0)	13.8 (8.3)	<0.001	10.9 (2.5)	12.7 (5.7)	<0.001
Chair rise time (s)	15.4 (3.4)	19.1 (3.2)	<0.001	18.3 (5.2)	20.6 (6.2)	0.002
Self-report	Median (IQR)	Median (IQR)	*P*-value**	Median (IQR)	Median (IQR)	*P*-value**
SF-36 General health	72 (62–85)	60 (45–77)	<0.001	75 (62–87)	67 (57–77)	<0.001
SF-36 Physical functioning	90 (80–95)	85 (55–90)	<0.001	85 (65–95)	75 (55–90)	0.002

DXA, dual-energy X-ray absorptiometry; anthro, anthropometry; TUG, 6-m timed up and go.

**P*-value for differences between those without sarcopenia (no sarcopenia + pre-sarcopenia) and those with sarcopenia (sarcopenia + severe sarcopenia).

***P*-value for the Wilcoxon two-sample test between those without sarcopenia and those with sarcopenia.

FFM was defined both as an index and as the lowest third of FFM. The prevalence of sarcopenia, when defined as an index, was 1.9% in men and 2.5% in women aged 60–69 years, but increased to 16% and 13%, respectively, over the age of 80 years. Men and women with sarcopenia had reduced FFM, fat mass and grip strength compared with those without sarcopenia. We agree with the observation made by Castillo *et al.* [14] that using thirds to investigate sarcopenia as well as other classifications is useful when appropriate reference groups are unavailable.

In the current study, we assessed whether sarcopenia identified by the EWGSOP definition had an impact on HRQoL and have shown that HCS PP men and women with sarcopenia had poorer self-reported GH and PF scores. This is consistent with a previous study where we found that grip strength was associated with HRQoL [28]. A recent study which compared HRQoL in those diagnosed with 'sarco-osteopenia' with HRQoL in healthy subjects, showed lower scores in the role-physical, vitality and role-emotional domains consistent with sarcopenia impacting adversely on HRQoL [29].

The prevalence of sarcopenia will clearly vary according to which diagnostic criteria are applied to different study samples. This is evident in studies that have defined sarcopenia as a skeletal muscle mass index and in those that have used anthropometry as a marker of muscle mass [14, 18, 26]. A few consensus operational definitions of sarcopenia have been developed based on low muscle mass and gait speed [18, 30], but these have invariably relied on comparison with healthy young reference values. In spite of methodological differences, the prevalence of sarcopenia in our study is broadly comparable with that from similar studies in the literature [14, 26, 31]. The EWGSOP consensus definition relies on ascertainment of gait speed and muscle mass by any means available and we believe that the algorithm is of practical use especially when a reference sample with which to compare muscle mass is unavailable. The EWGSOP definitions, usefully, also identify those with, and who are at risk of sarcopenia. This permits the use of targeted intervention strategies to minimise risk of adverse health outcomes as a consequence of the later development of sarcopenia.

This study has a number of potential limitations. As discussed by Bijlsma *et al.* [26] although gait speed represents muscle function it is dependent on intact cognition, neural control and joint control; therefore, the algorithm may not be practical in older patients who are unable to mobilise efficiently. In this setting, a single measure of muscle function such as grip strength may be better to ascertain whether a patient has sarcopenia. This clearly requires further research. A relatively small sample size in the HSS as well as a healthy participant effect in HSS and HCS may have underestimated the prevalence of sarcopenia in the current study. The use of FFM as a marker of low muscle mass could be questioned but we suggest this is a pragmatic implementation of the EWGSOP criteria in the absence of availability of other measures of muscle mass in the HCS PP sample. Moreover, we have shown that skin-fold-based FFM and DXA LM were highly correlated among HSS men and led to similar sarcopenia classification. We acknowledge that the same magnitude of correlation between skin-fold-based FFM and DXA LM may not be evident in women; this requires further investigation. Finally, the HCS PP participants represent the young–old end of the spectrum of older people. Future follow-up studies of the HCS cohort could yield useful data on sarcopenia prevalence as well as functional and mortality data in the oldest old.

Previous studies have used height-adjusted lean and FFM in their definitions of sarcopenia; it is unclear whether this markedly affects those who are identified as having sarcopenia or the overall prevalence of sarcopenia. Furthermore, the EWGSOP guidelines do not explicitly advocate application of height-adjusted values in the EWGSOP algorithm [1]. We have implemented a simple unadjusted form of the EWGSOP algorithm which could be applied in a range of health-care settings where the reliable ascertainment of height may not be possible; however, we acknowledge that other approaches are clearly possible.

This study also has a number of strengths. First, the study was conducted on a large sample of well-characterised community-dwelling older men and women living in a defined geographical area. Secondly, as far as we are aware our study is one of the first to describe the prevalence of sarcopenia in the UK using the EWGSOP criteria. Thirdly, the HCS participants have been compared with those in the nationally representative Health Survey for England and have been found to be broadly comparable in terms of their health and lifestyle [19]. We, therefore, suggest that the results from the current study could be reasonably generalised to the wider population of older men and women in England.

In conclusion, it is time to act. Sarcopenia is associated with multiple adverse outcomes and there is an increased need for its recognition in clinical practice as well as in research. Several consensus definitions exist. We found the EWGSOP consensus definition of practical use in identifying the prevalence of sarcopenia among community-dwelling older people in the UK. We suggest that the FFM approach can be used to implement the EWGSOP algorithm in the absence of DXA LM data. The next step is to define sarcopenia in other ageing cohorts as well as among older people in a range of health-care settings.

Key points

- Sarcopenia is associated with multiple adverse outcomes.
- The EWGSOP consensus definition provides a practical means of identifying sarcopenia in community-dwelling older people.
- Sarcopenia now needs to be defined in other ageing cohorts as well as among older people in a range of health-care settings.

Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

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Authors' contributions

H.P.P., H.E.S., S.R., H.D., H.C.R., M.E., E.D., C.C. and A. A.S. participated in the conception, design and conduct of the study. H.E.S. and K.J. conducted statistical analyses. H.P.P. drafted the first version of the manuscript. All authors read and approved the final manuscript.

Conflicts of interest

None declared.

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