Dynapenia and sarcopenia identify walking speed decline in women but not in men

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Abstract

Objective: To determine the best indicator of mobility decline between dynapenia, low skeletal muscle mass index (SMMI), and sarcopenia defined by the *EWGSOP*2 using different cutoff points for grip strength. **Methods:** A longitudinal study was conducted with a follow-up of eight years, involving 2,680 individuals aged 60 and older who participated in the ELSA study with a walking speed greater than 0.8 m/s at baseline. Dynapenia was defined using different cutoff points for grip strength. SMMI was defined by the 20th percentile of the entire ELSA sample distribution and sarcopenia was defined based on the *EWGSOP2*, using different cutoff points for grip strength. Mobility was analysed using the walking speed test. **Results:** Over time, the greatest decline in walking speed occurred in dynapenic women with grip strength < 17 kg (-0.005 m/s per year; 95% CI: -0.01 to -0.001) and < 20 kg (-0.007 m/s per year; 95% CI: -0.01 to -0.001). With regards to sarcopenia, the greatest walking speed decline occurred in women with probable sarcopenia when defined by grip strength < 17 kg [(-0.006 m/s per year; 95% CI: -0.01 to -0.001) or grip strength < 20 kg (-0.007 m/s per year; 95% CI: -0.01 to -0.001)]. Dynapenia in men as well as low SMMI and sarcopenia in men and women did not enable identifying the risk of mobility decline. **Conclusion:** Dynapenia and probable sarcopenia defined by grip strength < 17 kg and < 20 kg enabled identifying walking speed decline over time only in women.

Keywords: mobility, sarcopenia, grip strength, trajectories, dynapenia, older people.

Introduction

As a complex functional activity that depends on one's health status, motor control, musculoskeletal performance, sensory and perceptual functions, and cognition, mobility measured by walking speed is considered the sixth vital sign.[1,2] Moreover, walking speed is a reliable, valid, sensitive, specific measure that has the potential to predict functional decline, falls, hospitalisation, and death.[1,2] Thus, mobility decline is a complex process considered an important adverse outcome of reduced neuromuscular strength and sarcopenia.[3–7]

The age-related reduction in neuromuscular strength is defined as dynapenia, whereas sarcopenia is a musculoskeletal disease characterised by the age-related generalised progressive loss of muscle mass and function.[8] In its updated version, the *European Working Group on Sarcopenia in Older People 2* (*EWGSOP2*) instituted a new way of diagnosing sarcopenia, in which low muscle mass was no longer considered the main determinant; the new main determinant became dynapenia measured by grip strength, which is better than muscle mass for the early identification of negative outcomes.[8]

There is no consensus in the literature on the best cutoff point for defining dynapenia,[8,9] which impacts the diagnosis of sarcopenia and has resulted in divergences in terms of the prevalence of the condition and its association with adverse outcomes.[8–10] The main cutoff points reported in the literature capable of identifying limited mobility range from 16 to 22 kg for women and from 26 to 39 kg for men.[11–18] Most of these cutoff points are from cross-sectional studies that defined mobility limitation as a gait speed ≤ 0.8m/s as the outcome. Cutoff points for men and women, respectively, were < 39/22 kg in the American population[16], < 32/21 kg in the English and Brazilian populations[19], < 30/20 kg in the Italian population[11], < 26/17 kg in the Brazilian population[14], and

< 26/16 kg according to the sarcopenia project to the Foundation for the US National Institutes of Health[20]. The only study that used the T-score ≤ -2.5 SD in an English population between four and 90 years of age found cutoff points of < 27 kg for men and < 16 kg for women i.e., the cut-off points currently recommended by the *EWGSOP2*[12]. Moreover, a longitudinal study with mortality as the outcome found that when used with the *EWGSOP2* consensus to define sarcopenia, grip strength < 36 kg for men and < 23 kg for women were the only cutoff points capable of identifying the risk of death in 14 years of follow-up.[21] To date, no longitudinal studies have investigated the trajectories of the best indicator of mobility decline stratified by sex in individuals without mobility limitation at baseline.

This variation in cutoff points in the literature may be explained by the different methods used for measuring neuromuscular strength, different characteristics of the samples studied, and the inclusion of individuals with and without mobility decline at baseline.[22] Moreover, sex exerts an influence on this variation, as women have less muscle strength and mass, greater intramuscular fat infiltration, and a greater frequency of diseases, such as osteoarthritis, compared to men, which may lead to greater neuromuscular impairment and a poorer mobility performance over time.[23]

Therefore, the present study aimed to determine the best indicator of mobility decline measured by walking speed (m/s) between dynapenia, low skeletal muscle mass index (SMMI), and sarcopenia defined by the *EWGSOP*2 using different cutoff points for grip strength (< 39, < 36, < 32, < 30, < 27, and < 26 kg for men and < 23, < 22, < 21, < 20, < 17, and < 16 kg for women) in individuals without mobility limitation at baseline (walking speed > 0.8 m/s) in an eight-year follow-up period.

Methods

Study population

The data analysed here are from the *English Longitudinal Study of Ageing* (*ELSA*), which is a panel study initiated in 2002 of a representative sample of community-dwelling English men and women aged 50 and older. Detailed information on the *ELSA* study methods can be found elsewhere.[24]

The baseline for the present study was the second wave of the *ELSA* study (2004), involving 6,183 participants aged 60 or older, when anthropometric measures and physical performance were recorded for the first time. The individuals were reassessed after four and eight years.

Among the 6,183 individuals, 159 did not perform the walking speed and grip strength tests, and an additional 1,984 participants were excluded due to missing data on covariates (n = 2,143). Furthermore, 1,360 were excluded due to having a baseline walking speed of ≤ 0.8 m/s, indicating low mobility. Thus, the final analytical sample comprised 2,680 individuals (1,298 men and 1,382 women) aged 60 or older without low mobility at baseline.

Mobility assessment

Mobility was assessed by measuring walking speed (best time between two trials) on a flat surface, using or not a gait-assistance device, at a normal pace over a distance of 2.4 meters.[24] Walking speed was analysed as a continuous quantitative variable in m/s.

Neuromuscular strength assessment

Grip strength was determined using the *Smedley's for Hand* handgrip dynamometer (range: 0 to 100 kg) with the participant standing, arm against the trunk, and elbow flexed at 90 degrees.[24,25] Three maximum tests were performed with the participant's dominant hand, respecting a one-minute rest interval between trials. The highest strength value was considered for analysis.[24,25] The most widely used cutoff points in the literature were adopted for the definition of dynapenia: < 39,[16] < 36,[21] < 32,[17] < 30,[10,11] < 27,[8] and < 26 kg[20] for men and < 23,[21] < 22,[16] < 21,[17] < 20,[10,11] < 17,[14] and < 16 kg[8] for women.

Determination of skeletal muscle mass

Lee's equation was used to estimate skeletal muscle mass (SMM): SMM = (0.244 x body weight in kg) + (7.8 x height in m) + (6.6 x sex) – (0.098 x age) + (skin colour – 3.3).[26,27] Zero was used for women and 1 for men; zero was used for Whites, 1.4 for Blacks, and -1.2 for Asians.[27] This equation has been validated and has an excellent correlation with SMM measured by magnetic resonance ($R^2 = 0.86$; $p < 0.001$).[28] After determining the skeletal muscle mass (SMM), the skeletal muscle mass index (SMMI) was calculated by dividing the SMM in kg by the square of the height.[29,30] The cutoff point adopted in this study for low SMMI was the 20th percentile of the entire ELSA sample distribution of the SMMI, as recommended by the EWGSOP consensus. Thus, < 9.24 kg/m^2 for men and < 6.52 kg/m^2 for women indicated low SMMI.[28,29,31,32]

Veronese *et al.* used the same equation to investigate the association between multimorbidity and the onset of sarcopenia in 12 years in the English population. Spexoto *et al.* used the equation to assess the accuracy of cutoff points for grip strength to define sarcopenia according to the *EWGSOP2* as a risk factor for mortality in 14 years also in the English population.[21,33]

Determination of sarcopenia

Sarcopenia was based on the European Working Group on Sarcopenia in Older People 2 (EWGSOP2). Two components were used for the diagnosis: low muscle strength (dynapenia)[30] according to the different cutoff points described in the literature and low SMMI (< 9.24 kg/m^2 for men and < 6.52 kg/m^2 for women).[34] In the EWGSOP2 definitions, different constructs were defined for the diagnosis of sarcopenia using different cutoff points for grip strength: < 39,[16] < 36,[21] < 32,[17] < 30,[10,11] < 27,[8] and < 26 kg[20] for men and < 23,[21] < 22,[16] < 21,[17] < 20,[10,11] < 17,[14] and < 16 kg[8] for women. Individuals with normal muscle strength and SMMI were classified as non-sarcopenic. Those with only a low grip strength were classified as probable sarcopenic and those with both low grip strength and low SMMI were classified as sarcopenic. Severe sarcopenia was not included in the analysis, as it depends on walking speed, which was the outcome of the present study.

Covariates

The covariates included in the present analysis constitute a wide range of factors associated with reductions in muscle mass, neuromuscular strength, and walking speed,[35] such as age,[36] marital status,[37] income and schooling,[38] skin colour,[39] physical activity level,[40] alcohol intake,[41] smoking,[41] self-reported medical diagnosis of stroke,[41] cancer,[41] diabetes *mellitus*,[42] heart disease,[38,41] lung disease,[41] hypertension,[41] osteoarthritis,[42] osteoporosis,[43] depressive symptoms,[41] cognition,[44] vision,[44] hearing,[44] back, hip, knee, and/or foot pain,[38] history of falls,[41] weight,[45] height,[45] and waist circumference.[23] Detailed information on how these measures were obtained can be found in the supplementary material (Covariates section).

Statistical analysis

A descriptive analysis was conducted to characterise the sample. Mean and standard deviation values were calculated for quantitative variables and percentages for qualitative variables. Differences between (1) included and excluded participants (due to missing data) as well as (2) between sexes at baseline were determined using the chi-squared test and Student's t-test. A p-value < 0.05 was considered indicative of statistical significance.

To estimate walking speed trajectories over time as a function of dynapenia (using different cutoff points for grips strength), low IMME, and sarcopenia (also using different cutoff points for grips strength), generalised linear mixed models were created using the XTMIXED command in the STATA 16® SE program (StataCorp, College Station, TX, USA). These models deal better with unbalanced data in studies with repeated measures, enabling the statistical modelling of time-dependent changes in the outcome and the magnitude of associations between variables.[46,47] The analyses were stratified by sex, as differences are reported between men and women in associations between mobility decline and dynapenia, low SMMI, and sarcopenia status.

Walking speed decline rates were compared using ß coefficients and 95% confidence intervals (CI). In the final models, the intercept represents the estimated mean difference in walking speed at baseline among the participants as a function of dynapenia status, low SMMI, and sarcopenia, taking individuals without dynapenia, with normal SMMI, and without sarcopenia as the reference categories, respectively. On the slope, time (in years) indicates the magnitude of the trajectory of walking speed decline independently of the covariables (as if time *per se* were the determinant of decline). The interaction between time and each state of dynapenia, low SMMI, and sarcopenia represent the estimated difference in the annual rate of walking speed decline (slope) between each of the groups, with the comparison of dynapenic individuals and non-dynapenic individuals

(reference group); individuals com low SMMI and those with normal SMMI; and individuals with probable sarcopenia or sarcopenia and the non-sarcopenic group, investigating the annual rate of walking speed decline in each group in the respective models.

All analyses incorporated weights obtained through inverse probability weighting based on the probability of participation and survival of individuals during the follow-up period. The strategy aimed to reduce survival bias and minimise losses to follow-up common in longitudinal studies. [48]

Results

Among the 2,680 participants without mobility limitation at baseline (1,298 men and 1,382 women), 2,111 (1,004 men and 1,107 women) and 1,666 (758 men and 908 women) were reassessed after four and eight years, respectively. A little more than 62% of the initial analytical sample participated in the three waves of the study and 78% participated in two waves. The characteristics of the sample at baseline are displayed in Table 1 stratified by sex.

The average age of the participants at baseline was 68 years for both men and women. Women were less likely to have a conjugal life, had less schooling, consumed less alcohol, smoked less, had a lower frequency of diabetes *mellitus* and heart disease and a greater prevalence of lung disease, osteoporosis, osteoarthritis, pain, falls, and depressive symptoms compared to men. Men had a poorer mean memory performance, poorer hearing, greater frequency of abdominal obesity, greater mean grip strength, greater mean SMMI, and greater average walking speed as well as a lower frequency of dynapenia compared to women, except when the cutoff point adopted for grip strength was < 39 kg for men and < 22 kg for women (Table 1). The prevalence of probable sarcopenia and sarcopenia was higher among the women than the men, except when the cutoff point

adopted for grip strength was < 39 kg for men and < 22 kg for women. As expected, the prevalence of both dynapenia as well as probable sarcopenia and sarcopenia increased when raising the cutoff points for grip strength for defining dynapenia (Table 1).

Table 1. Sociodemographic, behavioural, clinical, and anthropometric characteristics of 2,680 participants of the *ELSA* Study without mobility limitation at baseline stratified by sex (2004-2005).

	Total (n = 2,680)	**Men** (n = 1,298)	**Women** (n = 1,382)
Sociodemographic characteristics			
Age, years (mean ± SD)	68.6 ± 6.5	68.8 ± 6.4	68.5 ± 6.5
Age, (%)			
60-69 years	60.6	59.4	61.7
70-79 years	32.7	33.9	31.6
80 years or older	6.7	6.7	6.7
Ethnicity (white), (%)	99.2	99.2	99.2
Wealth (quintiles), (%)			
1st quintile (highest)	28.8	30.4	27.3
2nd quintile	24.0	23.9	24.0
3rd quintile	21.6	21.3	21.9
4th quintile	16.0	15.7	16.2
5th quintile (lowest)	9.6	8.7	10.6
Marital status (with conjugal life), (%)	73.7	83.2*	64.8*
Schooling, years (%)			
> 13 years	27.5	33.9*	21.6*
12-13 years	24.4	25.0	23.9
0-11 years	48.1	41.1*	54.5*
Behavioural characteristics			
Physical activity level (active), (%)	98.5	98.1	98.9
Alcohol intake per week, (%)			
Never or rarely	15.0	9.6*	20.0*
Frequently	46.6	45.1	48.0
Daily	38.4	45.3*	32.0*
Smoking, (%)			
Non-smoker	39.0	29.4*	48.0*
Ex-smoker	51.0	60.1*	42.3*
Smoker	10.0	10.5	9.7
Clinical and anthropometric characteristics			
Stroke (yes), (%)	3.2	4.1	2.4
Cancer (yes), (%)	8.8	8.1	9.5

Diabetes *mellitus* (yes), (%)	7.0	9.2*	4.8*
Heart disease (yes), (%)	20.9	24.1*	17.8*
Lung disease (yes), (%)	15.1	14.7*	15.6*
Systemic arterial hypertension (yes), (%)	43.2	42.8	43.7
Osteoporosis (yes), (%)	5.9	1.7*	9.9*
Depressive symptoms (yes), (%)	8.6	6.2*	10.9*
Memory score, points (mean ± SD)	10.2 ± 3.1	9.8 ± 3.0*	10.7 ± 3.1*
Vision, (%)			
Good	91.6	91.9	91.2
Fair	7.2	7.2	7.2
Poor	1.1	0.8	1.5
Blind	0.1	0.1	0.1
Hearing, (%)			
Good	81.3	75.3*	87.0*
Fair	15.0	19.5*	10.8*
Poor	3.7	5.2*	2.2*
Osteoarthritis (yes), (%)	33.5	27.3*	39.3*
Back, hip, knee, or foot pain (yes), (%)	24.3	21.3*	27.2*
Fall (yes), (%)	25.7	19.3*	31.6*
Waist circumference (≤ 102 M and ≤ 88 W), (%)	52.4*	56.0*	48.9*
Muscle strength (kg), (mean ± SD)	32.2 ± 10.4	40.3 ± 8.0*	24.6 ± 5.4*
Dynapenia (< 26 M and < 16 W), (%)	3.7	2.7*	4.7*
Dynapenia (< 26 M and < 17 W), (%)	4.6	2.7*	8.4*
Dynapenia (< 27 M and < 16 W), (%)	4.4	4.0	4.7
Dynapenia (< 30 M and < 20 W), (%)	11.8	8.2*	15.3*
Dynapenia (< 32 M and < 21 W), (%)	17.5	13.2*	21.6*
Dynapenia (< 36 M and < 23 W), (%)	31.5	27.7*	35.1*
Dynapenia (< 39 M and < 22 W), (%)	34.1	41.0*	27.6*
SMMI, kg/m² (mean ± SD)	8.8 ± 1.7	10.1 ± 1.0*	7.6 ± 1.2*
Low SMMI (< 9.24 kg/m^2 M and < 6.52 kg/m^2 W), (%)	16.7	17.1	16.3
Sarcopenia (< 26 M and < 16 W), (%)			
Non-sarcopenic	96.3	97.3	95.3
Probable sarcopenic	2.4	1.4*	3.3*
Sarcopenic	1.3	1.3	1.4
Sarcopenia (< 26 M and < 17 W), (%)			
Non-sarcopenic	94.4	97.3*	91.6*
Probable sarcopenic	3.8	1.4*	6.1*

Sarcopenia	1.8	1.3	2.3
Sarcopenia (< 27 M and < 16 W), (%)			
Non-sarcopenic	95.6	96	95.3
Probable sarcopenic	2.8	2.3	3.3
Sarcopenic	1.6	1.7	1.4
Sarcopenia (< 30 M and < 20 W), (%)			
Non-sarcopenic	88.2	91.8*	84.7*
Probable sarcopenic	8.6	5.6*	11.4*
Sarcopenic	3.2	2.6	3.9
Sarcopenia (< 32 M and < 21 W), (%)			
Non-sarcopenic	82.5	86.8*	78.4*
Probable sarcopenic	12.7	9.1*	16.1*
Sarcopenic	4.8	4.1	5.5
Sarcopenia (< 36 M and < 23 W), (%)			
Non-sarcopenic	68.5	72.3*	64.9*
Probable sarcopenic	23.4	20.1*	26.5*
Sarcopenic	8.1	7.6	8.6
Sarcopenia (< 39 M and < 22 W), (%)			
Non-sarcopenic	65.9	59.0*	72.4*
Probable sarcopenic	25.4	30.7*	20.5*
Sarcopenic	8.7	10.3*	7.1*
Walking speed, (m/s) (mean ± SD)	1.07 ± 0.2	1.09 ± 0.2*	1.06 ± 0.2*

Note: Data expressed as mean and proportions. Abbreviations: *ELSA*: English Longitudinal Study of Ageing; SD: standard deviation; M: men; W: women. SMMI: skeletal muscle mass index. * $p < 0.05$

The participants excluded at baseline due to missing data were older, non-white, had a lower income, lower schooling, were less likely to have a conjugal life, were less physically active, consumed less alcohol, more were smokers, had greater frequencies of stroke, diabetes, heart disease, lung disease, hypertension, osteoporosis, osteoarthritis, pain, depression, and falls, had a lower memory score, worse perception of vision and hearing, and a lower frequency of abdominal obesity compared to the participants included (Supplementary Table 1).

Tables 2, 3, and 4 display the estimated parameters of the generalised linear mixed models (baseline) and for changes in walking speed as a function of dynapenia and sarcopenia using different cutoff points for grip strength and low SMMI stratified by sex and per year for the eight-year follow-up period (slope).

In men, regarding dynapenia at the intercept, the average walking speed in dynapenic individuals was lower than in non-dynapenic individuals when the adopted cutoff points were < 30, < 36, and < 39 kg. On the slope, however, no cutoff point used for grip strength enabled the identification of the risk of mobility decline (Table 2). Regarding low SMMI, no significant difference between groups was found on either the intercept or slope (Table 4). For sarcopenia on the intercept, sarcopenic men had a slower average walking speed than non-sarcopenic men at baseline independently of the cutoff point adopted for grip strength. However, average walking speed was lower among those with probable sarcopenia compared to non-sarcopenic men at baseline only when probable sarcopenia was defined with cutoff points of < 36 kg and < 39 kg. On the slope, neither sarcopenia nor probable sarcopenia enabled identifying the risk of mobility decline, independently of the cutoff point adopted for grip strength (Table 2).

Table 2. Adjusted generalised linear mixed models for walking speed trajectories in an eight-year follow-up period according to dynapenia and sarcopenia status in 1,298 men who participated in the *ELSA* Study (2004/2005 – 2012/2013).

Men (n = 1,298)						
Dynapenia	**< 26 kg**	**< 27 kg**	**< 30 kg**	**< 32 kg**	**< 36 kg**	**< 39 kg**
	Estimated parameters (95% CI)					
Intercept						
Non-Dynapenic	Reference	Reference	Reference	Reference	Reference	Reference
Dynapenic	-0.046 (-0.10 – 0.01) (p=0.107)	-0.028 (-0.07 – 0.02) (p=0.226)	**-0.034*** **(-0.07 – -0.001)** **(p=0.040)**	-0.028 (-0.06 – 0.001) (p=0.057)	**-0.040**** **(-0.06 – -0.02)** **(p=0.001)**	**-0.040**** **(-0.06 – -0.02)** **(p< 0.01)**
Slope						
Time, years	**-0.024**** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.024**** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.023**** **(-0.04 – -0.01)** **(p=0.001)**	**-0.023**** **(-0.04 – -0.01)** **(p=0.001)**	**-0.022**** **(-0.04 – -0.01)** **(p=0.001)**	**-0.021**** **(-0.04 – -0.01)** **(p=0.002)**
Time x Non-Dynapenic	Reference	Reference	Reference	Reference	Reference	Reference
Time x Dynapenic	0.001 (-0.01 – 0.01) (p=0.897)	-0.003 (-0.01 – 0.01) (p=0.457)	-0.002 (-0.01 – 0.01) (p=0.587)	-0.0001 (-0.01 – 0.01) (p=0.958)	0.000 (-0.01 – 0.01) (p=0.915)	-0.003 (-0.01 – 0.01) (p=0.179)
Sarcopenia	**SMMI < 9.24 kg/m^2 and grip strength < 26 kg**	**SMMI < 9.24 kg/m^2 and grip strength < 27 kg**	**SMMI < 9.24 kg/m^2 and grip strength < 30 kg**	**SMMI < 9.24 kg/m^2 and grip strength < 32 kg**	**SMMI < 9.24 kg/m^2 and grip strength < 36 kg**	**SMMI < 9.24 kg/m2 and grip strength < 39 kg**
	Estimated parameters (95% CI)					
Intercept						
Non-Sarcopenic	Reference	Reference	Reference	Reference	Reference	Reference
Probable Sarcopenic	0.015 (-0.06 – 0.09) (p=0.698)	0.007 (-0.05 – 0.07) (p=0.815)	-0.017 (-0.06 – 0.02) (p=0.392)	-0.013 (-0.05 – -0.02) (p=0.448)	**-0.036**** **(-0.06 – -0.01)** **(p=0.006)**	**-0.035**** **(-0.06 – -0.01)** **(p=0.003)**

Sarcopenic	**-0.124** **(-0.20 – -0.05)** **(p=0.001)**	**-0.093** **(-0.16 – -0.03)** **(p=0.003)**	**-0.079** **(-0.13 – -0.03)** **(p=0.003)**	**-0.072** **(-0.12 – -0.03)** **(p=0.001)**	**-0.057** **(-0.10 – -0.02)** **(p=0.008)**	**-0.058** **(-0.10 – -0.02)** **(p=0.002)**
Slope						
Time, years	**-0.024** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.024** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.023** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.023** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.022** **(-0.04 – -0.01)** **(p< 0.01)**	**-0.021** **(-0.03 – -0.01)** **(p=0.002)**
Time x Non-Sarcopenic	Reference	Reference	Reference	Reference	Reference	Reference
Time x Probable Sarcopenic	-0.005 (-0.02 – 0.01) (p=0.427)	-0.005 (-0.02 – 0.01) (p=0.342)	-0.002 (-0.01 – 0.01) (p=0.678)	-0.001 (-0.01 – 0.01) (p=0.806)	-0.0001 (-0.01 – 0.01) (p=0.928)	-0.004 (-0.01 – 0.001) (p=0.115)
Time x Sarcopenic	0.006 (-0.01 – 0.02) (p=0.396)	0.002 (-0.01 – 0.02) (p=0.722)	0.001 (-0.01 – 0.01) (p=0.911)	0.002 (-0.01 – 0.01) (p=0.600)	0.000 (-0.01 – 0.01) (p=0.916)	-0.002 (-0.01 – 0.01) (p=0.556)

Note: Model adjusted by age, ethnicity, schooling years, physical activity level, alcohol intake, smoking, depression, memory performance, vision, hearing, hypertension, lung disease, heart disease, diabetes, stroke, cancer, osteoporosis, osteoarthritis, back, hip, knee, and/or foot pain, history of falls, waist circumference, and height. Abbreviations: 95% CI: 95% confidence interval. *p < 0.05. **p < 0.01.

Among women considering dynapenia on the intercept, the average walking speed among dynapenic individuals was lower than that of non-dynapenic individuals when the cutoff points adopted were < 21, < 22, and < 23 kg. Throughout the eight-year follow-up, women with dynapenia defined by the grip strength cutoff points of < 17 kg or < 20 kg had greater walking speed decline [(-0.005 m/s per year; 95% CI: -0.01 to -0.001) and (-0.007 m/s per year; 95% CI: -0.01 to -0.001), respectively] compared to those without dynapenia (Table 3). In clinical terms, this means a decline of -0.14 m/s in eight years in the group with grip strength < 17 kg and a decline of -0.15 m/s among those with grip strength < 20 kg (Figure 1 and Supplementary Table 2). Regarding low SMMI, no difference was found between groups on either the intercept or slope (Table 4). For sarcopenia on the intercept, women with sarcopenia defined by grip strength < 20, < 21, < 22, and < 23 kg had a slower average walking speed than non-sarcopenic women at baseline (Table 3). However, average walking speed was lower among probable sarcopenic women compared to non-sarcopenic women at baseline only when probable sarcopenia was defined by cutoff points of < 21, < 22, and < 23 kg. Throughout the eight-year follow-up, women with probable sarcopenia defined by grip strength cutoff points < 17 or < 20 kg had greater walking speed decline [(-0.006 m/s per year; 95% CI: -0.01 to -0.001 for grip strength < 17 kg), and (-0.007 m/s per year; 95% CI: -0.01 to -0.001 for grip strength < 20 kg)] compared to those without sarcopenia. In clinical terms, this means a decline in eight years of -0.15 m/s in the group of women with probable sarcopenia with both cutoff points (< 17 kg and < 20 kg) (Figure 1 and Supplementary Table 3). For sarcopenic women, no grip strength cutoff point adopted enabled the identification of the risk of mobility decline, although the < 20 kg cutoff point achieved borderline significance ($p = 0.054$) (Table 3).

Table 3. Adjusted generalised linear mixed models for walking speed trajectories in an eight-year follow-up period according to dynapenia and sarcopenia status in 1,382 women who participated in the *ELSA* Study (2004/2005 – 2012/2013).

	Women (n = 1,382)					
	< 16 kg	**< 17 kg**	**< 20 kg**	**< 21 kg**	**< 22 kg**	**< 23 kg**
	Estimated parameters (95% CI)					
Intercept						
Non-Dynapenic	Reference	Reference	Reference	Reference	Reference	Reference
Dynapenic	-0.025 (-0.06 – 0.01) (p=0.144)	-0.020 (-0.05 – 0.01) (p=0.188)	-0.025 (-0.06 – 0.01) (p=0.099)	**-0.045**** **(-0.07 – -0.02)** **(p=0.001)**	**-0.036**** **(-0.06 – -0.01)** **(p=0.002)**	**-0.043**** **(-0.06 – -0.02)** **(p < 0.01)**
Slope						
Time, years	**-0.014*** **(-0.03 – -0.001)** **(p=0.008)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.013)**	**-0.013**** **(-0.02 – -0.001)** **(p=0.010)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.017)**	**-0.012*** **(-0.02 – -0.001)** **(p=0.029)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.026)**
Time x Non-Dynapenic	Reference	Reference	Reference	Reference	Reference	Reference
Time x Dynapenic	-0.005 (-0.01 – 0.001) (p=0.105)	**-0.005*** **(-0.01 – -0.001)** **(p=0.039)**	**-0.007**** **(-0.01 – -0.001)** **(p=0.008)**	-0.003 (-0.01 – 0.001) (p=0.309)	-0.003 (-0.01 – 0.001) (p=0.277)	-0.002 (-0.01 – 0.001) (p=0.442)
Sarcopenia	**SMMI < 6.52 kg/m^2 and grip strength < 16 kg**	**SMMI < 6.52 kg/m^2 and grip strength < 17 kg**	**SMMI < 6.52 kg/m^2 and grip strength < 20 kg**	**SMMI < 6.52 kg/m^2 and grip strength < 21 kg**	**SMMI < 6.52 kg/m^2 and grip strength < 22 kg**	**SMMI < 6.52 kg/m^2 and grip strength < 23 kg**
	Estimated parameters (95% CI); (p-value)					
Intercept						
Non-Sarcopenic	Reference	Reference	Reference	Reference	Reference	Reference
Probable Sarcopenic	-0.019 (-0.06 – 0.02)	-0.017 (-0.05 – 0.02)	-0.019 (-0.05 – 0.02)	**-0.040**** **(-0.07 – -0.01)**	**-0.036**** **(-0.06 – -0.01)**	**-0.045**** **(-0.07 – -0.02)**

	(p=0.380)	(p=0.344)	(p=0.285)	**(p=0.004)**	**(p=0.004)**	**(p < 0.01)**
Sarcopenic	-0.043 (-0.09 – 0.01) (p=0.084)	-0.028 (-0.08 – 0.02) (p=0.287)	**-0.050*** **(-0.10 – -0.001)** **(p=0.038)**	**-0.066**** **(-0.11 – -0.02)** **(p=0.002)**	**-0.040*** **(-0.08 – -0.001)** **(p=0.048)**	**-0.040*** **(-0.08 – -0.001)** **(p=0.038)**
Slope						
Time, years	**-0.015**** **(-0.03 – -0.001)** **(p=0.009)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.014)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.014)**	**-0.013*** **(-0.02 – -0.001)** **(p=0.023)**	**-0.011*** **(-0.02 – -0.001)** **(p=0.046)**	**-0.012*** **(-0.02 – -0.001)** **(p=0.042)**
Time x Non-Sarcopenic	Reference	Reference	Reference	Reference	Reference	Reference
Time x Probable Sarcopenic	-0.006 (-0.01 – 0.001) (p=0.134)	**-0.006*** **(-0.01 – -0.001)** **(p=0.050)**	**-0.007*** **(-0.01 – -0.001)** **(p=0.023)**	-0.002 (-0.01 – 0.001) (p=0.556)	-0.001 (-0.01 – 0.001) (p=0.637)	-0.0001 (-0.01 – 0.001) (p=0.867)
Time x Sarcopenic	-0.003 (-0.01 – 0.01) (p=0.486)	-0.005 (-0.01 – 0.001) (p=0.230)	-0.008 (-0.02 – 0.001) (p=0.054)	-0.005 (-0.01 – 0.001) (p=0.207)	-0.007 (-0.01 – 0.001) (p=0.065)	-0.007 (-0.01 – 0.001) (p=0.074)

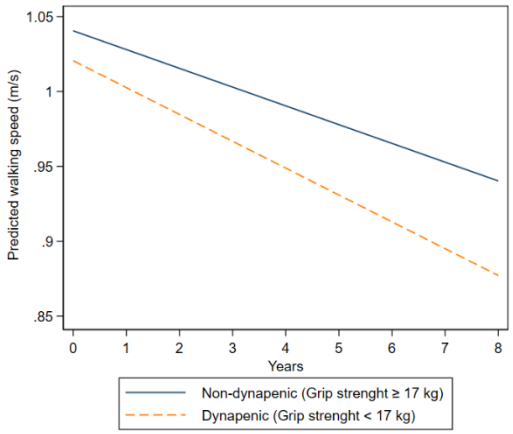
Note: Model adjusted by age, ethnicity, schooling years, physical activity level, alcohol intake, smoking, depression, memory performance, vision, hearing, hypertension, lung disease, heart disease, diabetes, stroke, cancer, osteoporosis, osteoarthritis, back, hip, knee, and/or foot pain, history of falls, waist circumference, and height. Abbreviations: 95% CI: 95% confidence interval. *p < 0.05. **p < 0.01.

Table 4. Adjusted generalised linear mixed models for walking speed trajectories in eight years according to SMMI status in 1,298 men and 1,382 women who participated in the *ELSA* Study (2004/2005 – 2012/2013).

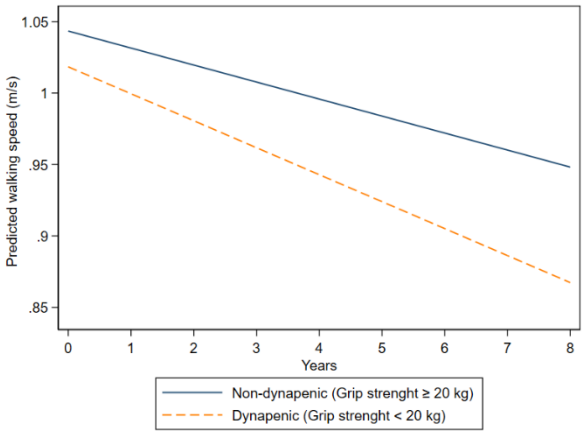
	Men (n = 1,298)	**Women (n = 1,382)**
SMMI	**Estimated parameters (95% CI)**	
Intercept		
SMMI ≥ 9.24 kg/m^2 M and ≥ 6.52 kg/m^2 W	Reference	Reference
SMMI < 9.24 kg/m^2 M and < 6.52 kg/m^2 W	-0.002 (-0.04 – 0.03) (p=0.897)	-0.013 (-0.04 – 0.02) (p=0.422)
Slope		
Time. Years	**-0.024** **(-0.04 – -0.01)**** **(p < 0.01)**	**-0.013** **(-0.02 – -0.001)*** **(p=0.028)**
SMMI ≥ 9.24 kg/m^2 M and ≥ 6.52 kg/m^2 W	Reference	Reference
SMMI < 9.24 kg/m^2 M and < 6.52 kg/m^2 W	-0.002 (-0.01 – 0.01) (p=0.635)	-0.005 (-0.01 – 0.001) (p=0.103)

Note: Model adjusted by age, ethnicity, schooling years, physical activity level, alcohol intake, smoking, depression, memory performance, vision, hearing, hypertension, lung disease, heart disease, diabetes, stroke, cancer, osteoporosis, osteoarthritis, back, hip, knee, and/or foot pain, history of falls, waist circumference, and height. Abbreviations: 95% CI: 95% confidence interval. *p < 0.05. **p < 0.01.

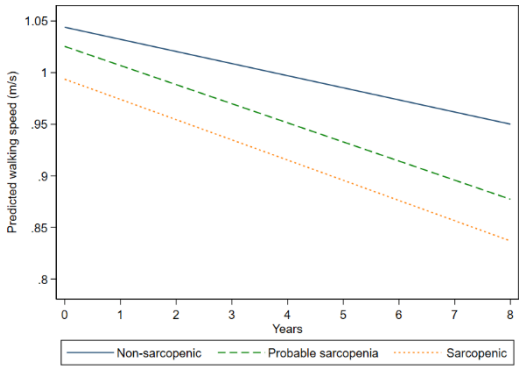
Graph A



Graph B



Graph C



Graph D

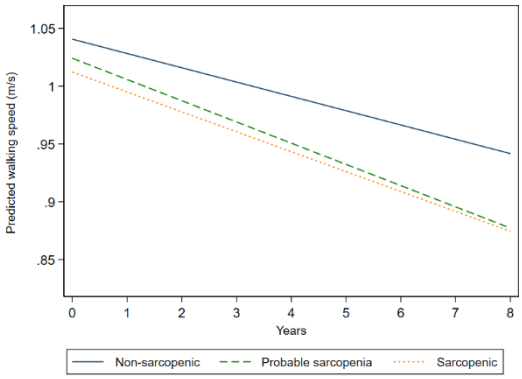


Figure 1. Trajectory of walking speed in 1,382 women without mobility limitation at baseline in eight-year follow-up period according to dynapenia and sarcopenia status. Graph A: dynapenia defined by grip strength < 17 kg versus grip strength ≥ 17 kg; Graph B: dynapenia defined by grip strength < 20 kg versus grip strength ≥ 20 kg; Graph C: sarcopenia status with low grip strength defined by grip strength < 17 kg versus grip strength ≥17 kg; Graph D: sarcopenia status with low grip strength defined by grip strength < 20 kg versus grip strength ≥ 20 kg.

DISCUSSION

To the best of our knowledge, this is the first study to compare dynapenia defined by different grip strength cutoff points, low SMMI, and sarcopenia according to the *EWGSOP2* also using different grip strength cutoff points to identify the best indicator for detecting mobility decline in individuals with walking speed > 0.8 m/s at baseline. The main findings demonstrated that dynapenic women and those with probable sarcopenia defined by grip strength < 17 and < 20 kg were at greater risk of mobility decline over time. However, sarcopenia in women and low SMMI, dynapenia, and sarcopenia in men did not detect the risk of mobility decline.

Only the grip strength cutoff points proposed in the cross-sectional studies conducted by Lauretani *et al.*[11] (2003) and Vasconcelos *et al.*[14] (2016) were in agreement with the results of the present study for women (< 17 kg and < 20 kg, respectively). It is possible that the cutoff point of < 16 kg[12,13] did not achieve significance on the slope in this study due to the small number of women in this category (4.7%). If the sample size in this group had been a little larger, we might have found that all cutoff points below 20 kg would be able to identify the risk of mobility decline in women. This conclusion is important, as it enables screening and interventions focused on a population at imminent risk of developing mobility limitations. However, the fact that higher cutoff points were not associated with mobility decline in women is relevant, as it demonstrates that, among the diverse factors capable of exerting an influence on mobility included in the present study, there may be a strength reduction threshold capable of mediating the decline in walking speed in women. However, using lower cutoff points based on population standard deviations, as recommended by *EWGSOP2*, and not defined based on the capacity to predict adverse outcomes in older adults may also result in the late identification of the individuals at risk. This issue appears more intricate in men and requires a thorough investigation.

Unfortunately, we have not found any longitudinal trajectory study using similar methods to ours, making it difficult to compare the findings. However, diverse methodological and biological factors may have led us to find that lower cutoff points for grip strength used to define dynapenia and probable sarcopenia according to the *EWGSOP2* were associated with mobility decline in women but not in men. From the methodological standpoint, all previous studies have had a cross-sectional design and included participants with or without slowness.[11–17] Men and women who already experience slowness are more likely to have poor health and faster functional decline accompanied by the loss of muscle mass, strength, and neuromuscular power. [49] This situation favours the identification of higher or lower cutoff points depending on the clinical and functional status of the sample analysed, with different sensitivity and specificity values.[17,21] However, none of the studies could establish a relationship of causality between low grip strength or probable sarcopenia and slowness. Moreover, many studies have applied distinct protocols for measuring grip strength and defining slowness.[11,17] Lastly, many variables strongly associated with mobility decline were not included in the final association models between dynapenia and slowness, potentially leading to overestimated associations, especially when higher cutoff points were identified.[14,16]

Biologically, there are important differences between men and women concerning the quantity of muscle mass, muscle strength, muscle power and risk factors for mobility decline. Such differences demonstrate how men and women experience muscle loss and functional decline differently, which appears to have influenced the distinct results found in the present study.[50] Men have a greater reserve of muscle mass and neuromuscular strength due to the greater thickness and cross-sectional area of the muscles as well as the greater quantity of type II fibres, greater capacity with regards to anaerobic metabolism, small proportion, size variation, and grouping of type I fibres, higher levels of testosterone, growth hormone, and insulin-like growth factor signalling, contributing to greater muscle strength, power, and reserve in comparison to women.[51] In contrast,

women have greater atrophy of type II fibres, a predominance of oxidative metabolism, a greater rate of autophagy, smaller number of satellite cells, lower mitochondrial ATP production, greater production of free radicals, greater accumulation of intramuscular fat, and higher body mass index, which contribute to a lower muscle reserve.[52]

Moreover, women have factors that can lead to greater protein catabolism, such as higher concentrations of inflammatory markers (interleukin-6 and C-reactive protein) as well as a reduction in the secretion of hormones, such as oestrogen, during menopause, which lead to the accelerated loss of skeletal muscle mass and neuromuscular strength.[53,54] There is also evidence that women have a greater reduction in muscle sensitivity to insulin, which culminates in muscle loss due to the poor suppression of glycogenesis and an imbalance in protein degradation and synthesis.[55–57]

With regards to intramuscular fat deposits, which have a direct negative effect on muscle contraction properties and generate chronic inflammation that accelerates the process of protein catabolism,[58–60] women after menopause have greater intramuscular fat infiltration and peripheral subcutaneous adipose tissue, especially in the abdominal region and lower limbs, compared to men.[45,53,61–63] Last but not least, there is evidence that women perform less physical activity than men, despite being more involved in housework, which can also influence the different declines in muscle mass and strength between the sexes.[64]

Furthermore, the prevalence of chronic diseases, such as osteoarthritis, is higher in women than men.[65] This is due to menopause, decreased curvatures and dimensions of the femur and tibia, reduced muscle mass, lower neuromuscular strength, slower contraction velocity, decreased neuromuscular power and diminished joint cartilage thickness.[65] Women with osteoarthritis also

experience a greater decline in subsarcolemmal mitochondrial density and slower myosin-actin cross-bridge kinetics compared to men with osteoarthritis.[52]

Therefore, as women have a lower muscle reserve than men, crossing the limit of < 20 kg grip strength would be capable of influencing the trajectory of mobility decline when used to define both dynapenia and probable sarcopenia.[52] On the other hand, low grip strength and SMMI alone or combined, as recommended in the *EWGSOP2* consensus on sarcopenia, seem not to exert an influence on walking speed decline in men, perhaps because men have a greater muscle reserve or because they initially lost the mechanisms responsible for muscle power.[66,67] This argument is strengthened by findings described by Jones and collaborators (2021),[67] who demonstrated that grip strength is threefold more associated with physical functioning in women than men. However, Laddu and collaborators (2020)[66] showed that muscle power is more related to neuromuscular function than neuromuscular strength in men. This points to an important opportunity for future studies, as it is possible that tracking mobility decline in the long term in men should not be based on neuromuscular strength or only on this aspect, but rather muscle power, given the differences in muscle quantity and composition between the sexes.

The present study has strong points that should be acknowledged. The study was conducted with a large representative sample of older English men and women followed up for eight years. To our knowledge, this is the first longitudinal study to compare dynapenia defined with different cutoff points, low SMMI, and sarcopenia to identify which of these three aspects would best identify a mobility decline. Finally, excluding individuals with a baseline walking speed ≤ 0.8 m/s enabled the analysis of the decline trajectory in older adults with normal mobility.

However, this study also has limitations that should be recognized. Our results should be considered in the context of community-dwelling individuals aged 60 or older. Thus, caution should be exercised in the interpretation of the results in the clinical/hospital setting and nursing homes/assisted living facilities. It is important to note the limitation in determining skeletal muscle mass with an equation. However, this does not mean that the findings obtained from the equation are invalid, as the equation has been tested against gold-standard methods, such as magnetic resonance and dual-energy x-ray absorptiometry and found to be reliable. The fact that the ELSA study does not have data on hormonal biochemical exams constitutes another limitation, as altered serum concentrations of testosterone and oestrogen are known to exert an influence on muscle mass and neuromuscular strength in men and women. The exclusion of individuals for whom no data was available on handgrip strength, skeletal muscle mass, or other covariables may have led to an underestimation of the associations found, as those who did not perform the handgrip test or undergo the anthropometric measurements have worse health conditions, as confirmed in our supplementary analyses. However, even when analysing a sample with good mobility at the onset of the study as well as better socioeconomic, behavioural, and clinical aspects, it was possible to find that grip strength cutoff points of < 17 and < 20 kg for defining dynapenia and probable sarcopenia were better for identifying the risk of walking speed decline in women. Information on diseases was based on the participants' self-reports of medical diagnoses. Although this may introduce bias, studies have shown that self-reported data are valid and consistent with medical diagnoses.[68] Physical activity level was also self-reported, which may have underestimated the prevalence of physically active participants in the sample analysed. However, this is a recurrent condition in studies that use this assessment method.[69,70] Lastly, losses to follow-up in longitudinal studies may be an unavoidable source of bias. However, inverse probability weighting was employed, as it is recommended for reducing bias.[48]

Directions for future studies: as men have greater muscle mass reserve, strength, and power and women have a greater frequency of factors that reduce muscle reserve, future studies should analyse differences between the sexes more accurately, considering not only the quantity of muscle mass but also changes in the contractile properties of muscle that result in reductions in muscle strength and power with the advance in age. It is important to examine muscle indicators in men, as they can predict a decline in walking speed in longitudinal studies.

CONCLUSION

Women 60 years of age or older without mobility limitation who have dynapenia and probable sarcopenia defined by grip strength < 17 kg and < 20 kg are at greater risk of walking speed decline over time. Sarcopenia in women and low SMMI, dynapenia, and sarcopenia in men were not capable of identifying the risk of walking speed decline.

From the clinical standpoint, these cutoff points can be useful for identifying women at risk of walking speed decline so that they may be included in early rehabilitation programs to avoid functional loss. Furthermore, public policies focused on maintaining muscle health and improving or maintaining mobility need to be implemented to avert dependence in older adults.

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