Body Composition in Healthy Aging

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ABSTRACT: Health risks in elderly people cannot be evaluated simply in conventional terms of body fatness or fat distribution. Elderly people have less muscle and bone mass, expanded extracellular fluid volumes, and reduced body cell mass compared to younger adults. These nonfat components of body composition play critical roles, influencing cognitive and physical functional status, nutritional and endocrine status, quality of life, and comorbidity in elderly people. Different patterns of "disordered body composition" have different relationships to these outcomes and may require different, tailored approaches to treatment that combine various exercise regimens and dietary supplements with hormone replacement or appetite-stimulating drugs. Skeletal muscle atrophy, or "sarcopenia," is highly prevalent in the elderly population, increases with age, and is strongly associated with disability, independent of morbidity. Elders at greatest risk are those who are simultaneously sarcopenic and obese. The accurate identification of sarcopenic obesity requires precise methods of simultaneously measuring fat and lean components, such as dual-energy X-ray absorptiometry.

INTRODUCTION

Health risks in elderly people cannot be evaluated simply in conventional terms of body fatness and fat distribution. Elderly people have less muscle and bone mass, expanded extracellular fluid volumes, and reduced body cell mass compared to younger adults.[1,2] Nonfat components of body composition play critical roles influencing health in elderly people. *Health* must be defined broadly in elderly people in terms of interrelated dimensions of cognitive and physical functional status, nutritional and endocrine status, quality of life, and comorbidity. The term *frailty* is applied to elderly people with multiple problems in these dimensions who are at increased risk for mortality.[3] Changes in body composition in old age cannot be viewed simplistically as a result of changes in the balance between energy intake and expenditure; they also include complex changes in the hormones regulating metabolism, such as growth and sex hormones.[4,5] It is controversial, however, whether replacement of these hormones improves body composition or enhances the effects of exercise.[6–8] Age-related changes in the dietary intake, absorption, and metabolism of fat, protein, fiber, vitamins, and minerals also are important factors.[9] The associations of these factors with body composition must be considered within the background of the high burden of chronic morbidity in elderly people.

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Body composition is more difficult to assess in elderly than in younger people.[1] Noninvasive methods are needed to assess muscle mass and function, bone mineral, and body fluid distribution, in addition to body fat and fat distribution. Different patterns of "disordered body composition" have different relationships to morbidity, disability, and health status. These patterns are difficult to identify using conventional anthropometric measures, such as body mass index, waist/hip ratio, or midarm muscle area. For example, skeletal muscle atrophy, or "sarcopenia," is highly prevalent in the elderly population and is strongly associated with disability, independent of morbidity.[10] Elders at greatest risk, however, are those who are simultaneously sarcopenic and obese. The accurate identification of sarcopenic obesity requires precise methods of simultaneously measuring fat and lean components, such as dual-energy X-ray absorptiometry.

This paper presents data from two studies conducted by our research group on body composition, health, and aging in elderly men and women: the New Mexico Aging Process Study (NMAPS) and the New Mexico Elder Health Survey (NMEHS). Its purpose is to compare the health and functional status of elderly men and women classified on the basis of their body composition as sarcopenic, sarcopenic obese, obese, and normal.

PARTICIPANTS AND METHODS

The New Mexico Aging Process Study is an ongoing, longitudinal study of nutrition and health status in approximately 400 elderly men and women. Although the NMAPS began in 1979, annual measurements of body composition, using DXA (Lunar DPX) and other laboratory-based methods, began only in 1993. Extensive data are also collected annually for health and functional status, physical activity, dietary intake, serum nutrients and hormones, falls, and other factors associated with body composition, using standardized methods, as described elsewhere.[11] Disability is assessed using the Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) questionaires.[12,13] Balance and gait abnormalities are assessed using Tinetti's instrument.[14]

The majority (95%) of NMAPS participants are non-Hispanic Whites, aged 60 years and greater, who were selected for good health at the time of enrollment: people with such serious acute and chronic illnesses as active cancer, recent myocardial infarction, type 2 diabetes, and uncontrolled hypertension are considered ineligible. Participants are not dropped from the study, however, if any of these conditions develop later. Overall, the NMAPS could be described as a cohort of economically secure, "relatively" healthy older men and women who may represent what has been called "successful aging."[15] The cross-sectional data used in the present report were collected in 1995.

The New Mexico Elder Health Survey was a population-based, cross-sectional survey conducted between 1992 and 1995 that included 883 elderly, community-dwelling residents of Bernalillo County (Albuquerque), New Mexico. Study participants were selected randomly from the Health Care Finance Authority (HCFA: Medicare) listings for Bernalillo County, New Mexico, and not with regard to health or body composition. Roughly equal numbers of Hispanic and non-Hispanic White

men and women were sampled. The study design and methods were described in detail in previous publications.[16]

In contrast to the NMAPS, the NMEHS included a broad range of people with different socioeconomic, health, and ethnic status, and is, consequently, more representative of older men and women with "usual aging." For example, about 26% of the men and 19% of the women had diagnosed non-insulin-dependent diabetes (NIDDM) in the NMEHS, whereas none of the NMAPS participants have been subsequently diagnosed with NIDDM after entering the study. On the other hand, the prevalence of coronary heart disease is the same in both studies: approximately 29% in the men and 20% in the women. Sixty-six percent of the non-Hispanic Whites versus 26% of the Hispanics had incomes >$20,000 per year, compared to 73% of the NMAPS participants. In the NMEHS, 33% of the non-Hispanic Whites and 8% of the Hispanics had graduated from college, whereas more than 50% have a college degree in the NMAPS.

The same methods used in the NMAPS were applied to measure health, and functional and nutritional status in the NMEHS. For budgetary reasons, body composition was measured using DXA only for a randomly selected subsample of 199 people, using the same machine applied in the NMAPS. Anthropometric equations calibrated against DXA were developed to predict muscle mass and percent body fat in the total study sample, as described below. The Human Research Review Committee of the University of New Mexico School of Medicine approved all procedures, and all participants gave informed consent.

Statistical Analyses

We established previously that DXA estimates of skeletal muscle mass are highly correlated with those from imaging methods, such as computed tomography and magnetic resonance imaging.[17] Estimates of muscle volumes from these imaging methods are highly accurate compared to ones from cadavers.[18] Skeletal muscle mass was measured directly using DXA in the NMAPS participants, but we had to establish an accurate anthropometric equation for predicting DXA muscle mass for the total NMEHS population. The random subsample of 199 participants with DXA data was further subdivided randomly into two groups: (1) an equation development group ($n = 149$); and (2) a cross-validation group ($n = 50$). Equations were developed for predicting DXA-measured appendicular skeletal muscle mass (ASM), as well as percent body fat (%Fat), from anthropometric variables by stepwise regression using data for the equation development group. The resulting equations were

$$\begin{aligned}\text{ASM} = {} & 0.2487(\text{weight}) + 0.0483(\text{height}) - 0.1584(\text{hip circumference}) \\ & + 0.0732(\text{grip strength}) + 2.5843(\text{gender}) + 5.8828 \; [R^2 = 0.91, \text{SEE} = 1.58]\end{aligned} \tag{1}$$

$$\begin{aligned}\%\text{Fat} = {} & 0.2034\ (\text{waist circumference}) + 0.2288\ (\text{hip circumference}) \\ & + 3.6827\ (\ln[\text{triceps skinfold}]) - 10.9814\ (\text{gender}) - 14.3342 \\ & [R^2 = 0.79, \text{SEE} = 3.94\%].\end{aligned} \tag{2}$$

The accuracy of these predictive equations was tested by comparing the predicted values to the measured ones in the 50 participants in the cross-validation group. In addition, the accuracy of the equations was further tested by applying them to an in-

dependent sample of 301 elderly participants in the NMAPS in whom body composition was measured using the same DXA. Predicted %Fat was correlated highly with DXA in the cross-validation group ($R^2 = 0.82$, SEE = 4.05%), as well as in the Aging Process Study ($R^2 = 0.76$, SEE = 4.42%). Predicted muscle mass was also correlated highly with DXA in the cross-validation group ($R^2 = 0.86$, SEE = 1.72 kg), as well as in the Aging Process Study ($R^2 = 0.89$, SEE = 1.42 kg). Thus, we may infer that predicted %Fat and muscle mass had average accuracies of approximately ±4% and ±1.7 kg, respectively, in the total sample. Further details on the cross-validation of these equations were published earlier.[10]

The classification of individuals as sarcopenic requires a measure or index that expresses muscle mass relative to skeletal size and sex-specific criteria for defining "deficient" relative skeletal muscle mass. To derive an index muscle mass that adjusts for differences in skeletal size, we followed the approach taken to defining body mass indices. We derived a "relative skeletal muscle index" (RSMI) as predicted (NMEHS) or measured (NMAPS) muscle mass (kg) divided by stature (m) squared (kg/m^2). *Sarcopenia* was defined as values less than –2 SD below the sex-specific mean for RSMI in a healthy, younger person (mean age = 29 years), or less than 7.26 kg/m^2 in men, and less than 5.45 kg/m^2 in women.[10] *Obesity* was defined as values greater than the median %Fat for each sex (NMEHS and NMAPS combined), or greater than 27% in men and 38% in women. The cutpoint for obesity was chosen to provide sufficient numbers of people in each category and was not based on standard criteria for defining obesity. Presently, ours is the only published criterion for defining sarcopenia from muscle mass. There is no standard cutoff value for defining obesity from %Fat in elderly men and women. The participants in both samples were cross-classified by these cutpoints to define sarcopenic, sarcopenic-obese,

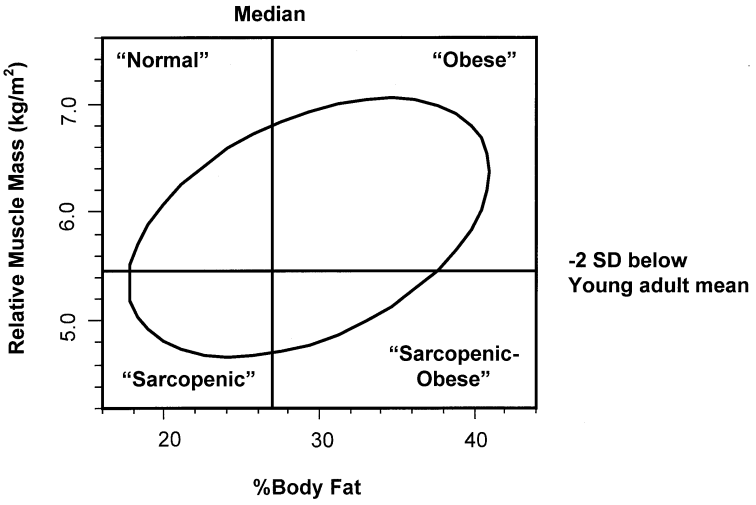

FIGURE 1. Theoretical relationship between Relative Skeletal Muscle Mass Index and %Fat, illustrating the approach used to categorize subjects as "Normal," "Obese," "Sarcopenic," and "Sarcopenic-Obese."

TABLE 1. Demographics, body composition, and dietary intake by sarcopenic body fat classification: New Mexico Elder Health Survey

	Men				Women			
	Sarcopenic		Normal Muscle Mass		Sarcopenic		Normal Muscle Mass	
	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese
n	93	19	120	198	83	12	119	187
Age (years) (a,b)	76.6 ± 7.3	77.6 ± 7.5	72.3 ± 4.7	72.5 ± 4.8	76.3 ± 7.1	79.5 ± 7.0	73.6 ± 5.7	72.8 ± 5.6
Ethnicity (% hispanic) (a,b)	46.3	56.5	37.4	52.7	48.2	75.0	34.5	51.3
%Low income (a,b)	25.8	42.9	10.3	9.2	43.7	72.7	29.2	30.7
RSMI (kg/m^2) (a,b)	6.8 ± 0.6	6.9 ± 0.3	7.7 ± 0.3	8.1 ± 0.5	5.1 ± 0.3	5.1 ± 0.3	5.9 ± 0.4	6.4 ± 0.6
% Fat (a,b)	22.5 ± 2.7	28.4 ± 1.5	25.0 ± 1.6	31.1 ± 3.1	32.3 ± 2.7	42.2 ± 4.3	35.2 ± 2.0	43.4 ± 4.0
BMI (kg/m^2) (a,b)	21.5 ± 1.9	24.4± 1.8	24.9 ± 1.4	28.7 ± 2.8	20.5 ± 2.1	27.1 ± 3.2	24.2 ± 2.0	29.9 ± 3.9
Waist hip ratio (a,b)	0.94 ± 0.05	0.99 ± 0.04	0.98 ± 0.05	1.02 ± 0.05	0.82 ± 0.06	0.85 ± 0.06	0.86 ± 0.07	0.90 ± 0.06
Grip/wgt (kg/kg) (a,b)	0.49 ± 0.12	0.38 ± 0.12	0.53 ± 0.09	0.44 ± 0.09	0.33 ± 0.11	0.22 ± 0.09	0.37 ± 0.09	0.29 ± 0.08
Energy intake (kcals/day)	1824 ± 554	2241 ± 111	31867 ± 667	1808 ± 662	1426 ± 583	1244 ± 534	1369 ± 429	1404 ± 580
Protein intake (% kcals)	14.4 ± 2.5	15.6 ± 2.8	15.4 ± 2.3	515.6 ± 2.6	14.4 ± 2.6	15.2 ± 2.8	14.9 ± 2.2	15.9 ± 2.9

NOTE: All values are means and standard deviations or percents where indicated. Statistically significant ($p < 0.01$) differences between groups (a) in men, (b) in women. Low income <$15,000 per year.

ABBREVIATIONS: RSMI, relative skeletal muscle index = appendicular skeletal muscle mass (kg)/stature $(m)^2$; BMI, body mass index (weight (kg)/stature $(m)^2$; Waist Hip Ratio, waist/hip circumference ratio; Grip/Wgt, grip strength (kg) divided by body weight (kg).

TABLE 2. Morbidity by sarcopenic body fat classification: New Mexico Elder Health Survey

	Men				Women			
	Sarcopenic		Normal Muscle Mass		Sarcopenic		Normal Muscle Mass	
	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese
n	93	19	120	198	83	12	119	187
Cancer	22.1	21.7	20.3	24.4	19.5	8.3	12.3	16.0
Stroke	12.6	13.0	4.9	11.4	12.2	8.3	8.4	7.5
CHD	34.7	34.8	26.0	28.4	18.3	41.7	15.0	18.5
NIDDM (a,b)	18.0	30.4	18.8	34.4	10.7	20.0	11.4	27.4
Gall Bladder	17.9	30.4	15.5	19.9	24.4	33.3	22.9	30.5
Arthritis	61.1	47.8	64.2	54.7	68.3	83.3	69.8	78.6
COPD (a,b)	15.8	17.4	4.9	7.5	6.1	25.0	11.9	9.6
Osteoporosis(b)	1.7	0.4	2.2	3.6	16.0	40.0	10.1	11.2

NOTE: All values are percents. Statistically significant ($p < 0.01$) differences between groups (a) in men, (b) in women. CHD, coronary heart disease; NIDDM, non-insulin-dependent diabetes mellitus; COPD, chronic obstructive pulmonary disease.

TABLE 3. Serum concentrations by sarcopenic body fat classification: New Mexico Aging Process Study (1995)

	Men				Women			
	Sarcopenic		Normal Muscle Mass		Sarcopenic		Normal Muscle Mass	
	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese	Nonobese	Obese
n	18	18	35	35	22	10	72	59
Age	79.5 ± 6.0	79.8 ± 6.2	76.9 ± 5.6	76.2 ± 5.2	79.1 ± 1.3	75.6 ± 5.4	74.7 ± 6.2	77.6 ± 6.8
Testosterone (nmol/L) (a)	14.7 ± 1.1	10.7 ± 1.1	14.2 ± 0.8	12.8 ± 0.8	—	—	—	—
Estrone (pmol/L)	—	—	—	—	172.4 ± 46.8	211.6 ± 68.7	175.6 ± 28.4	176.5 ± 26.0
IGF_1(ng/mL) (a)	155.5 ± 11.9	131.1 ± 12.0	157.0 ± 8.5	157.1 ± 8.5	137.3 ± 11.5	138.9 ± 16.8	125.3 ± 7.0	134.2 ± 6.4
Leptin (a,b)	6.9 ± 1.0	10.0 ± 1.0	6.5 ± 0.8	8.1 ± 0.8	19.5 ± 1.8	23.7 ± 2.5	18.0 ± 1.2	21.5 ± 1.2
Fasting insulin (a,b)	9.5 ± 1.4	10.9 ± 1.4	7.2 ± 1.0	11.4 ± 1.0	6.3 ± 0.9	8.3 ± 1.4	6.5 ± 0.6	10.9 ± 0.5
Fasting glucose	93.6 ± 2.8	91.7 ± 2.8	94.6 ± 2.0	97.0 ± 2.0	91.9 ± 2.6	88.5 ± 3.9	87.8 ± 1.6	93.1 ± 1.5
Albumin	4.1 ± 0.05	4.0 ± 0.05	4.2 ± 0.04	4.2 ± 0.04	4.2 ± 0.05	4.1 ± 0.08	4.2 ± 0.03	4.1 ± 0.03
Total cholesterol	200.5 ± 8.6	201.7 ± 8.7	197.6 ± 6.1	200.8 ± 6.2	228.6 ± 8.3	256.2 ± 12.5	225.2 ± 5.1	227.4 ± 4.7

NOTE: All values, except age, are age-adjusted means and standard errors. The means for serum leptin are additionally adjusted for total body fat mass by least squares regression. Statistically significant ($p < 0.01$) differences between groups (a) in men, (b) in women.

obese, and normal groups. FIGURE 1 illustrates the resulting cross-classification of RSMI by %Fat and the cutpoints used to define sarcopenia and obesity.

Analysis of variance was used to test for differences among the four sarcopenia body fat groups for continuous covariates, such as age, dietary-intake variables, serum albumin, cholesterol, glucose, insulin, leptin, and hormone concentrations. Multiple logistic regression was used to identify risk factors for being in the sarcopenic, sarcopenic-obese, or obese groups. Candidate risk factors included age (>75 years), ethnicity, morbidity, smoking, alcohol consumption (low, medium, high), physical activity (low, medium, high), and self-reported weight gain or loss in the past year. Finally, multiple logistic regression was used to estimate relative odds ratios for various sequelae of sarcopenia, sarcopenic-obesity, or obesity, using the normal group as the referent category. Specific sequelae studied were having three or more physical disabilities, one or more balance and gait abnormalities, or falls in the past year. These regressions were adjusted for age, ethnicity, smoking, and comorbidity. All analyses were conducted separately for each sex and each study sample.

RESULTS

The prevalence of sarcopenia and sarcopenic obesity increases with age, as shown in FIGURE 2. The prevalence of sarcopenia, regardless of body fatness, increases from about 15% in those 60 to 69 years of age, to about 40% in those older than 80 years. The specific prevalence of sarcopenic obesity increases from about 2% in those 60 to 69 years of age to about 10% in those over 80 years. Interestingly,

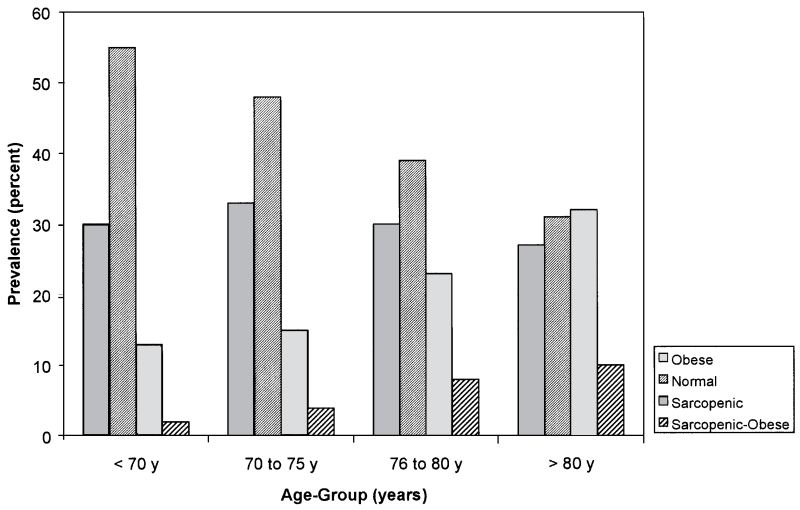

FIGURE 2. Prevalences of obesity, sarcopenia, and sarcopenic-obesity by age in the combined New Mexico Elder Health Survey and New Mexico Aging Process Study.

the prevalence of people who are purely obese decreases with age from about 55% to about 30%. This does not necessarily indicate that older people lose body fat with age. It suggests that many obese individuals may convert to sarcopenic obesity with increasing age; that is, they may maintain a constant fat mass while losing muscle mass.

TABLE 1 compares sarcopenia body fat groups for a variety of covariates in the NMEHS. Sarcopenic, obese, and nonobese men and women are three to six years older on average than obese and nonobese groups with normal muscle mass. This finding is confirmed in the NMAPS (see TABLE 3). In our population-based survey, Hispanics were more likely than non-Hispanic Whites to be either obese or sarcopenic, and the prevalence of sarcopenic obesity was especially elevated (75%) in the Hispanic women. The prevalences of sarcopenia and sarcopenic obesity, in particular, were increased in those with low incomes (<$15,000 per annum). It is apparent that sarcopenic obese men and women have nearly as high a %Fat, on average, as the normal muscle mass obese groups (28.4% versus 31.1% in men, and 42.2% versus 43.4% in women), but low relative skeletal muscle mass as in the sarcopenic low-fat groups. The combination of low muscle mass with high body fat results in the sarcopenic obese groups having body mass indices that do not reflect their actual obesity: 24.4 kg/m^2 in men, and 27.1 kg/m^2 in women. Waist/hip ratio is increased in the obese group, but not in the sarcopenic obese group, so it is not obvious that the later group includes individuals with visceral obesity. An important observation that has functional significance is the significantly lower grip strength per kilogram body weight in the sarcopenic obese groups. There are no significant differences in energy and protein intakes among the groups, which suggests that sarcopenia and sarcopenic obesity are not strongly associated with differences in the intakes of these macronutrients.

TABLE 2 compares the groups for prevalences of morbidity, using data from the NMEHS. There is no obvious pattern of association with cancer, stroke, coronary heart disease, or osteoarthritis. The prevalences of type 2 diabetes (NIDDM) and gall bladder disease are increased in obese groups, regardless of sarcopenia. The prevalence of chronic obstructive pulmonary disease (COPD) is increased in the both sarcopenic nonobese and obese groups in the men, and in the sarcopenic obese group in the women.

TABLE 3 compares the groups for age-adjusted serum concentrations of hormones, insulin, glucose, albumin, and cholesterol using data from the NMAPS, inasmuch as these are more complete than in the NMEHS. Serum total testosterone and IGF_1 are both significantly lower in men with sarcopenic obesity than in the other groups. In women, there are no significant differences between groups for serum estrone or IGF_1. Serum leptin, additionally adjusted for body fat mass, is significantly elevated in both the men and the women with sarcopenic obesity. Fasting insulin is significantly increased in the obese groups, regardless of muscle mass. There are no differences among groups for serum albumin or total cholesterol.

TABLE 4 (NMEHS) and TABLE 5 (NMAPS) show the odds ratios for the associations of body composition categories with self-reported physical disabilities (IADLs), balance and gait abnormalities (Tinetti), and self-reported falls in the past year. Both obesity and sarcopenia are associated with functional impairment, disabilities, and falls in both "usual" and "successful" aging cohorts. These associations are independent of age, ethnicity, smoking, and comorbidity. What is remarkable is

TABLE 4. Odds ratios (95% CI) for three or more physical disabilities, balance and gait abnormalities, and falls in the past year by sarcopenia body fat classification: New Mexico Elder Health Survey (*n* = 883)

	Three or more	One or more abnormalities of		
	Physical Disabilities	Balance	Gait	Falls in Past Year
Men				
Normal Muscle				
Nonobese	1.00	1.00	1.00	1.00
Obese	1.34 (0.48–4.12)	1.90 (0.54–8.83)	1.24 (0.63–2.51)	1.41 (0.80–2.52)
Sarcopenic				
Nonobese	3.78 (1.36–11.67)	5.16 (1.46–24.33)	1.08 (0.46–2.49)	2.12 (1.08–4.18)
Obese	8.72 (2.52–32.80)	3.96 (0.64–24.43)	4.41 (1.53–13.04)	3.34 (1.37–8.26)
Women				
Normal Muscle				
Nonobese	1.00	1.00	1.00	1.00
Obese	2.15 (1.11–4.30)	0.84 (0.29–2.54)	1.34 (0.65–2.71)	1.45 (0.80–2.64)
Sarcopenic				
Nonobese	2.96 (1.35–6.60)	0.98 (0.30–3.19)	0.95 (0.40–2.19)	1.66 (0.80–3.42)
Obese	11.98 (3.07–61.56)	1.21 (0.15–6.67)	5.45 (1.44–22.58)	2.12 (0.86–5.05)

NOTE: Sarcopenic = RSMI < 25th percentile for each sex. Obese = %Fat > median for each sex. All odds ratios were adjusted for age, ethnicity, smoking, and comorbidity by multiple logistic regression.

that the strongest association within each sex is with sarcopenic obesity. For example, the odds ratio for three or more physical disabilities is 8.72 (95% confidence interval 2.52–32.8) in sarcopenic obese men in the NMEHS, and 11.98 (3.07–61.6) in the women. Similarly, the sex-adjusted odds ratio for three or more physical disabilities is 4.12 (1.24–15.5) in the NMAPS. Thus, whereas both obesity and sarcopenia have independent associations with functional status, disability, and falls, their combination in sarcopenic obesity has the greatest impact.

DISCUSSION

This paper builds on previous work by our group, describing body composition changes with aging and the associations of sarcopenia and obesity with various health factors in both usual and successful cohorts of elderly people.[1,2,10,11,19] The novel aspect of the present study is our identification of a small subgroup of people who are simultaneously sarcopenic and obese. Our data show that many of the deleterious health and functional sequelae of old age are concentrated in this sarcopenic obese subgroup. Because sarcopenic obese elderly individuals have increased body

TABLE 5. Odds ratios (95% CI) for three or more physical disabilities, balance and gait abnormalities, and falls in the past year by sarcopenia body fat classification: New Mexico Aging Process Study, 1995 (*n* = 272)

	3 or more	1 or more abnormalities of		
	Physical Disabilities	Balance	Gait	Falls in Past Year
Normal Muscle				
Nonobese	1.00	1.00	1.00	1.00
Obese	2.33 (0.68–8.81)	3.45 (1.23–10.7)	2.21 (0.99–5.05)	1.41 (0.80–2.52)
Sarcopenic				
Nonobese	2.07 (0.65–7.35)	2.35 (0.86–6.96)	1.44 (0.66–3.21)	2.12 (1.08–4.18)
Obese	4.12 (1.24–15.5)	6.36 (2.25–19.9)	3.21 (1.39–7.69)	3.34 (1.37–8.26)

NOTE: Sarcopenic = RSMI < 25th percentile for each sex. Obese = %Fat > median for each sex. All odds ratios were adjusted for age, sex, smoking, and comorbidity by multiple logistic regression.

fat that masks their sarcopenia, they may not be recognized as "frail" unless muscle strength or functional performance is tested.

Our data suggest that sarcopenia, obesity, and sarcopenic obesity may be considered patterns or "syndromes of disordered body composition" that have somewhat different associations with age, health, and functional status. It is not yet clear exactly how these syndromes evolve, especially sarcopenic obesity. Future research with the longitudinal NMAPS, and other similar studies, may help to elucidate this question. Such studies will be important to determine optimal methods for preventing both sarcopenia and obesity in old age. It is also useful to question whether these syndromes might require different tailored approaches to treatment, combining either aerobic or resistive exercise, dietary supplements, hormone replacement, or possibly appetite-stimulating drugs. Improved methods of identifying different patterns of disordered body composition in elderly people are needed so that such optimal treatments can be prescribed and improvement measured.

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