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Research Article

Sarcopenia and Health Care Utilization in Older Women

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Abstract

Background: Although there are several consensus definitions of sarcopenia, their association with health care utilization has not been studied.
Methods: We included women from the prospective Study of Osteoporotic Fractures with complete assessment of sarcopenia by several definitions at the Study of Osteoporotic Fractures Year 10 (Y10) exam (1997–1998) who also had available data from Medicare Fee-For-Service Claims (*N* = 566) or Kaiser Encounter data (*N* = 194). Sarcopenia definitions evaluated were: International Working Group, European Working Group for Sarcopenia in Older Persons, Foundation for the NIH Sarcopenia Project, Baumgartner, and Newman. Hurdle models and logistic regression were used to assess the relation between sarcopenia status (the summary definition and the components of slowness, weakness and/or lean mass) and outcomes that included hospitalizations, cumulative inpatient days/year, short-term (part A paid) skilled nursing facility stay in the 3 years following the Y10 visit.
Results: None of the consensus definitions, nor the definition components of weakness or low lean mass, was associated with increased risk of hospitalization or greater likelihood of short-term skilled nursing facility stay. Women with slowness by any criterion definition were about 50% more likely to be hospitalized; had a greater rate of hospitalization days amongst those hospitalized; and had 1.8 to 2.1 times greater likelihood of a short-term skilled nursing facility stay than women without slowness. There was the suggestion of a protective association of low lean mass by the various criterion definitions on short-term skilled nursing facility stay.
Conclusion: Estimated effects of sarcopenia on health care utilization were negligible. However, slowness was associated with greater health care utilization.

Keywords: Epidemiology—Fee for service—Women—Walking speed

Sarcopenia has been conceptualized as the loss of muscle mass and accompanying decline in physical performance seen with advancing age (1,2). Early operational definitions of sarcopenia included only appendicular lean mass (ALM) from dual energy x-ray absorptiometry (3). More recently, consensus groups have proposed clinical definitions of sarcopenia that also include muscle strength and/or physical performance in addition to lean body mass (2,4,5).

Previous reports have investigated the possible link between sarcopenia and various health outcomes including falls, fractures, and mortality (6,7), but there are little data regarding health care utilization

or cost associated with the various sarcopenia definitions in community dwelling adults. A paper by Janssen estimated the costs associated with sarcopenia (defined by low ALM/height^2 alone) as \$18.5 billion in 2000 (8). However, this study has a number of limitations. First, the authors did not use participant level cost estimates. Second, they utilized a number of assumptions which may have over- or underestimated the true costs of sarcopenia. Finally, unlike the three more recently proposed definitions of sarcopenia, the authors did not include measures of strength or physical performance in the definition of sarcopenia. Some components of the sarcopenia definitions, namely walking

speed and strength, have been associated with increased risk of hospitalization in older adults (9,10), but it is unknown whether all of the various sarcopenia definitions are similarly related to hospitalizations or post-hospital skilled nursing facility (SNF) stays intended for rehabilitation. There are at least two compelling reasons to describe the relation between sarcopenia and health care utilization. First, such analyses will allow us to test the general hypothesis that those with sarcopenia are less robust than those without, and are therefore more likely to have higher risks of a variety of health outcomes including greater health care use. Second, increased health care cost and burden are often cited as one reason for developing interventions to thwart sarcopenia (11), and data to support or refute such an association would provide guidance about the potential utility of such interventions.

Using Medicare Fee-For-Service (FFS) claims data and Kaiser Encounter data linked to cohort data from the Study of Osteoporotic Fractures (SOF), a prospective cohort study of older women, we aimed to determine whether sarcopenia status as delineated by a variety of definitions (and the individual components of these definitions) was associated with future health care utilization, including hospitalization, and short-term stay in SNF.

Methods

In 1986–1988, 9,704 ambulatory Caucasian women were recruited to participate in the SOF at four academic U.S. clinical centers (12). Black women were initially excluded due to their low incidence of fractures; at the Year 10 SOF visit (1997–1998), 662 black women were recruited, bringing total enrollment to 10,366 women. Participants returned to the clinical centers approximately every 2 years for assessment.

Medicare Data Linkage

Linkage of the SOF cohort to Medicare claims data was completed as previously described (13,14). Of the 10,366 women enrolled in the SOF, 9,986 were alive as of January 1, 1991, and of these women, 9,381 (93.9%) were determined to be valid linkages to Medicare claims data. Participants at the SOF Portland site were originally recruited into the study through membership in the Kaiser Permanente Northwest health plan, and thus there was a high rate (96%) of Medicare Advantage enrollment (Part C plan) at this site. Thus, SOF Portland participants were also linked to Kaiser Permanente Northwest Encounter records as of January 1, 1991. In combining Medicare claims and Kaiser Permanente Northwest encounter records, 9,381 SOF participants (93.9% of surviving SOF participants as of January 1, 1991) were linked to claims data.

Clinic Measures

Whole-body dual energy x-ray absorptiometry scans were completed at the Year 10 visit on Hologic QDR-2000 scanners. Women walked at their usual pace over a 6-meter course; the average speed of two trials in meters/second was calculated. Grip strength was measured twice on each hand using handheld Jamar dynamometers; maximum strength was analyzed. Ability and time to rise from a chair five times was assessed. Participants self-reported functional limitations (any difficulty with activities of daily living or instrumental activities of daily living: walking 2–3 blocks, climbing up 10 steps, preparing meal, heavy housework, shopping); alcohol use (any vs none); smoking status (current vs past or never); history of fracture since age 50; physician diagnosis of medical conditions (see footnote, Table 2). Height was measured with stadiometers and weight using balance beam scales; body mass index (BMI) was calculated as weight (kg)/height^2 (m^2).

Hospitalization and Short-term SNF Stay

Days of hospitalization were derived for participants enrolled in Medicare FFS using their MEDPAR inpatient claims. For women at the SOF Portland site, we used Kaiser Encounter data to determine hospitalization and cumulative inpatient days.

For women enrolled in FFS, short-term stays in SNF designed to provide skilled nursing and rehabilitation were determined as the Medicare Part A covered benefit that followed an inpatient stay. Women with Kaiser Encounter data were excluded from the short-term SNF stays analyses.

Enrollment in Medicare and Kaiser fluctuated over time, thus the follow-up time was limited to 3 years after the Year 10 clinic visit.

Sarcopenia Definitions

Published operational definitions for sarcopenia include: Baumgartner (3); Newman (15); the International Working Group (IWG) (5); the European Working Group on Sarcopenia Older Persons (EWGSOP) (4); European Society for Clinical Nutrition and Metabolism Special Interest Group on cachexia-anorexia in chronic wasting diseases (ESPEN) (16); the Society of Sarcopenia, Cachexia, and Wasting Disorders (SCWD) (17); and the Foundation for the NIH Sarcopenia Project (FNIH Sarcopenia Project) (2) (Table 1). The ESPEN and SCWD recommendations were similar to EWGSOP and IWG, respectively, and therefore were not analyzed separately. All of the consensus definitions of sarcopenia are similar in that all combine lean mass assessed by dual energy x-ray absorptiometry with a strength and/or a physical performance component as part of a summary index; the Newman and Baumgartner definitions rely on lean mass estimates without strength or walking speed.

Analysis Sample

At the Year 10 visit, 7,670 women provided at least some data (5,470 had a clinic visit, 566 had a home visit, 1,634 completed questionnaires). Of those who completed a clinic visit, a random subset ($N = 1,285$) also completed a whole-body dual energy x-ray absorptiometry scan. Valid data for ALM, total fat, height, weight, grip strength, and gait speed were available for 1,236 women. Of these, 1,176 women were enrolled in Medicare or Kaiser at any point following their Year 10 clinic visit, and 831 were enrolled in FFS or Kaiser in at least the month following their Year 10 clinic visit. Of these, 760 women were enrolled in FFS or Kaiser for at least 3 years following Year 10 (or died within 3 years following Year 10) and had completed data for covariates and were included in the hospitalization analyses. Of these, 566 were enrolled in FFS and were included in the short-term SNF stay analyses (Figure 1).

Statistical Analyses

We used two-part models ("hurdle" models) (18) 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 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 counts of inpatient data were estimated using log-link functions. We used logistic regression to estimate the odds ratios of short-term SNF stays associated with sarcopenia status. All models were adjusted for covariates

Table 1. Criteria and Prevalence for Consensus Definitions of Sarcopenia in the Study of Osteoporotic Fractures (SOF)

	Slowness		Weakness		Low Lean Mass		Summary Definition	
	Definition	Prevalence	Definition	Prevalence	Definition	Prevalence	Definition	Prevalence
International Working Group (IWG)	Gait speed <1.0 m/s	70.4%	Not included	N/A	$ALM/ht^2 \leq 5.67\,kg/m^2$	22.6%	Sarcopenia: both slowness and weakness	16.3%
European Working Group on Sarcopenia Older Persons (EWGSOP)	Gait speed ≤0.8 m/s	30.4%	Grip strength <20 kg	62.1%	$ALM/ht^2 \leq 5.67\,kg/m^2$	22.6%	(a) Sarcopenia: low lean mass plus either slowness or weakness (b) Severe sarcopenia: all three criteria	Sarcopenia: 19.0% Severe sarcopenia: 6.1%
Foundation for the NIH (FNIH) Sarcopenia Project primary definition	Gait speed ≤0.8 m/s	30.4%	Grip strength <16 kg	32.6%	ALM/BMI < 0.512	19.1%	(a) weakness and low lean mass (b) slowness with weakness and low lean mass*	Weakness and low lean mass: 8.3% Slowness with weakness and low lean mass: 4.3%
FNIH Sarcopenia Project alternative definition	Gait speed ≤0.8 m/s	30.4%	Grip strength <16 kg	32.6%	ALM < 15.02	36.3%	(a) weakness and low lean mass (b) slowness with weakness and low lean mass*	Weakness and low lean mass: 18.3% Slowness with weakness and low lean mass: 7.6%
Baumgartner	Not included	N/A	Not included	N/A	$ALM/ht^2 < 5.45\,kg/m^2$	15.3%	Presence of low lean mass	15.3%
Newman	Not included	N/A	Not included	N/A	Residual of actual ALM – predicted ALM from equation† $\leq -1.53\,kg/m^2$	20.0%	Presence of low lean mass	20.0%

Notes: *Since prevalence of EWGSOP severe sarcopenia was low, both sarcopenia and severe sarcopenia were analyzed together. The prevalence of FNIH "slowness with weakness and low lean mass" was also uncommon to it was not analyzed separately.

†The equation used to calculate residuals was ALM (kg) = −13.19 + 14.75 × height (m) + 0.23 × total fat mass (kg) as derived for women in the Health ABC study (17).
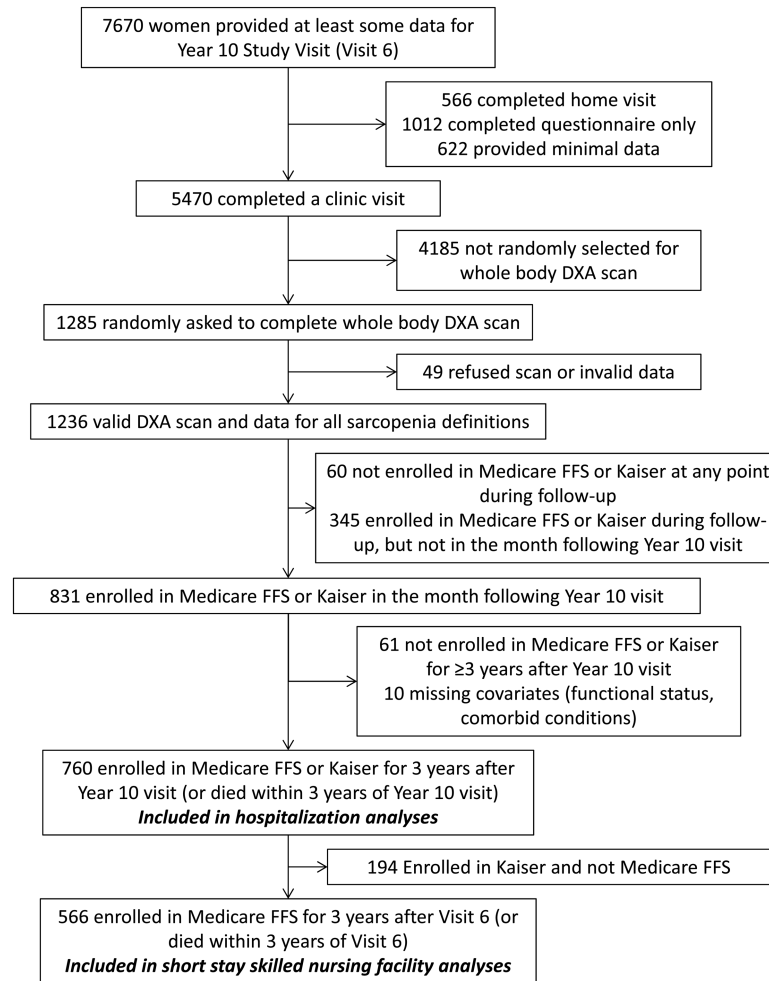
ALM = appendicular lean mass.

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┌─────────────────────────────────────────────┐
│ 7670 women provided at least some data for   │
│        Year 10 Study Visit (Visit 6)         │
└─────────────────────────────────────────────┘
                      │
                      │      ┌──────────────────────────────────┐
                      ├─────▶│ 566 completed home visit         │
                      │      │ 1012 completed questionnaire only│
                      │      │ 622 provided minimal data        │
                      ▼      └──────────────────────────────────┘
┌─────────────────────────────────────┐
│    5470 completed a clinic visit     │
└─────────────────────────────────────┘
                      │
                      │      ┌──────────────────────────────────┐
                      ├─────▶│ 4185 not randomly selected for   │
                      │      │        whole body DXA scan        │
                      ▼      └──────────────────────────────────┘
┌──────────────────────────────────────────────────────┐
│ 1285 randomly asked to complete whole body DXA scan  │
└──────────────────────────────────────────────────────┘
                      │
                      │      ┌──────────────────────────────────┐
                      ├─────▶│ 49 refused scan or invalid data  │
                      ▼      └──────────────────────────────────┘
┌────────────────────────────────────────────────────────┐
│ 1236 valid DXA scan and data for all sarcopenia        │
│ definitions                                            │
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                      │      ┌────────────────────────────────────────────┐
                      ├─────▶│ 60 not enrolled in Medicare FFS or Kaiser   │
                      │      │     at any point during follow-up           │
                      │      │ 345 enrolled in Medicare FFS or Kaiser      │
                      │      │     during follow-up, but not in the month  │
                      │      │     following Year 10 visit                 │
                      ▼      └────────────────────────────────────────────┘
┌──────────────────────────────────────────────────────────┐
│ 831 enrolled in Medicare FFS or Kaiser in the month      │
│          following Year 10 visit                          │
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                      │
                      │      ┌────────────────────────────────────────────┐
                      ├─────▶│ 61 not enrolled in Medicare FFS or Kaiser   │
                      │      │     for ≥3 years after Year 10 visit        │
                      │      │ 10 missing covariates (functional status,   │
                      │      │     comorbid conditions)                    │
                      ▼      └────────────────────────────────────────────┘
┌──────────────────────────────────────────────────────────┐
│ 760 enrolled in Medicare FFS or Kaiser for 3 years after │
│ Year 10 visit (or died within 3 years of Year 10 visit)  │
│ *Included in hospitalization analyses*                   │
└──────────────────────────────────────────────────────────┘
                      │
                      │      ┌──────────────────────────────────────────┐
                      ├─────▶│ 194 Enrolled in Kaiser and not Medicare   │
                      │      │     FFS                                    │
                      ▼      └──────────────────────────────────────────┘
┌──────────────────────────────────────────────────────────┐
│ 566 enrolled in Medicare FFS for 3 years after Visit 6 (or│
│ died within 3 years of Visit 6)                          │
│ *Included in short stay skilled nursing facility analyses*│
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Figure 1. Inclusion of participants in analyses.

(see footnote, Table 3). Women were censored at time of death, outcome or end of follow-up period (3 years after the clinic visit).

Results

Characteristics of participants by hospitalization status are presented in Table 2. Women who were hospitalized during follow-up were older, had worse physical performance, reported more functional limitations, were less likely to consume alcohol and had a greater comorbidity burden than women who were not hospitalized. There were no differences by hospital status in race, lean mass (by any definition), grip strength, body size, fracture history, or smoking status. Characteristics of participants by presence or absence of sarcopenia for each definition are presented in Supplementary Table 1. Women with sarcopenia by any definition were older than those without, except for the Newman definition where age was similar. Women classified as having sarcopenia (by any definition) were weaker and had lower lean mass than those classified as not having sarcopenia. Associations between sarcopenia classification and other covariates varied by the definition utilized.

Sarcopenia and Hospitalization Status

In the 3 years after the sarcopenia assessment, of the 760 women in the analysis, 342 (45.0%) experienced at least one hospitalization. Estimated effects of sarcopenia status on health care utilization were

negligible and many had confidence intervals that excluded clinically important effect sizes (Table 3). Slowness, by either the FNIH or EWGSOP definition (≤0.8 m/s), or IWG definition (<1.0 m/s), was associated with an increased likelihood of hospitalization. None of the other components of sarcopenia were associated with likelihood of hospitalization. Only the slowness component of the FNIH or EWGSOP definitions (≤0.8 m/s) had a borderline association with the rate ratio of inpatient days once hospitalized; none of the other definitions or their components was associated with an increased rate of inpatient days once hospitalized. The mean rate of inpatient days among all women was significantly higher in those who met the slowness definition by IWG (<1.0 m/s) or FNIH/EWGSOP (≤0.8 m/s), but did not differ for the other summary definitions or their components.

Sarcopenia and Likelihood of Short-term SNF Stay

In the 3 years after the sarcopenia assessment, of the women with available data, 75 (13.3%) women had at least one short-term SNF stay. Slowness by the IWG definition (walking speed <1.0 m/s) or the FNIH definition/EWGSOP definition (≤0.8 m/s) was associated with 1.8- to 2.1-fold-increased likelihood of short-term SNF stay (Table 3). Low lean mass by the FNIH primary definition (ALM/BMI<0.512) and FNIH alternative definition (ALM < 15.02 kg) were associated with a lower likelihood of SNF stay, and the association between low lean mass by other definitions (IWG or EWGSOP

Table 2. Characteristics of Participants by Hospitalization Status During Follow-up

	No Hospitalization During Follow-up (N = 418)	At Least One Hospitalization During Follow-up (N = 342)
Age (y)	**76.9 ± 4.6**	**78.0 ± 5.1**
White race	220 (52.6)	168 (49.1)
Weight (kg)	69.6 ± 13.8	70.5 ± 15.3
Height (m)	158.4 ± 5.8	158.1 ± 6.4
BMI (kg/m^2)	27.7 ± 5.3	28.2 ± 5.9
ALM/ht^2 (kg/m^2)	6.4 ± 1.0	6.5 ± 1.1
ALM (kg)	16.1 ± 2.8	16.3 ± 3.0
ALM/BMI	0.59 ± 0.08	0.59 ± 0.09
Residual of ALM: actual ALM – predicted ALM from equation† (kg)	0.21 ± 2.15	0.26 ± 2.30
Grip strength (kg)	18.5 ± 4.8	18.2 ± 4.6
Walking speed (m/s)	**0.93 ± 0.19**	**0.83 ± 0.23**
Chair stands time (s)	**13.8 ± 5.4**	**15.5 ± 7.1**
Inability to rise from chair	**39 (9.3)**	**60 (17.5)**
Functional limitations	**142 (34.0)**	**200 (58.5)**
History of fracture since age 50	149 (35.7)	134 (39.2)
Smoking	29 (6.9)	27 (7.9)
Alcohol	**169 (40.4)**	**110 (32.3)**
Comborbidity*		
0	**85 (20.3)**	**35 (10.2)**
1–2	**261 (62.4)**	**181 (52.9)**
3+	**72 (17.2)**	**126 (36.8)**

Notes: Bold text indicates *p* < .05.

*Rheumatoid arthritis, osteoarthritis, diabetes, chronic obstructive pulmonary disease (COPD), angina, hypertension, congestive heart failure, heart attack, hyperthyroid, Parkinson's disease and stroke.

†From the Newman sarcopenia definition: ALM (kg) = –13.19 + 14.75 × height (m) + 0.23 × total fat mass (kg) as derived for women in the Health ABC study (17); the cut-point for the residual was ≤ –1.53 kg/m^2.

ALM = appendicular lean mass; BMI = body mass index.

or Baumgartner, ALM/ht^2 ≤ 5.67 kg/m^2 and Newman, residual ≤ –1.53 kg/m^2) suggested a lower likelihood of short-term SNF stay, however, the associations were not statistically significant. None of the other definitions or their components was significantly associated with short-term SNF stay.

Discussion

In this cohort of community dwelling older women, none of the consensus definitions of sarcopenia evaluated was associated with measures of health care utilization, specifically hospitalization and short-term SNF stay. Weakness (low grip strength) was unrelated to these health care utilization outcomes, regardless of the specific criterion definition used. Low lean mass was not associated with hospitalization, although there was the suggestion of a protective effect of low lean mass (by the various definition criteria) on risk of short-term SNF stay. On the other hand, women with slowness compared to those without slowness were more likely to be hospitalized, had a greater rate of hospitalization and were more likely to have a short-term SNF stay.

Our results differ somewhat from a previous study of the relation between sarcopenia and hospitalization in older Chinese men and women in Hong Kong (6). In that study, sarcopenia (by a variety of definitions) was generally associated with greater likelihood of having more than 20 days of hospitalization over 7 years in men; in women, the associations were of borderline significance but power was limited as few participants experienced the outcome. The differences between these studies may be due to study design (such as the length of follow-up or the definition of the outcome). On the other hand, these results may indicate that sarcopenia definitions have different associations with various outcomes in different populations; further research using similar analysis techniques and identical outcome definitions will more directly address this issue.

The associations we observed between slowness and health care utilization, rather than weakness or low lean mass, may reflect the multifactorial nature of the determinants of walking speed and slowness. Many disparate factors are associated with impaired walking speed, including arthritis (19), cardiopulmonary disease and deficits (20), poor cognitive function (21), and many other conditions (22). Thus, given the multifactorial nature of deficits in walking speed, slowness may be a better measure of overall health than weakness or low lean mass, and this may explain why we observed that slowness was more strongly related to acute inpatient and SNF utilization than measures of lean mass or weakness.

The suggestion of a protective effect of low lean mass on short-term SNF stay warrants further discussion, as this finding does not support the hypothesis that low lean mass is detrimental to health outcomes. One explanation for this association may be that there is a U-shaped relationship between lean mass and short-term SNF stay, whereby women with the either highest or lowest lean mass have the highest risk of short-term SNF stay relative to women with intermediate levels of lean mass. It may be that in the SOF study of generally healthy women, there are few with particularly low lean mass and that the current low lean mass cut-points do not adequately identify those with extremely low lean mass that may be associated with poor health. In this scenario, we would also observe a higher risk of SNF stay among those with the very highest lean mass, as these individuals would have high lean mass due to obesity and very large body size rather than from greater fitness or physical activity. Therefore, under this theory, we observed a protective effect of low lean mass since there were too few low values to reflect a detrimental effect. It may be that a larger study in a population with lower lean mass values would demonstrate different associations. On the other hand, it may be that low lean mass is, in fact, protective for SNF stay, either directly, or through its correlation to greater body size and obesity.

Our results are similar to previous reports that demonstrate a strong association between measured walking speed and hospitalization risk (9,10). In addition, self-reported inability to walk ¼ mile has been associated with greater health care costs and more hospitalizations (23). Furthermore, in previous analyses in older men, we found that the strongest association between sarcopenia definitions (and their components) and clinical outcomes including falls, fractures, disability and mortality were between slowness and these outcomes, but with nonsignificant or less strong associations for the other components (weakness, low lean mass) or the summary definitions (article in press). Thus, we generally conclude that any associations between consensus definitions of sarcopenia and clinical outcomes are likely due to the slowness component of these definitions. These data provide further evidence that slowness, rather than sarcopenia per se, may be the most useful identifying individuals at greatest risk of adverse health outcomes.

In contrast to the findings of Janssen (8), we did not find a strong relationship between sarcopenia and health care utilization, although in this report we did not specifically estimate costs. However, health

Table 3. Association Between Various Definitions of Sarcopenia and Hospitalization (*N* = 760) and Short-term Nursing Facility (SNF) Stay (*N* = 566) Over 3 Years in Older Women

	Likelihood of Hospitalization* OR (95% CI)	Rate Ratio of Inpatient Days Among Those Hospitalized* (95% CI)	Mean Rate of Inpatient Days Among All Women (d/y)*	Likelihood of SNF Stay[†] (OR, 95% CI)
IWG summary definition				
Sarcopenia	1.19 (0.78–1.83)	0.89 (0.72–1.16)	1.36 (0.96–1.78)	0.72 (0.34–1.54)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.39 (1.17–1.58)	1.00 (referent)
IWG definition components				
Slowness	1.55 (1.08–2.21)	1.06 (0.80–1.44)	1.50 (1.23–1.76)	1.81 (0.87–3.77)
No slowness	1.00 (referent)	1.00 (referent)	1.10 (0.79–1.46)	1.00 (referent)
Low lean mass	0.94 (0.64–1.37)	0.88 (0.71–1.11)	1.22 (0.89–1.59)	0.52 (0.25–1.09)
No low lean mass	1.00 (referent)	1.00 (referent)	1.43 (1.21–1.65)	1.00 (referent)
European Working Group for Sarcopenia in Older Persons (EWGSOP) summary definition				
Sarcopenia	0.96 (0.64–1.44)	0.92 (0.75–1.17)	1.27 (0.91–1.70)	0.47 (0.21–1.06)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.41 (1.19–1.61)	1.00 (referent)
EWGSOP definition components				
Weakness	0.87 (0.63–1.22)	1.26 (0.93–1.70)	1.47 (1.18–1.73)	1.19 (0.67–2.13)
No weakness	1.00 (referent)	1.00 (referent)	1.26 (0.94–1.57)	1.00 (referent)
Slowness	1.43 (1.00–2.04)	1.27 (0.99–1.65)	1.84 (1.37–2.36)	2.14 (1.22–3.73)
No slowness	1.00 (referent)	1.00 (referent)	1.20 (0.98–1.37)	1.00 (referent)
Low lean mass	0.94 (0.64–1.37)	0.88 (0.71–1.11)	1.22 (0.90–1.56)	0.52 (0.25–1.09)
No low lean mass	1.00 (referent)	1.00 (referent)	1.43 (1.19–1.65)	1.00 (referent)
Foundation for the NIH (FNIH) Sarcopenia Project primary summary definition				
Weakness with low lean mass	0.82 (0.47–1.43)	0.93 (0.69–1.27)	1.17 (0.72–1.69)	0.47 (0.17–1.29)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.40 (1.19–1.59)	1.00 (referent)
FNIH primary definition components				
Weakness	0.97 (0.69–1.38)	1.31 (1.04–1.59)	1.64 (1.25–2.02)	0.83 (0.47–1.49)
No weakness	1.00 (referent)	1.00 (referent)	1.28 (1.05–1.48)	1.00 (referent)
Slowness	1.43 (1.00–2.04)	1.27 (1.00–1.67)	1.84 (1.37–2.36)	2.14 (1.22–3.73)
No slowness	1.00 (referent)	1.00 (referent)	1.20 (0.99–1.39)	1.00 (referent)
Low lean mass	0.99 (0.67–1.46)	1.00 (0.80–1.27)	1.37 (0.99–1.80)	0.47 (0.23–0.96)
No low lean mass	1.00 (referent)	1.00 (referent)	1.39 (1.15–1.60)	1.00 (referent)
FNIH alternative summary definition				
Weakness with low lean mass	0.92 (0.60–1.39)	1.06 (0.83–1.39)	1.40 (0.96–1.89)	0.36 (0.16–0.80)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.38 (1.16–1.55)	1.00 (referent)
FNIH alternative definition components				
Weakness	0.97 (0.69–1.38)	1.31 (1.04–1.65)	1.64 (1.25–2.06)	0.83 (0.47–1.49)
No weakness	1.00 (referent)	1.00 (referent)	1.28 (1.05–1.48)	1.00 (referent)
Slowness	1.43 (1.00–2.04)	1.27 (0.99–1.66)	1.84 (1.41–2.37)	2.14 (1.22–3.73)
No slowness	1.00 (referent)	1.00 (referent)	1.20 (0.97–1.37)	1.00 (referent)
Low lean mass	0.86 (0.62–1.20)	1.00 (0.80–1.30)	1.31 (0.98–1.66)	0.37 (0.20–0.69)
No low lean mass	1.00 (referent)	1.00 (referent)	1.42 (1.16–1.64)	1.00 (referent)
Baumgartner definition				
Sarcopenia	1.09 (0.70–1.68)	0.87 (0.68–1.14)	1.27 (0.90–1.70)	0.58 (0.25–1.36)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.40 (1.18–1.61)	1.00 (referent)
Newman definition				
Sarcopenia	1.10 (0.75–1.61)	0.80 (0.65–0.98)	1.21 (0.91–1.50)	0.57 (0.28–1.19)
No sarcopenia	1.00 (referent)	1.00 (referent)	1.43 (1.19–1.67)	1.00 (referent)

Notes: Models adjusted for age, clinical center, functional limitations (any difficulty with activities of daily living or instrumental activities of daily living: walking 2–3 blocks, climbing up 10 steps, preparing meal, heavy housework, shopping), and comorbidity score (none, 1, or 2 or more from the list of prevalent fracture, arthritis, diabetes, chronic obstructive pulmonary disease [COPD], angina, hypertension, congestive heart failure [CHF], MI, Parkinson's, stroke, thyroid problem). IWG: presence of slowness (gait < 1.0 m/s) and low lean mass (ALM/ht^2 ≤ 5.67 kg/m^2). EWGSOP: presence of slowness (gait ≤0.8 m/s) plus low lean mass (ALM/ht^2 ≤ 5.67 kg/m^2) or weakness (grip < 20 kg). FNIH primary definition: Presence of both weakness (grip < 16 kg) and low lean mass (ALM/BMI < 0.512); slowness defined as gait ≤0.8 m/s. FNIH alternative definition: Presence of both weakness (grip < 16 kg) and low lean mass (ALM<0.15.02); slowness defined as gait ≤0.8 m/s. Baumgartner: ALM/ht^2 < 5.45 kg/m^2. Newman: Residual of actual ALM – predicted ALM from prediction equation ≤ – 1.53 kg/m^2.

*Calculated using Logit-Poisson Hurdle model, bootstrapped CI's presented for annualized rate of inpatient days. Analyses limited to women with Medicare Fee-for-Service claims (all clinics) or Kaiser Encounter data (Portland clinic only). *N* = 760.

[†]Calculated using logistic regression. Analyses limited to women with Medicare Fee-for-Service claims (all clinics). *N* = 566.

ALM = appendicular lean mass; BMI = body mass index; CI = confidence interval; EWGSOP = European Working Group for Sarcopenia in Older Persons; FNIH = Foundation for NIH Sarcopenia Project; IWG = International Working Group; MI = myocardial infarction; NIH = National Institute of Health.

care utilization and cost should demonstrate similar relationships with sarcopenia, and it is unlikely that specific investigation of cost per se would significantly alter our overall conclusions.

Our study has several strengths. We used data from a very well characterized cohort of older community dwelling women and determined health care use through a unique linkage to both Medicare claims and Kaiser Encounter data. However, a number of important limitations must be noted. First, our study included mostly white older women who were healthy enough to return to our clinical centers, so generalizations to other populations such as younger adults, other races, men and the institutionalized may be limited. Second, the data were subset to women with data from Medicare FFS and/or Kaiser, which may also limit generalizability to other health care systems. Third, our sample size was relatively small limiting our power to detect small to moderate effects. However, given our point estimates and confidence intervals, any detrimental effect of sarcopenia on health care use that we would have missed would be of marginal clinical importance. Fourth, the prevalence of sarcopenia varies markedly by definition, and there is no gold standard definition of sarcopenia. With new and evolving definitions for sarcopenia currently under development, it is possible that a future definition of sarcopenia would identify women who would have greater health care utilization.

In summary, we found that slowness was associated with increased health care utilization in older women. In general we did not find evidence of increased health care utilization for those classified with sarcopenia, weakness, or low lean mass by a variety of proposed definitions. Thus, current sarcopenia definitions are unlikely to identify older women who are likely to have greater health care utilization.

Supplementary Material

Please visit the article online at http://biomedgerontology.oxfordjournals.org/ to view supplementary material.

Funding

Conflict of Interest

P.M.C. reports consulting with Eli Lilly and Kinemed, and grants to her institution from Eli Lilly, GSK, IMS Health and Merck, all for work outside of this manuscript. All other authors report no conflicts.

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