Nutritional risk assessment and obesity in rural older adults: a sex difference[1–3]

Jenny H Ledikwe, Helen Smiciklas-Wright, Diane C Mitchell, Gordon L Jensen, Janet M Friedmann, and Christopher D Still

ABSTRACT

Background: Many older Americans are overweight or obese, but it is unclear whether obesity is associated with other nutritional risk indicators.

Objective: This study investigated sex-associated differences in nutritional risk among community-dwelling, rural older adults and determined whether weight status [body mass index (BMI; in kg/m^2) and waist circumference] was related to other measures of nutritional risk.

Design: This cross-sectional study explored relations between weight status and nutritional risk, which was determined on the basis of the Level II Screen, overall diet quality, nutrient intakes, and plasma biomarkers.

Results: Of the 179 subjects, 44% were overweight (BMI 25–29.9) and 35% were obese (BMI > 30). There were few differences in nutrient intakes between older men and women after we controlled for energy intake. In women, BMI was directly associated with multiple additional nutritional risk indicators, including the number of Level II items ($r = 0.30$), intakes of fat ($r = 0.26$) and saturated fat ($r = 0.21$), and homocysteine concentration ($r = 0.25$). Weight status in women was inversely associated with intakes of carbohydrates ($r = -0.25$), fiber ($r = -0.35$), folate ($r = -0.24$), magnesium ($r = -0.29$), iron ($r = -0.22$), and zinc ($r = -0.23$); Healthy Eating Index scores ($r = -0.22$); and plasma pyridoxal 5′ phosphate ($r = -0.30$). Associations with waist circumference were similar. In men, weight status was associated only with plasma cobalamin ($r = -0.33$ for BMI) and pyridoxal 5′ phosphate ($r = -0.24$ for waist circumference).

Conclusions: Overweight and obese older women, particularly those living alone, may be at greater nutritional risk than are men with a high BMI. Targeted nutritional intervention emphasizing nutrient-dense food choices to improve dietary patterns may be warranted. *Am J Clin Nutr* 2003;77:551–8.

KEY WORDS Nutritional risk, Nutrition Screening Initiative, Level II Screen, rural, aging, elderly, obesity

INTRODUCTION

Many older Americans are overweight or obese (1–3). This is a considerable public health concern given that elevated weight status increases the risk of comorbidities (4), functional decline (2, 5, 6), impaired quality of life (7), increased use of health care resources (8), and mortality (9). However, obesity is only one of a number of nutritional risk factors that may contribute to adverse health outcomes for older adults. Other indicators of nutritional risk include sociodemographic factors such as income (10) and living arrangements (11), oral health (12–14), functional status (13), use of multiple medications (13, 14), and, more directly, diet quality (15) and plasma biomarkers (14, 16). Nutritional risk, for the purposes of this article, is broadly defined to include nutrition-related risk factors postulated to be associated with adverse outcomes in older adults. These nutrition-related risk factors include items from the Nutrition Screening Initiative Level II Nutrition Screen (17), overall poor diet quality, nutrient intakes below recommended amounts, and plasma biomarker values above or below defined threshold values.

Although high body weights are a prevalent nutritional risk factor in older adults (12–14), it is unclear from the literature how obesity is associated with other nutritional risk indicators. Weight status was found to be associated with several plasma biomarkers (18, 19) and functional status (2); however, studies investigating how weight relates to dietary components have been limited in scope, focusing mostly on macronutrients and including subjects of mixed ages (20, 21). A comprehensive study with multiple measures of nutritional risk is needed in older adults. Sex should be considered when determining how weight status relates to other nutritional risk indicators, because sex-associated differences in various nutritional risk factors have been noted. These risk factors include weight (1), sociodemographic factors (12), oral health (12), functional status (2), and nutrient status (12, 22, 23).

The objectives of this study were to identify sex-associated differences in nutritional risk among community-dwelling, rural older adults and to determine whether weight status, as assessed with body mass index (BMI) and waist circumference, is related to other measures of nutritional risk. Rural older adults have been found particularly vulnerable to nutritional inadequacies

[1] From the Diet Assessment Center, Nutrition Department, Pennsylvania State University, University Park, PA (JHL, HS-W, and DCM); the Center for Human Nutrition, Vanderbilt University Medical Center (GLJ and JMF), Nashville, TN; and the High Risk Obesity Clinics, Geisinger Medical Center, Danville, PA (CDS).

[2] Supported by the US Department of Agriculture, Agricultural Research Service under agreement #58-1950-1-137; VA Tennessee Valley GRECC; and NIH DK 26657. Additional support provided through a National Institute on Aging traineeship.

[3] Reprints not available. Address correspondence to JH Ledikwe, 5 Henderson Building, Pennsylvania State University, University Park, PA 16801. E-mail: mvh111@psu.edu.

Received April 22, 2002.

Accepted for publication July 18, 2002.

(24). Contributing factors may include social and geographic isolation, limited access to transportation, and limited availability of nutrition-related services. A better understanding of the associations between potentially modifiable nutritional risk factors, such as weight status and diet, may guide interventions to decrease healthcare resource use and to improve the quality of life for rural older adults.

SUBJECTS AND METHODS

Subjects

The subjects were a subset of the Geisinger Rural Aging Study (GRAS), a nutritional-risk screening study involving > 20 000 rural Pennsylvanians age ≥ 65 y (14). All GRAS participants were enrolled in a Medicare risk program administered through the Geisinger Health Care System, a not-for-profit health maintenance organization that provides services for many persons residing in small towns with populations of ≤ 2499 (25). Study procedures were approved by the Geisinger and Pennsylvania State University human investigation review boards.

Letters introducing the study were mailed to 944 individuals selected from the first 9989 GRAS participants by using a computer-generated random scheme. Inclusion criteria included having a phone, living in the community, and consenting to a home visit. Up to 3 attempts were made to reach each prospective participant by telephone (26). Of the 797 individuals reached by telephone, 210 provided written informed consent to participate and were each scheduled for a home visit; 10 withdrew before the home visit. During the home visit, the Mini Mental State Examination (27) and the Geriatric Depression Scale (28) were used for exclusion purposes. Of the 200 potential participants, 1 was excluded because of poor cognitive function (Mini Mental State Examination score ≤ 23), 6 were excluded because of depression (Geriatric Depression Scale score ≥ 6), 11 withdrew, and 1 died. The GRAS subset did not differ significantly from the large GRAS cohort regarding sex, age, demographics, anthropometric measures, and serum cholesterol and albumin. Individuals in the GRAS subset were less likely than were those in the large GRAS cohort to report having a poor appetite and needing assistance with bathing, traveling, and food preparation. However, these differences were quite small and were most likely a result of the tendency for individuals with more limitations to be less interested in research studies.

Demographics and health status

Demographic data collected during the home visit included age, sex, education level achieved, and marital status. The presence or absence of > 30 different health conditions was ascertained by asking subjects if a physician had ever told them they had each condition, including various cardiovascular diseases, gastrointestinal diseases, musculoskeletal diseases, and cancers. Data were collected on the use of medications and dietary supplements.

Anthropometric measures

Height and weight measurements were completed during the home visit by trained research dietitians using a portable digital scale (UC300; A & D Engineering, Mitpiltas, CA) and a stadiometer (Infant/Child/Adult Height Measuring Board; Shorr Productions, Olney, MD). BMI was calculated as weight (kg)/height (m)^2. Waist circumference was measured with a flexible, nonelastic measuring tape. Standardized procedures developed on the basis of the National Health and Nutrition Examination Survey were followed (29). Every twentieth participant was measured by both research dietitians to monitor interrater reliability.

Level II Nutrition Screen

The Level II Nutrition Screen (LII) is 1 of 3 tools developed by the Nutrition Screening Initiative, a collaborative effort of the American Dietetic Association, the American Academy of Family Practitioners, and the National Council on the Aging Inc to aid in the evaluation of the nutritional status of older persons (17). The Nutrition Screening Initiative tools include the DETERMINE checklist, which is a brief public-awareness tool; the Level I Nutrition Screen, which is a risk-assessment tool intended for use by health care professionals; and the more comprehensive LII, which was developed for use by medical and nutrition professionals. A modified LII was administered by telephone, as described previously (5, 14, 30). It consisted of 42 items pertaining to use of medications, oral health, eating habits, living environment, and functional status (activities of daily living and independent activities of daily living). Skinfold-thickness and arm-circumference measures on the Nutrition Screening Initiative LII were not included because of the method of administration by telephone. The single question "Do you feel depressed?" was substituted for formal testing of mental and cognitive status because the Geriatric Depression Scale and Mini Mental State Examination had been used for exclusion criteria.

Trained interviewers from the Penn State Diet Assessment Center collected the data using an electronic version of the survey tool created in MICROSOFT ACCESS, version 97 (Microsoft Corp, Redmond, WA) for real-time data entry during the interview. The LII also includes laboratory data, with thresholds for albumin and cholesterol. Plasma samples collected at the home visit were analyzed for these biomarkers and compared with Nutrition Screening Initiative recommendations (17). No standardized scoring algorithm is available for the LII. For the purpose of this analysis, the number of unfavorable LII items was summed for each participant to create an LII summary score. The LII does include self-reported height and weight, with BMI values > 27 considered a risk item; however, self-reported and measured BMI were excluded from the summary score because comparisons were made between LII score and weight status.

Dietary intake and diet quality

After the home visit, the staff of the Penn State Diet Assessment Center collected 5 random, 24-h dietary recalls by telephone from each participant at 2-mo intervals. For each participant, data were collected on 3 weekdays and 2 weekend days. The NUTRITION DATA SYSTEM software, food database version 12A, nutrient database version 28 (Nutrition Coordinating Center, University of Minnesota, Minneapolis) was used for data collection and analysis with a multiple-pass technique (31) to facilitate recall. Two-dimensional visuals of cups, spoons, bowls, and various shapes (32) were used by participants and interviewers to assist with portion-size estimation. The prevalence of inadequate nutrient intakes was determined by using the estimated average requirement cutoff method (33) for nutrients with an established estimated average requirement (34–37). For other nutrients, mean intakes were compared with Adequate Intake recommendations (33). Nutrient intake

TABLE 1
Comparison of subject characteristics and anthropometric data by sex

	Men (n = 81)	Women (n = 98)
Age (y)	73.3 ± 5.0[1]	73.5 ± 5.0
Married (%)	84	64[2]
Widowed (%)	11	30[2]
High school education or higher (%)	74	85
Illnesses (no.)	4.6 ± 2.7	4.2 ± 2.7
Medications (no.)	3.0 ± 2.9	2.4 ± 2.2
Vitamin-and-mineral supplement use (%)	67	68
Tobacco use (%)	20	5[2]
Alcohol use (%)[3]	6	1
Anthropometric data		
BMI (kg/m^2)	28.5 ± 3.6	28.3 ± 4.7
Underweight, BMI < 18.5 (%)	0	0
Normal weight, BMI 18.5–24.9 (%)	14	26
Overweight, BMI 25.0–29.9 (%)	51	38
Obesity category I, BMI 30.0–34.9 (%)	32	25
Obesity category II, BMI 35.0–39.9 (%)	4	7
Obesity category III, BMI ≥40 (%)	0	2
Waist circumference (cm)	103.7 ± 9.6	89.1 ± 11.4[4]
Waist circumference > NIH risk cutoff[5] (%)	58	50

[1] $\bar{x}$ ± SD.
[2,4] Significantly different from men: [2] $P < 0.01$ (chi-square), [4] $P < 0.0001$ (analysis of variance).
[3] Reported having ≥1 alcoholic drink/d for women and ≥2 for men.
[5] Cutoffs are >102 cm for men and >88 cm for women (46).

estimates reflect the foods consumed and do not include intake from supplements.

Healthy Eating Index (HEI) scores, which reflect overall diet quality, were calculated (38). Ten components including 5 food groups (grains, vegetables, fruit, milk, and meat), 4 nutrients (sodium, cholesterol, total fat, and saturated fat), and a measure of dietary variety were each assigned a score ranging from 0 to 10 on the basis of the criteria set by the US Department of Agriculture, for a total possible score of 100 (38). The HEI does not include an energy component. The intake of foods from the different food groups was determined on the basis of methodology described elsewhere (39).

Biomarkers of nutrient status

A venous blood sample (30.5 mL) was obtained from each participant during the home visit and was placed on ice for transport. The serum was separated by centrifugation (3000 × g for 12 min at 2–8 °C) and stored at −70 °C. The following laboratory analyses were conducted at Tufts University. Plasma concentrations of folate and cobalamin (vitamin B-12) were measured by using competitive protein-binding assays (BioRad, Hercules, CA). Pyridoxal 5′ phosphate (PLP) was measured with a radioenzymatic assay (40); homocysteine was determined with HPLC (41), and 25-hydroxyvitamin D was measured with a competitive protein-binding assay (42). Serum concentrations of albumin, prealbumin, C-reactive protein, and cholesterol were determined at Geisinger Medical Center by using rate nephrolometry (Beckman Reagents Array 360; Beckman Instruments, Brea, CA). Unfavorable values were designated as follows: plasma folate < 6.8 nmol/L (43), PLP ≤ 18.1 nmol/L (44), plasma vitamin B-12 < 258 pmol/L (43), 25-hydroxyvitamin D < 12.0 nmol/L (43), homocysteine > 14.0 μmol/L (44), C-reactive protein < 10.0 mg/L (18), prealbumin < 170 mg/L, plasma albumin < 35.0 g/L (17), and cholesterol < 4.14 or > 6.21 mmol/L (17).

Statistical analyses

The data were analyzed with SAS, version 8 (SAS Institute Inc, Cary, NC). Measured BMI values were standardized to assess for potential outliers with z scores > 3.29 (45); 2 cases with raw BMI values > 53 fit this criterion and were excluded. Categorical variables were summarized by using frequencies and percentages. Means and standard deviations were calculated for continuous variables and normality was assessed. Variables not normally distributed were log transformed before analysis. To assess differences between men and women, chi-square analysis and analysis of variance were performed on categorical variables and continuous variables, respectively. Pearson's product-moment correlation coefficients were used to determine the association between measured BMI and waist circumference and the associations between the biomarker values. Logistic regression was used to determine whether individual LII items were associated with measured BMI. Associations between weight status and nutritional risk were assessed by using partial Pearson's product-moment correlation coefficients adjusted for energy intake, age, tobacco use, and alcohol use.

RESULTS

Subject characteristics by sex

The GRAS subset included 81 men and 98 women aged 66–87 y. Virtually the entire sample (> 99%) was non-Hispanic white, which is consistent with the demographic composition of central Pennsylvania. Subject characteristics by sex are shown in **Table 1**. Women were more likely than men to be widowed and were less likely to be married. The predominant medical conditions reported were hypertension (50%), elevated cholesterol (48%), arrhythmia (26%), ulcer or gastritis (20%), angina (18%), gallbladder disease (18%), chronic obstructive pulmonary disease (14%), coronary artery disease (13%), diverticulosis (13%), type 2 diabetes (13%), and myocardial infarction (12%). There was no difference between men and women in the total number of medical conditions reported; however, angina, coronary artery disease, and myocardial infarction were more common in men than in women (data not shown). Men were more likely than women to report current use of tobacco products.

BMI values ranged from 20.7 to 41.6 (excluding 2 persons with BMI > 53). On the basis of the NIH guidelines (46), none of the subjects were underweight (BMI < 18.5), 21% were normal weight (BMI 18.5–24.9), and 44% were overweight (BMI 25–29.9). Another 28% were classified as being in obesity category I (BMI 30–34.9), 6% were in obesity category II (BMI 35–39.9), and 1% were in obesity category III (BMI ≥ 40). The data appear to follow the same pattern that was found in the larger GRAS cohort, in which women were more likely than men to have low or high BMI values (2, 5, 14); however, the percentages of men and women in the 5 BMI categories did not differ significantly, most likely because of small cell sizes in the higher BMI categories. On average, men had a higher waist circumference than did women, but there was no significant difference between men and women in the percentages of participants with waist circumferences above the NIH risk cutoffs (102 cm for men and 88 cm for women) (46). BMI was highly correlated with waist circumference (r = 0.73, $P < 0.0001$).

TABLE 2
Selected Level II Nutrition Screen risk items by sex[1]

	Men (*n* = 81)	Women (*n* = 98)
	n (%)	
Age ≥75 y	27 (33)	31 (32)
Lives alone	12 (15)	30 (31)[2]
Lives on an income of <$6000/y	3 (4)	9 (9)
Uses ≥3 prescription drugs, over-the-counter medications, or vitamin-and-mineral supplements	53 (65)	56 (57)
Self-reported BMI (kg/m^2) >27	45 (56)	49 (50)
Self-reported BMI <22	5 (6)	11 (11)
Lost ≥4.5 kg (10 lb) in past 6 mo	13 (16)	12 (12)
Gained ≥4.5 kg (10 lb) in past 6 mo	10 (12)	11 (11)
Usually eats alone	12 (15)	28 (29)[2]
Follows a special diet	14 (17)	15 (15)
Has poor appetite	2 (2)	5 (5)
Has eating problems (difficulty chewing or swallowing or pain in mouth, teeth, or gums)	6 (7)	11 (11)
Spends <$25–$30 per person on food/wk	9 (11)	25(26)[2]
Feels depressed	1 (1)	5 (5)
Is housebound	6 (7)	9 (9)
Has any functional limitation[3]	6 (7)	18 (18)[2]
Plasma albumin <35.0 g/L[4,5]	0 (0)	0 (0)
Plasma cholesterol <4.14 mmol/L[4,5]	8 (11)	9 (10)
Plasma cholesterol >6.21 mmol/L[4,5]	12 (16)	23 (24)
Level II Nutrition Screen score[5]	6.3 ± 2.9	6.3 ± 3.0

[1] Data were collected by telephone, except for plasma samples, which were obtained at the home visit.
[2] Significantly different from men, $P < 0.05$ (chi-square).
[3] Functional limitations include needing help with bathing, dressing, grooming, toileting, eating, walking, traveling outside the home, preparing food, and shopping for food or other necessities.
[4] Risk thresholds proposed by the Nutrition Screening Initiative (17).
[5] Data were missing for 6 men and 4 women.

Nutritional risk and nutritional status by sex

Nutritional risk

The mean LII score was 6.3 for both men and women (**Table 2**). The most prevalent risk items were using ≥3 medications and supplements, self-reported BMI >27, age >75 y, living alone, eating alone, serum cholesterol >240 mg/dL, and limited spending on food. Women were more likely than were men to live alone, eat alone, spend a limited amount of money on food, and report having any functional limitation.

Nutritional status: nutrient intake

The energy and nutrient intakes of the GRAS subset are summarized in **Table 3**. Women had a lower reported energy intake than men; this difference remained significant after controlling for age, tobacco use, and alcohol use. Women also had lower reported absolute intakes of all the nutrients studied. However, after adjusting for energy intake in addition to age, tobacco use, and alcohol use, the differences in nutrient intakes between men and women were only significant for protein and vitamin D. Comparisons were also made between men and women by living arrangement. Among those who lived with others, there were few differences in nutrient intakes between men and women. However, when evaluating only participants who lived alone, women living alone reported lower intakes of energy, protein, vitamin B-12, vitamin D, calcium, magnesium, iron, and zinc compared with men living alone (data not shown). Women living alone also reported lower intakes of protein, vitamin B-12, vitamin E, and zinc than women living with others (data not shown).

The majority of participants had inadequate intakes of folate (79%), magnesium (82%), and vitamin E (91%); women were more likely than were men to have an inadequate intake of folate. Inadequate intakes of zinc (44%) and vitamin B-6 (32%) were common. Mean intakes of vitamin B-12 were above the Adequate Intake values, suggesting a low prevalence of inadequate intakes. Mean intakes of vitamin D and calcium were substantially less than the Adequate Intake (33).

HEI scores were 68.3 and 70.8 for men and women, respectively. The US Department of Agriculture has proposed that scores of ≤80 indicate diets that need improvement. The majority of participants (88%) fell into this category.

Nutritional status: plasma biomarkers

There were no significant differences between men and women in plasma biomarker values (Table 3). Three percent of the participants had PLP concentrations ≤18.1 nmol/L and 25% had low plasma cobalamin concentrations. Approximately 10% of the participants had elevated concentrations of homocysteine and C-reactive protein. Homocysteine concentrations were inversely correlated with plasma PLP ($r = -0.25$, $P < 0.002$), folate ($r = -0.24$, $P < 0.002$), and cobalamin ($r = -0.36$, $P < 0.0001$). High C-reactive protein concentrations were associated with low PLP ($r = -0.15$, $P < 0.05$) and high folate ($r = 0.18$, $P < 0.05$) concentrations.

Correlations of weight status with nutritional risk and nutritional status

The associations of BMI and the LII summary score, dietary intakes, and nutrient biomarkers are shown in **Table 4** as partial Pearson's product-moment correlation coefficients. Correlations between waist circumference and the LII summary score, dietary intakes, and nutrient biomarkers were similar to correlations with BMI (data not shown).

The LII summary scores were positively associated with BMI and waist circumference for women, indicating that the number of nutritional risk factors increases with both BMI and waist circumference. Logistic regression analyses showed that the following LII items were associated with elevated BMI ($P < 0.05$) in women: living alone, self-reported weight gain of ≥10 pounds in the past 6 mo, and several individual limitations in activities of daily living and independent activities of daily living (data not shown). For men, elevated BMI was associated with not having a self-reported weight gain of ≥10 pounds in the past 6 mo and with not following a special diet (data not shown).

For men, there was no association between BMI or waist circumference and intakes of any nutrients. However, for women, there were significant correlations for several macronutrients and micronutrients. BMI and waist circumference were both positively associated with fat and saturated fat intakes and negatively associated with intakes of carbohydrate, fiber, folate, magnesium, iron, and zinc and the HEI score.

For men, high BMI was associated with low plasma cobalamin concentrations, whereas high waist circumference was associated with low plasma PLP. For women, BMI and waist circumference were both negatively associated with plasma PLP and positively associated with plasma homocysteine values.

DISCUSSION

Many of the older adults in this study were at nutritional risk, as shown by multiple measures of nutrition status. Several of the

TABLE 3
Dietary intakes and nutrient biomarkers by sex[1]

	Recommendations for dietary intakes[2] and laboratory thresholds for nutrient biomarkers	Value		Percentage with at-risk values[3]	
		Men (n = 81)	Women (n = 98)	Men (n = 81)	Women (n = 98)
Dietary intakes					
Energy (kJ/d)		7574 ± 2102[4]	5898 ± 1693[5]		
Protein (g/d)		70.0 ± 17.8	54.1 ± 16.0[6]		
Carbohydrate (g/d)		239.0 ± 69.5	193.8 ± 60.9		
Fat (g/d)		64.1 ± 25.6	49.2 ± 17.9		
Saturated fat (g/d)		22.5 ± 10.3	17.2 ± 7.2		
Fiber (g/d)		17.5 ± 6.4	15.4 ± 5.9		
Folate (μg)	400	271.8 ± 96.0	231.6 ± 108.1	69	87[7]
Vitamin B-6 (mg/d)	1.7 (M), 1.5 (F)	1.9 ± 0.7	1.5 ± 0.6	28	35
Vitamin B-12 (μg/d)	2.4	4.9 ± 4.3	3.4 ± 3.0	NA[8]	NA[8]
Vitamin D (μg/d)	10 or 15[9]	5.6 ± 3.2	3.7 ± 2.0[6]	NA[8]	NA[8]
Calcium (mg/d)	1200	756 ± 287	611 ± 262	NA[8]	NA[8]
Magnesium (mg/d)	420 (M), 320 (F)	278.0 ± 84.1	226.4 ± 76.4	85	80
Iron (mg/d)	8	15.4 ± 5.8	11.8 ± 4.8	0	0
Zinc (mg/d)	11 (M), 8 (F)	10.1 ± 3.6	8.2 ± 4.1	48	40
Vitamin E (mg/d)	15	7.8 ± 3.4	7.1 ± 5.2	88	93
HEI score	80	68.3 ± 8.9	70.8 ± 8.4	85	91
Nutrient biomarkers[10]					
Plasma folate (nmol/L)	<6.8	37.4 ± 19.5	41.5 ± 20.6	0	1
Plasma pyridoxal 5′ phosphate (nmol/L)	≤18.1	99.2 ± 86	104 ± 110	3	3
Plasma cobalamin (pmol/L)	<258	376 ± 204	353 ± 157	25	25
Plasma 25-hydroxyvitamin D (nmol/L)	<12.0	100.8 ± 38.4	85.1 ± 30.5	0	0
Homocysteine (μmol/L)	>14.0	10.2 ± 3.0	9.7 ± 4.2	12	9
C-reactive protein (mg/L)	>10.0	3.9 ± 6.6	3.0 ± 3.6	8	5
Prealbumin (mg/L)	<170	286 ± 51	265 ± 53	0	3
Albumin (g/L)	<35.0	43.9 ± 0.1	43.1 ± 0.1	0	0
Cholesterol (mmol/L)	>6.21	5.25 ± 0.96	5.61 ± 0.93	16	23

[1] The significance test for energy intake was adjusted for age, tobacco use, and alcohol use. All other significance tests were adjusted for energy intake, age, tobacco use, and alcohol use. NA, not applicable; HEI, Healthy Eating Index.
[2] Recommendations were determined on the basis of the Dietary Reference Intakes (34–37), biomarker thresholds (17, 43, 44), and US Department of Agriculture HEI (38).
[3] At-risk cutoffs were determined by using the estimated average requirement cutoff method for nutrients (33), the US Department of Agriculture "needs improvement" guidelines for the HEI score (38), and nutrient biomarker recommendations (17, 43, 44).
[4] $\bar{x}$ ± SD.
[5–7] Significantly different from men: [5] $P < 0.0001$ (ANOVA), [6] $P < 0.05$ (ANOVA), [7] $P < 0.05$ (chi-square).
[8] The percentage of a population with inadequate intakes cannot be assessed for nutrients with Adequate Intake values (33).
[9] Recommendation is 10 μg for persons aged 51–70 y and 15 μg for persons aged >70 y.
[10] Data are missing for 6 men and 4 women.

LII items which were most prevalent in this sample were associated previously with adverse health outcomes, including functional limitations (14), health care costs (14), and hospitalization (13).

Many of the participants had poor-quality diets, as indicated by the results of the multidimensional HEI and by intakes of individual nutrients that were below current recommendations. These findings are consistent with the results of other studies (12, 22, 23) and nationwide data (47). Most notable were the low intakes of folate, vitamin B-6, vitamin D, calcium, magnesium, zinc, and vitamin E. Because the intake data were collected during the fortification period, the nutrient database may not have reflected true folate intakes. Inadequate intakes of any of these nutrients pose potential public health consequences by increasing the risk of vascular diseases (48), impaired immune function (49), and cognitive status (50). Furthermore, recent associations between poor diet quality and undesirable plasma biomarkers (51) and mortality (15) emphasize the importance of dietary patterns to health and longevity.

The assessed dietary risk in this population may have been inflated by underreporting (52), which can be as high as 30% of intake (53) and is more common in older adults and overweight individuals (54). However, plasma biomarkers did provide evidence of nutritional inadequacy because cobalamin values were low for almost 25% of the sample and several subjects had low PLP values. Given the associations of these biomarkers with increased homocysteine values in this study and others (16, 44), low concentrations of PLP and cobalamin could have serious consequences.

Particularly notable in this study are the sex differences in how body size relates to other nutritional risk indicators, even though there were few differences in nutrient intakes between men and women. In women, elevated BMI or waist circumference was associated with multiple additional nutritional risk indicators, including LII items, nutrient intakes, HEI scores, and plasma biomarkers. In men, however, weight status was only associated with plasma cobalamin and PLP.

TABLE 4
Partial correlation coefficients between BMI and Level II Nutrition Screen, dietary intakes and nutrient biomarkers[1]

	Partial *r* with BMI	
	Men (*n* = 81)	Women (*n* = 98)
Level II Nutrition Screen summary score	−0.01	0.30[2]
Dietary intakes		
Energy (kJ/d)	−0.22	−0.13
Protein (g/d)	−0.12	−0.05
Carbohydrate (g/d)	0.01	−0.25[3]
Fat (g/d)	0.09	0.26[3]
Saturated fat (g/d)	0.10	0.21[3]
Fiber (g/d)	0.09	−0.35[4]
Folate (μg/d)	−0.06	−0.24[3]
Vitamin B-6 (mg/d)	0.04	−0.15
Vitamin B-12 (μg/d)	−0.06	−0.08
Vitamin D (μg/d)	−0.11	0.01
Calcium (mg/d)	0.05	−0.07
Magnesium (mg/d)	0.07	−0.29[2]
Potassium (mg/d)	−0.02	−0.18
Iron (mg/d)	−0.07	−0.22[3]
Zinc (mg/d)	−0.07	−0.23[3]
Vitamin E (mg/d)	0.13	−0.16
Healthy Eating Index score	−0.05	−0.22[3]
Nutrient biomarkers		
Plasma folate (nmol/L)	−0.09	−0.09
Plasma pyridoxal 5′ phosphate (nmol/L)	−0.17	−0.30[4]
Plasma cobalamin (pg/mL)	−0.33[2]	0.13
Plasma 25-hydroxyvitamin D (ng/mL)	−0.05	−0.19
Homocysteine (μmol/L)	0.08	0.25[3]
C-reactive protein (mg/dL)	0.04	0.19
Prealbumin (mg/dL)	0.07	0.01
Albumin (g/L)	0.04	0.05
Cholesterol (mmol/L)	0.02	0.02

[1] The significance test for energy intake was adjusted for age, tobacco use, and alcohol use. All other significance tests were adjusted for energy intake, age, tobacco use, and alcohol use. Data were missing for 6 men and 4 women for the Level II Nutrition Screen score and all nutrient biomarkers.

[2–4] Significant correlation: [2] $P < 0.01$, [3] $P < 0.05$, [4] $P < 0.001$.

The lower nutrient intakes and HEI scores with higher BMI or waist circumference indicate that older overweight and obese women are less likely than are overweight and obese men to meet nutrient requirements and have healthy eating patterns. Given that diet patterns rich in nutrient-dense foods have beneficial effects on homocysteine and blood vitamins (55, 56), it is plausible that suboptimal nutrient intakes contributed to the unfavorable associations of weight status with homocysteine and plasma PLP in women.

Sex differences in the associations between weight status and health have been reported by others. Measures of body fatness were associated with blood pressure in women only (57). Friedmann et al (2) reported that BMI was more strongly correlated with functional limitations in women than in men. Previous studies investigating the correlations between diet and body composition also found that adiposity was positively associated with dietary fat intake (20, 21) and inversely associated with fiber intake (21). Although these relations did not differ by sex, the studies were not conducted solely in older adults. Because the correlation between weight status and fiber intake was higher than were other correlations with weight status in women, fiber intake may play an important role in attaining and maintaining a healthy weight. Further research is warranted regarding the relations between fiber intake and weight status.

The source of the discrepancy between men and women regarding how body size relates to other nutritional risk indicators is unclear. Social factors, especially living arrangements, may play a role. Older women were more likely than were older men to live alone, which was associated with higher BMI values. Furthermore, when controlling for energy intakes, women living alone reported lower intakes of several nutrients than did men living alone or women living with others. Other studies also indicated that living and eating alone influence diet quality (11, 51). A second explanation for the discrepancy between men and women is that the presence of functional limitations, which reportedly increase with BMI in older women (2, 5), may affect nutrient intakes and diet quality. A third explanation is a survivor effect in which the sex difference in mortality could lead men with multiple nutrition-related risk factors to die earlier than women with multiple risk factors. Also, because age is associated with nutritional risk, it is plausible that the obese women may have been older than the obese men; however, age was controlled for in the analyses and there was no sex difference in age. Finally, it is plausible that weight loss before the study could have obscured the relation between BMI and nutritional risk in men; a previous study found that the increased risk for coronary heart disease associated with BMI was masked by prior weight loss (58). However, in this study, there was no difference between the percentages of men and women who reported losing ≥ 10 pounds in the previous 6 mo.

The associations between weight status and other markers of nutritional risk are worrisome, given the growing prevalence of overweight and obesity among older adults. It is clear that high body weights are common among community-dwelling rural elders, and similar findings were reported in urban homebound elders (59). The prevalences of overweight and obesity were higher in the GRAS subset than in older subjects in the third National Health and Nutrition Examination Survey (1). Other studies also indicate that obesity is more prevalent in rural older adults than in nationally representative samples of older adults (2, 14, 60, 61). This study was unable to address any associations between underweight and other measures of nutritional risk because there were no subjects with a BMI < 18.5. Other studies also found that underweight was uncommon among community-dwelling older adults (2, 5, 14, 62). It is unclear whether the relations between weight status and nutritional risk in rural older women drawn from a Medicare health plan can be generalized to other populations of older persons. Given the cross-sectional nature of this study, further research is needed to assess the stability of the associations between weight status and other nutritional risk measures over time. Further work is also necessary to clarify how these associations are related to health and longevity through examination of quality of life as well as objective resource measures, such as hospital admissions and physician contacts.

Conclusions

Multiple measures indicate that this population is at nutritional risk. Overweight and obesity are prevalent among community-dwelling, rural older adults. Although there are few differences in nutrient intakes between older men and women after controlling for energy intake, high BMI is related to multiple additional nutritional risk factors in women. This finding suggests that overweight and obese older women, particularly those living alone, may be at greater nutritional risk than are men with high BMI values. These data indicate that overweight and obesity can be associated with inadequate intakes of desirable nutrients and unhealthy dietary patterns in rural older adults. Given that weight loss in older adults has been associated with functional decline (5), it may be more appropriate to suggest weight maintenance rather than weight loss; however, further work in this area is needed. It appears that overweight and obese women represent a nutritionally vulnerable group in need of targeted nutritional interventions to improve dietary patterns through increased consumption of nutrient-dense foods. Because older adults are a very heterogeneous group, further investigations are needed to discern the health consequences of different amounts of nutrient intake in obese older women. A better understanding of factors that are associated with adverse health outcomes, such as weight status and diet, may play a role in decreasing the use of health care services and improving the quality of life for older adults.

The authors thank the staff at the Clinical Nutrition Research Center at Geisinger Medical Center in Danville, PA for their efforts in data collection, entry, and management.

All of the authors were involved in planning the study design. Overall study direction was by HS-W and GLJ. Dietary and screening data were collected under the supervision of HS-W and DCM. Biochemical and anthropometric data were collected under the supervision of GLJ, JMF, and CDS. Data analysis was the primary responsibility of JHL, who was also responsible for the first draft of the manuscript. All authors were closely involved in revisions and final approval. None of the authors have had any financial or personal interest in the organization that sponsored the research.

REFERENCES

1. Flegal KM, Carroll MD, Kuczmarski RJ, Johnson CL. Overweight and obesity in the United States: prevalence and trends, 1960–1994. Int J Obes Relat Metab Disord 1998;22:39–47.
2. Friedmann JM, Elasy T, Jensen GL. The relationship between body mass index and self-reported functional limitation among older adults: a gender difference. J Am Geriatr Soc 2001;49:398–403.
3. Harris J, Smiciklas-Wright H, Mitchell D, Friedmann JM, Jensen GL. Underweight, overweight and weight change among community-dwelling, rural older adults. FASEB J 2001;15:239.4 (abstr).
4. Must A, Spadano J, Coakley EH, Field AE, Colditz G, Dietz WH. The disease burden associated with overweight and obesity. JAMA 1999;282:1523–9.
5. Jensen GL, Friedmann JM. Obesity is associated with functional decline among community dwelling rural older persons. J Am Geriatr Soc 2002;50:918–23.
6. Launer LJ, Harris T, Rumpel C, Madans J. Body mass index, weight change, and risk of mobility disability in middle-aged and older women. The epidemiologic follow-up study of NHANES I. JAMA 1994;271:1093–8.
7. Ford ES, Moriarty DG, Zack MM, Mokdad AH, Chapman DP. Self-reported body mass index and health-related quality of life: findings from the behavioral risk factor surveillance system. Obes Res 2001;9:21–31.
8. Wolf AM, Colditz GA. Current estimates of the economic cost of obesity in the United States. Obes Res 1998;6:97–106.
9. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW Jr. Body-mass index and mortality in a prospective cohort of U.S. adults. N Engl J Med 1999;341:1097–105.
10. Murphy SP, Rose D, Hudes M, Viteri FE. Demographic and economic factors associated with dietary quality for adults in the 1987–88 Nationwide Food Consumption Survey. J Am Diet Assoc 1992;92:1352–7.
11. Davis MA, Murphy SP, Neuhaus JM, Gee L, Quiroga SS. Living arrangements affect dietary quality for U.S. adults aged 50 years and older: NHANES III 1988–1994. J Nutr 2000;130:2256–64.
12. Posner BM, Jette A, Smigelski C, Miller D, Mitchell P. Nutritional risk in New England elders. J Gerontol 1994;49:M123–32.
13. Jensen GL, Friedmann JM, Coleman CD, Smiciklas-Wright H. Screening for hospitalization and nutritional risks among community-dwelling older persons. Am J Clin Nutr 2001;74:201–5.
14. Jensen GL, Kita K, Fish J, Heydt D, Frey C. Nutritional risk screening characteristics of rural older persons: relation to functional limitations and health care charges. Am J Clin Nutr 1997;66:819–28.
15. Kant AK, Schatzkin A, Graubard BI, Schairer C. A prospective study of diet quality and mortality in women. JAMA 2000;283:2109–15.
16. Boushey CJ, Beresford SA, Omenn GS, Motulsky AG. A quantitative assessment of plasma homocysteine as a risk factor for vascular disease. Probable benefits of increasing folic acid intakes. JAMA 1995;274:1049–57.
17. The Nutrition Screening Initiative. Incorporating nutrition screening and interventions into medical practice. Washington, DC: The Nutrition Screening Initiative, 1994.
18. Visser M, Bouter LM, McQuillan GM, Wener MH, Harris TB. Elevated C-reactive protein levels in overweight and obese adults. JAMA 1999;282:2131–5.
19. Perry AC, Applegate EB, Allison ML, Miller PC, Signorile JF. Relation between anthropometric measures of fat distribution and cardiovascular risk factors in overweight pre- and postmenopausal women. Am J Clin Nutr 1997;66:829–36.
20. Miller WC, Lindeman AK, Wallace J, Niederpruem M. Diet composition, energy intake, and exercise in relation to body fat in men and women. Am J Clin Nutr 1990;52:426–30.
21. Nelson LH, Tucker LA. Diet composition related to body fat in a multivariate study of 203 men. J Am Diet Assoc 1996;96:771–7.
22. Cid-Ruzafa J, Caulfield LE, Barron Y, West SK. Nutrient intakes and adequacy among an older population on the eastern shore of Maryland: the Salisbury Eye Evaluation. J Am Diet Assoc 1999;99:564–71.
23. Bates CJ, Prentice A, Finch S. Gender differences in food and nutrient intakes and status indices from the National Diet and Nutrition Survey of people aged 65 years and over. Eur J Clin Nutr 1999;53:694–9.
24. Marshall TA, Stumbo PJ, Warren JJ, Xie XJ. Inadequate nutrient intakes are common and are associated with low diet variety in rural, community-dwelling elderly. J Nutr 2001;131:2192–6.
25. Klein GL, Kita K, Fish J, Sinkus B, Jensen GL. Nutrition and health for older persons in rural America: a managed care model. J Am Diet Assoc 1997;97:885–8.
26. Taylor-Davis S, Smiciklas-Wright H, Davis AC, Jensen GL, Mitchell DC. Time and cost for recruiting older adults. J Am Geriatr Soc 1998;46:753–7.
27. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12:189–98.
28. Yesavage JA, Brink TL, Rose TL, et al. Development and validation of a geriatric depression screening scale: a preliminary report. J Psychiatr Res 1982;17:37–49.
29. US Department of Health and Human Services, National Center for Health Statistics, Centers for Disease Control and Prevention. NHANES III anthropometric procedures video. Washington, DC: Government Printing Office, 1996a (stock no. 017-022-01335-5).
30. Mitchell DC, Smiciklas-Wright H, Friedmann JM, Jensen GL. Dietary intake assessed by the Nutrition Screening Initiative Level II Screen is a sensitive but not a specific indicator of nutritional risk in older adults. J Am Diet Assoc 2002;102:842–4.
31. Smiciklas-Wright H, Mitchell D, Ledikwe JH. Dietary intake assessment: methods for adults. In: Berdanier CD, ed. CRC handbook of nutrition and food. Boca Raton, FL: CRC Press, 2001.

The American Journal of Clinical Nutrition

32. Nutrition Consulting Enterprises. Food portion visual. Framingham, MA: Nutrition Consulting Enterprises, 1981.
33. Food and Nutrition Board. Dietary reference intakes applications in dietary assessment. Washington, DC: National Academy Press, 2000.
34. Food and Nutrition Board. Dietary reference intakes for thiamin, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, pantothenic acid, biotin, and choline. Washington, DC: National Academy Press, 1998.
35. Food and Nutrition Board. Dietary reference intakes for vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, molybdenum, nickel, silicon, vanadium and zinc. Washington, DC: National Academy Press, 2001.
36. Food and Nutrition Board. Dietary reference intakes for vitamin C, vitamin E, selenium, and carotenoids. Washington, DC: National Academy Press, 2000.
37. Food and Nutrition Board. Dietary reference intakes for calcium, phosphorus, magnesium, vitamin D and floride. Washington, DC: National Academy Press, 1997.
38. Bowman SA, Lino M, Gerrior SA, Basiotis PP. The Healthy Eating Index: 1994–96, CNPP-5. Alexandria, VA: US Department of Agriculture, Center for Nutrition Policy and Promotion, 1998.
39. Mitchell DC. Database requirements to meet food grouping needs. J Food Composition Analysis 2001;14:279–285.
40. Reynolds RD. Vitamin B6. In: Pesce AJ, Kaplan LA, eds. Methods in clinical chemistry. St Louis: CV Mosby Co, 1987:558–68.
41. Araki A, Sako Y. Determination of free and total homocysteine in human plasma by high- performance liquid chromatography with fluorescence detection. J Chromatogr 1987;422:43–52.
42. Mayer E, Schmidt-Gayk H. Interlaboratory comparison of 25-hydroxyvitamin D determination. Clin Chem 1984;30:1199–204.
43. Sauberlich HE. Laboratory tests for the assessment of nutritional status. 2nd ed. Washington, DC: CRC Press, 1999.
44. Selhub J, Jacques PF, Wilson PW, Rush D, Rosenberg IH. Vitamin status and intake as primary determinants of homocysteinemia in an elderly population. JAMA 1993;270:2693–8.
45. Tabachnick BG, Fidell L. Using multivariate statistics. 4th ed. Boston: Allyn and Bacon, 2001.
46. National Institutes of Health. The practical guide: identification, evaluation and treatment of overweight and obesity in adults. Washington, DC: National Heart, Lung and Blood Institute, National Institutes of Health, 2000.
47. Food and nutrient intakes by individuals in the United States, by sex and age, 1994–96. Beltsville, MD: US Department of Agriculture, Agricultural Research Service, 1998.
48. Koehler KM, Pareo-Tubbeh SL, Romero LJ, Baumgartner RN, Garry PJ. Folate nutrition and older adults: challenges and opportunities. J Am Diet Assoc 1997;97:167–73.
49. Lesourd BM, Mazari L, Ferry M. The role of nutrition in immunity in the aged. Nutr Rev 1998;56:S113–25.
50. La Rue A, Koehler KM, Wayne SJ, Chiulli SJ, Haaland KY, Garry PJ. Nutritional status and cognitive functioning in a normally aging sample: a 6-y reassessment. Am J Clin Nutr 1997;65:20–9.
51. Hann CS, Rock CL, King I, Drewnowski A. Validation of the Healthy Eating Index with use of plasma biomarkers in a clinical sample of women. Am J Clin Nutr 2001;74:479–86.
52. Seale JL, Klein GL, Friedmann JM, Jensen GL, Mitchell DC, Smiciklas-Wright H. Energy expenditure measured by doubly labeled water, activity recall, and diet records in the rural elderly. Nutrition 2002;18:568–73.
53. Goris AH, Westerterp-Plantenga MS, Westerterp KR. Undereating and underrecording of habitual food intake in obese men: selective underreporting of fat intake. Am J Clin Nutr 2000;71:130–4.
54. Briefel RR, Sempos CT, McDowell MA, Chien S, Alaimo K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. Am J Clin Nutr 1997;65(suppl):1203S–9S.
55. Broekmans WM, Klopping-Ketelaars IA, Schuurman CR, et al. Fruits and vegetables increase plasma carotenoids and vitamins and decrease homocysteine in humans. J Nutr 2000;130:1578–83.
56. de Jong N, Paw MJ, de Groot LC, et al. Nutrient-dense foods and exercise in frail elderly: effects on B vitamins, homocysteine, methylmalonic acid, and neuropsychological functioning. Am J Clin Nutr 2001;73:338–46.
57. Gryglewska B, Grodzicki T, Kocemba J. Obesity and blood pressure in the elderly free-living population. J Hum Hypertens 1998;12:645–7.
58. Harris TB, Launer LJ, Madans J, Feldman JJ. Cohort study of effect of being overweight and change in weight on risk of coronary heart disease in old age. BMJ 1997;314:1791–4.
59. Millen BE, Silliman RA, Cantey-Kiser J, et al. Nutritional risk in an urban homebound older population. The nutrition and healthy aging project. J Nutr Health Aging 2001;5:269–77.
60. National Center for Health Statistics. Health, United States, 2001 with urban and rural health chartbook. Hyattsville, MD: National Center for Health Statistics, 2001.
61. Rothacker DQ, Blackburn GL. Obesity prevalence by age group and 5-year changes in adults residing in rural Wisconsin. J Am Diet Assoc 2000;100:784–90.
62. Arroyo P, Loria A, Fernandez V, et al. Prevalence of pre-obesity and obesity in urban adult Mexicans in comparison with other large surveys. Obes Res 2000;8:179–85.

The American Journal of Clinical Nutrition