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Frequency of eating occasions and weight change in the NHANES I Epidemiologic Follow-up Study

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OBJECTIVE: To examine the association of frequency of eating occasions with prospective, and retrospective weight change.

DESIGN: Data from the NHANES I (1971–75) Epidemiologic Follow-up Study (NHEFS, 1982–84) (n = 7147) was used. Weight change was defined as the difference between the weight measured at follow-up in 1982–84 and the weight measured at baseline in 1971–75. Baseline frequency of eating occasions was estimated by summation of actual times at which food was reported consumed in a 24-h dietary recall. Follow-up frequency of eating was estimated from subject responses at follow-up to number of meals and snacks consumed daily.

RESULTS: Men and women reported (mean ± s.e.) baseline frequency of 5.3 ± 0.06 and 4.9 ± 0.03 eating occasions, respectively. Frequency of eating occasions at follow-up was 3.6 ± 0.02 occasions in both men and women. Baseline body mass index and frequency of eating were inversely related in multivariate regression analyses in both men and women ($P < 0.02$). Regression analyses adjusted for multiple covariates showed no association between weight change and frequency of eating at baseline or follow-up.

CONCLUSION: Baseline frequency and subsequent weight change or follow-up frequency and preceding weight change were unrelated in the NHEFS cohort.

Keywords: body weight, NHANES I, NHEFS, meal patterns, meal frequency, thermic effect of food, cohort

Introduction

It has been suggested that frequency of meal intake may affect the extent of post-prandial thermogenesis or thermic effect of food (TEF), and therefore influence total daily energy expenditure and energy balance.[1,2] The energy expenditure for TEF primarily represents the energy required for digestion, absorption, transport, metabolism, and storage of nutrients after ingestion of a meal, and is approximately 10% of total daily energy intake.[2]

Frequency of food ingestion has been consistently shown to affect metabolic response as measured in circulating insulin and lipid levels.[3–8] In experimental animals, meal feeding versus nibbling has been reported to be associated with greater body fatness.[9] Leveille[10] has suggested that in laboratory animals, decreased meal frequency may affect the adipocyte metabolism by favoring lipogenesis and thus promote obesity. A limited number of descriptive epidemiologic studies have also reported an inverse association between meal frequency and body weight or body fatness.[3,11] Such an observation would suggest that TEF and therefore total energy expenditure is greater among individuals with a pattern of more frequent feeding. However, results from studies using isocaloric loads fed for short and/or long duration with varying frequency of meal ingestion are not always consistent with this notion.[12–20]

The purpose of our study was to examine the association of frequency of eating occasions with weight change over an 8–10 year follow-up period in a large cohort of men and women.

Methods

The first National Health and Nutrition Examination Survey (NHANES 1) was conducted from 1971–75 by the National Center for Health Statistics (NCHS).[21] The NHANES I Epidemiologic Follow-up Study (NHEFS) was initiated in 1982 by NCHS and other Public Health Service agencies of the United States, including the National Institutes of Health.[22] The aim of NHEFS is to relate mortality and morbidity at follow-up to nutritional, health and other information collected in NHANES I.[22] Respondents who were 25–74 years of age at the time of initial survey (n = 14,407) were considered eligible for follow-up.[22] The augmentation phase of NHANES I included 3059 adults, for whom dietary information was not obtained. We excluded these respondents from the eligible cohort.

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, or missing weight at follow-up interview (n = 3257);

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pregnant at follow-up (n = 15); and unreliable reported weight (n = 5). The final analytic cohort (n = 7147) was aproximately 68% of the eligible cohort of 10 424 with usable dietary information, and included 2580 men and 4567 women. The distributions of variables such as age, eating frequency, baseline BMI, and energy intake in the analytic cohort (n = 7147) were similar to those in the eligible cohort (n = 10 424) before exclusions.

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.[21] Estimates of nutrient intake were obtained using US Department of Agriculture food composition data for the amounts of food reported consumed in each recall.[23] Information on covariates such as age, income, education, smoking status, and level of physical activity was obtained at baseline.[21]

Frequency of eating occasions at baseline in 1971–75
As part of the baseline 24-h recall respondents were asked to report the actual time of day for each food recalled as consumed. We estimated the frequency of eating occasions from examining the time of day the foods were consumed. For each 24-h recall, we summed the actual reported times of day at which energy yielding foods were consumed. All foods recalled at one reported time (e.g., foods consumed as part of a meal) were taken to represent one eating occasion. Because TEF is a function of ingestion of macronutrients, eating occasions where only non-caloric foods such as water or diet soda were consumed were not counted as eating occasions.

Frequency of eating occasions at follow-up in 1982–84
At follow-up interview respondents were asked one question each regarding the number of meals and number of snacks consumed daily (Appendix 1). We combined responses to these two questions to obtain the number of eating occasions at follow-up. Forty-six respondents did not answer the two questions, leaving 7101 respondents in the follow-up eating occasion cohort.

At baseline in 1971–75, body weight and height were measured using standardized procedures in examination trailers.[21] At follow-up in 1982–84, weight was measured using a portable scale in subject's home,[24] but height was not measured. Information regarding health status was also obtained at follow-up.[22]

Statistical methods
Weight change was defined as the difference between the follow-up and the baseline weight. Descriptive statistics for baseline nutrient intake, baseline body mass index (BMI), weight change, and other variables were obtained by frequency of eating occasion, by sex.

The association of weight change with frequency of eating occasions at baseline and at follow-up was examined using sex-specific regression analyses in which the frequency of eating occasions variable was entered either as a continuous or as a categorical variable. Modeling of the frequency of eating occasion variable as a categorical variable avoids the assumption of linearity inherent in models including the frequency variable as a continuous variable. The results from these two analytical approaches were generally similar and therefore, we present summary results from analyses where meal frequency was modeled as a continuous variable.

All regression analyses were run with and without adjustment for variables that may potentially affect body weight. With the exception of the physical activity variable, the potential confounders for both baseline and follow-up regression analyses were similar and included race (white, non-white), education (<12, 12, >12 years), smoking status (never, former and current smoker), age and body mass index (BMI) at baseline (continuous), length of follow-up (continuous), energy intake (continuous), alcohol (g of ethanol) intake (0, < 9.35 g and ≥ 9.35 g/d for men; and 0, < 2.35 g, ≥ 2.35 g/d for women), special diet status (yes, and no), and parity (women only). Information on self-reported level of usual physical activity was obtained at baseline and at follow-up (a lot, moderate, and little), therefore, the baseline and the follow-up multivariate regression models included the baseline and the follow-up level of physical activity, respectively. Additionally, because changes in body weight may be affected by the presence of morbidity, 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, using the criteria of Williamson *et al.*[25] The morbidity variable ranged from 0–3, where 0 = no, 1 = 1 positive response, 2 = 2 positive responses, and 3 = 3 or more positive responses.

To examine whether age, energy intake, baseline BMI, level of physical activity, smoking status, alcohol intake, and level of morbidity modify the relation of eating occasions with weight change (effect modification), the association of weight change with frequency of eating occasions was also examined within different strata of these variables.

Statistical software suitable for analyses of complex survey data were used to estimate standard errors for means,[26] and linear regression coefficients.[27]

Results

Table 1 presents the proportion of respondents in various categories of frequency of eating occasions at baseline and at follow-up. Two or fewer eating occasions were reported by only 2% of the cohort at baseline 24-h recall. At follow-up, from a summary of two questions on snack and meal frequency, nearly 15% of the cohort reported eating frequency of ≤ 2 occasions. Conversely, nearly 30% of the analytic cohort reported ≥ 6 eating occasions at baseline using a 24-h recall relative to only 5% at follow-up based on answers to two questions on meal and snack frequency.

Tables 2 and 3 present mean ± standard error of selected variables by categories of eating occasions at baseline and at follow-up, respectively. The mean age of men and women in the analytic cohort was 44.5 and 45.9 years, respectively. At baseline, relative to all other categories, the eating occasion category of ≤ 2 was associated with the

Table 1 Proportion of respondents in categories of frequency of eating occasions at baseline, and at follow-up, by sex, by age

	Frequency of eating occasions at baseline ≤ 2	3	4	5	6	≥ 7
	%					
All	2.35	15.77	27.16	24.47	15.91	14.34
Men						
All ages	2.29	14.46	24.38	23.84	17.05	17.98
< 50 y	1.76	11.04	20.63	24.54	19.10	22.93
≥ 50 y	2.82	17.95	28.21	23.12	14.97	12.93
Women						
All ages	2.39	16.51	28.73	24.83	15.26	12.28
< 50 y	2.49	14.43	27.45	24.99	16.22	13.68
≥ 50 y	2.21	19.97	30.85	24.56	13.68	8.78
	Frequency of eating occasions at follow-up					
All	14.52	35.38	31.08	13.53	3.80	1.69
Men						
All ages	13.97	35.64	32.28	12.96	3.75	1.41
< 50 y	15.17	34.57	30.33	15.01	3.85	1.08
≥ 50 y	12.75	36.74	34.28	10.85	3.64	1.74
Women						
All ages	14.83	35.23	30.40	13.86	3.83	1.85
< 50 y	16.60	32.10	30.23	15.11	3.92	2.05
> 50 y	11.89	40.42	30.70	11.78	3.69	1.52

Frequency of eating occasions at baseline (1971–75) was computed from summation of actual number of distinct times food was reported as consumed in a 24-h dietary recall.
Frequency of eating occasions at follow-up (1982–84) was derived from combining respondent answers to one question each about number of meals and snacks eaten per day.

Table 2 Mean ± s.e.m. of selected variables by frequency of eating occasions at baseline, by sex

	Frequency of eating occasions at baseline ≤ 2	3	4	5	6	≥ 7
Men						
n	59	373	629	615	440	464
Age* (y)	43.10 ± 2.4	48.60 ± 0.9	46.66 ± 0.7	43.57 ± 0.5	43.27 ± 0.7	42.47 ± 0.5
Weight change* (kg)	1.17 ± 0.8	1.83 ± 0.5	1.78 ± 0.3	1.91 ± 0.3	3.07 ± 0.5	1.99 ± 0.4
Baseline BMI* (kg/m^2)	25.95 ± 1.0	26.10 ± 0.2	26.29 ± 0.2	25.93 ± 0.2	25.75 ± 0.3	25.57 ± 0.2
TSF (mm)	11.97 ± 1.3	12.53 ± 0.4	12.24 ± 0.4	12.68 ± 0.3	12.63 ± 0.3	11.99 ± 0.2
SSF* (mm)	17.43 ± 2.3	17.79 ± 0.5	16.83 ± 0.4	17.14 ± 0.5	16.92 ± 0.5	15.74 ± 0.3
Cholesterol (mg/dl)	214.00 ± 8.7	226.00 ± 2.6	219.00 ± 2.5	219.00 ± 2.7	215.00 ± 3.0	219.00 ± 3.2
Energy* (kcal)	1453.00 ± 128	1961.00 ± 75	2246.00 ± 44	2506.00 ± 47	2624.00 ± 50	2806.00 ± 59
Fat* (% energy)	36.00 ± 2.0	38.05 ± 0.7	38.12 ± 0.5	36.91 ± 0.5	36.14 ± 0.5	36.11 ± 0.5
Alcohol* (g)	11.60 ± 0.8	10.50 ± 3.9	8.80 ± 0.8	11.00 ± 0.8	17.90 ± 3.7	18.10 ± 1.7
Women						
n	109	754	1312	1134	697	561
Age* (y)	45.95 ± 1.6	48.57 ± 0.5	46.42 ± 0.5	46.00 ± 0.5	44.48 ± 0.6	43.79 ± 0.7
Weight change* (kg)	4.06 ± 0.9	1.26 ± 0.4	2.15 ± 0.3	2.58 ± 0.2	3.11 ± 0.3	3.34 ± 0.5
Baseline BMI* (kg/m^2)	27.02 ± 1.0	26.56 ± 0.2	25.61 ± 0.2	24.86 ± 0.2	24.40 ± 0.2	24.21 ± 0.3
TSF* (mm)	25.07 ± 1.2	25.00 ± 0.3	24.41 ± 0.3	23.62 ± 0.2	23.42 ± 0.3	22.64 ± 0.5
SSF* (mm)	22.54 ± 1.6	21.62 ± 0.5	20.38 ± 0.3	18.52 ± 0.3	18.21 ± 0.5	17.24 ± 0.6
Cholesterol* (mg/dl)	214.00 ± 4.2	226.00 ± 2.6	221.00 ± 2.3	220.00 ± 1.9	219.00 ± 3.5	215.00 ± 2.2
Energy* (kcal)	920.00 ± 79	1246.00 ± 29	1445.00 ± 25	1568.00 ± 22	1759.00 ± 30	1839.00 ± 45
Fat (% of energy)	34.59 ± 2.0	36.98 ± 0.5	36.47 ± 0.3	36.14 ± 0.3	36.58 ± 0.3	36.34 ± 0.4
Alcohol* (g)	4.00 ± 0.3	3.40 ± 0.6	3.70 ± 0.6	4.20 ± 0.6	4.20 ± 0.3	5.10 ± 0.6

Frequency of eating occasions at baseline (1971–75) was computed by summation of actual number of distinct times food was reported as consumed in a 24-h dietary recall.
* *The association of each variable with frequency of eating was significant ($P < 0.05$)*
BMI = Body mass index
Cholesterol = plasma cholesterol (measured at baseline)
TSF = triceps skinfold (measured at baseline)
SSF = subscapular skinfold (measured at baseline)

Table 3 Mean ± s.e.m. of selected variables by frequency of eating occasions at follow-up, by sex

	Frequency of eating occasions at follow-up ≤ 2	3	4	5	≥ 6
Men					
n	358	913	827	332	132
Age (y)	43.35 ± 0.7	44.93 ± 0.5	45.15 ± 0.5	43.22 ± 0.5	44.49 ± 1.3
Weight change (kg)	1.90 ± 0.3	1.88 ± 0.3	2.23 ± 0.3	2.66 ± 0.5	2.60 ± 0.9
Baseline BMI (kg/m^2)	26.12 ± 0.3	26.17 ± 0.2	25.89 ± 0.1	25.14 ± 0.3	25.69 ± 0.4
TSF* (mm)	12.35 ± 0.4	12.90 ± 0.3	12.40 ± 0.2	11.16 ± 0.4	11.36 ± 0.4
SSF* (mm)	16.70 ± 0.6	17.50 ± 0.4	16.94 ± 0.3	15.14 ± 0.6	15.72 ± 0.8
Cholesterol (mg/dl)	219.00 ± 2.8	218.00 ± 2.1	220.00 ± 2.1	218.00 ± 2.8	220.00 ± 5.4
Energy* (kcal)	2553.00 ± 78	2313.00 ± 37	2478.00 ± 38	2642.00 ± 75	2536.00 ± 110
Fat (% energy)	37.29 ± 0.7	36.58 ± 0.4	37.43 ± 0.3	36.73 ± 0.7	36.87 ± 1.2
Alcohol* (g)	19.28 ± 2.5	13.89 ± 1.1	10.21 ± 0.6	13.61 ± 3.1	11.34 ± 2.5
Women					
n	673	1599	1380	629	258
Age (y)	43.70 ± 0.5	47.36 ± 0.4	46.36 ± 0.4	44.21 ± 0.6	44.63 ± 0.8
Weight change (kg)	2.06 ± 0.5	2.15 ± 0.2	2.91 ± 0.2	2.73 ± 0.4	2.98 ± 0.7
Baseline BMI (kg/m^2)	25.45 ± 0.3	25.33 ± 0.2	25.11 ± 0.1	24.67 ± 0.2	25.68 ± 0.5
TSF (mm)	23.65 ± 0.4	23.82 ± 0.3	24.07 ± 0.3	23.81 ± 0.4	24.36 ± 0.8
SSF (mm)	19.08 ± 0.5	19.42 ± 0.4	19.57 ± 0.3	18.87 ± 0.5	19.46 ± 0.9
Cholesterol* (mg/dl)	221.00 ± 2.6	223.00 ± 1.6	222.00 ± 2.0	215.00 ± 2.6	212.00 ± 3.4
Energy* (kcal)	1479.00 ± 29	1462.00 ± 22	1560.00 ± 31	1719.00 ± 34	1697.00 ± 46
Fat (% of energy)	36.73 ± 0.5	36.12 ± 0.2	36.32 ± 0.3	36.91 ± 0.5	37.23 ± 0.7
Alcohol* (g)	6.80 ± 1.1	4.25 ± 0.3	3.12 ± 0.3	3.40 ± 0.6	2.55 ± 0.3

Frequency of eating occasions at follow-up (1982–84) was derived from combining respondent answers to one question each about number of meals and snacks eaten per day.
* *The association of each variable with frequency of eating was significant ($P < 0.05$)*
BMI = Body mass index
Cholesterol = plasma cholesterol (measured at baseline)
TSF = triceps skinfold (measured at baseline)
SSF = subscapular skinfold (measured at baseline)

smallest mean weight change in men, but the largest mean weight change in women. In women, mean baseline BMI, triceps skinfold, subscapular skinfold, and plasma cholesterol decreased with increasing baseline frequency of eating occasions ($P < 0.006$). In men, the mean baseline BMI and subscapular skinfold decreased with increasing baseline eating frequency; trends in triceps skinfold, and plasma cholesterol were not consistent. Mean dietary energy and alcohol intake increased with increasing baseline eating frequency in both men and women.

At follow-up, the highest frequency category (≥ 6) was associated with largest mean weight change and baseline BMI in women but not men (Table 3). Mean plasma cholesterol measured at baseline was inversely associated with frequency of eating at follow-up in women but not men. Mean alcohol intake decreased with increasing frequency of eating at follow-up in both men and women.

Whites, respondents with > 12 years education, and ≥ 1 poverty income ratio (PIR) reported a higher mean frequency both at baseline and at follow-up. Current smokers, and alcohol drinkers reported a higher mean frequency of eating occasions at baseline, but lower frequency at follow-up. Self-reported level of usual physical activity at baseline or at follow-up were not related with frequency of eating at baseline or follow-up. (Data not shown).

Table 4 presents mean ± standard error of baseline and follow-up frequency of eating occasions by categories of weight change. At baseline, men and women reported a mean frequency of 5.3 and 4.9 eating occasions, respectively; at follow-up the mean frequency was 3.6 eating occasions for both men and women. No clear relation between frequency of eating and weight change was evident.

Table 5 presents regression coefficient ± standard error associated with baseline frequency and subsequent weight change, and follow-up frequency of eating and preceding weight change from unadjusted, age-adjusted, and multiple-covariate-adjusted models, by sex. At baseline, weight change and frequency of eating occasions were positively related in unadjusted models in men and women. For every unit increase in frequency of eating, men and women gained 0.22 ($P = 0.03$) and 0.34 ($P = 0.0002$) kg of body weight, respectively, over the period of follow-up. After adjustment for age, and other confounders, this relationship was no longer significant. At follow-up, there was no association of weight change with eating frequency in men or women.

We repeated all regression analyses after exclusion of respondents claiming to be on a special diet. The strength and the direction of the association between weight change and eating frequency at baseline or follow-up were essentially unchanged following these exclusions.

At baseline, there was no association of weight change with frequency of eating occasions for any level of energy intake, baseline BMI, smoking status, physical activity, alcohol intake, and morbidity in men. In men aged ≥ 50 eating frequency and weight change were inversely related in multivariate model ($\beta = 0.30$, $P = 0.01$), but not in simpler models. In women, the regression coefficient for fre-

Table 4 Mean ± s.e.m. of frequency of eating occasions by categories of weight change

		Categories of weight change (kg)					
	All	*< -5*	*-5 to -3*	*-3 to <3*	*3 to < 5*	*5 to < 10*	*≥ 10*
Frequency of eating occasions at baseline (from 24-h recall)							
All	5.1 ± 0.04	4.9 ± 0.06	4.9 ± 0.11	5.1 ± 0.04	5.1 ± 0.07	5.2 ± 0.07	5.2 ± 0.12
Men	5.3 ± 0.06	5.2 ± 0.06	5.0 ± 0.14	5.3 ± 0.08	5.2 ± 0.13	5.4 ± 0.14	5.5 ± 0.17
Women	4.9 ± 0.03	4.7 ± 0.07	4.8 ± 0.14	4.9 ± 0.05	5.1 ± 0.07	5.0 ± 0.06	5.0 ± 0.12
Frequency of eating occasions at follow-up (from questionaire)							
All	3.6 ± 0.02	3.5 ± 0.06	3.7 ± 0.07	3.6 ± 0.04	3.6 ± 0.04	3.6 ± 0.04	3.7 ± 0.06
Men	3.6 ± 0.03	3.5 ± 0.07	3.6 ± 0.10	3.6 ± 0.05	3.5 ± 0.06	3.6 ± 0.07	3.7 ± 0.08
Women	3.6 ± 0.02	3.5 ± 0.07	3.7 ± 0.09	3.5 ± 0.04	3.7 ± 0.06	3.6 ± 0.06	3.7 ± 0.07

Table 5 Regression coefficient (beta ± standard error) associated with frequency of eating occasions at baseline and at follow-up, by sex

	Frequency of eating occasions at baseline			
	β	*s.e.$^{\beta}$*	*F*	*P*
Men				
Unadjusted	0.2196	0.1006	4.76	0.036
Age-adjusted	0.0758	0.0997	0.58	0.452
Multivariate	0.0211	0.1221	0.03	0.863
Women				
Unadjusted	0.3445	0.0827	17.35	0.000
age-adjusted	0.1561	0.0798	3.82	0.058
Multivariate	0.1101	0.0873	1.59	0.215
	Frequency of eating occasions at follow-up			
	β	*s.e.$^{\beta}$*	*F*	*P*
Men				
Unadjusted	0.1874	0.1372	1.86	0.181
Age-adjusted	0.1931	0.1386	1.94	0.173
Multivariate	0.0859	0.1336	0.41	0.524
Women				
Unadjusted	0.3208	0.1660	3.73	0.061
Age-adjusted	0.2854	0.1602	3.17	0.083
Multivariate	0.2299	0.1494	2.37	0.132

Frequency of eating occasions at baseline (1971–75) was computed from summation of actual number of distinct times food is reported as consumed in a 24-h dietary recall (n = 7147).
Frequency of eating occasions at follow-up (1982–84) was derived from combining respondent answers to one question each about number of meals and snacks eaten per day (n = 7101).
Unadjusted: dependent variable = weight change; independent variable = frequency of eating occasions (continuous).
Age-adjusted: dependent variable = weight change; independent variables = frequency of eating occasions (continuous), age, and age.^{2}
Multivariate: dependent variable = weight change; independent variables = frequency of eating occasions (continuous), age, age^2, length of follow-up, education, race, baseline BMI, energy intake, smoking status, level of usual physical activity at baseline and at follow-up, alcohol intake, morbidity, special diet status, parity (women only). The baseline multivariate regression model included 7081 respondents (2556 men and 4525 women) with complete covariate information. The follow-up multivariate regression model included 6981 respondents (2515 men and 4466 women) with complete covariate information.

quency of eating occasions was positive in former smokers (β = 0.80, P = 0.02), lowest tertile of energy intake (β = 0.45, P = 0.038), and lowest tertile of BMI (β = 0.28, P = 0.04), in both unadjusted and fully adjusted models(data not shown).

At follow-up, frequency of eating occasions and weight change were not related in regression analyses stratified by ages < 50, ≥ 50, level of energy intake, baseline BMI, smoking status, alcohol intake, physical activity at follow-up, and morbidity in men. In women with low alcohol intake, eating frequency and weight change were related in unadjusted and fully adjusted models (β = 0.51, P = 0.04) (data not shown).

Discussion

The hypothesis regarding the potential effect of meal frequency on TEF, total daily energy expenditure, and longterm energy storage is not supported by the data presented. To our knowledge, the association of longterm weight change (8–10 years) with frequency of food ingestion in adults has not been examined previously. However, the findings of this epidemiologic study confirm the results of several feeding frequency trials. These trials failed to find any differences in the total 24-h energy expenditure[17–20] or body weight[12,13,20] of subjects on regimens of varying meal frequency. Furthermore, the reported effect of bolus versus frequent feeding on TEF is equivocal.[14–16]

It has been suggested that there may be an interaction of frequency of food ingestion with physical activity. However, in both men and women in the analytic cohort, self-reported physical activity at baseline or follow-up and frequency of food ingestion at baseline or follow-up were unrelated ($P > 0.05$). Further, no relation between baseline or follow-up frequency of eating occasions and weight change was observed within different strata of physical activity (data not shown).

The measures of eating frequency at baseline and follow-up are not comparable and show relatively poor association. (Kendall's tau-b coefficient for concordance between the two frequencies was 0.10). Hence our decision not to combine the two frequencies. We are unaware of any previous study comparing baseline and follow-up assessments of eating frequency. In response to questions regarding number of meals and snacks consumed daily at follow-up, respondents may group different eating occasions and provide answers expected to conform with what they perceive as typical meal patterns. Therefore, for the hypothesis under examination in this study, the baseline frequency (from a 24-h recall) may be of greater value since each eating occasion may theoretically relate to thermic effect of food. It is remarkable, however, that given the nature of measures of frequency at baseline and at follow-up, eating frequency and weight change show similar relationship in both prospective and retrospective analyses.

The extent to which these two different measures of eating frequency reliably estimate 'usual' frequency is not known. Our estimate of baseline frequency of food ingestion, similar to that of Metzner *et al.*,[11] is derived from a single 24-h dietary recall, and may lead to misclassification of respondents into categories of 'usual' frequency of food ingestion.[28,29] In women, plasma cholesterol measured at baseline was inversely related ($P < 0.01$) to frequency of food ingestion at baseline as well as follow-up in unadjusted regression models (but not after adjustment for multiple covariates). This observation is partially in accordance with reports from some epidemiologic,[3,6] and metabolic studies,[4,5,7,8] and may support the validity of these measures in approximately 'usual' frequency in women.

Because dietary measurement methods used at follow-up were different from those at baseline, we are unable to examine the extent of changes in frequency of food ingestion over the period of follow-up. To our knowledge, trends in changes in the frequency of eating in the US population have also not been documented. Respondents may have changed their patterns of frequency of food ingestion in response to changes in a multitude of factors such as lifestyle, living arrangement, aging, morbidity, and body weight. Repeated estimates of frequency of food ingestion over follow-up may be necessary for better classification of respondents into categories of frequency of food ingestion.

In concurrence with previous reports,[3,11] baseline frequency of eating occasions was inversely related with baseline BMI in unadjusted and multiple-covariate-adjusted regression models in both men and women in this cohort ($P < 0.02$). (Lack of an association between frequency of eating at follow-up and baseline BMI may partially be attributable to methodologic limitations discussed above.) Energy intake, however, was positively associated with baseline frequency of eating (Table 2). It is probable that a high baseline BMI may be a cause rather than a consequence (as has been suggested previously)[3,11] of eating less frequently at baseline. At baseline, the lowest frequency category (≤ 2) was associated with highest mean baseline BMI, lowest mean energy intake, and largest mean weight gain in women. Conversely, at follow-up, the highest frequency category (≥ 6), had women with the highest mean weight gain, highest mean baseline BMI, and a high energy intake. (We caution however, that number of respondents in the ≤ 2 category at baseline and ≥ 6 category at follow-up are relatively small.) We felt that respondents in the ≤ 2 category at baseline were more likely to be dieters. With these considerations in mind, we repeated all regression analyses with exclusion of respondents in the ≤ 2 category; however, the resulting parameter estimates were essentially unchanged (data not shown). Whether a weight related differential in ability or willingness to recall all eating occasions exists, is not known.

In conclusion, there was no independent association of frequency of food ingestion estimated from a 24-h dietary recall with prospective weight change or frequency of eating estimated from answers to questions on number of meals and snacks consumed daily with weight change over the preceding 8–10 years in the NHEFS cohort.

Appendix 1

At the follow-up interview in 1982–84, respondents were asked the following two questions:

(1) How many meals do you usually eat a day?
(2) Including evening snacks, how many between-meal snacks do you have per day?

The subject responses to these two questions (numbers per day) were combined to obtain the number of eating occasions at follow-up.

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