Published in final edited form as:

J Nutr Health Aging. 2016 ; 20(8): 790–796. doi:10.1007/s12603-015-0707-5.

Is meeting the recommended dietary allowance (RDA) for protein related to body composition among older adults?: Results from the Cardiovascular Health of Seniors and Built Environment Study

Jeannette M. Beasley^a [Assistant Professor], Andrea Deierlein^b [Postdoctoral Fellow], Kimberly Morland^c [Associate Professor], Evelyn Granieri^d [Chief of the Division of Geriatric Medicine], and Arlene Spark^e [Professor]

^aAlbert Einstein College of Medicine, 1300 Morris Park Avenue, Belfer 1301, Bronx, NY 10461

^bIcahn School of Medicine at Mount Sinai 17 East 102 Street New York, NY 10029

^cIcahn School of Medicine at Mount Sinai 17 East 102 Street New York, NY 10029

^dColumbia University College of Physicians and Surgeons, 630 W 168th Street, New York, NY 10034

^eCUNY 365 Fifth Avenue, New York, NY 10016

Abstract

Objective—Studies suggest protein intake may be associated with lower body weight, but protein has also been associated with preservation of lean body mass. Understanding the role of protein in maintaining health for older adults is important for disease prevention among this population.

Design—Cross-sectional study of the relationship of dietary protein on body composition.

Setting—New York City community centers

Participants—1,011 Black, White, and Latino urban men and women 60–99 years of age

Measurements—Protein intake was assessed using two interviewer-administered 24-hour recalls, and body composition was assessed using bioelectrical impedance analysis (BIA) of fat mass (kg) (FM), fat free mass (kg) (FFM), and impedance resistance (Ohms).

Statistical Analysis—Indices of FM and FFM were calculated by dividing BIA measurements by height squared (m²), and percent FFM was calculated by dividing FFM by the sum of FM and FFM. Log linear models adjusting for age (continuous), race/ethnicity, education, physical activity (dichotomized at the median), hypertension, diabetes, and total calories (continuous).

Results—Just 33% of women and 50% of men reported meeting the RDA for protein. Both fat free mass index (FFMI) and fat mass index (FMI) were negatively associated with meeting the RDA for protein (Women: FFMI -1.78 95% CI [-2.24, -1.33], FMI -4.12 95% CI [-4.82, -3.42])

Men: FFMI -1.62 95% CI [-2.32, -0.93] FMI -1.80 95% CI [-2.70, -0.89]). After accounting for confounders, women and men consuming at least 0.8 g/kg/day had a 6.2% (95% CI: 5.0%, 7.4%) and a 3.2% (95% CI 1.1%, 5.3%) higher percent fat free mass, respectively.

Conclusions—FFM, FFMI, FM, and FMI were inversely related to meeting the RDA for protein. Meeting the RDA for protein of at least 0.8g/kg/day was associated with a higher percentage of fat free mass among older adults. These results suggest meeting the protein recommendations of at least 0.8 g/kg/day may help to promote lower overall body mass, primarily through loss of fat mass rather than lean mass.

Keywords

Bioelectrical Impedance Analysis; protein; body composition; 24 hour recall; fat mass; fat free mass; older adults

Introduction

The United States National Health and Nutrition Examination survey (NHANES) (2009-2010) suggests protein intake ranges from 14 to 16 percent of energy intake.[1] Summing across age (n=23,876 adults 19 years) and gender groups using NHANES data from 2001-2010, Pasiakos *et al* reported deciles of usual protein intake ranged from a median of 0.68 to 1.51 g/kg body weight, and that most Americans consume at least the recommended dietary allowance (RDA) for protein of 0.8 g/kg body weight/day. [2] [3] However, fewer overweight and obese individuals met the RDA for protein [2], and analyses were not stratified by age, so it remains unclear what percentage of older, overweight individuals are meeting the RDA for protein.

Furthermore, there is a long-standing debate over whether the RDA for protein of 0.8 g/kg body weight/day increases with advancing age[4]. As recently reviewed by international expert committees and other researchers [5-7], adequate protein intake is essential among older adults in particular for several reasons: 1) anabolic resistance, or the reduced sensitivity of muscle to amino acids from dietary sources due to factors such as decreased uptake by muscle, reduced signaling for protein synthesis, and reduced digestive capacity; 2) inflammatory conditions that cause increased metabolism of dietary protein (i.e. heart failure) and/or 3) prolonged disuse of muscle (i.e. due to injury or bed rest) may increase muscle protein breakdown. [5,7-9].

Adequate dietary protein intakes are important, especially in older adults, because protein likely plays a critical role in preserving fat free mass (FFM)[10]. Low FFM has been identified as an independent risk factor for functional impairment and mortality [11]. In large scale studies, FFM is often used as a proxy for skeletal muscle mass. However, FFM represents a heterogeneous compartment that also comprises organ mass and parts of connective tissue [12] and may remain stable in an individual with reduced skeletal muscle mass if connective tissue increases due to advancing age or adiposity[13]. In order to account for body size, researchers have scaled FFM and its counterpart, fat mass (FM), to height squared to generate a fat free mass index (FFMI= FFM/height²) and fat mass index (FMI= FM/height²), respectively.[13,14] Thereby, the sum of the FFM and FMI would

equal body mass index (BMI).[15] However, using height to scale for body size among overweight and obese individuals does not account for excess adiposity.[13] An alternative parameterization for accounting for body size has been to express FFM as a percentage of total body mass.[12]

Given the uncertainty about protein intakes among older adults, particularly among overweight and obese adults, the purpose of this analysis was to examine the associations between meeting the RDA for protein intake (>0.8 grams per kilogram body weight per day) and body composition measures among a multi-ethnic urban population of older adults. Due to differences in methodology of measuring body composition, several measures relating to FFM and FM were examined.

Methods

A cross-sectional analysis was conducted using data from the Cardiovascular Health of Seniors and the Built Environment Study, where Black, White and Latino men and women 60-99 years old were enrolled from New York City community centers between January 2009-June 2011 ($n=1,453$). Eligible participants spoke English or Spanish and lived in Brooklyn or Queens for at least one year prior to enrollment. All study procedures were approved by the Institutional Review Board at Icahn School of Medicine at Mount Sinai. Of the 1,453 enrolled participants, 1,011 were eligible and included in the current analysis. Exclusion criteria included: <60 years ($n=21$); self-reported race/ethnicity other than Black, White, or Hispanic ($n=44$), both dietary recalls were missing or implausible, defined as energy intakes <500 or >5000 calories ($n=82$), body composition data were missing ($n=132$), or covariates were missing ($n=63$).

Dietary Assessment

Participants completed two interviewer-administered 24-hour recalls on non-consecutive days using Nutrition Data System for Research (NDSR) (Nutrition Coordinating Center, University of Minnesota, MN). First recalls were collected in person and second recalls were conducted by telephone. Interviewers attempted to conduct the second recall within ten days of the first, and greater than 95% of recalls were collected within three months of each other. Nutrient intakes from two dietary recalls were averaged when both recalls were completed and had plausible reported energy intakes ($n=967$). Nutrient intakes from one recall were used when only one recall was completed and/or had a plausible reported energy intake ($n=207$). Each participant's daily protein intake (g) was divided by their body weight (kg) to generate protein intake in units of g/kg body weight/day. Protein intake was then dichotomized using the RDA for protein intake of >0.8 g/kg/day.

Body Composition Measures

All body composition measurements were taken while participants were wearing light clothing and no shoes. Standing height was measured using a stadiometer. Body composition was assessed using bioelectrical impedance analysis (BIA) (Tanita Body Composition Analyzer, TBF-300A) which has been validated as a measure of fat mass (kg) (FM), fat free mass (kg) (FFM), BIA resistance (Ohms), and weight.[16] These

measurements were used to calculate additional body composition variables including: percent fat free mass (FFM (kg)/total body weight (kg) *100%), fat free mass index (FFMI= FFM/height², kg/m²), and fat mass index (FMI= FM/height², kg/m²).[17]. Skeletal mass (kg) was calculated with the validated formula (height²/BIA-resistance × 0.401) + (gender × 3.825) + (age × -0.071)]+5.102.[18]

Covariates

Age was based on birth date and categorized as 60-70 (Referent), 71-80, and 81-99 years (for stratified analyses); race/ethnicity was categorized as White, Black, and Hispanic; and highest attained educational level was categorized as less than high school (grades 1-8), high school (grades 9-12 and trade school), and college or higher. Marital status was considered as married/living with a partner or single. Income was self-reported as the annual household income from all sources during the previous year and dichotomized using a cut-point of \$30,000. Total energy intake (calories) and alcohol intake (categorized as any or none) were estimated from the 24 hour recalls. Measurements of health status included self-report of ever having a physician diagnosis of hypertension, diabetes, or cancer of any type. Lastly, physical activity was assessed using the Community Healthy Activities Model Program for Seniors (CHAMPS), a self-report physical activity questionnaire for older adults. [19]. CHAMPS assesses the weekly intensity, duration, and frequency of many physical activities usually performed by older adults. Total physical activity was dichotomized using the sample median of 34 MET hours of any physical activity per week.

Statistical Analysis

Analyses were conducted using STATA 13.0 (College Station, TX). Gender and age-specific associations between each body composition measure (FFM (kg), FM (kg), percent FFM, FFMI, skeletal mass (kg) and FMI) and meeting the RDA for protein intake (>0.8 g/kg body weight) were estimated using multivariable log linear models. Backward stepwise regression was used to develop final models, which included age (continuous), race/ethnicity, education, physical activity (dichotomized at the median), hypertension, diabetes, and total calories (continuous) (n=1,011). Significance tests were two-sided with an alpha of <0.05.

Results

The study sample was a multi-ethnic population of Black (46%), White (23%), and Latino (31%) urban adults spanning a four decade age range: 60-70 years (40.9%); 71-80 years (37.0%) and 81-99 years (22.1%)(Table 1). The majority of participants were women, unmarried, overweight or obese, had annual incomes less than \$30,000, and attended high school or college. Most participants reported not drinking alcohol per the 24-hour recall data and were sedentary, as previously described [20]. More than two-thirds reported ever having hypertension; almost one third reported diabetes and 14% were cancer survivors (Table 1).

Percent FFM ranged from 41.5% to 93.3%, with a mean of 63.4% (SD=9.6%) (Table 2). Absolute FFM (mean=47.8 g, SD= 9.1 g) and fat mass (mean=29 g, SD=12.4 g) had a greater range than FFMI (mean=18.8 kg/m², SD=2.8 kg/m²) and fat mass index (mean=11.5

kg/m², SD=4.9 kg/m²), as these measures were scaled to height. Average skeletal mass was lower in women compared to men (21.9 (SD=11.9) kg versus 32.1 (SD=30.5) kg). Likewise, percent skeletal mass was 29.3% in women and 40.3% in men, but neither of the skeletal mass measures varied widely by age category.

Just over one third of women reported meeting the RDA for protein (Table 3). On average, women consuming at least 0.8 g/kg/day had a 6.1% (95% CI: 5.0%, 7.4%) higher percent fat free mass. For each of the absolute body composition measures (fat free mass, fat free mass index, fat mass, and fat mass index), there was an inverse relationship with meeting the RDA for protein. Adjustment for confounders did not substantively affect the estimates. In multivariate models, fat free mass (kg), fat free mass index (kg/m²), fat mass (kg), and skeletal mass (kg) were lower among those who met the RDA for protein (-5.6, -1.8, -11.0, and -3.3, respectively). However, the effect of meeting the protein recommendation was also positive for percent skeletal mass (2.36%, 95% CI 0.27%, 4.50%) in adjusted models. As age increased, the strength of the association attenuated, particularly for fat free mass and fat mass. For fat free mass and skeletal mass, the relationship between fat free mass and meeting the RDA became weaker among women over 80 years (Table 3). For fat mass, there was ~3kg decline in the effect size in each decade (i.e. -13.3, -10.6, and -7.4 among women in their sixties, seventies, and over 80, Table 3).

Approximately half (49%) of the men met the RDA for protein intake (Table 4). Similar to women, men consuming at least the RDA for protein had a higher percent fat free mass, but lower values for all other body composition measures compared to men who consumed <0.8 g/kg protein (Table 4). Among men, fat free mass (kg), fat free mass index (kg/m²), fat mass (kg), fat mass index (kg/m²), and skeletal mass (kg), were lower among those who met the RDA for protein (-6.7, -1.6, -6.0, -1.8, and -6.9 respectively). With increasing age, the strength of the association attenuated, particularly for fat free mass and fat mass. However, the strength of the association with percent fat free mass was smaller (3.2%, 95% CI 1.1%, 5.3%), and it tended to decrease with age among men (0.3% among 81+ year olds versus 4.0% among 60-70 year olds).

Discussion

Less than half of the participants reported consuming the RDA for protein, which is substantively lower than estimates from nationally representative samples such as NHANES. It is interesting that our population shows higher skeletal muscle mass than the NHANES data.[18] Contrary to our hypothesis, meeting the RDA for protein intake was associated with lower fat free mass even after adjustment for height (fat free mass index) and covariates in this large, multi-ethnic, community-based study. However, meeting the RDA for protein was also associated with a decrease in fat mass (with the magnitude of the effect being twice as large as fat free mass for women). So among both women and men, meeting the RDA for protein was associated with higher percent fat free mass and skeletal mass, although effects varied by age group.

A cross-sectional analysis among 387 postmenopausal women aged 60-90 years observed no association between lean mass measured via dual x-ray absorptiometry and protein intake,

but those with a higher fat/lean ratio were more likely to consume protein below the RDA. [21] Furthermore, a meta-analysis of 24 randomized controlled trials (mean duration of diet 12 weeks) reported that in the setting of energy restriction, a high protein diet produced more favorable changes in weighted mean differences for body weight (-0.79 kg; 95% CI: -1.50, -0.08 kg) and FM (FM; -0.87 kg; 95% CI: -1.26, -0.48 kg) while FFM was preserved and mitigation of reductions in fat-free mass (FFM; 0.43 kg; 95% CI: 0.09, 0.78 kg). A systematic review of the literature relating the health effects of protein intake among healthy adults reported data from a single randomized controlled trial lasting 6 months, and stated evidence as inconclusive regarding the relation of protein intake to change in body composition.[22] Consistent with recent reviews,[23,24] we also used 1.0 g/kg body weight as the cutoff for meeting protein recommendations, but there were no substantive differences with respect to associations with body composition measures. Trials administering protein supplements enriched in specific amino acids, such as leucine [25] and cysteine[26], suggest focusing on the protein quality as well as quantity may be important in future work.

The strengths of these findings include the multi-ethnic population; the age range of the cohort; and the fact the older adults are community dwelling and ambulatory. However, there are limitations to the current study that need to be considered when interpreting the results. First, the sample is drawn from community centers in an urban setting and therefore may not be generalizable to all older Americans. Second, similar to NHANES, diet was assessed using two 24 hour recalls, and we did not have biomarkers of energy or protein intake to correct for potential measurement error. Third, we did not account for the prevalence of sarcopenia in this population, because we did not have a measure of muscle strength.[27] It is possible that increased protein for individuals with sarcopenia may not be as effective in increasing lean mass or skeletal mass as for older adults who do not already have their lean mass compromised. Furthermore, individuals with sarcopenic obesity may metabolize protein less efficiently.[28] Because these conditions are grouped in these analyses and sarcopenia is likely to be present given the age of the population, the interaction of sarcopenia cannot be ruled out as a factor influencing these findings. Fourth, we used the current recommendation for protein intake as the cut point for these categorical analyses which may have limited our ability to observe effects at higher levels of intake. We addressed this concern by evaluating the effects at 1.0 kg per kg of body weight and the effects on body composition did not change except for percent of skeletal mass. For example, overall, women meeting the 1.0 kg recommendation had a 4.46% (95% CI 1.89%, 7.02%) higher percent skeletal mass and the effects were greatest among the youngest age group.

In conclusion, among this large, multi-ethnic, community-based cohort of older adults, participants were predominantly overweight (>80%) and more than half were not meeting the RDA for protein. Protein is the only macronutrient having recommendations explicitly expressed in relation to body size. Data from this cohort of predominantly overweight older Americans suggest meeting protein recommendations may be more of a challenge for heavier individuals. FFM, FFMI, FM, skeletal mass (kg) and FMI were inversely related to meeting the RDA for protein. Meeting the RDA for protein of at least 0.8g/kg/day was associated with a higher percentage of fat free mass and skeletal mass among older adults. Significant associations were observed for both men and women, with the stronger

relationship among the youngest age group. These results suggest meeting the protein recommendations of at least 0.8 g/kg/day may help to promote lower overall body mass, primarily through loss of fat mass rather than the preservation of lean mass.

Acknowledgments

This study was supported by R00AG035002 and R01HL0865507.

References

1. Phillips SM, Fulgoni VL 3rd, Heaney RP, Nicklas TA, Slavin JL, Weaver CM. Commonly consumed protein foods contribute to nutrient intake, diet quality, and nutrient adequacy. *Am J Clin Nutr*. 2015
2. Fulgoni VL 3rd. Current protein intake in America: analysis of the National Health and Nutrition Examination Survey, 2003–2004. *Am J Clin Nutr*. 2008; 87(5):1554S–1557S. [PubMed: 18469286]
3. Pasiakos SM, Lieberman HR, Fulgoni VL. Higher-Protein Diets Are Associated with Higher HDL Cholesterol and Lower BMI and Waist Circumference in US Adults. *J Nutr*. 2015; 145(3):605–614. [PubMed: 25733478]
4. Fukagawa NK. Protein requirements: methodologic controversy amid a call for change. *Am J Clin Nutr*. 2014; 99(4):761–762. [PubMed: 24572564]
5. Deutz NE, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: recommendations from the ESPEN Expert Group. *Clin Nutr*. 2014; 33(6):929–936. [PubMed: 24814383]
6. Volpi E, Campbell WW, Dwyer JT, et al. Is the optimal level of protein intake for older adults greater than the recommended dietary allowance? *J Gerontol A Biol Sci Med Sci*. 2013; 68(6):677–681. [PubMed: 23183903]
7. Bauer J, Biolo G, Cederholm T, et al. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE Study Group. *Journal of the American Medical Directors Association*. 2013; 14(8):542–559. [PubMed: 23867520]
8. Kim IY, Schutzler S, Schrader A, et al. Quantity of dietary protein intake, but not pattern of intake, affects net protein balance primarily through differences in protein synthesis in older adults. *American journal of physiology Endocrinology and metabolism*. 2015; 308(1):E21–28. [PubMed: 25352437]
9. Layman DK, Anthony TG, Rasmussen BB, et al. Defining meal requirements for protein to optimize metabolic roles of amino acids. *Am J Clin Nutr*. 2015
10. Rodriguez NR. Introduction to Protein Summit 2.0: continued exploration of the impact of high-quality protein on optimal health. *Am J Clin Nutr*. 2015
11. Franssen FM, Rutten EP, Groenen MT, Vanfleteren LE, Wouters EF, Spruit MA. New reference values for body composition by bioelectrical impedance analysis in the general population: results from the UK Biobank. *Journal of the American Medical Directors Association*. 2014; 15(6):448 e441–446. [PubMed: 24755478]
12. Bony-Westphal A, Muller MJ. Identification of skeletal muscle mass depletion across age and BMI groups in health and disease--there is need for a unified definition. *Int J Obes (Lond)*. 2015; 39(3):379–386. [PubMed: 25174451]
13. Heymsfield SB, Heo M, Thomas D, Pietrobelli A. Scaling of body composition to height: relevance to height-normalized indexes. *Am J Clin Nutr*. 2011; 93(4):736–740. [PubMed: 21248190]
14. VanItallie TB, Yang MU, Heymsfield SB, Funk RC, Boileau RA. Height-normalized indices of the body's fat-free mass and fat mass: potentially useful indicators of nutritional status. *Am J Clin Nutr*. 1990; 52(6):953–959. [PubMed: 2239792]
15. Heymsfield SB, Gonzalez MC, Lu J, Jia G, Zheng J. Skeletal muscle mass and quality: evolution of modern measurement concepts in the context of sarcopenia. *Proc Nutr Soc*. 2015:1–12.

16. Jebb SA, Cole TJ, Doman D, Murgatroyd PR, Prentice AM. Evaluation of the novel Tanita body-fat analyser to measure body composition by comparison with a four-compartment model. *Br J Nutr.* 2000; 83(2):115–122. [PubMed: 10743490]
17. Janssen I, Heymsfield SB, Baumgartner RN, Ross R. Estimation of skeletal muscle mass by bioelectrical impedance analysis. *J Appl Physiol* (1985). 2000; 89(2):465–471. [PubMed: 10926627]
18. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *J Am Geriatr Soc.* 2002; 50(5): 889–896. [PubMed: 12028177]
19. Stewart AL, Mills KM, King AC, Haskell WL, Gillis D, Ritter PL. CHAMPS physical activity questionnaire for older adults: outcomes for interventions. *Med Sci Sports Exerc.* 2001; 33(7): 1126–1141. [PubMed: 11445760]
20. Evenson KR, Morland KB, Wen F, Scanlin K. Physical activity and sedentary behavior among adults 60 years and older: New York City residents compared with a national sample. *Journal of aging and physical activity.* 2014; 22(4):499–507. [PubMed: 24152536]
21. Gregorio L, Brindisi J, Kleppinger A, et al. Adequate dietary protein is associated with better physical performance among post-menopausal women 60-90 years. *The journal of nutrition, health & aging.* 2014; 18(2):155–160.
22. Wycherley TP, Moran LJ, Clifton PM, Noakes M, Brinkworth GD. Effects of energy-restricted high-protein, low-fat compared with standard-protein, low-fat diets: a meta-analysis of randomized controlled trials. *Am J Clin Nutr.* 2012; 96(6):1281–1298. [PubMed: 23097268]
23. Paddon-Jones D, Leidy H. Dietary protein and muscle in older persons. *Current opinion in clinical nutrition and metabolic care.* 2014; 17(1):5–11. [PubMed: 24310053]
24. Wolfe RR. The role of dietary protein in optimizing muscle mass, function and health outcomes in older individuals. *Br J Nutr.* 2012; 108(2):S88–93. [PubMed: 23107552]
25. Komar B, Schwingshackl L, Hoffmann G. Effects of leucine-rich protein supplements on anthropometric parameter and muscle strength in the elderly: a systematic review and meta-analysis. *The journal of nutrition, health & aging.* 2015; 19(4):437–446.
26. Karelis AD, Messier V, Suppere C, Briand P, Rabasa-Lhoret R. Effect of cysteine-rich whey protein (immunocal(R)) supplementation in combination with resistance training on muscle strength and lean body mass in non-frail elderly subjects: a randomized, double-blind controlled study. *The journal of nutrition, health & aging.* 2015; 19(5):531–536.
27. Paddon-Jones D, Campbell WW, Jacques PF, et al. Protein and healthy aging. *Am J Clin Nutr.* 2015
28. Hickson M. Nutritional interventions in sarcopenia: a critical review. *Proc Nutr Soc.* 2015:1–9.

Table 1
Participant Characteristics (N, %) in the Cardiovascular Health of Seniors and Built Environment Study, n= 1,011

Characteristic	n	%
Gender	1011	
Female	781	77.3
Male	230	22.7
Age	1011	
60-70	414	40.9
71-80	374	37.0
81-99	223	22.1
Race/Ethnicity	1011	
Black	462	45.7
White	235	23.2
Hispanic	314	31.1
Education (Highest level completed)	1011	
Less than High School	257	25.4
High School	513	50.7
Some College or Graduate	241	23.8
Annual Income	891	
<=\$30,000	742	83.3
>\$30,000	149	16.7
Alcohol Intake	1011	
No	867	85.8
Yes	144	14.2
Currently Married	1011	
No	793	78.4
Yes	218	21.6
BMI	1011	
Normal Weight	198	19.6
Overweight	346	34.2
Obese (BMI 30-35)	266	26.3
> Obese (BMI >35)	201	19.9
Physical Activity (median)	1011	
<=34	506	50.1
>34	505	49.9
Hypertension, prevalent	700	69.2
Diabetes, prevalent	295	29.2

Table 2
Anthropometric and body composition measures and protein intakes among participants in the Cardiovascular Health of Seniors and Built Environment Study, (n= 1,011), stratified by gender and age category

		All		60-70 years		71-80 years		81+ years		p-value
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Women	n	781		310		282		189		
Anthropometric and body composition measures										
Body Mass Index	kg/m ²	31.0	6.8	31.8	7.1	31.2	6.8	29.1	6.0	<0.001
Fat Free Mass	kg	44.7	7.0	45.8	7.5	44.8	7.0	42.8	5.7	<0.001
Fat Free Mass Index	kg/m ²	18.3	2.8	18.2	2.9	18.5	2.9	18.4	2.6	0.51
Percent Fat Free Mass	%	60.7	8.2	58.7	8.0	60.2	7.1	64.5	8.6	<0.001
Fat Mass	kg	30.8	12.2	34.4	13.1	30.9	10.8	24.9	10.4	<0.001
Fat Mass Index	kg/m ²	12.5	4.7	13.6	5.1	12.7	4.3	10.6	4.2	<0.001
Skeletal Muscle Mass	kg	21.9	11.6	22.9	17.0	21.5	6.1	20.8	5.2	0.11
Percent Skeletal Muscle Mass	%	29.3	12.3	28.8	17.5	28.5	6.2	31.3	7.6	0.04
Protein Intake measures										
Percent Calories from Protein	%	18.6	4.8	19.2	5.1	18.6	4.6	17.6	4.6	<0.01
Grams/Day	g/d	53.9	18.4	56.3	17.5	53.5	19.3	50.6	17.9	<0.01
Grams/Kilogram Body Weight/Day	g/kg/d	0.8	0.3	0.7	0.3	0.7	0.3	0.8	0.3	0.25
Men	n	230		104		92		34		
Anthropometric and body composition measures										
Body Mass Index	kg/m ²	28.1	4.8	28.8	5.5	27.6	4.2	27.0	3.9	0.09
Fat Free Mass	kg	57.6	8.7	59.2	9.2	57.4	8.1	53.5	7.2	<0.01
Fat Free Mass Index	kg/m ²	20.2	2.6	20.4	2.6	20.2	2.7	19.8	2.5	0.48
Percent Fat Free Mass	%	73.0	7.6	71.9	7.4	73.7	7.9	74.2	7.4	0.16
Fat Mass	kg	22.4	10.0	24.5	11.2	21.2	8.6	19.4	8.6	0.01
Fat Mass Index	kg/m ²	7.8	3.4	8.4	3.7	7.4	3.0	7.1	3.0	0.06
Skeletal Muscle Mass	kg	32.1	22.5	30.5	6.7	34.6	34.5	29.9	7.8	0.37
Percent Skeletal Muscle Mass	%	40.3	23.9	36.9	6.0	43.8	36.7	41.2	8.6	0.13
Protein Intake measures										
Percent Calories from Protein	%	19.2	4.8	18.6	4.6	19.9	5.0	19.0	4.8	0.13

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

	All			60-70 years			71-80 years			81+ years			p-value
	Mean	SD		Mean	SD		Mean	SD		Mean	SD		
Grams/Day	g/day	67.3	27.5	67.4	23.6		68.5	34.1		63.4	17.0		0.65
Grams/Kilogram Body Weight/Day	g/kg/d	0.9	0.4	0.8	0.4		0.9	0.5		0.9	0.2		0.66

Table 3

Associations (β +/- 95% CI) between body composition and meeting the RDA for protein intake (0.8 g/kg/day) in the Cardiovascular Health of Seniors and Built Environment Study by age among women

	All (n=781)		60-70 years (n=310)		71-80 years (n=282)		81+ years (n=189)	
	β	95% CI	β	95% CI	β	95% CI	β	95% CI
>0.8 g/kg/day, n (%)		281 (36%)		108 (35%)		95 (34%)		78 (41%)
Percent Fat Free Mass								
Unadjusted	6.1	(5.0, 7.2)	6.6	(4.9, 8.4)	4.8	(3.1, 6.5)	6.0	(3.6, 8.4)
Multivariate	6.2	(5.0, 7.4)	7.4	(5.4, 9.3)	5.2	(3.2, 7.2)	5.0	(2.3, 7.8)
Fat Free Mass, kg								
Unadjusted	-5.0	(-5.9, -4.0)	-5.8	(-7.4, -4.1)	-5.1	(-6.7, -3.5)	-3.2	(-4.8, -1.6)
Multivariate	-5.6	(-6.7, -4.6)	-6.1	(-8.0, -4.3)	-6.4	(-8.2, -4.6)	-3.2	(-5.1, -1.4)
Fat Free Mass Index, kg/m²								
Unadjusted	-1.6	(-2.0, -1.2)	-2.0	(-2.7, -1.4)	-1.7	(-2.4, -1.0)	-1.0	(-1.7, -0.2)
Multivariate	-1.8	(-2.2, -1.3)	-1.9	(-2.6, -1.2)	-1.9	(-2.7, -1.1)	-1.1	(-1.9, -0.2)
Fat Mass, kg								
Unadjusted	-10.5	(-12.1, -8.8)	-12.2	(-15.0, -9.4)	-9.1	(-11.6, -6.7)	-8.3	(-11.1, -5.5)
Multivariate	-11.0	(-12.7, -9.3)	-13.3	(-16.4, -10.2)	-10.6	(-13.3, -7.8)	-7.4	(-10.6, -4.2)
Fat Mass Index, kg/m²								
Unadjusted	-4.0	(-4.6, -3.4)	-4.7	(-5.8, -3.6)	-3.5	(-4.4, -2.5)	-3.3	(-4.4, -2.1)
Multivariate	-4.1	(-4.8, -3.4)	-4.9	(-6.1, -3.7)	-3.8	(-5.0, -2.7)	-2.9	(-4.2, -1.6)
Skeletal Muscle Mass, kg								
Unadjusted	-2.9	(-4.6, -1.3)	-3.2	(-7.2, 0.8)	-3.5	(-4.9, -2.0)	-1.7	(-3.2, -0.2)
Multivariate	-3.3	(-5.2, -1.3)	-3.0	(-7.8, 1.7)	-4.3	(-5.9, -2.6)	-2.0	(-3.7, -0.2)
Skeletal Muscle Mass, %								
Unadjusted	4.0	(1.8, 6.2)	5.8	(0.7, 10.9)	2.0	(0.1, 4.0)	3.7	(1.0, 6.4)
Multivariate	4.5	(1.9, 7.0)	6.8	(0.8, 12.7)	2.6	(0.2, 5.0)	2.7	(-0.5, 5.8)

Multivariate models adjusted for age, race, hypertension, diabetes, education, physical activity, and energy intake.

Associations (β +/- 95% CI) between body composition and meeting the RDA for protein intake (0.8 g/kg/day) in the Cardiovascular Health of Seniors and Built Environment Study by age among men

Table 4

	All (n=230)		60-70 years (n=104)		71-80 years (n=92)		81+ years (n=34)	
>0.8 g/kg/day, n (%)	β	95% CI	β	95% CI	β	95% CI	β	95% CI
		112 (49%)		47 (46%)		44 (48%)		20 (59%)
Percent Fat Free Mass								
Unadjusted	3.9	(1.9, 5.8)	4.0	(1.2, 6.8)	4.7	(1.6, 7.9)	0.3	(-5.0, 5.7)
Multivariate	3.2	(1.1, 5.3)	4.3	(1.2, 7.5)	3.6	(-0.03, 7.2)	0.8	(-5.5, 7.0)
Fat Free Mass, kg								
Unadjusted	-5.8	(-8.0, -3.7)	-7.7	(-11.0, -4.4)	-3.9	(-7.2, -0.6)	-3.6	(-8.6, 1.5)
Multivariate	-6.7	(-9.0, -4.5)	-8.6	(-12.1, -5.0)	-4.8	(-8.5, -1.1)	-4.6	(-10.8, 1.6)
Fat Free Mass Index, kg/m²								
Unadjusted	-1.6	(-2.2, -0.9)	-2.0	(-2.9, -1.0)	-0.9	(-2.0, 0.2)	-2.1	(-3.7, -0.5)
Multivariate	-1.6	(-2.3, -0.9)	-2.2	(-3.2, -1.1)	-0.8	(-2.0, 0.5)	-1.6	(-3.7, 0.5)
Fat Mass, kg								
Unadjusted	-6.4	(-8.9, -4.0)	-7.5	(-11.6, -3.4)	-6.3	(-9.7, -3.0)	-1.8	(-8.0, 4.4)
Multivariate	-6.0	(-8.7, -3.3)	-7.6	(-12.3, -2.9)	-5.7	(-9.6, -1.9)	-3.2	(-10.5, 4.1)
Fat Mass Index, kg/m²								
Unadjusted	-2.0	(-2.9, -1.2)	-2.3	(-3.7, -0.9)	-2.1	(-3.2, -0.9)	-0.9	(-3.0, 1.3)
Multivariate	-1.8	(-2.7, -0.9)	-2.3	(-3.8, -0.7)	-1.7	(-3.0, -0.4)	-1.1	(-3.5, 1.4)
Skeletal Muscle Mass, kg								
Unadjusted	-5.5	(-11.3, 0.3)	-4.2	(-6.7, -1.7)	-6.8	(-21.1, 7.6)	-5.5	(-10.8, -0.2)
Multivariate	-6.9	(-13.5, -0.3)	-4.5	(-7.3, -1.6)	-9.5	(-26.1, 7.09)	-6.2	(-12.8, 0.44)
Skeletal Muscle Mass, %								
Unadjusted	0.9	(-6.1, 8.0)	3.0	(0.4, 5.6)	-0.2	(-17.4, 17.0)	-3.1	(-9.7, 3.5)
Multivariate	1.6	(-10.2, 7.1)	4.3	(1.0, 7.7)	-2.9	(-24.9, 19.2)	-1.3	(-10.0, 7.3)

Multivariate models adjusted for age, race, hypertension, diabetes, education, physical activity, and energy intake