Proportion of energy intake from fat and subsequent weight change in the NHANES I Epidemiologic Follow-up Study[1–3]

Ashima K Kant, Barry I Graubard, Arthur Schatzkin, and Rachel Ballard-Barbash

ABSTRACT We examined the association of percent energy intake from fat with subsequent weight change in 2580 men and 4567 women, using data from the National Health and Nutrition Examination Survey (NHANES) I Epidemiologic Follow-up Study (NHEFS). Weight change was defined as the difference between the follow-up weight (NHEFS, 1982–1984) and the baseline weight (NHANES I, 1971–1974). Fat intake was estimated from a 24-h dietary recall obtained at baseline. Regression analyses adjusted for potential confounders showed no significant association of percent fat energy with weight change in men. Among women aged <50 y, the inverse relation of percent fat energy with weight change was significant ($\beta = -0.052$, $P = 0.04$). After exclusion of respondents with any morbidity from the analytic cohort, percent fat energy and weight change were positively associated in men ($\beta = 0.046$, $P = 0.05$), but not in women. In conclusion, percent fat energy intake and weight change were inversely related in women aged <50 y in the NHEFS cohort, but positively associated in men without any morbidity. *Am J Clin Nutr* 1995;61:11–7

KEY WORDS Body weight, dietary fat, obesity, NHANES I, NHEFS, weight change, diet composition, nutrition surveys, energy requirements

Introduction

Several reports have suggested that dietary fat intake, independent of total energy intake, may be a determinant of body weight and adiposity (1–8). Proportion of daily energy as fat, estimated from a food-frequency questionnaire (1) or diet records (2–4), has been reported to be higher in the diets of overweight subjects. A positive association between sensory preference for fat and body fatness has also been reported (5). Short-term feeding studies have reported that subjects on low-fat diets may not compensate for dilution of energy density by increasing the quantity of food consumed and, as a consequence, lose body weight (6–8).

The arguments for the role of dietary fat in promoting weight gain include the following: *1*) dietary fat, due to its well-known palatability and energy density, may promote excessive energy intake (9); and *2*) the metabolic efficiency of converting dietary fat into body-fat stores is thought to be greater than that of other macronutrients (10).

The available information on whether long-term regulation of energy intake in humans is influenced by differences in macronutrient composition of the diet is limited. In 30–55-y-old women participating in the Nurses Health Study cohort, the association of dietary fat intake with weight gain in the first 2 y of follow-up differed from the subsequent 4 y in both strength and direction (11). Potential confounders such as level of physical activity and smoking status were not included in these analyses. Klesges et al (12), however, reported a positive association between proportion of fat energy and weight change (adjusted for activity, smoking, alcohol use, etc) over a 3-y period in both men and women.

The purpose of our study was to examine the relation of percent energy from dietary fat intake with changes in body weight over an 8–10-y follow-up period in a large cohort of men and women.

Methods

The first National Health and Nutrition Examination Survey (NHANES I) was conducted from 1971 to 1975 by the National Center for Health Statistics (NCHS) (13). The NHANES I Epidemiologic Follow-up Study (NHEFS) was initiated in 1982 by the NCHS and other Public Health Service agencies, including the National Institutes of Health (14). The aim of NHEFS is to relate mortality and morbidity at follow-up to nutritional, health, and other information collected in NHANES I (14). Respondents who were 25–74 y of age at the time of initial survey ($n = 14\,407$) were considered eligible for follow-up (14). The augmentation phase of NHANES I included 3059 adults, for whom dietary information was not obtained. We excluded these respondents from the eligible cohort.

[1] From the City University of New York, Queens College, Flushing, NY, and the National Cancer Institute, Bethesda, MD.

[2] Presented in part at the 1993 Experimental Biology Meeting, New Orleans.

[3] Reprints not available. Address correspondence to AK Kant, Queens College of the City University of New York, Remsen Hall, Room 306E, 65-30 Kissena Boulevard, Flushing, NY 11367.

Received February 22, 1994.
Accepted for publication July 28, 1994.

Analytic cohort

From the entire NHEFS cohort, exclusions were made for unsatisfactory 24-h recalls based on interviewers' judgement (n = 205), atypical intake due to illness on the day of recall (n = 272), recalls obtained from proxies (n = 334), transcription errors in 24-h recalls (n = 45), and recalls of pregnant and lactating women at baseline (n = 125). Some respondents were in more than one exclusion category. These exclusions, based on reliability of baseline 24-h recall data, yielded a cohort of 10 424 individuals. From this initial cohort, exclusions were made for lack of follow-up weight due to known or suspected death or unknown status (n = 3257), unreliable reported weight (n = 5), and pregnancy at follow-up (n = 15). The final analytic cohort thus included 2580 men and 4567 women (n = 7147).

A single 24-h dietary recall was administered to each respondent at baseline in NHANES I by a trained dietary interviewer using three-dimensional food models to enable estimation of amount of food consumed (13). Estimates of nutrient intake were obtained by using US Department of Agriculture food-composition data for the amounts of food reported consumed in each recall (15). Information on age, income, education, smoking status, level of physical activity, etc, was obtained at baseline (13).

At baseline in 1971–1975, body weight (in disposable paper uniforms and slippers) and height were measured by using standardized procedures in examination trailers (13). At follow-up in 1982–1984, weight was measured (with indoor clothing and without shoes) on a portable scale in the subject's home, but height was not measured (16). Because sex, age, body size, and season-adjusted estimates of weight of indoor clothing are not available for this cohort, we did not adjust the follow-up weight for weight of indoor clothing. Furthermore, our intent was to examine the association of fat intake with weight change from baseline, and not severity or extent of absolute weight change over this period. Such analyses would be unchanged by the subtraction of a constant estimated weight of indoor clothing from the follow-up weight.

Statistical methods

Weight change was defined as the difference between follow-up and baseline weights. Descriptive statistics for baseline nutrient intake, baseline body mass index (BMI), and weight change were obtained by sex-specific quartiles of percent energy from dietary fat. Mean weight change associated with various categories of fat intake was estimated by age and sex. Descriptive statistics for nutrient intake were also obtained by categories of weight change defined by Colditz et al (11).

The association of intake of percent of energy from fat at baseline, and weight change was examined by using sex-specific regression analyses in data stratified by age. In two separate approaches, percent energy from fat was entered either as a continuous variable, or grouped scores (1–4) across quartiles of fat intake were entered as a trend variable in regression analyses. Third, to avoid the assumption of linearity inherent in these analyses, categories formed by quartiles of percent energy from fat were also modeled as a categorical variable. The results from these different analytical approaches were similar and therefore results presented are from models in which percent energy from fat was entered as a continuous variable. All regression analyses were run with and without adjustment for variables that may potentially affect body weight. The potential confounders included race, education (<12, 12, and >12 y), smoking status (never, former, and current smoker), age at baseline (continuous), length of follow-up (continuous), level of self-reported usual (nonrecreational) physical activity at baseline (high, moderate, and low), energy intake (continuous), baseline BMI (continuous), alcohol intake (none, low, and high), special diet status (yes and no), and parity (women only). Additionally, because changes in body weight may be affected by the presence of certain medical conditions, a trend variable based on physician-confirmed diagnosis of heart condition, diabetes, hypertension, or thyroid disease, and hospitalization since 1970 for cirrhosis, colitis, chronic bronchitis, or cancer was created by using the criteria of Williamson et al (17). The morbidity variable ranged from 0 to 3, where 0 is no, 1 is one positive response, 2 is two positive responses, and 3 is three or more positive responses.

Due to the correlation of dietary fat with total energy intake, the association of weight change with fat intake was also examined within different strata (tertiles) of energy intake. Similar stratum-specific regression analyses were also performed for differing levels of usual physical activity reported at baseline, tertiles of BMI, and levels of morbidity.

Statistical software suitable for analyses of complex survey data were used to estimate SEMs (18) and linear-regression coefficients (19). The NCHS calculated and provided a sample weight for each sampled individual with data in the NHANES I data set. These sample weights adjust for probability of selection and nonresponse (13). We repeated the regression analyses without consideration for the complex survey data; the regression coefficients and their SEs were generally smaller in these unweighted analyses, but the overall results obtained did not differ from weighted analyses. The results presented were those obtained from weighted analyses.

Results

The mean age of the analytic cohort at baseline was ≈45 y and the mean length of follow-up was 10.6 y (**Table 1**). Table 1 also lists the mean ± SE of energy and macronutrient intakes (as % of energy), and the proportion of respondents in categories of potential risk factors for changes in body weight, by quartile of percent of energy from fat for men and women. Highest mean BMI was associated with first quartile of percent fat energy in both men and women. With increasing percent fat energy intake, total energy intake increased and percent energy from carbohydrate and alcohol intakes declined.

Male smokers were more likely to be in the upper quartiles of percent fat energy (Table 1). The percentage of men and women reporting heavy activity varied little by quartile of percent fat energy. The upper two quartiles of percent fat energy had a somewhat higher proportion of men and women with no morbidity (Table 1).

The mean ± SE of weight change associated with each quartile of percent of energy from fat, by sex and age group, is presented in **Table 2**. Mean reported weight change was 2.1 kg in men and 2.5 kg in women. Within each quartile of fat intake, the youngest two and the oldest age groups reported the largest mean weight change.

Table 3 presents selected baseline and dietary variables, by categories of weight change, for men and women in the ana-

TABLE 1
Selected baseline and dietary characteristics of the analytic cohort, by quartiles of percent energy from fat and by sex[1]

	Quartile of % of energy intake from fat[1]				
	All	Q1	Q2	Q3	Q4
Men					
n	2580	645	645	645	645
Age (y)	44.6 ± 0.3[2]	44.9 ± 0.6	45.1 ± 0.6	44.8 ± 0.7	43.5 ± 0.6
Length of follow-up (y)	10.6 ± 0.1	10.6 ± 0.1	10.5 ± 0.1	10.6 ± 0.1	10.7 ± 0.1
BMI[3]	25.9 ± 0.1	26.4 ± 0.2	26.0 ± 0.2	25.4 ± 0.1	25.8 ± 0.2
Energy (kJ)	10260 ± 117	9104 ± 197	10184 ± 176	10335 ± 247	11461 ± 255
Protein (% of energy)	16.6 ± 0.1	16.4 ± 0.3	16.4 ± 0.3	16.6 ± 0.2	17.0 ± 0.3
Fat (% of energy)	37.0 ± 0.2	26.2 ± 0.2	34.4 ± 0.1	39.8 ± 0.1	47.9 ± 0.2
Carbohydrate (% of energy)	42.1 ± 0.3	48.5 ± 0.7	44.8 ± 0.4	41.4 ± 0.4	33.5 ± 0.3
Alcohol (g ethanol)	13.3 ± 0.8	16.2 ± 1.4	13.9 ± 1.4	11.6 ± 1.4	11.3 ± 1.4
% Nonwhite	13	15	10	12	14
% With >12 y education	28	31	25	28	27
% Current smokers	40	36	35	44	43
% With heavy activity[4]	53	49	55	55	53
% With no morbidity	50	48	50	53	50
Women					
n	4567	1141	1142	1142	1142
Age (y)	45.9 ± 0.3	47.4 ± 0.6	46.4 ± 0.4	45.2 ± 0.5	44.7 ± 0.4
Length of follow-up (y)	10.6 ± 0.1	10.6 ± 0.1	10.6 ± 0.1	10.6 ± 0.1	10.6 ± 0.1
BMI	25.2 ± 0.1	25.7 ± 0.2	24.7 ± 0.2	25.3 ± 0.2	25.1 ± 0.2
Energy (kJ)	6455 ± 71	5343 ± 113	6392 ± 105	6601 ± 105	7074 ± 138
Protein (% of energy)	17.0 ± 0.1	17.1 ± 0.3	16.9 ± 0.2	16.9 ± 0.2	17.3 ± 0.2
Fat (% of energy)	36.4 ± 0.1	25.6 ± 0.2	33.6 ± 0.1	39.0 ± 0.1	47.2 ± 0.2
Carbohydrate (% of energy)	44.7 ± 0.3	54.2 ± 0.6	47.8 ± 0.3	42.8 ± 0.2	34.4 ± 0.4
Alcohol (g ethanol)	3.9 ± 0.3	5.7 ± 0.6	4.2 ± 0.6	3.1 ± 0.3	3.1 ± 0.3
% Nonwhite	17	21	13	15	17
% With >12 y education	21	22	20	21	20
% Current smokers	31	30	29	30	34
% With heavy activity	46	46	47	47	46
% With no morbidity	46	43	46	48	48
% With parity of 0	16	16	16	17	15

[1] Men: Q1 <31.43, Q2 31.43–37.17, Q3 37.18–42.67, and Q4 >42.67; women: Q1 <30.72, Q2 30.72–36.16, Q3 36.17–41.91, and Q4 >41.91.
[2] $\bar{x}$ ± SE.
[3] In kg/m^2.
[4] Physical activity refers to respondent-described level of usual physical activity (nonrecreational) and was reported in three categories (heavy, moderate, and low).

lytic cohort. Overall, no clear trends in dietary fat intake with weight change were evident in men or women. In men, a slight trend for increasing fat intake was noted in weight-change categories showing mean weight gain only (3 to ≥10 kg).

Table 4 presents the regression coefficients ($\beta \pm$ SE) for percent of energy from fat for unadjusted and fully adjusted regression models for men and women, stratified by age. A positive association between percent of energy from fat and weight change was noted in men aged ≥ 50 y (P = 0.04) in the unadjusted regression models. However, after adjustment for potential confounders (baseline BMI, race, education, age, total energy intake, smoking status, level of physical activity, length of follow-up, morbidity, alcohol intake, and special diet status), the association was no longer significant. Baseline age and BMI, length of follow-up, moderate level of physical activity, and lack of information about alcohol status were strong predictors of weight change in men.

Among women aged <50 y, the regression coefficient for percent of energy from dietary fat was significant in both unadjusted ($\beta = -0.0646$, $P = 0.01$) and fully adjusted ($\beta = -0.0526$, $P = 0.04$) regression models (Table 4). Baseline age and BMI, low level of education, special diet status, and lack of information about parity and smoking status were strong predictors of weight change in women.

In regression models that excluded respondents scoring one or more on the morbidity variable, the association of dietary fat with weight change was significant in men (n = 1301, $\beta = 0.0467$, $P = 0.05$), but inverse (NS) in women (**Table 5**).

The association of dietary fat with weight change in different strata (tertiles) of energy intake was not significant in men or women, except for men and women in the lowest tertile of energy intake (**Table 6**). For men in the first tertile of energy intake, the association was not significant after multivariate adjustment. For women in the lowest tertile of energy intake, the regression coefficient for percent of energy from dietary fat was significant ($\beta = -0.0704$, $P = 0.01$) in the multivariate-regression model.

In regression models stratified for tertiles of BMI, there was no association of dietary fat intake with weight change in either men or women (data not shown). A similar lack of association was noted in regression analyses stratified by level of physical activity, except in women with a moderate level of physical

TABLE 2
Weight change, by quartiles of fat intake and by sex and age group[1]

	Quartile of % of energy from fat intake[2]				
	All	Q1	Q2	Q3	Q4
			kg		
Men					
All ages	2.11 ± 0.2	1.79 ± 0.3	1.69 ± 0.2	2.39 ± 0.4	2.58 ± 0.4
25–34 y	4.24 ± 0.3	3.72 ± 0.8	4.60 ± 0.5	3.75 ± 0.7	4.80 ± 0.9
35–44 y	2.79 ± 0.3	3.45 ± 0.7	2.32 ± 0.6	3.45 ± 1.0	1.89 ± 0.5
45–54 y	1.59 ± 0.3	0.96 ± 0.6	0.22 ± 0.6	2.56 ± 0.8	2.62 ± 0.8
55–64 y	0.23 ± 0.4	−0.27 ± 0.6	−0.32 ± 0.6	0.50 ± 0.9	1.08 ± 1.0
65–74 y	−2.03 ± 0.3	−2.70 ± 0.4	−1.75 ± 0.8	−1.55 ± 0.5	−2.10 ± 0.5
Women					
All ages	2.49 ± 0.2	2.53 ± 0.3	2.72 ± 0.2	2.23 ± 0.2	2.47 ± 0.3
25–34 y	5.09 ± 0.3	6.02 ± 0.5	5.17 ± 0.6	5.10 ± 0.5	4.14 ± 0.7
35–44 y	3.86 ± 0.3	4.44 ± 0.8	4.45 ± 0.6	3.56 ± 0.5	3.22 ± 0.6
45–54 y	2.44 ± 0.4	2.32 ± 1.0	2.98 ± 0.6	1.44 ± 0.7	2.95 ± 0.6
55–64 y	0.28 ± 0.4	0.34 ± 0.6	0.90 ± 0.6	−0.39 ± 0.6	0.13 ± 0.9
65–74 y	−3.07 ± 0.3	−3.06 ± 0.6	−3.79 ± 0.6	−2.64 ± 0.5	−2.63 ± 0.6

[1] $\bar{x}$ ± SE. Weight change = weight at follow-up − weight at baseline (unadjusted for weight of indoor clothing worn at follow-up). Age refers to age at baseline, NHANES I, 1971–74 (13).
[2] Men: Q1 <31.43, Q2 31.43–37.17, Q3 37.18–42.67, and Q4 >42.67; women: Q1 <30.72, Q2 30.72–36.16, Q3 36.17–41.91, and Q4 >41.91.

activity [regression coefficient (β) for fat from the multivariate-regression model was −0.0746, P = 0.01].

Discussion

The association of baseline percent energy intake from fat with subsequent weight change over 8–10 y of follow-up was not significant in this cohort of men and women (except in women aged <50 y, but the association was in a direction reverse of expected). Leibel et al (20) also observed that macronutrient composition of the diet did not affect the amount of energy required for maintaining body weight of subjects housed in a metabolic ward for an average of 33 d. Klesges et al (12), however, found the proportion of fat energy to be a positive predictor of weight change over a 3-y follow-up period.

Among the reasons for a lack of a relationship between percent fat energy and weight change in this cohort may be the following. Dietary fat as a source of energy tends to be highly correlated with total energy intake. Although we included total energy intake as a potential confounder in all multivariate-regression models reported in this paper, it may not be possible to examine the independent effect of dietary fat in these analyses. To further explore the effect of energy intake on the association of fat intake with weight change, we examined the fat–weight change association within each tertile of energy intake. The significantly inverse association of fat intake with weight change was observed in women in the lowest tertile of

TABLE 3
Selected baseline and dietary characteristics of the analytic cohort, by categories of weight change

	Categories of weight change					
	<−5 kg	−5 to <−3 kg	−3 to <3 kg	3 to <5 kg	5 to <10 kg	≥10 kg
Men						
n	381	211	972	307	472	237
Percent of men (%)	14.77	8.18	37.67	11.90	18.29	9.19
Baseline age (y)	48 ± 0.7[1]	49 ± 0.9	46 ± 0.4	45 ± 0.7	41 ± 0.8	38 ± 0.7
Weight change (kg)	−9.5 ± 0.4	−3.9 ± 0.1	0.14 ± 0.1	4.01 ± 0.1	7.07 ± 0.1	14.8 ± 0.4
Baseline BMI[2]	28.5 ± 0.4	26.4 ± 0.4	25.8 ± 0.1	25.2 ± 0.3	25.0 ± 0.2	25.4 ± 0.3
Fat (% of energy)	36.3 ± 0.7	37.4 ± 0.8	36.8 ± 0.4	36.0 ± 0.6	37.6 ± 0.5	38.1 ± 0.6
Energy (kJ)	9787 ± 285	9586 ± 385	10155 ± 163	10134 ± 272	10858 ± 226	10666 ± 339
Women						
n	712	301	1515	549	894	596
Percent of women (%)	15.59	6.59	33.17	12.02	19.58	13.05
Baseline age (y)	53 ± 0.6	49 ± 1.1	48 ± 0.3	44 ± 0.6	43 ± 0.5	39 ± 0.6
Weight change (kg)	−10.6 ± 0.3	−3.9 ± 0.1	0.33 ± 0.1	4.01 ± 0.1	7.28 ± 0.1	15.8 ± 0.3
Baseline BMI	29.2 ± 0.3	26.3 ± 0.5	24.7 ± 0.2	23.6 ± 0.3	24.2 ± 0.2	25.1 ± 0.2
Fat (% of energy)	36.0 ± 0.3	36.2 ± 0.6	36.9 ± 0.3	36.1 ± 0.3	36.6 ± 0.3	35.7 ± 0.4
Energy (kJ)	5911 ± 121	6053 ± 176	6467 ± 105	6890 ± 125	6739 ± 155	6308 ± 121

[1] $\bar{x}$ ± SE. Weight change = weight at follow-up − weight at baseline (unadjusted for weight of indoor clothing worn at follow-up).
[2] In kg/m^2.

TABLE 4
Regression coefficients associated with percent of energy from fat, in men and women[1]

	$\beta \pm SE^{\beta}$	P
Men		
All ages (n = 2580)		
Univariate	0.0428 ± 0.0223	0.06
Multivariate	0.0209 ± 0.0216	0.33
<50 y (n = 1304)		
Univariate	0.0220 ± 0.0286	0.44
Multivariate	0.0040 ± 0.0277	0.88
≥50 y (n = 1276)		
Univariate	0.0658 ± 0.0308	0.04
Multivariate	0.0579 ± 0.0346	0.10
Women		
All ages (n = 4567)		
Univariate	−0.0110 ± 0.0167	0.51
Multivariate	−0.0333 ± 0.0189	0.08
<50 y (n = 2849)		
Univariate	−0.0646 ± 0.0251	0.01
Multivariate	−0.0526 ± 0.0251	0.04
≥50 y (n = 1718)		
Univariate	0.0073 ± 0.0309	0.81
Multivariate	−0.0185 ± 0.0303	0.55

[1] Univariate: dependent variable is weight change, independent variable is % of energy from fat; multivariate: dependent variable is weight change, independent variables are % of energy from fat, baseline age, race, education, baseline BMI, energy intake, smoking status, level of usual physical activity, length of follow-up, alcohol intake, morbidity, special-diet status, and parity (women only).

energy intake only (Table 6). (Many women in the lowest tertile of energy intake at baseline may have been on energy- or fat-restricted diets or underreported fat intake due to a high BMI at baseline. The mean baseline BMI for women in the lowest, middle, and high levels of energy intake was 26.2, 25.4, and 24.1, respectively.) It is interesting to note that the regression coefficient for total energy intake in multivariate-regression models was not significant for men and women in the analytic cohort. Braitman et al (21) also did not observe an association between reported energy intake and body weight at baseline in an analyses of NHANES I data (21).

To exclude the possibility that weight change over follow-up may be related to preclinical or clinical conditions, we also examined the association of percent fat energy with weight change after exclusion of respondents with varying levels of morbidity since 1970 (Table 5). After exclusion of men scoring one or more on the morbidity variable (n = 1279), the relation of percent fat energy with weight change was significantly positive. (Kendall's τ coefficient for correlation of the morbidity score with percent fat energy was −0.01 in men and −0.05 women.) The positive association of percent fat energy with weight change in men without morbidity may reflect either a true effect modification or differential reliability of reporting due to the presence of morbidity. However, among women without morbidity the association of weight change with percent fat energy remained insignificantly inverse.

The estimate of dietary fat intake in the present study is derived from a single 24-h dietary recall, and therefore may be a relatively poor indicator of customary food intake of respondents in the cohort. Sources of measurement error in 24-h dietary-recall data have been discussed by Beaton et al (22) and Bingham (23), and can lead to an attenuation of the diet and disease relationship, if any. Estimates of intra- to interindividual variance ratios for percent energy from fat range from 1.4 to 1.8 for British men (7-d weighed diet records) (24), 2.5

TABLE 5
Regression coefficients associated with percent of energy from fat for men and women scoring 0 on the morbidity variable[1]

	$\beta \pm SE^{\beta}$	P
Men (n = 1301; mean age = 41.2 y, mean weight change = 2.83 kg)		
Univariate	0.0615 ± 0.0254	0.02
Multivariate	0.0467 ± 0.0230	0.05
Women (n = 2111; mean age = 42.0 y, mean weight change = 3.14 kg)		
Univariate	−0.0224 ± 0.0154	0.15
Multivariate	−0.0265 ± 0.0176	0.14

[1] Morbidity variable: a trend variable based on physician-confirmed diagnosis of heart condition, diabetes, hypertension, or thyroid disease, and hospitalization since 1970 for cirrhosis, colitis, chronic bronchitis, or cancer was created by using the criteria of Williamson et al (17). The morbidity variable ranged from 0 to 3, where 0 is no, 1 is 1 positive response, 2 is 2 positive responses, and 3 is 3 or more positive responses. The mean percent energy from fat for men scoring 0, 1, 2, or 3 on the morbidity score was 37, 37, 36, and 36, respectively. For women scoring 0, 1, 2, and 3 on the morbidity score, the mean percent energy from fat was 37, 36, 36, and 35, respectively. Univariate: dependent variable is weight change; independent variable is % of energy from fat. Multivariate: dependent variable is weight change; independent variables are % energy from fat, baseline age, race, education, baseline BMI, energy intake, smoking status, level of usual physical activity, length of follow-up, alcohol intake, special-diet status, and parity (women only).

TABLE 6
Regression coefficients associated with percent of energy from fat, for men and women in different strata (tertiles) of energy intake[1]

	$\beta \pm SE^{\beta}$	P
Men (n = 2580)		
First tertile (n = 860)		
Univariate	0.0856 ± 0.0406	0.04
Multivariate	0.0451 ± 0.0452	0.32
Second tertile (n = 860)		
Univariate	0.0258 ± 0.0328	0.43
Multivariate	−0.0031 ± 0.0325	0.92
Third tertile (n = 860)		
Univariate	0.0063 ± 0.0425	0.88
Multivariate	0.0080 ± 0.0438	0.85
Women (n = 4567)		
First tertile (n = 1522)		
Univariate	−0.0522 ± 0.0266	0.06
Multivariate	−0.0704 ± 0.0259	0.01
Second tertile (n = 1523)		
Univariate	−0.0101 ± 0.0351	0.77
Multivariate	−0.0229 ± 0.0361	0.53
Third tertile (n = 1522)		
Univariate	0.0136 ± 0.0399	0.73
Multivariate	0.0030 ± 0.0355	0.93

[1] Univariate: dependent variable is weight change, independent variable is % of energy from fat; multivariate: dependent variable is weight change, independent variables are % of energy from fat, baseline age, race, education, baseline BMI, smoking status, level of usual physical activity, length of follow-up, alcohol intake, morbidity, special-diet status, and parity (women only).

for Finnish men (24-d diet records) (25), 2.2 and 1.6 for Canadian men and women, respectively, (six 24-h dietary recalls) (22), and 2.6 for subjects in a hypertension study (7-d diet records) (26). Using data from the 1989–91 US Department of Agriculture Continuing Survey of Food Intakes by Individuals (one 24-h recall and two self-administered diet records, 3061 men and 4333 women aged ≥25 y), we estimated (unpublished) an intraindividual-interindividual variance ratio for percent fat energy to be ≈2.2. Thus, with a variance ratio of ≈2.5, the regression coefficients in Table 4 may be considered to be attenuated by nearly 70% (27). As suggested by Beaton et al (22), we have presented dietary and other data, using weight change as a classification variable (Table 3).

It is also possible that estimates of intake of percent fat energy at any one time may indeed have low ability to predict weight change over a long follow-up period, due to changes made by respondents in their diet in response to body weight. Therefore, unless estimates of fat intake are available at several points in the period of follow-up, no conclusions regarding the effect of body weight on fat intake are possible. Note however that descriptive studies (1–3) have reported higher (not lower) fat intakes by individuals with greater body weight and adiposity. However, we did not observe an association between baseline BMI and dietary fat intake in the NHANES I cohort. In regression analyses with baseline BMI as a dependent variable, energy-adjusted and multiple-covariate-adjusted regression coefficients for percent fat energy in men were −0.018 (P = 0.13) and −0.014 (P = 0.24), respectively; for women these coefficients were −0.006 (P = 0.53) and 0.0008 (P = 0.91). Also, as reported elsewhere (28), women classified as overweight at baseline in the NHANES I were more likely to show major weight gain at follow-up. Such an observation argues against sustained changes in diets (during the follow-up period) of respondents classified as overweight at baseline. Nevertheless, an analysis of the food-frequency data obtained at follow-up may possibly show a different relationship between dietary fat and weight change.

Furthermore, if there is differential estimation of usual food intake based on respondents' body weight (29) or other unknown factors, it may affect the reliability of estimates of fat and energy intakes obtained in this and other studies. The significantly inverse association of percent fat energy with weight change in women aged <50 y may partially relate to such a reporting bias. In BMI stratum-specific analyses, however, the direction of the association remained inverse (NS) in women in each of the three tertiles of BMI; among men, the direction remained positive (NS) in the first and third tertiles but was inverse (NS) in the second tertile (data not shown).

Finally, our study is limited by a lack of consideration for the strong familial and genetic factors that are known to affect energy expenditure (10) and, therefore, energy storage. The potential interaction of predisposition to energy storage and varying metabolic response to macronutrient intake (10) cannot be examined in the data presented. The study also lacks body-composition and body-fat-distribution data, which in laboratory animals has been shown to change with dietary macronutrient intake without affecting body weight (30).

In conclusion, in our analyses the positive association between estimates of dietary fat intake at any one time with subsequent long-term weight change was limited to men scoring zero on the morbidity variable. However, several feeding studies (6–8) and an intervention trial (31) have shown the benefits of conscious reduction in percent fat energy intake for achieving weight loss. Also, because of the body of evidence supporting the link between dietary fat intake and risk of chronic diseases (32), reduction of dietary fat intake remains a desirable goal.

We thank Lisa Licitra Kahle, IMS, Silver Spring, MD, for computing assistance.

References

1. Tucker LA, Kano M. Dietary fat and body fat: a multivariate study of 205 adult females. Am J Clin Nutr 1992;56:616–22.
2. Dreon DM, Frey-Hewitt B, Ellsworth N, Williams PT, Terry RB, Wood PD. Dietary fat: carbohydrate ratio and obesity in middle-aged men. Am J Clin Nutr 1988;47:995–1000.
3. 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.
4. Romieu I, Willett WC, Stampfer MJ, et al. Energy intake and other determinants of relative weight. Am J Clin Nutr 1988;47:406–12.
5. Mela DJ, Sacchetti DA. Sensory preferences for fats: relationship with diet and body composition. Am J Clin Nutr 1991;53:908–15.
6. Prewitt TE, Schmeisser D, Bowen P, et al. Changes in body weight, body composition, and energy intake in women fed high- and low-fat diets. Am J Clin Nutr 1991;54:304–10.
7. Lissner L, Levitsky DA, Strupp BJ, Kalkwarf HJ, Roe DA. Dietary fat and the regulation of energy intake in human subjects. Am J Clin Nutr 1987;46:886–92.
8. Kendall A, Levitsky DA, Strupp BJ, Lissner L. Weight loss on a low-fat diet: consequence of the imprecision of the control of food intake in humans. Am J Clin Nutr 1991;53:1124–9.
9. Rolls BJ, Shide DJ. The influence of dietary fat on food intake and body weight. Nutr Rev 1992;50:283–90.
10. Sims EAH, Danforth E. Expenditure and storage of energy in man. J Clin Invest 1987;79:1019–25.
11. Colditz GA, Willett WC, Stampfer MJ, London SJ, Segal MR, Speizer FE. Patterns of weight change and their relation to diet in a cohort of healthy women. Am J Clin Nutr 1990;51:1100–5.
12. Klesges RC, Klesges LM, Haddock CK, Eck LH. A longitudinal analysis of the impact of dietary intake and physical activity and weight change in adults. Am J Clin Nutr 1992;55:818–22.
13. National Center for Health Statistics. Instruction manual: data collection. Part 15a. Hanes Examination staff procedures manual for Health and Nutrition Examination Survey, 1971–73. Washington, DC: US Government Printing Office, 1972. (Publication 722–554/89.)
14. Cornoni-Huntley J, Barbano HE, Brody JA, et al. National Health and Examination I—epidemiologic followup survey. Public Health Rep 1983;98:245–51.
15. Watt BK, Merrill AL. Composition of foods: raw, processed, prepared. Agriculture handbook no. 8 (revised). Washington, DC: US Government Printing Office, 1963.
16. National Center for Health Statistics. Plan and operation of NHANES I Epidemiologic Followup Study, 1982–84. Vital Health Stat Ser [1] 1987; 22.
17. Williamson DF, Madans J, Anda RF, Kleinman JC, Giovino GA, Byers T. Smoking cessation and severity of weight gain in a national cohort. N Engl J Med 1991;324:739–45.
18. Shah BV. SESUDAAN: Standard Errors Program for Computing of Standardized Rates from Sample Survey Data. Research Triangle Park, NC: Research Triangle Institute, 1981.
19. Holt MM. SURREGR: Standard errors of regression coefficients from sample survey data. Research Triangle Park, NC: RTI, 1977. (revised in 1982 by BV Shah.)

20. Leibel RL, Hirsch J, Appel BE, Checani GC. Energy intake required to maintain body weight is not affected by wide variations in diet composition. Am J Clin Nutr 1992;55:350–5.
21. Braitman LE, Adlin EV, Stanton JL. Obesity and caloric intake: the National Health and Nutrition Examination Survey of 1971–1975 (HANES I). J Chronic Dis 1985;38:727–32.
22. Beaton GH, Milner J, Corey P, et al. Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Am J Clin Nutr 1979;32:2546–59.
23. Bingham SA. The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. Nutr Abstr Rev 1987;57:704–43.
24. Marr JW, Heady JA. Within- and between-person variation in dietary surveys: number of days needed to classify individuals. Hum Nutr Appl Nutr 1986;40A:347–364.
25. Hartman AM, Brown CC, Palmgren J, et al. Variability in nutrient and food intakes among older middle-aged men. Implications for design of epidemiologic and validation studies using food recording. Am J Epidemiol 1990;132:999–1012.
26. Liu K. Statistical issues related to the design of dietary survey methodology for NHANES III. In: Briefel RB, Sempos CT, eds. Dietary methodology workshop for the third National Health and Nutrition Examination survey. National Center for Health Statistics. Vital Health Stat Ser [4] 1992;27.
27. Snedecor GW, Cochran WG. Statistical methods. Ames, IA: Iowa University Press, 6th ed. 1967:164–5.
28. Williamson DF, Kahn HS, Remington PL, Anda RF. The 10-year incidence of overweight and major weight gain in US adults. Arch Intern Med 1990;150:665–72.
29. Heitmann BL. The influence of fatness, weight change, slimming history, and other lifestyle variables on diet reporting in Danish men and women aged 35–65 years. Int J Obes 1993;17:329–36.
30. Boozer CN, Brasseur A, Atkinson RL. Dietary fat affects weight loss and adiposity during energy restriction in rats. Am J Clin Nutr 1993; 58:846–52.
31. Sheppard L, Kristal AR, Kushi LH. Weight loss in women participating in a randomized trial of low-fat diets. Am J Clin Nutr 1991;54: 821–8.
32. National Research Council. Committee on Diet and Health. Diet and health: implications for reducing chronic disease risk. Washington, DC: National Academy of Sciences, 1989.