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Sarcopenia Definitions Considering Body Size and Fat Mass Are Associated With Mobility Limitations: The Framingham Study

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Background. Sarcopenia defined by lean mass has been inconsistently associated with disability in elders. Studies suggest that definitions should consider body size and additional influences of high fat mass (FM; sarcopenic-obesity). We examined sarcopenia accounting for body size, and sarcopenic-obesity, in relation to mobility limitations among 767 elderly men and women (mean age 79 years) from the Framingham Study.

Methods. Whole-body dual-energy x-ray absorptiometry measured appendicular lean mass (ALM) and total FM in 1992–1995. Sarcopenia was defined in two ways: ALM/height squared (ALM/ht^2) and ALM adjusted for height and FM (residuals). Sarcopenic-obesity categories (referent, obese, sarcopenic, and sarcopenic-obese) were defined by cross-classifying ALM/ht^2 and obesity (% body fat: more than 30 for men and more than 40 for women). Mobility limitation was defined as self-reported inability to walk one-half mile, climb stairs, or perform heavy housework. Sex-specific logistic regression calculated odds ratios (OR) and 95% confidence intervals (CI) for mobility limitation, adjusting for covariates.

Results. Sixteen percent of men and 30% of women had mobility limitation. Among men, both ALM/ht^2 (OR = 6.3, 95% CI = 2.5–16.1) and residuals (OR = 4.6, 95% CI = 2.0–10.5) sarcopenia were associated with increased limitation. For sarcopenic-obesity, odds of limitation was higher in sarcopenic (OR = 6.1, 95% CI = 2.2–16.9) and sarcopenic-obese categories (OR = 3.5, 95% CI = 1.0–12.7) but suggested no synergistic effect. In women, only residuals sarcopenia was associated with higher odds of limitation (OR = 1.8, 95% CI = 1.2–2.9).

Conclusions. Low lean mass is associated with mobility limitations after accounting for body size and fat, and lean and FM have independent effects on mobility in elders. These findings support previous reports that sarcopenia definitions should consider body size and fat.

Key Words: Sarcopenia—Lean mass—Disability.

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AGE-RELATED loss of muscle mass and strength, termed sarcopenia, is common among older adults and is associated with serious consequences, such as functional limitations, comorbidities, and mortality. Studies that have examined the relation between sarcopenia and mobility limitations in older adults have found conflicting results (1–5). This is perhaps due to the lack of a widely accepted definition of sarcopenia. Among the first to examine this question were Visser and colleagues (6), who found no association between sarcopenia and mobility limitation when sarcopenia was defined by low lean mass among elderly Framingham Study participants. They did report, however, that greater fat mass (FM) was associated with mobility limitation. These findings were later confirmed among older adults participating in the National Health and Nutrition Examination Study III (1), suggesting FM may be more important for mobility than lean mass in older adults. Similarly, in the Health, Aging, and Body Composition Study, sarcopenia, based on low appendicular lean mass (ALM) adjusted for height squared, was not associated with incident mobility limitation (2). Yet when ALM was adjusted for both height and FM using the residuals method, sarcopenic women were at increased risk of future mobility limitation, suggesting that lean mass influences mobility in elders after accounting for body size and FM (2).

It has been hypothesized that the combination of high FM and low lean mass may act synergistically so that older individuals with both may have greater mobility limitations compared with having either condition alone. Results from previous studies of this concept of "sarcopenic-obesity" and mobility limitations have, however, been contradictory as some support this hypothesis (5,7,8), whereas others do not (1,9,10).

Given the conflicting data across studies of sarcopenia and mobility limitations, there exists a need to further examine this relation using appropriate sarcopenia measures. Thus, to expand on the results reported by Visser in the Framingham Study (6), the objective of this study was to examine two previously published measures of sarcopenia, which incorporate body size and FM, and their association with self-reported mobility limitation among community-dwelling older men and women. Additionally, to examine whether elders with both low lean mass and high FM are at even greater risk than those with either condition alone, we determined the association of sarcopenic-obesity with mobility limitation.

Materials and Methods

Study Sample

The study sample was derived from the Framingham Heart Study original cohort, a large population-based study that began in 1948 in order to study risk factors for heart disease (11). A two-thirds sample from the town of Framingham, MA was recruited. Five thousand two hundred and nine men and women were enrolled who were 28–62 years of age. The cohort has been followed biennially since that time. Of the 1,166 members who attended the biennial examination in 1992–1995, 847 had a whole-body dual-energy x-ray absorptiometry (DXA) scan. Of those, 767 had information on mobility limitation, complete covariate information, and were included in this analysis. All participants in the Framingham Study provided informed consent, and the study was approved by the Boston University School of Medicine and Hebrew Rehabilitation Center IRBs.

Measures of Mobility Limitation

Participants were asked "do you have difficulty walking one-half mile (4–6 blocks)?" Those who reported some difficulty, a lot of difficulty, inability, or did not do on doctor's orders were considered to be limited in walking one-half mile, whereas those who reported little or no difficulty were not (12).

Participants were also queried, "Are you able to walk up and down stairs to the second floor without any help?" and "Are you able to do heavy work around house like shovel snow or wash windows, walls, or floors without help?" Participants who were unable or who required human assistance were considered to be limited in these activities, whereas those reporting independence were not (13).

A combined measure of mobility limitation, defined as limitation in at least one of the three activities, was created from the above items.

Body Composition

Whole-body DXA scans were obtained using a Lunar DPX-L (LunarCorp, Madison, WI) to assess body composition as previously described (6). ALM was calculated as the sum of lean mass of arms and legs (kg; [14]). Percent FM was calculated as total body FM (kg) divided by the sum of total body lean mass (kg), FM (kg), and bone mineral content (kg), multiplied by 100. Due to time constraints, participants were scanned with the DPX-L in "Fast" mode, regardless of body thickness. Consequently, for 77 participants, there was poor x-ray beam penetration within the trunk region, which precluded calculation of valid measures of percent body fat.

Sarcopenia-ALM/ht^2

Based on the definition by Baumgartner and colleagues (15), relative lean mass (ALM/ht^2) was calculated as the ratio of ALM (kg) and height squared (m; [2,4,7,15]). Participants were categorized as having sarcopenia based on ALM/ht^2 cut-points defined in previous studies (>2 *SD* below sex-specific means of normal reference population: 7.26 kg/m^2 for men and 5.45 kg/m^2 for women [7,15,16]).

Sarcopenia-Residuals

A second definition of sarcopenia was calculated by obtaining residuals from the regression of ALM (kg) on height (m) and whole-body total FM (kg), separately for men and women, as previously described by Newman and colleagues (4). Sex-specific quartiles of the residuals were calculated, and participants in the lowest quartile were considered to be sarcopenic.

Sarcopenic-Obesity

A four-level variable was created to represent sarcopenic-obesity as follows: neither obese nor sarcopenic (referent), obese only, sarcopenic only, and sarcopenic-obese.

Sarcopenia was defined using sarcopenia-ALM/ht^2, as shown above. Obesity was defined as percent FM more than 30% and 40% for men and women, respectively. Individuals categorized as both sarcopenic and obese were considered sarcopenic-obese (1,10,15,16).

Covariates

We considered the following covariates in our analysis: age (years), education level (high school graduate, yes/no), current smoker (yes/no), alcohol use (ounces per week), number of comorbidities (0, 1, and 2+), body mass index (BMI; kg/m^2, ALM/ht^2 model only), current estrogen use (yes/no; women only), and physical activity. Comorbidities included a history of cardiovascular disease, diabetes, cancer, hip fracture, or depression. Histories of cancer and hip fracture have been validated by review of medical records.

History of cardiovascular disease has been adjudicated by a review panel using medical records. History of diabetes is based on blood glucose levels and reported use of glucose lowering medications. A participant was depressed if they scored more than 16 on the Center for Epidemiologic Studies Depression Scale (17). A three level comorbidity score was created by summing the total number of comorbidities (0, 1, 2+). Information on physical activity, measured by the Physical Activity Scale for the Elderly (18), was available in a subset of 430 participants.

Statistical Analysis

Sex-specific multivariable-adjusted logistic regression was used to calculate odds ratios (OR) and 95% confidence intervals (CI) for the cross-sectional association between sarcopenia and sarcopenic-obesity measures and limitation in at least one mobility item (dependent variable; walk one-half mile, walk up and down stairs, and heavy work around the house), adjusting for age, smoking status, alcohol use, education level, number of comorbidities, BMI, and estrogen use. Separate analyses conducted among those participants with information on Physical Activity Scale for the Elderly indicated that it was not a confounder, thus we present results from models not adjusting for physical activity. A second separate analysis including only participants who had valid percent FM measurements indicated the same pattern of results, thus models are presented including those who were missing percent FM. To determine whether specific mobility items influenced any observed associations, logistic regression models were repeated for each individual mobility item separately.

Results

In the 274 men and 493 women who had whole-body DXA scans and information on mobility limitation, mean age was 79 years (range 72–92 years), and mean percent body fat was 35.7 ± 9 kg (Table 1). Men had greater absolute and relative ALM and lower percent body fat compared with women. Using sarcopenia-ALM/ht^2, 19% of men and 13% of women were considered sarcopenic, whereas, by definition, 25% of men and women were considered sarcopenic using sarcopenia-residuals. Using the sarcopenic-obesity definition, 12% of men and 9% of women were considered to be sarcopenic only, and 8% of men and 4% of women were considered to be sarcopenic-obese. Compared with men, a greater proportion of women (30% vs 16%) reported limitation in at least one mobility item. Limitations in walking one-half mile were reported by 9% of men and 16% of women, whereas 9% of men and 21% of women indicated limitation in doing heavy work around the house. Few participants reported limitation in walking up and down one flight of stairs: 3% for both men and women.

Table 1. Descriptive Characteristics (mean ± *SD* or *n* (%)) of Men and Women of the Framingham Heart Study With Baseline Whole-Body DXA Scans Between 1992 and 1995

	Men, *n* = 274	Women, *n* = 493
Age (y)	78.2 ± 4.3	78.7 ± 4.4
Current smoker (yes/no)	17 (6%)	43 (9%)
Alcohol use (ounces/wk)	3.0 ± 4.4	1.2 ± 2.2
High school graduate (yes/no)	187 (68%)	356 (72%)
Comorbidity*		
0	89 (32%)	209 (42%)
1	123 (45%)	194 (39%)
2+	62 (23%)	90 (18%)
BMI (kg/m^2)	27.0 ± 3.9	26.5 ± 5.0
Estrogen user (current yes/no)	—	28 (6%)
ALM (kg)	23.1 ± 3.0	15.1 ± 2.1
ALM/ht^2 (kg/m^2)	8.0 ± 0.9	6.2 ± 0.7
% Total body fat	27.5 ± 6.4	39.3 ± 7.9
Sarcopenia-ALM/ht^2	53 (19%)	62 (13%)
Sarcopenia-residuals	52 (25%)	114 (24%)
Sarcopenic-obesity		
Referent	105 (38%)	191 (39%)
Obese	116 (42%)	240 (49%)
Sarcopenic	32 (12%)	43 (9%)
Sarcopenic-obese	21 (8%)	19 (4%)
Mobility limitation		
Heavy housework	25 (9%)	105 (21%)
Walk one-half mile	24 (9%)	78 (16%)
Climbing stairs	7 (3%)	15 (3%)
At least one limitation	43 (16%)	147 (30%)

Notes: BMI = body mass index; ALM = appendicular lean mass; DXA = dual-energy x-ray absorptiometry.

*Comorbidity: history of cardiovascular disease, diabetes, cancer, hip fracture, or depression.

Sarcopenia

Men who were sarcopenic by the ALM/ht^2 definition had an approximately sixfold increased odds of limitation in one or more mobility items (OR = 6.31, 95% CI = 2.48–16.05; Table 2). This association was similar for the sarcopenia-residuals, which adjusted for both height and FM (OR = 4.6, 95% CI = 1.96–10.53). Among women, sarcopenia was not associated with mobility limitation when defined by ALM/ht^2, yet those with sarcopenia based on residuals had a nearly twofold increased risk of being limited in at least one mobility item (OR = 1.8, 95% CI = 1.15–2.93).

Sarcopenic-Obesity

Among the sarcopenic-obesity categories, men with only sarcopenia had sixfold increased odds of one or more mobility limitations compared with the referent group (OR = 6.1, 95% CI = 2.18–16.90; Table 3). Sarcopenic-obese men were 3.5 times as likely to have a mobility limitation compared with the referent group, although the CI included the null value (OR = 3.5, 95% CI = 0.98–12.72). Among women, both the sarcopenia only and obese only categories had approximately a 60% increased risk of mobility limitation, although CI for both categories included the null (sarcopenia only: OR = 1.6, 95% CI = 0.77–3.39; obese only: OR = 1.6,

Table 2. Crude and Multivariable-Adjusted* OR and 95% CI for Association of Two Definitions of Sarcopenia and Mobility Limitation in 274 Men and 493 Women of the Framingham Original Cohort

	Men				Women			
	n Total	*n* With Mobility Limitation†	Crude OR (95% CI)	Adjusted OR (95% CI)	*n* Total	*n* With Mobility Limitation†	Crude OR (95% CI)	Adjusted OR (95% CI)
ALM/ht²								
Yes‡	53 (19%)	18 (34%)	4.03 (1.99–8.16)	6.31 (2.48–16.05)	62 (13%)	20 (32%)	1.14 (0.64–2.02)	1.40 (0.73,2.66)
No	221 (81%)	25 (11%)	1.0	1.0	431 (87%)	127 (29%)	1.0	1.0
Residuals								
Yes§	52 (25%)	18 (35%)	4.73 (2.19–10.22)	4.55 (1.96–10.53)	114 (24%)	43 (38%)	1.65 (1.06–2.57)	1.83 (1.15–2.93)
No	159 (75%)	16 (10%)	1.0	1.0	365 (76%)	98 (27%)	1.0	1.0

Notes: BMI = body mass index; ALM = appendicular lean mass; CI = confidence intervals; OR = Odds Ratio.

*Adjusted for age, current smoker, alcohol use, education, comorbidity, BMI (ALM/ht² model only), and estrogen use (women only).

† Self-reported limitation in walking one-half mile, walking up and down stairs, or doing heavy work around the house.

‡ ALM/ht² cutoffs 7.26 kg/m² in men and 5.45 kg/m² for women.

§ Residuals cutoffs 1.6 in men and 1.14 in women.

95% CI = 1.00–2.46). Sarcopenic-obesity among women, however, was not associated with increased risk of mobility limitation.

Individual Mobility Items

Among men, both sarcopenia definitions were associated with a fourfold to sixfold increased risk for limitation in performing heavy work around the house. Using sarcopenia-ALM/ht^2, there was a sixfold increased risk for limitation in walking up and down a flight of stairs (crude model only), though CI were extremely wide (Table 4). Neither sarcopenia definition was associated with walking limitation. For sarcopenic-obesity, similar results were observed in performing heavy housework for men with only sarcopenia, yet there was no increased risk for any mobility limitation in men with only obesity or in men with sarcopenic-obesity.

Among women, sarcopenia-residuals was associated with a twofold increased risk for limitation in performing heavy work around the house but not in walking one-half mile or walking up and down stairs (Table 4). Sarcopenia-ALM/ht^2 was not associated with limitation in any individual item. For sarcopenic-obesity categories, the associations of sarcopenic-obesity with stair climbing and walking one-half mile could not be estimated due to few women in these categories. Women in obese only, sarcopenic only, and sarcopenic-obesity categories had approximately twofold greater odds of limitation in heavy work around the house, although CI included the null value. It should be noted that some of the individual mobility item models have questionable model fit due to very small numbers of participants falling into the disabled and sarcopenic groups. Models, which have questionable fit, are noted in Table 4.

Discussion

We observed that sarcopenia was associated with fourfold to sixfold increased risk of self-reported mobility limitation in community-dwelling older men, whether defined by ALM/ht^2 or by residuals of height and FM adjusted lean mass. Among women, however, only sarcopenia defined by the residuals method was associated with a twofold increased risk of mobility limitation. When we examined sarcopenic-obesity, men with sarcopenia alone had six times the risk of mobility limitation compared with the referent group (neither obesity nor sarcopenia), yet there was no evidence of a synergistic effect between sarcopenia and obesity. Women with obesity alone and sarcopenic alone had approximately 60% increased risk of mobility limitation compared with the referent group, though there was no evidence of increased risk in the sarcopenic-obese group.

Table 3. Crude and Multivariable-Adjusted* Odds Ratio (OR) and 95% Confidence Intervals (CI) for Association of Sarcopenic-Obesity and Mobility Limitation in 274 Men and 493 Women of the Framingham Original Cohort

	Men				Women			
	n Total	*n* Mobility Limitation†	Crude OR (95% CI)	Adjusted OR (95% CI)	*n* Total	*n* Mobility Limitation†	Crude OR (95% CI)	Adjusted OR (95% CI)
Adjusted*								
Neither (referent)	105 (38%)	9 (9%)	1.0	1.0	191 (39%)	49 (26%)	1.0	1.0
Obese	116 (42%)	16 (14%)	1.71 (0.72–4.05)	1.76 (0.72–4.30)	240 (49%)	78 (33%)	1.40 (0.82–2.13)	1.57 (1.00–2.46)
Sarcopenic	32 (12%)	13 (41%)	7.30 (2.73–19.49)	6.08 (2.18–16.90)	43 (9%)	15 (35%)	1.55 (0.77–3.15)	1.61 (0.77–3.39)
Sarcopenic-obese	21 (8%)	5 (24%)	3.33 (0.99–11.23)	3.52 (0.98–12.72)	19 (4%)	5 (26%)	1.04 (0.35–3.02)	1.15 (0.37–3.55)

*Adjusted for age, current smoker, alcohol use, education, comorbidity, and estrogen use (women only).

† Self-reported limitation in walking one-half mile, walking up and down stairs, or doing heavy work around the house.

Table 4. Crude and Multivariable-Adjusted* OR and 95% CI for Association of Sarcopenia and Sarcopenic-Obesity With Individual Mobility Disability Items in 274 Men and 493 Women in the Framingham Study

	Men			Women		
	Walk One-Half Mile	Climb Stairs	Heavy House Work	Walk One-Half Mile	Climb Stairs	Heavy House Work
Sarcopenia						
Crude						
ALM/ht^2	1.83 (0.72–4.66)	5.93 (1.29–27.36)	4.68 (2.00–10.99)	0.53 (0.22–1.28)	1.11 (0.24–5.04)	1.54 (0.84–2.83)
Residuals	2.32 (0.83–6.44)	3.18 (0.62–16.28)	4.47 (1.80–11.09)	1.27 (0.72–2.23)	1.19 (0.37–3.82)	1.90 (1.18–3.08)
Adjusted*						
ALM/ht^2	3.33 (0.97–11.40)	—†	5.96 (1.88–18.86)	0.75 (0.29–1.93)	—†	1.89 (0.95–3.76)
Residuals	1.86 (0.60–5.72)	—†	4.30 (1.58–11.72)	1.27 (0.71–2.26)	—†	2.11 (1.27–3.51)
Sarcopenic-obesity						
Crude						
Neither (referent)	1.0	1.0	1.0	1.0	1.0	1.0
Obese	1.73 (0.62–4.85)	0.45 (0.04–5.01)	1.48 (0.47–4.68)	—†	—†	1.42 (0.88–2.30)
Sarcopenic	2.36 (0.62–8.94)	5.33 (0.85–33.41)	7.83 (2.40–25.56)	—†	—†	1.98 (0.92–4.28)
Sarcopenic-obese	2.75 (0.63–12.01)	2.58 (0.22–29.77)	3.33 (0.73–15.19)	—†	—†	1.71 (0.58–5.08)
Adjusted*						
Neither (referent)	1.0	1.0	1.0	1.0	1.0	1.0
Obese	2.01 (0.68–5.97)	—†	1.55 (0.48–5.08)	—†	—†	1.61 (0.96–2.68)
Sarcopenic	1.74 (0.43–7.00)	—†	6.38 (1.85–21.92)	—†	—†	2.12 (0.94–4.78)
Sarcopenic-obese	2.46 (0.50–12.06)	—†	3.20 (0.63–16.11)	—†	—†	1.99 (0.63–6.25)

Notes: ALM = appendicular lean mass; BMI = body mass index; CI = confidence intervals; OR = odds ratios.

*Adjusted for age, current smoker, alcohol use, education, comorbidity, BMI (ALM/ht^2 model only), and estrogen use (women only).

† Model did not converge or questionable model fit due to insufficient numbers.

The previous study by Visser and colleagues (6) in this same cohort indicated that low lean mass (total lean mass and leg lean mass) was not associated with mobility disability. Low lean mass was identified by the lowest tertile of lean mass, and regression models were adjusted for height and FM. In our study, sarcopenia-ALM/ht^2 was associated with mobility limitation in men only, whereas sarcopenia-residuals was associated with mobility limitation in both men and women. Our results are in agreement with previous studies suggesting that the residuals method may be a more appropriate definition of low lean mass compared with those based on lean mass alone or lean mass normalized for height (2,4). Newman and colleagues (4) first showed that the ALM/ht^2 definition likely misclassifies many obese people as nonsarcopenic. For a given height, obese individuals tend to have more absolute lean mass than those who are non-obese, but their lean mass is relatively small in terms of their overall body size. Sarcopenia defined using the residuals method accounts for this by determining how far an individual's ALM deviates from what would be expected given their height and total body FM. Furthermore, despite the previous results from Visser, as well as other studies suggesting that muscle function (eg, strength) is a more important determinant of mobility than muscle mass (19–21), our results suggest that DXA-derived lean mass is indeed important for mobility limitation.

Visser showed an important FM effect independent of lean mass in Framingham Study participants but did not explore the possibility that lean mass and FM may also work synergistically to influence mobility. Our analysis of sarcopenic-obesity suggested that individuals with obese alone and sarcopenic alone had some increased risk, but there was no evidence of a synergistic effect on mobility. Although Newman and colleagues (4) did not examine the concept of sarcopenic-obesity, they did present percentages of obese participants, defined using BMI greater than or equal to 30, who were considered sarcopenic by the ALM/ht^2 and residuals definitions. Using this BMI-based definition of sarcopenic-obesity in our cohort, we had 1.6% and 0% of obese men and women, respectively (ALM/ht^2 definition), and 19% of both obese men and women (residuals definition) who are sarcopenic. These reflect a similar prevalence of sarcopenia in the obese group in both men and women as compared with Newman and colleagues (4) We also found similar adjusted and crude OR using BMI to define obesity compared with using percent whole-body fat to define obesity (results not presented). Our findings are consistent with results from the National Health and Nutrition Examination Study III and others who have found no synergist effect of low lean mass and high body fat (1,9,10) but differed from the previous Epidemiology of Osteoporosis Study and others who have found a combined effect (5,7,8). Although our results were similar, we found greater OR for the associations between sarcopenic-obesity and mobility limitation in men and similar magnitude OR in women compared with the results of Davison (1). Compared with the results in the study of Italian women by Zoico and colleagues (10), we found a smaller, although the same trend, of results. These differences could be due to the differences in sample size of the different studies. The potential interaction between lean mass and FM in relation to mobility limitations warrants further investigation in larger cohorts.

We found much stronger associations in men than in women across all of the sarcopenia and sarcopenic-obesity definitions. This discrepancy is apparently due to the lower rates of mobility limitation in the referent groups for the men (9%–11%) compared with the women (26%–29%) because rates were comparable in the sarcopenia and sarcopenic-obesity groups. This is perhaps a result of dichotomizing lean mass to define sarcopenia. Both sarcopenia definitions are based on somewhat arbitrary cut-points (<2 *SD* below the mean of a reference population; lowest quartile of residuals) and therefore likely do not adequately characterize the relation with disability across the full range of lean mass. Perhaps, definitions of sarcopenia should be based on the dose–response relation of lean mass with the risk of mobility limitation, as has been done previously for strength measures (22). Additional studies are needed to elucidate the sex differences in the relation between muscle mass and mobility disability.

We examined individual mobility items to determine whether specific activities were driving any of the associations observed with the combined outcome. In both men and women, associations between sarcopenia and mobility limitation were largely driven by reported limitations in doing heavy work around the house rather than walking or climbing stairs. In women, limitations due to obesity resulted from walking difficulty. Additional studies with larger proportions of older adults reporting mobility limitation could perhaps identify specific activities for which sarcopenia and obesity have greater relative influence and thus provide further insight to the relations of lean mass and FM with mobility. Our findings suggest that excess FM should be targeted to maintain walking abilities, whereas lean mass may be important to sustain more strenuous activities.

Strengths and Limitations

This study has important limitations that should be acknowledged. First, we used self-reported information on mobility limitations instead of observed performance measures, as they were not available at the time of the DXA measurements. Second, small numbers of individuals in the sarcopenic-obesity categories limited our power to detect associations. The cross-sectional study design precludes any conclusions regarding any causal associations between sarcopenia measures and mobility limitations. Third, our sarcopenia measures may not fully characterize the relation between sarcopenia and mobility as lean mass does not fully explain muscle function (19,23). Fourth, our exclusively Caucasian study population limits the generalizability of our results to other populations. Finally, this study did not include homebound or nursing home participants, although it is possible that the associations found in this study would have been strengthened if such participants had been included. It is also important to note that those missing a whole-body DXA scan were older, less likely to be a high school graduate, and more likely to have a mobility limitations compared with those who had a whole-body DXA scan. Additionally, participants who were missing information on mobility limitation were, on average, older than those who were not missing information on mobility limitation. Depending on the strength of the association among those who were missing data, our estimates may over- or underestimate the true associations of sarcopenia and sarcopenic-obesity with mobility limitations in our study population.

Despite the aforementioned limitations, there are also important strengths. This is a population-based study that was not selected based on disability status. We have large numbers of both elderly men and women. Also, DXA is an objective and precise assessment of body composition measures.

Conclusion

Sarcopenia defined using lean mass is associated with self-reported mobility limitations among community-dwelling older men and women when accounting for both height and FM. High FM also contributes to mobility problems, but our results suggest that its combination with low lean mass (sarcopenic-obesity) may not pose additional risk. Future studies of lean mass and mobility-related outcomes should account for the effects of body height and fatness. Additional longitudinal studies are needed to establish a causal relation between sarcopenia and mobility limitation, as are studies with larger numbers of individuals who are both sarcopenic and obese.

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