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Research Article

Clinical Definitions of Sarcopenia and Risk of Hospitalization in Community-Dwelling Older Men: The Osteoporotic Fractures in Men Study

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Abstract

Background: The association between various definitions of sarcopenia and hospitalization has not been evaluated in community-dwelling older men.

Methods: We used data from 1,516 participants at Visit 3 of the Osteoporotic Fractures in Men (MrOS) study who also had linked Medicare Fee-For-Service Claims data available. We examined the association between several sarcopenia definitions (International Working Group, European Working Group for Sarcopenia in Older Persons, Foundation for the NIH Sarcopenia Project, Baumgartner, and Newman) and hospitalization, using two-part ("hurdle") models, adjusted for age, clinical center, functional limitations, self-reported health, comorbidity, and cognitive function. Predictors included sarcopenia status (the summary definitions and the components of slowness, weakness, and/or lean mass); outcomes included hospitalization and cumulative inpatient days/year in the 3 years following the Visit 3 exam.

Results: After accounting for confounding factors, none of the summary definitions or the definition components (slowness, weakness, or low lean mass) were associated with likelihood of hospitalization, the rate ratio of inpatient days among those hospitalized, or the mean rate of inpatient days amongst all participants.

Conclusions: Sarcopenia was not associated hospitalization in community-dwelling older men. These results provide further evidence that current sarcopenia definitions are unlikely to identify those who are most likely to have greater hospitalization.

Keywords: Sarcopenia—Epidemiology—Gait—Hospital related

Introduction

Little is known about whether sarcopenia (the age-related loss of muscle mass and accompanying decline in physical function) is related to health care utilization and hospitalization in community-dwelling adults. A previous report by Janssen *et al.* estimated the health care costs associated with sarcopenia (defined by low appendicular lean mass/height^2) as $18.5 billion in 2000. However, this study has a number of limitations. It did not use individual level cost estimates and only evaluated one definition of sarcopenia. Many competing definitions of sarcopenia have been proposed, including definitions that use only lean mass, and others that are more integrated which use slowness (based on walking speed) or weakness (based on grip strength) as part of a summary definition. Using data from a cohort of community-dwelling older women, we found little evidence to support associations between several competing definitions of sarcopenia, (including Baumgartner (1); Newman (2); the International Working Group [IWG] (3); the European Working Group on Sarcopenia Older Persons [EWGSOP] (4); and the Foundation for

the NIH Sarcopenia Project [FNIH Sarcopenia Project] (5)) and subsequent health care utilization, although the slowness component of several of these definitions did identify women with at risk for greater health care use (6). A Portuguese study of nearly 700 hospitalized adults aged ≥18 years evaluated low lean mass (assessed by bioelectrical impedance analysis) and weakness (assessed by grip strength) and found that sarcopenia by these components was associated with longer length of hospital stay, although the associations were strongest in the youngest adults (≤65 years) (7). Another study, limited to hospitalized older European adults, found that presence of sarcopenia was related to increased hospitalization costs (7).

Thus, using Medicare Fee-For-Service (FFS) claims data linked to cohort data from the Osteoporotic Fractures in Men (MrOS Study), a prospective cohort study of older community-dwelling men, we aimed to determine whether sarcopenia as classified by a variety of definitions (and the individual components of these definitions) was associated with likelihood of hospitalization and rate of inpatient days.

Methods

Study population

Between 2000 and 2002, 5,994 ambulatory community-dwelling men aged ≥65 years without bilateral hip replacements were enrolled in MrOS, a multicenter cohort study of aging and osteoporosis (8,9). Between 2007 and 2009, 4,681 surviving participants returned for a third clinic visit, home visit, or completed questionnaires. All men provided written informed consent, and the study was approved by the Institutional Review Board at each center.

Clinical measurements

Weight was measured on a balance beam or digital scale, and height by wall-mounted stadiometers. Body mass index was calculated as weight (kg)/height^2 (m^2). Appendicular lean mass was assessed by DXA (Hologic 4500 scanners, Waltham, MA) as previously described (10). Gait speed was measured over a 6 m course using the average of two trials (m/s) (11). Grip strength (kg) was assessed using Jamar handheld dynamometers; the maximum value of two trials in each hand was analyzed. Men self-reported functional limitations, defined as the presence of difficulty/inability to complete any of several tasks related to self-care (see footnote Table 1). Participants also self-reported race, smoking status, health status (excellent/good vs. fair/poor/very poor). Teng MMSE test was administered by trained clinical staff for global cognitive function (higher scores represent better function) (12). Comorbidity burden was assessed using the Elixhauser comorbidity index, a sum of the presence of 31 specific medical conditions by using ICD-9 diagnostic codes in MedPAR (Part A claims), Hospital Outpatient, and Carrier (Physician/Supplier Part B claims) files for each MrOS FFS participant in the 12 months preceding the Visit 3 examination (13).

Sarcopenia definitions

We evaluated the following definitions of sarcopenia, as previously described: (14) Baumgartner (1); Newman (2); the IWG (3); the EWGSOP (4); and the FNIH Sarcopenia Project (5) (see footnote, Table 2). The consensus definitions are similar in that all combine lean mass assessed by DXA with a strength and/or physical performance component; the Newman and Baumgartner definitions rely lean mass and body size or composition estimates alone (without inclusion of physical performance). For the FNIH and Newman definitions, we used both the primary definition in primary analyses and report alternative definition in the Supplementary Table.

Medicare data linkage

Linkage of the MrOS cohort to Medicare claims data was completed as previously described. Of the 5,994 men enrolled initially in MrOS, 5,876 (98.0%) were determined to have valid linkages to Medicare claims data; of these, 2,997 (51.0%) were enrolled in Medicare Fee-For-Service for at least one month after the baseline exam.

Analysis subset

Of the 4,681 men who attended part of Visit 3 (or completed a study questionnaire), 3,621 had a clinic visit and complete data needed for calculating all of the sarcopenia definitions (Figure 1). Men who did not have a complete clinic visit (N = 1060) were older and less healthy than hen who had a completed clinic visit (N = 3,621; Supplementary Table 3). Of the men with a complete clinic visit, 1,516 men were enrolled in Medicare Fee-For-Service for at least one month following Visit 3, and comprised the analytic cohort for these analyses. Among those with a complete clinic visit, there were few differences between men enrolled in Medicare FFS (N = 1516, analytic cohort) and those who were not enrolled in Medicare FFS (N = 2105, Supplementary Table 3).

Statistical analyses

Participant characteristics were compared by the presence/absence of the various sarcopenia definitions using t-tests for continuous normal variables, Kruskall–Wallis tests for skewed continuous variables, and chi-square tests for categorical variables. We used two-part models ("hurdle" models) (15) with bootstrapping to estimate the likelihood of hospitalization, the rate ratio of inpatient hospital days amongst those hospitalized, and the mean number of inpatient days among all participants (with 95% confidence intervals) according to sarcopenia status, for each definition or component separately. The two-part "hurdle" mode estimates the odds of being hospitalized (yes/no) using a logit function, and then among those who are hospitalized, the means of inpatient days were estimated using log-link functions. We used two-part models ("hurdle" models) (15) with bootstrapping to estimate the likelihood of hospitalization, the rate ratio of inpatient hospital days amongst those hospitalized, and the mean number of inpatient days among all participants (with 95% confidence intervals) according to sarcopenia status, for each definition or component separately. The two-part "hurdle" mode estimates the odds of being hospitalized (yes/no) using a logit function, and then among those who are hospitalized, the means of inpatient days were estimated using log-link functions, adjusted for follow-up time using an offset of the logarithm of follow-up time. These so-called hurdle models allow for analysis of outcome data, such as our hospitalization outcomes that include many observations with no events, and additional observations with many events. The outcome data are specified to be modeled by two different statistical processes: binomial distribution (no hospitalization vs hospitalization); and a truncated-at-zero distribution (eg, truncated Poisson) governing all positive counts for nonzero outcomes. Advantages of these models include (a) they allow for simultaneous calculation of odds ratios for any event versus none, and also for rate ratios (using count data) among those who have had an event, as well as mean rates, (b) they allow for predictors to be different or have different degrees of association with the chance of hospitalization as opposed to hospitalization days, and (c) they allow analysis of the mean number of

Table 1. Characteristics of Participants by Presence of Sarcopenia as Defined by Proposed Clinical Definitions, Among MrOS Men at Study Visit 3 Who Were Also Enrolled in Medicare Fee-for-Service

		International Working Group			European Working Group			FNIH definition 1			FNIH definition 2			Baumgartner definition			Newman definition		
	Overall sample $N = 1516$	No sarcopenia ($N = 1,362$)	Sarcopenia ($N = 154$, 10.2%)	p value	No sarcopenia ($N = 1,402$)	Sarcopenia ($N = 114$, 7.5%)	p value	Normal ($N = 1,473$)	Weakness and low lean mass ($N = 43$, 2.8%)	p value	No sarcopenia ($N = 1,491$)	Slowness, weakness and low lean mass ($N = 25$, 1.6%)	p value	No sarcopenia ($N = 1,057$)	Sarcopenia ($N = 459$, 30.3%)	p value	No sarcopenia ($N = 1,095$)	Sarcopenia ($N = 421$, 27.8%)	p value
Age, years	79.2 (5.2)	78.8 (5.0)	83.0 (5.4)	<.001	78.9 (5.0)	83.3 (5.4)	<.001	79.1 (5.1)	83.9 (5.6)	<.001	79.1 (5.1)	84.7 (6.0)	<.001	78.5 (4.9)	80.9 (5.3)	<.001	78.7 (5.1)	80.6 (5.2)	<.001
Nonwhite race	136 (9.0%)	118 (8.7%)	18 (11.7%)	.210	121 (8.6%)	15 (13.2%)	.100	133 (9.0%)	3 (7.0%)	.640	134 (9.0%)	2 (8.0%)	.860	95 (9.0%)	41 (8.9%)	.970	105 (9.6%)	31 (7.4%)	.174
BMI, kg/m^2	27.0 (3.7)	27.3 (3.7)	24.4 (2.9)	<.001	27.2 (3.7)	24.1 (2.8)	<.001	27.0 (3.7)	27.1 (4.1)	.760	27.0 (3.7)	27.1 (5.0)	.880	28.1 (3.5)	24.3 (2.6)	<.001	27.4 (3.6)	25.9 (3.6)	<.001
ALM/ht^2, kg/m^2	7.7 (0.9)	7.9 (0.9)	6.6 (0.5)	<.001	7.8 (0.9)	6.6 (0.5)	<.001	7.8 (0.9)	7.1 (1.0)	<.001	7.7 (0.9)	7.1 (1.3)	.028	8.2 (0.7)	6.7 (0.4)	<.001	8.1 (0.8)	6.8 (0.6)	<.001
Grip strength, kg	39.1 (8.5)	40.0 (8.1)	31.0 (7.6)	<.001	40.1 (7.8)	25.9 (5.2)	<.001	39.5 (8.1)	21.1 (2.8)	<.001	39.3 (8.2)	20.5 (2.8)	<.001	40.7 (8.3)	35.4 (7.8)	<.001	40.6 (8.4)	35.1 (7.5)	<.001
Walking speed, m/s	1.13 (0.23)	1.17 (0.21)	0.83 (0.13)	<.001	1.15 (0.21)	0.88 (0.24)	<.001	1.14 (0.22)	0.83 (0.25)	<.001	312 (21.0%)	20 (80.0%)	<.001	221 (20.9%)	111 (24.3%)	.140	214 (19.5%)	118 (28.2%)	<.001
Functional limitation*	332 (21.9%)	261 (19.2%)	71 (46.4%)	<.001	268 (19.1%)	64 (56.6%)	<.001	303 (20.6%)	29 (67.4%)	<.001	81.5 (12.7)	74.3 (15.0)	.005	85.0 (12.3)	72.9 (9.3)	<.001	82.4 (12.7)	78.6 (12.5)	<.001
Weight, kg	81.4 (12.8)	82.5 (12.6)	71.7 (10.2)	<.001	82.3 (12.5)	69.6 (9.5)	<.001	81.6 (12.7)	74.6 (12.6)	<.001	173.7 (6.6)	165.3 (5.6)	<.001	173.7 (6.6)	173.2 (6.8)	.230	173.4 (6.7)	174.0 (6.6)	.094
Height, cm	173.5 (6.7)	173.8 (6.6)	171.2 (6.6)	<.001	173.9 (6.5)	169.7 (6.9)	<.001	173.8 (6.5)	165.6 (5.3)	<.001	27 (1.8%)	0 (0.0%)	.500	18 (1.7%)	9 (2.0%)	.730	21 (1.9%)	6 (1.4%)	.513
Smoking (current)	27 (1.7%)	25 (1.8%)	2 (1.3%)	.630	23 (1.6%)	4 (3.5%)	.150	27 (1.8%)	0 (0.0%)	.370	1,304 (87.8%)	18 (72.0%)	.018	932 (88.4%)	390 (85.3%)	.100	962 (88.2%)	360 (85.7%)	.195
Excellent/good health	1,322 (87.5%)	1,202 (88.6%)	120 (77.9%)	<.001	1,235 (88.4%)	87 (76.3%)	<.001	1,292 (88.0%)	30 (69.8%)	<.001	2.7 (2.3)	3.6 (3.8)	.240	2.5 (2.2)	3.1 (2.6)	<.001	2.5 (2.2)	3.2 (2.7)	<.001
Elixhauser score	2.7 (2.4)	2.5 (2.2)	3.9 (3.1)	<.001	2.6 (2.3)	3.9 (3.2)	<.001	2.6 (2.3)	3.9 (3.7)	.029	92.7 (6.3)	89.0 (9.0)	.060	93.0 (6.4)	92.0 (6.4)	.008	92.9 (6.4)	92.1 (6.4)	.035
Teng MMSE	92.7 (6.4)	93.0 (6.2)	89.5 (7.7)	<.001	93.0 (6.1)	88.8 (8.6)	<.001	92.7 (6.4)	90.1 (7.4)	.012	131.6 (66.1)	87.9 (59.8)	.001	136.2 (65.9)	118.5 (65.3)	<.001	137.4 (66.3)	113.9 (63.0)	<.001
Physical activity score (PASE)	130.9 (66.2)	135.0 (65.2)	94.5 (63.6)	<.001	134.8 (65.3)	82.8 (58.0)	<.001	131.8 (66.2)	98.6 (57.9)	.001	8.8 (4.8)	9.4 (5.7)	.53	8.7 (4.9)	9.1 (4.8)	.08	8.5 (4.8)	9.5 (4.8)	<.001
Number of prescription medications	8.8 (4.9)	8.7 (4.9)	9.8 (4.8)	.006	8.7 (4.8)	10.7 (5.2)	<.001	8.8 (4.9)	9.6 (5.1)	.26	1.5 (1.1)	1.8 (1.3)	.17	1.5 (1.1)	1.6 (1.1)	.04	1.5 (1.1)	1.7 (1.2)	<.001
Number of comorbidities†	1.5 (1.1)	1.5 (1.1)	1.9 (1.2)	<.001	1.5 (1.1)	1.9 (1.3)	.004	1.5 (1.1)	1.9 (1.2)	.03	79.1 (5.1)	84.7 (6.0)	<.001	78.5 (4.9)	80.9 (5.3)	<.001	78.7 (5.1)	80.6 (5.2)	<.001

Notes: IWG: presence of slowness (gait < 1.0 m/s) and low lean mass (ALM/ht^2 ≤ 7.23 kg/m^2). EWGSOP: presence of slowness (gait ≤ 0.8 m/s) plus low lean mass (ALM/ht^2 ≤ 7.23 kg/m^2) or weakness (grip < 30 kg). FNIH primary definition: presence of both weakness (grip < 26 kg) and low lean mass (ALM/BMI < 0.789); slowness defined as gait ≤0.8 m/s. Baumgartner: ALM/ht^2 < 7.23 kg/m^2. Newman definition: the equation to calculate residuals is ALM (kg) = −22.48 + 24.14 * height (m) + 0.21 * total fat mass (kg) as derived for men in the Health ABC study (17); the cut-point for the residual is ≤−2.29 kg/m^2 (derived from the Health ABC cohort). ALM = appendicular lean mass, BMI = body mass index, EWGSOP = European Working Group for Sarcopenia in Older Persons, FNIH = Foundation for NIH Sarcopenia Project, IWG = International Working Group, NIH = National Institute of Health.

*Functional limitation defined as inability to do any of the following: walk 2–3 blocks, climb 10 steps, shop, prepare meals, or do heavy housework. †Comorbidities include diabetes, stroke, Parkinson's, myocardial infarction (MI), congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), cancer, and hypertension. Prevalence of each individual disease by sarcopenia status is presented in Supplementary Table 2.

Table 2. Association Between Various Definitions of Sarcopenia and Hospitalization Over Three Years in Older Men

	Age-adjusted			Multivariate adjusted		
	Likelihood of hospitalization*	Rate ratio of inpatient days among those hospitalized*	Mean rate of inpatient days among all men (days/year)*	Likelihood of hospitalization*	Rate ratio of inpatient days among those hospitalized*	Mean rate of inpatient days among all men (days/year)*
	OR (95% CI)	(95% CI)		OR (95% CI)	(95% CI)	
International Working Group (IWG) summary definition						
Sarcopenia (*N* = 154)	1.28 (0.90, 1.82)	1.22 (0.95, 1.53)	1.78 (1.31, 2.34)†	0.91 (0.61, 1.34)	1.09 (0.89, 1.40)	1.71 (1.14, 2.40)
No sarcopenia (*N* = 1362)	1.0 (referent)	1.0 (referent)	1.27 (1.12, 1.41)	1.0 (referent)	1.0 (referent)	1.65 (1.28, 2.08)
IWG definition components						
Slowness (*N* = 388)	1.81 (1.41, 2.33)	1.28 (1.05, 1.55)	1.98 (1.61, 2.36)†	1.19 (0.89, 1.59)	1.11 (0.88, 1.39)	1.87 (1.38, 2.40)
No slowness (*N* = 1128)	1.0 (referent)	1.0 (referent)	1.11 (0.96, 1.26)	1.0 (referent)	1.0 (referent)	1.55 (1.21, 1.94)
Low lean mass (*N* = 459)	1.02 (0.81, 1.29)	1.03 (0.86, 1.23)	1.36 (1.12, 1.62)	0.95 (0.74, 1.22)	1.01 (0.85, 1.20)	1.64 (1.19, 2.07)
No low lean mass (*N* = 1057)	1.0 (referent)	1.0 (referent)	1.30 (1.13, 1.47)	1.0 (referent)	1.0 (referent)	1.66 (1.28, 2.10)
European Working Group for Sarcopenia in Older Persons (EWGSOP) summary definition						
Sarcopenia (*N* = 114)	1.27 (0.85, 1.90)	1.20 (0.92, 1.57)	1.78 (1.22, 2.46)	0.83 (0.53, 1.29)	1.06 (0.82, 1.38)	1.59 (1.05, 2.23)
No sarcopenia (*N* = 1402)	1.0 (referent)	1.0 (referent)	1.29 (1.14, 1.42)	1.0 (referent)	1.0 (referent)	1.66 (1.30, 2.06)
EWGSOP definition components						
Weakness (*N* = 189)	1.43 (1.03, 1.97)	1.15 (0.90, 1.47)	1.77 (1.30, 2.38)	1.06 (0.74, 1.51)	1.02 (0.79, 1.31)	1.73 (1.19, 2.45)
No weakness (*N* = 1327)	1.0 (referent)	1.0 (referent)	1.26 (1.12, 1.39)	1.0 (referent)	1.0 (referent)	1.65 (1.29, 2.06)
Slowness (*N* = 122)	2.01 (1.34, 3.02)	1.30 (0.99, 1.66)	2.32 (1.63, 3.04)†	1.07 (0.67, 1.71)	1.09 (0.86, 1.40)	1.83 (1.18, 2.59)
No slowness (*N* = 1394)	1.0 (referent)	1.0 (referent)	1.25 (1.10, 1.38)	1.0 (referent)	1.0 (referent)	1.63 (1.30, 2.03)
Low lean mass (*N* = 459)	1.02 (0.81, 1.29)	1.03 (0.85, 1.24)	1.36 (1.09, 1.60)	0.95 (0.74, 1.22)	1.01 (0.84, 1.20)	1.64 (1.22, 2.12)
No low lean mass (*N* = 1507)	1.0 (referent)	1.0 (referent)	1.30 (1.14, 1.48)	1.0 (referent)	1.0 (referent)	1.66 (1.31, 2.09)
Foundation for the NIH (FNIH) Sarcopenia Project primary summary definition						
Weakness w/low lean mass (*N* = 43)	0.87 (0.46, 1.64)	1.14 (0.82, 1.70)	1.38 (0.77, 2.32)	0.48 (0.24, 0.98)	0.95 (0.70, 1.35)	1.05 (0.54, 1.89)
No weakness w/low lean mass (*N* = 1473)	1.0 (referent)	1.0 (referent)	1.32 (1.19, 1.46)	1.0 (referent)	1.0 (referent)	1.68 (1.30, 2.05)
Slowness, weakness, with low lean mass (*N* = 25)	0.86 (0.37, 1.97)	1.04 (0.59, 1.83)	1.25 (0.49, 2.60)	0.46 (0.19, 1.14)	0.93 (0.55, 1.69)	0.99 (0.38, 2.25)
No slowness, weakness w/low lean mass (*N* = 1,491)	1.0 (referent)	1.0 (referent)	1.32 (1.17, 1.47)	1.0 (referent)	1.0 (referent)	1.67 (1.32, 2.08)
FNIH primary definition components						
Weakness (*N* = 103)	0.91 (0.59, 1.40)	1.19 (0.85, 1.68)	1.48 (0.94, 2.18)	0.64 (0.40, 1.04)	1.03 (0.77, 1.40)	1.37 (0.84, 2.12)
No weakness (*N* = 1,413)	1.0 (referent)	1.0 (referent)	1.31 (1.16, 1.44)	1.0 (referent)	1.0 (referent)	1.68 (1.31, 2.10)
Slowness (*N* = 122)	2.01 (1.34, 3.02)	1.30 (1.03, 1.68)	2.32 (1.72, 3.10)†	1.07 (0.67, 1.71)	1.09 (0.84, 1.40)	1.83 (1.22, 2.58)
No slowness (*N* = 1394)	1.0 (referent)	1.0 (referent)	1.25 (1.10, 1.38)	1.0 (referent)	1.0 (referent)	1.63 (1.28, 2.02)
Low lean mass (*N* = 343)	1.24 (0.96, 1.60)	1.01 (0.84, 1.22)	1.47 (1.17, 1.75)	0.93 (0.70, 1.22)	0.88 (0.71, 1.04)	1.48 (1.13, 1.91)
No low lean mass (*N* = 1,173)	1.0 (referent)	1.0 (referent)	1.28 (1.12, 1.43)	1.0 (referent)	1.0 (referent)	1.76 (1.34, 2.20)
Baumgartner definition						
Sarcopenia (*N* = 459)	1.02 (0.81, 1.29)	1.03 (0.87, 1.23)	1.36 (1.12, 1.63)	0.95 (0.74, 1.22)	1.01 (0.84, 1.19)	1.64 (1.23, 2.11)
No sarcopenia (*N* = 1057)	1.0 (referent)	1.0 (referent)	1.30 (1.14, 1.48)	1.0 (referent)	1.0 (referent)	1.66 (1.29, 2.14)

Table 2. *Continued*

	Age-adjusted			Multivariate adjusted		
	Likelihood of hospitalization*	Rate ratio of inpatient days among those hospitalized*	Mean rate of inpatient days among all men (days/year)*	Likelihood of hospitalization*	Rate ratio of inpatient days among those hospitalized*	Mean rate of inpatient days among all men (days/year)*
	OR (95% CI)	(95% CI)		OR (95% CI)	(95% CI)	
Newman definition						
Sarcopenia (N = 421)	1.03 (0.81, 1.31)	0.99 (0.83 1.19)	1.33 (1.08, 1.60)	0.89 (0.69, 1.16)	0.93 (0.77, 1.10)	1.50 (1.10, 1.96)
No sarcopenia (N = 1095)	1.0 (referent)	1.0 (referent)	1.32 (1.15, 1.48)	1.0 (referent)	1.0 (referent)	1.72 (1.33, 2.18)

Notes: Multivariate models adjusted for age, clinical center, presence of a functional limitation, self-reported health status, Elixhauser score, and Teng MMSE score. IWG: presence of slowness (gait < 1.0 m/s) and low lean mass (ALM/ht^2 ≤ 7.23 kg/m^2). EWGSOP: presence of slowness (gait ≤ 0.8 m/s) plus low lean mass (ALM/ht^2 ≤ 7.23 kg/m^2) or weakness (grip < 30 kg). FNIH primary definition: presence of both weakness (grip < 26 kg) and low lean mass (ALM/BMI < 0.789); slowness defined as gait ≤0.8 m/s. Baumgartner: ALM/ht^2 < 7.23 kg/m^2. Newman definition: The equation to calculate residuals is ALM (kg) = –22.48 + 24.14 * height (m) + 0.21 * total fat mass (kg) as derived for men in the Health ABC study (17); the cut-point for the residual is ≤–0.204 kg/m^2 (derived from the Health ABC cohort). ALM = appendicular lean mass, BMI = body mass index, EWGSOP = European Working Group for Sarcopenia in Older Persons, FNIH = Foundation for NIH Sarcopenia Project, IWG = International Working Group, NIH = National Institute of Health.

*Calculated using Logit-Poisson Hurdle model, bootstrapped CI's presented for the rate ratio of inpatient days and annualized rate of inpatient days. †Mean rate of inpatient days significantly different from those who do not meet the definition/criteria (bootstrapped 95% CI excludes 0).

Figure 1. Study participants and analysis subset.

hospitalizations, which is more tightly correlated with health care utilization compared to an analysis of time to hospitalization, as would be studied using a survival analysis. Confidence intervals are calculated by bootstrapping so as to not rely on an assumption of a truncated Poisson distribution, which is often violated with data such as ours. To determine whether mean rates of hospitalization differed by sarcopenia status (or the components of the definitions), we calculated 95% confidence intervals for the differences by bootstrapping; if the confidence interval excluded zero the rates were considered statistically different.

Models were adjusted for age and clinical site, and then additionally adjusted for multiple potential confounders (see footnote, Table 2).

Results

Characteristics of participants by sarcopenia status

In general, the prevalence of sarcopenia using the consensus definitions was low (ranged from 1.6 to 10.2%) but was moderate for the definitions that include only lean mass (that is, the Baumgartner [30.3%] and Newman definitions [27.8%]; Table 1). Across the various sarcopenia definitions, men with sarcopenia were generally older, had lower lean mass, weaker grip strength, walked more slowly, were more likely to report functional limitations, had greater comorbidity burden, worse self-rated health, and had worse cognitive function than those without sarcopenia (Table 1). The relationship between sarcopenia and BMI varied by the definition employed.

Summary definitions of sarcopenia and hospitalization

In age and clinical center adjusted models, none of the summary definitions of sarcopenia were associated with the likelihood of hospitalization or the rate ratio of inpatient days among those hospitalized (Table 2). There was a suggestion of a modestly higher mean rate of inpatient days for all participants for those who met the IWG summary definition, and for the slowness component for all definitions.

After multivariate adjustment, none of the summary definitions of sarcopenia were associated with likelihood of hospitalization, the rate ratio of inpatient days among those hospitalized, or the mean rate of impotent days for all participants.

Components of definitions of sarcopenia and hospitalization

In age-adjusted models, slowness by any definition was associated with greater likelihood of hospitalization, a higher rate ratio of inpatient days amongst those hospitalized, and a greater mean number of days hospitalized amongst all participants.

There was a suggestion that weakness by the EWGSOP definition was associated with the likelihood of hospitalization and a greater mean rate of inpatient days amongst all participants, but not with a higher rate ratio of inpatient days amongst those hospitalized. None of the other components of the various definitions, including any measure of lean mass, were associated with hospitalization.

When adjusted for additional potential confounders, none of the definition components (slowness, weakness or low lean mass) were associated with the likelihood of hospitalization, the rate ratio of inpatient days among those hospitalized, or the mean rate of inpatient days amongst all participants. For the models examining slowness, adjustment for confounding factors attenuated the association with hospitalization.

None of the alternative FNIH or Newman definitions of sarcopenia (Supplementary Table) were associated with hospitalization in age and clinical center adjusted or multivariate adjusted models.

Discussion

In this cohort of community-dwelling men enrolled in Medicare Fee-for-Service, none of the definitions of sarcopenia evaluated were independently associated with likelihood of hospitalization, the rate ratio of inpatient days once hospitalized, or the mean rate of hospitalization amongst all participants. In addition, none of the components of these sarcopenia definitions (eg, slowness, weakness, or low lean mass) were independently associated with hospitalization.

Our results are consistent with our previous study in women in that none of the summary definitions of sarcopenia were associated with hospitalization. However, unlike our previous study in older women, slowness in men was not independently associated with hospitalization. Although significant in age and clinical center adjusted models, the association between slowness and hospitalization was strongly attenuated after adjustment by confounding factors. It is possible that this reflects a sex difference, in that walking speed may be more strongly associated with hospitalization in women than in men. Women have greater disability burden than men (16) and perhaps these discrepant findings reflect such sex differences. On the other hand, the discrepant results may also reflect differences between the cohorts and analytic strategy, as the current analysis in men accounted for somewhat different confounding factors than the study in women (due to different data collection in the cohorts), and the studies were completed during different calendar years amongst participants recruited from different geographical areas. In addition, women in the previous study were older and had slower walking speed than the men in the present analyses; perhaps a greater prevalence of slowness led to the different findings.

Other studies have suggested a relationship between sarcopenia and health care costs (17); and such studies are often cited to justify the development of interventions to combat sarcopenia (18). However, we did not find a strong association between sarcopenia and health care utilization as measured by hospitalization (although we did not specifically estimate costs; this will be a topic of future research). It is unlikely that specific investigation of cost per se would significantly alter our overall conclusion that sarcopenia as currently defined is largely unrelated to health care use once confounding factors are taken into account. Finally, our results are generally congruent with the Portuguese hospitalized patient study, as in that study, sarcopenia was not associated with length of hospital stay amongst individuals aged ≥65 years (7). A study of sarcopenia and health care costs, limited to hospitalized European adults (7), found that while presence of sarcopenia was associated with greater cost, the increased cost was greater among younger, rather than older, adults. It is possible an analysis similar to ours but in a younger population would find different results.

Why is there no association between the current definitions of sarcopenia and hospitalization in men? It could be that sarcopenia—regardless of the construct and specific definition used to define it—is unrelated to health care use. An alternative is that the definitions as currently constructed are incorrect, and that revision of these definitions would reveal an association between sarcopenia and hospitalization. The definitions evaluated herein were mostly based on expert opinion, or were developed using data-driven approaches against a narrow range of outcomes. Changes or updates to sarcopenia definitions by validating against a wider range of outcomes might yield different findings. In addition, some of these definitions are comprised of factors related to mobility, rather than just muscle mass alone, and therefore reflect a broader concept of sarcopenia that incorporates function rather than just a low absolute amount of muscle.

Our study has several strengths. We used data from a very well characterized cohort of older community-dwelling men and determined health care use through linkage to Medicare claims data. However, a number of important limitations must be noted. First, our study included relatively healthy older men; thus, generalizations to other populations such as younger adults and the institutionalized may be limited. For example, individuals with many previous hospitalizations may not have been healthy enough to attend the MrOS clinic visit, and it is unknown whether these findings would be similar in such a population. Second, the data were subset to men with data from Medicare FFS which may also limit generalizability to those who receive care from other health care systems. Third, our sample size was relatively small and we have had somewhat limited power to detect small effects. Although the prevalence of sarcopenia was low by some definitions, the relative size of the effect estimates were modest and confidence intervals excluded strong effect sizes which suggests that our study did not miss large, clinically important effects. Given the observational nature of this study, we may not have fully accounted for the potentially confounding factors, either by omission or through poor assessment. For example, our measure of functional status is not from a validated scale, and we have no information about diet or nutritional status; therefore, our accounting for functional status and diet may not be accurate, and the confounding effects of these factors may still be present.

In summary, sarcopenia was not associated hospitalization in community-dwelling older men. These results provide further evidence that current sarcopenia definitions are unlikely to identify those who are most likely to have greater hospitalization.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

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Disclosures

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