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Association between Eating Patterns and Obesity in a Free-living US Adult Population

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Some studies have suggested that eating patterns, which describe eating frequency, the temporal distribution of eating events across the day, breakfast skipping, and the frequency of eating meals away from home, may be related to obesity. Data from the Seasonal Variation of Blood Cholesterol Study (1994–1998) were used to evaluate the relation between eating patterns and obesity. Three 24-hour dietary recalls and a body weight measurement were collected at five equally spaced time points over a 1-year period from 499 participants. Data were averaged for five time periods, and a cross-sectional analysis was conducted. Odds ratios were adjusted for other obesity risk factors including age, sex, physical activity, and total energy intake. Results indicate that a greater number of eating episodes each day was associated with a lower risk of obesity (odds ratio for four or more eating episodes vs. three or fewer = 0.55, 95% confidence interval: 0.33, 0.91). In contrast, skipping breakfast was associated with increased prevalence of obesity (odds ratio = 4.5, 95% confidence interval: 1.57, 12.90), as was greater frequency of eating breakfast or dinner away from home. Further investigation of these associations in prospective studies is warranted.

eating; obesity; odds ratio

Abbreviations: CI, confidence interval; MET, metabolic equivalent; SD, standard deviation; SEASONS, Seasonal Variation of Blood Cholesterol Study.

The prevalence of obesity in the United States has increased substantially in the last two decades, particularly relative to other countries (1, 2). National surveys in the United States confirm that increases in prevalence of overweight and obesity have occurred within a short period of time. The most recent data derived from the Behavioral Risk Factor Surveillance System show that 19.8 percent of US adults are obese, defined as having a body mass index (weight (kg)/height (m)^2) equal to or greater than 30 kg/m^2, which percentage reflects a 61 percent increase since 1991 (3). Obesity, in turn, is a precursor to several major health problems, including, but not limited to, diabetes mellitus, coronary heart disease, and sleep-breathing disorders (4).

Changes in dietary habits and physical activity have been implicated as potential causes of obesity. Previous research has shown that weight depends on energy balance defined as the relation between energy intake and energy expenditure. Studies (5–9) have suggested that several characteristics of dietary behavior such as eating frequency, the temporal distribution of eating events across the day, breakfast skipping, and the frequency of meals eaten away from home, together referred to as "eating patterns," may influence body weight. However, these earlier studies of the effect of eating patterns on body weight have not accounted for the effects of total energy intake and physical activity, which may

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confound results and introduce misclassification of dietary variables (10).

The Seasonal Variation of Blood Cholesterol Study (SEASONS), a large prospective study, was designed to quantify the magnitude and timing of seasonal changes in blood lipids and to identify the major factors contributing to this variation including diet and physical activity (11). We have used cross-sectional data from this study to evaluate the relation between eating patterns and obesity, while controlling for the effects of physical activity and energy intake.

MATERIALS AND METHODS

Subject recruitment and study design

Individuals who were residents of Worcester County, Massachusetts, aged 20–70 years, and who had telephone service were eligible to participate in SEASONS. Participation was limited to individuals who were 1) not taking cholesterol-lowering medications; 2) not currently on lipid-lowering or weight-control diets; 3) free from possible causes of secondary hypercholesterolemia (e.g., hyperthyroidism, pregnancy); 4) not working night shift; and 5) free from chronic illness (e.g., cancer, renal disease, heart failure). Potential subjects were initially approached by Fallon Healthcare System telemarketers between December 1994 and February 1997. In addition, a recruiter was used to recruit members of ethnic minority groups who were not Fallon members to maximize the ethnic diversity of the study population. Each subject was compensated for her/his participation with a free portable blood pressure monitor and a monetary incentive for each completed clinic visit (maximum possible compensation: $70).

Approximately 5,000 individuals were contacted to determine their interest in study participation. From this sample, 1,254 met initial eligibility criteria and consented to making a baseline appointment. Of these, 427 (34 percent) failed to attend their first appointments, and 140 (11 percent) did not meet the formal eligibility requirements for the study. The remaining 641 (51 percent) individuals completed the baseline questionnaire, had at least one blood draw, and were considered to have formally entered the study. The institutional review boards of the Fallon Healthcare System and the University of Massachusetts Medical School approved all subject recruitment and data collection procedures. Each subject signed an approved informed consent form prior to entering the study.

Study participants were seen in the Fallon clinic for an initial baseline interview and then every 3 months over the next year. During each 3-month period, blood samples were collected for serum lipid assessment and body weight was measured. In addition, three 24-hour dietary recalls (12), including assessments of food intake on two weekdays and one weekend day selected randomly, were completed within a 42-day window surrounding each clinic visit (from –28 to +14 days). These 24-hour dietary recall data were collected using Nutrition Data System data entry and nutrient database software developed and maintained by the Nutrition Coordinating Center at the University of Minnesota, Minneapolis, Minnesota (12). The 24-hour physical activity recall (13), administered together with the dietary recall, was used to record the times each individual went to bed at night and arose from bed in the morning. All interviews were conducted by trained registered dietitians. Body weight was measured at each clinic visit, with the subject removing her shoes and wearing minimal layers of clothing. Height in meters was measured at baseline. Data on demographic variables were collected by a self-administered questionnaire at the baseline clinic visit. A total of fifteen 24-hour dietary and physical activity recalls were potentially available for each subject, with serum lipids and body weight each measured as many as five times.

Of the 641 subjects entering SEASONS, 267 subjects (41.9 percent) completed all fifteen 24-hour dietary recalls, and 503 subjects (78.8 percent) completed 10 or more dietary recalls. The 138 subjects who completed fewer than ten 24-hour dietary recalls were excluded from the analysis in order to achieve uniformly reliable dietary information. An additional four subjects who worked a night shift were also excluded. Thus, 499 men and women with a total of 6,931 dietary recalls were available for analysis. The average number of recalls was 13.4 (standard deviation (SD), 1.5) per subject. The average number of body mass index measures was 4.8 (SD, 0.6) per subject.

Statistical analyses

Body mass index was computed for each clinic visit using the following formula: weight (kg)/height (m)^2. Body mass index was averaged among subjects over all the days of measurement, and subjects were classified as "overweight" if their averaged body mass index was equal to or greater than 25 kg/m^2 and as "obese" if their averaged body mass index was equal to or greater than 30 kg/m^2 (14).

The 24-hour dietary and physical activity recall data were used to create the eating pattern variables of interest. The number of eating episodes per day was calculated using the definition by Gibney and Wolever (15), which classifies an eating episode as an event that provides at least 50 kcal (or 210 kJ) with a minimum time interval between episodes of at least 15 minutes; 50 kcal are equivalent to 0.5 cup (236.6 ml) of Coke (The Coca-Cola Company, Atlanta, Georgia), one slice of bread, 2 cups of coffee with milk and sugar, or 0.25 cup of cereal with milk. This definition allowed us to include all eating events in the calculation regardless of whether the subject considered the event to be a "meal" or a "snack." We then tallied the number of eating episodes for each study subject on each day and averaged the number of eating episodes from all recalls (n = 10–15).

To classify subjects as regularly eating or not eating breakfast, we used self-report of breakfast intake. Subjects were considered as usually consuming breakfast if they reported eating this meal on at least 75 percent of their 24-hour dietary recalls.

In addition to evaluating the self-report of "breakfast skipping," we also assessed whether the time of eating after awakening was associated with the risk of obesity. To accomplish this, for each day of measurement we subtracted the time of getting out of bed from the time of the first eating episode. This interval was then averaged among subjects over all the days of measurement, and subjects were divided into quartiles based on the length of the interval.

In addition, we measured the interval between the last eating episode and the time each subject went to bed. Interval times were averaged among subjects over all the days of measurement, and subjects were divided into quartiles. Similarly, we computed the average amount of time between waking and when the largest meal of the day (in kcal) was consumed and divided the subjects into quartiles based on the length of this interval.

Finally, we evaluated whether the frequency of eating meals away from home was associated with obesity. The frequencies of the total number of meals, breakfast, lunch, and dinner eaten away from home were each examined separately. The frequency of eating each meal away from home was calculated by dividing the number of each meal eaten away from home by the total number of days in which the meal was consumed. Subjects were then divided into quartiles based on this percentage.

We used the methods described by Ainsworth et al. (16) to estimate total daily energy expenditure based on the reported time spent at each activity and activity intensity. This method assumes that the resting metabolic rate is equal to 1 kcal/kg per hour and uses multiples of this resting value (i.e., metabolic equivalents (METs)) to estimate an absolute level of energy expenditure in specific MET levels. Weighted sums of the estimated energy expended in activity were calculated using the time reported at each intensity level of activity and the following MET weights: light (1.5 METs), moderate (4.0 METs), hard (6.0 METs), and very hard (8.0 METs). A validity study was conducted to estimate short-term physical activity using 24-hour recalls (17). Results showed that three 24-hour recalls of physical activity were observed to have a relative validity that was comparable with published data from other short-term activity assessments that also used the Baecke Questionnaire and activity monitors as criterion measures.

The risk (odds ratio) of obesity and associated 95 percent confidence intervals were estimated using logistic regression analysis with SAS software (18). Multivariable logistic regression modeling was used to adjust all risk estimates for covariates. Possible covariates, including participants' demographic characteristics, total physical activity, and total energy intake, were evaluated as potential confounders of the eating patterns and obesity relation; variables that were significantly associated with obesity at a p value of less than 0.20 were considered candidate variables to be entered into the final models. In addition, we included those variables frequently associated with the risk of obesity in other epidemiologic studies (4). Our final model included age, gender, educational level, total energy intake, and physical activity.

Tests for trend with two-sided p values were performed over the categories of each variable, with the median values of each category modeled as a single continuous variable.

Similar analyses were also conducted to evaluate factors associated with overweight.

RESULTS

Comparisons between the 499 subjects included and those excluded because of insufficient numbers of dietary recalls (n = 142) revealed no significant differences in terms of gender, educational level, or body mass index. However, included subjects were significantly more likely to be older, White, nonsmoking, and married and to have white-collar jobs than those excluded.

Descriptive characteristics of the subjects (n = 499) are given in table 1. Briefly, 50.3 percent of the participants were men, the average baseline age of both men and women was 48 years, and the average body mass indexes for men and women were 28.6 and 26.6 kg/m^2, respectively. Forty-eight percent of the men and 33 percent of the women were overweight, and 27 percent and 20 percent were obese, respectively. The study participants were predominantly White (87.7 percent), married (78.1 percent), educated (39.8 percent with a bachelor's degree or more), never smokers (84.8 percent), and employed in white-collar occupations (e.g., managerial, scientific, or office work) (37.4 percent).

On average, participants ate 3.92 times daily (SD, 0.8). The average total energy intake was 2,259 kcal (SD, 540) per day for men and 1,641 kcal (SD, 363) per day for women. A relatively small percentage of subjects (3.6 percent) was classified as breakfast skippers. On average, 29.7 percent of the meals were eaten away from home: 18.9 percent for breakfast, 53.5 percent for lunch, and 19.6 percent for dinner.

Table 1 presents the risk of obesity according to selected participant characteristics. Higher education was significantly associated with lower risk of obesity; the odds ratio for subjects with at least a bachelor's degree was 0.36 (95 percent confidence interval (CI): 0.21, 0.61; p for trend < 0.001), relative to those with a high school education or less. Physical activity was inversely associated with obesity (p for trend < 0.041). In contrast, age, race/ethnicity, gender, smoking status, occupational status, and total energy intake were not appreciably associated with the risk of obesity.

The association between each eating pattern variable and obesity is presented in table 2. Unadjusted odds ratios, age- and sex-adjusted odd ratios, and multivariate odd ratios adjusted for age, gender, total energy intake, total physical activity, and education are shown. The number of eating episodes was inversely associated with the risk of obesity. In comparison with subjects who reported three or fewer eating episodes per day, subjects who reported four or more eating episodes per day experienced a significant 45 percent lower risk of obesity (95 percent CI: 0.33, 0.91).

Skipping breakfast was associated with a significantly higher risk of obesity. Subjects who regularly skipped breakfast (i.e., 75 percent of days measured by 24-hour recall) had 4.5 times the risk of obesity as those who regularly consumed breakfast (95 percent CI: 1.57, 12.90). Because only 3.6 percent of the subjects self-reported that they skipped breakfast regularly, we also evaluated whether ever skipping breakfast on any of the study days was associated with obesity. Twenty-seven percent of the subjects reported

TABLE 1. Participants' characteristics and risk of obesity (*n* = 499), Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts, 1994–1998

	All		% obese (*n* = 116)	Odds ratio*	95% confidence interval
	No.	%			
Age (years)					
20–30	28	5.6	21	1.00	
31–40	98	19.6	26	1.20†	0.43, 3.30
41–50	140	28.1	19	0.85	0.31, 2.31
51–60	114	22.9	25	1.15	0.42, 3.34
61–70	119	23.8	25	1.16	0.43, 3.15
				p = 0.74‡	
Race					
White	426	87.7	23	1.00	
Others	60	12.3	25	1.19	0.61, 2.36
Gender					
Male	251	50.3	27	1.00	
Female	248	49.7	20	0.69§	0.45, 1.04
Education					
High school or less	152	30.8	32	1.00	
Post-high school	145	29.4	26	0.70	0.42, 1.19
Bachelor's degree or more	196	39.8	15	0.36	0.21, 0.61
				p < 0.001	
Smoking status					
Never	401	87.0	24	1.00	
Ever	60	13.0	17	0.64	0.31, 1.32
Occupational category					
White collar	185	37.4	20	1.00	
Service work	135	27.3	21	1.17	0.67, 2.05
Blue collar	67	13.5	28	1.51	0.79, 2.88
Unemployed/retired	108	21.8	28	1.64	0.89, 3.00
				p = 0.07	
Physical activity (MET¶-hours/day)					
Quartile 1	5.6#		28	1.00	
Quartile 2	8.4		25	0.92	0.52, 1.62
Quartile 3	11.2		20	0.63	0.35, 1.14
Quartile 4	17.7		20	0.56	0.31, 1.03
				p = 0.041	
Total energy intake (kcal/day)					
Quartile 1	1,703	(1,259)**	25	1.00	
Quartile 2	2,055	(1,486)	21	0.80	0.44, 1.46
Quartile 3	2,383	(1,724)	19	0.70	0.38, 1.29
Quartile 4	2,836	(2,078)	29	1.28	0.72, 2.28
				p = 0.40	

* Adjusted for age and gender, except as noted.
† Adjusted for sex only.
‡ *p* value for trend across categories calculated using the median value of each category as a continuous variable.
§ Adjusted for age only.
¶ MET, metabolic equivalent.
\# Median values for MET-hours/day in each quartile.
** Sex-specific quartile cutpoints used. Median quartile values for men and women are presented, with values for women in parentheses.

skipping breakfast at least once. Subjects who skipped breakfast at least once during the study had 1.34 times the risk of obesity as those who always consumed breakfast (95 percent CI: 0.81, 2.20). Energy intakes tended to be greater on days when subjects reported skipping breakfast (data not shown).

The average interval between the time out of bed and first eating, the average interval between the time of last episode

TABLE 2. Eating patterns in predicting obesity (*n* = 499), Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts, 1994–1998

	Unadjusted		Age and gender adjusted		Multivariate adjusted	
	OR*	95% CI*	OR	95% CI	OR†	95% CI
Average daily no. of eating episodes						
≤3 (*n* = 141)‡	1.00		1.00		1.00	
≥4 (*n* = 358)	0.61	0.39, 0.96	0.62	0.39, 0.97	0.55	0.33, 0.91
Eating breakfast§						
Yes (*n* = 481)	1.00		1.00		1.00	
No (*n* = 18)	4.42	1.70, 11.48	5.12	1.88, 13.92	4.50	1.57, 12.90
Average interval between time out of bed and first eating (hours)						
Quartile 1 (median, 0.8)	1.00		1.00		1.00	
Quartile 2 (median, 1.3)	0.91	0.42, 1.95	0.90	0.42, 1.95	0.86	0.38, 1.95
Quartile 3 (median, 1.9)	1.43	0.70, 2.92	1.45	0.70, 3.03	1.47	0.67, 3.25
Quartile 4 (median, 3.0)	1.56	0.77, 3.15	1.62	0.78, 3.36	1.73	0.78, 3.85
					p = 0.60¶	
Average interval between time of last episode of eating and time in bed (hours)						
Quartile 1 (median, 2.2)	1.00		1.00		1.00	
Quartile 2 (median, 3.0)	2.01	0.94, 4.31	2.08	0.96, 4.50	1.93	0.84, 4.45
Quartile 3 (median, 3.5)	1.50	0.69, 3.26	1.52	0.70, 3.30	1.27	0.55, 2.92
Quartile 4 (median, 4.5)	2.04	0.96, 4.34	2.04	0.95, 4.36	2.04	0.90, 4.63
					p = 0.85	
Average time of the largest episode of eating from waking up (hours)						
Quartile 1 (median, 7.5)	1.00		1.00		1.00	
Quartile 2 (median, 9.2)	1.17	0.58, 2.37	1.15	0.56, 2.35	1.44	0.67, 3.09
Quartile 3 (median, 10.1)	1.06	0.52, 2.18	1.01	0.48, 2.12	1.10	0.50, 2.43
Quartile 4 (median, 11.3)	1.03	0.49, 2.15	1.02	0.48, 2.17	1.37	0.58, 3.21
					p = 0.59	
Proportion of meals away from home (%)						
Breakfast						
Quartile 1 (median, 0)	1.00		1.00		1.00	
Quartile 2 (median, 6.7)	2.19	1.11, 4.33	2.29	1.15, 4.57	2.40	1.16, 4.98
Quartile 3 (median, 18.2)	2.86	1.49, 5.51	3.02	1.53, 5.93	2.98	1.46, 6.07
Quartile 4 (median, 46.2)	2.37	1.20, 4.66	2.50	1.23, 5.12	2.21	1.14, 4.69
					p = 0.29	
Lunch						
Quartile 1 (median, 15.1)	1.00		1.00		1.00	
Quartile 2 (median, 45.5)	0.56	0.31, 1.02	0.55	0.30, 1.01	0.55	0.29, 1.04
Quartile 3 (median, 66.7)	0.47	0.26, 0.86	0.43	0.22, 0.84	0.40	0.20, 0.80
Quartile 4 (median, 83.3)	0.82	0.47, 1.42	0.75	0.40, 1.41	0.70	0.36, 1.37
					p = 0.89	
Dinner						
Quartile 1 (median, 0)	1.00		1.00		1.00	
Quartile 2 (median, 9.1)	2.19	1.14, 4.19	2.32	1.20, 4.47	2.25	1.14, 4.43
Quartile 3 (median, 20.0)	1.72	0.88, 3.37	1.78	0.90, 3.53	1.90	0.94, 3.83
Quartile 4 (median, 38.5)	1.69	0.87, 3.29	1.73	0.88, 3.43	1.89	0.93, 3.83
					p = 0.31	

* OR, odds ratio; CI, confidence interval.
† Controlling for age, gender, total physical activity (metabolic equivalent-hours per day), total energy intake (kcal per day), and educational level.
‡ The reference group of ≤3 eating episodes was chosen because three meals comprise the standard number of meals per day and because of examination of the distribution of eating episodes.
§ Subjects were considered as usually consuming breakfast if they reported having it at least 75% of the days surveyed by 24-hour dietary recalls (*n* = 10–15 days).
¶ *p* value for trend across categories calculated using the median value of each category as a continuous variable.

of eating and time to bed, and the average time of the largest episode of eating from waking up were not significantly associated statistically with the risk of obesity.

A higher proportion of breakfast eating away from home was significantly associated with an increased risk of obesity. In comparison with subjects who rarely ate breakfast away from home, those consuming breakfast out frequently had more than twice the risk of obesity, although we did not observe evidence of a linear trend. An increased proportion of eating dinner away from home also was associated with an increased risk of obesity. Subjects eating dinner out frequently had an approximately twofold increased risk of obesity in comparison with subjects who rarely ate dinner away from home, although results were not significant. In contrast, eating lunch away from home was associated with a reduced risk of obesity; subjects in the second to fourth quartiles had a 30–60 percent lower risk of obesity in comparison with subjects who ate lunch out less frequently. We fit models that included terms for frequency of breakfasts, lunches, and dinners eaten away from home simultaneously. Adjustment for eating other meals away from home did not substantially change the relation between each meal and the risk of obesity, suggesting that the effect of each meal is independent from the others. We also evaluated the nutrient content of meals eaten at home and away from home. Both breakfasts and dinners eaten away from home were significantly higher in total calories, percentage of calories from total fat, and percentage of calories from saturated fat and lower in percentage of calories from protein, percentage of calories from carbohydrate, and fiber than were breakfasts or dinners eaten at home. Breakfasts eaten away from home had more than 105 kcal, 7 percent more fat, 2.8 percent more saturated fat, and 2.2 g less fiber per 1,000 kcal than breakfasts eaten at home. Lunches eaten away from home were significantly higher in total calories and the percentage of calories from total fat but lower in the percentage of calories from protein than lunches eaten at home.

We also examined the association between eating patterns and overweight. The direction of association between eating patterns and overweight is essentially the same as for obesity findings, although results were attenuated and in many cases no longer statistically significant. For example, subjects reporting four or more eating episodes per day experienced a 33 percent lower risk of overweight (95 percent CI: 0.41, 1.08).

DISCUSSION

Results from our study support the hypothesis that eating patterns are associated with obesity even after controlling for total energy intake and physical activity. A lower obesity risk was observed among subjects reporting larger numbers of eating episodes per day. In contrast, skipping breakfast was associated with increased risk of obesity, as was increasing the proportion of either breakfast or dinner eating away from home. However, the temporal distribution of eating events across the day was not related to obesity.

Although we have multiple measurements per subject, there is a large within-subject variation for both dietary intake and physical activity (17, 19), and SEASONS participants had relatively stable body weight during the study (mean weight change = –0.06 (SD, 8.8) pounds; 1 pound = 0.45 kg). Using the average of diet and physical activity measurements provides more precision. Therefore, a cross-sectional analysis was conducted to investigate the association between eating patterns and obesity. We also conducted a repeated-measures model with subjects treated as a random effect and considered body mass index as a continuous outcome variable. In these analyses, we found associations consistent with those reported in the cross-sectional analysis.

Results from previous studies suggest that eating frequency may be causally associated with body weight and weight changes. Bellisle et al. (20) reviewed the epidemiologic studies relating meal frequency to body weight and concluded that, although many studies fail to find any statistically significant relation, those observed are consistently inverse. Several studies have demonstrated that low meal frequency is associated with higher 24-hour insulin concentrations (21–25) when compared with high meal frequency. Eating multiple, small meals may suppress hunger and overall serum insulin concentrations (21). Insulin inhibits lipase enzyme activity and increases fat deposition. Since insulin is related to fatty acid storage, meal frequency may be one of the factors affecting body weight.

There also are reports suggesting that individuals who do not eat breakfast have a greater overall daily energy intake (8, 26). An animal study (27) suggests that, if an animal has been deprived of food for a long time and is then presented with unlimited food, that animal will eat a far greater quantity than does one that has been fed regularly. Conversely, an animal that has been force fed for several weeks eats relatively little when allowed to feed ad libitum. In a human study by Schlundt et al. (28), in which they instructed 35 individuals to keep a continuous record of their eating behavior during a 10-week behavioral weight loss program, an association between meal skipping and overeating at subsequent meals was documented. A study using data from the National Weight Control Registry (29) suggests that eating breakfast is a characteristic common to successful weight loss maintainers and may be a factor in their success. One could hypothesize that individuals who do not eat early in the day may tend to be hungry later on and then may consume a greater number of calories during the evening hours than individuals who eat consistently throughout the day (27). Greater energy intake may result in greater fat storage and, thus, may be one of the factors leading to an increase in body weight.

Finally, subjects who eat late in the evening may increase the amount of glucose stored in muscle as glycogen (7). In humans, muscle glycogen fluctuates in accordance with periods of muscle activity and subsequent carbohydrate consumption. Data suggest that the consumption of carbohydrate-rich foods in the late evening leads to increased glycogen levels in the muscles (7). Unless this stored glycogen is burned as fuel, it will ultimately be stored as fat. Therefore, consumption of late-evening meals with carbohydrate-rich foods may also be related to obesity through its effect on hormonal regulation of energy and lipid metabolism. However, we found that the interval of time between the last episode of eating and the time to bed was not associated with the risk of obesity. Further investigation is warranted to examine the association of this interval, as well as the nutrient composition (i.e., percentage of calories from carbohydrate) of the last eating episode, with obesity.

Results from our study suggest that a higher frequency of eating either breakfast or dinner away from home was associated with obesity. In agreement with these findings, a study by McCrory et al. (30) suggested that the frequency of consuming restaurant food was positively associated with increased body weight in adults. Data from the US Department of Agriculture's 1995 Continuing Survey of Food Intakes by Individuals suggest that food obtained away from home is generally higher in fat, saturated fat, and cholesterol (31) than food prepared at home, and our findings are consistent with this. In addition, a recent report examining food purchase and preparation trends in the United States between 1970 and 1998 suggests that Americans are eating more meals away from home (32).

Although we found that eating patterns were associated with obesity, the findings cannot be considered causal. For example, current diet may not be representative of diet in previous years (which is the diet that led to obesity, not the current diet). Our study population consisted largely of White, middle-class people who were members of a health maintenance organization. Moreover, as the study protocol involved a lengthy series of clinic visits and diet assessments, participants that stayed in the study were highly motivated. Selection factors relating to the participants' interest in their own health and time availability for participation may have created a fairly homogeneous study group. There is also potential selection bias because there are some discrepancies between the subjects included in and those excluded from the analysis. For these reasons, our findings may not be generalized to other socioeconomic strata and to other cultures and ethnic groups. There is inconsistency of findings concerning eating lunch away from home and eating breakfast or dinner away from home with obesity: People who ate lunch away from home frequently tended to be less obese, while people who ate breakfast or dinner away from home frequently tended to be more obese. Future analysis is warranted to investigate this finding. This study was not designed to determine whether these individuals brought their lunch to work (and thus are basically eating the same foods that they would at home) or whether they bought their lunch at a restaurant, etc. This may explain part of the difference in results. Finally, it must be noted that, in this study population, the rate of breakfast skipping was much lower (<4 percent) than the rate reported in the United States as a whole (about one fourth of all adults (26)).

Our study has several strengths. A total of fifteen 24-hour recalls were used to assess eating patterns, which will reduce within-person variation. Unannounced 24-hour dietary recalls were used to collect dietary data, with the short period of recall thought to minimize error in recall (i.e., omission and/or inclusion) (33), eliminate error due to long-term averaging (33), and minimize bias due to responses, such as social desirability, in the reporting of dietary intake (34). Another strength of this study is that multiple, 24-hour physical activity recalls as well as anthropometric measurements were collected, allowing us to examine the association between eating patterns and body weight while controlling for the effect of physical activity and total energy intake.

In conclusion, the results from our study suggest that eating patterns were independently associated with obesity. A similar trend was also observed between eating patterns and overweight. These findings are consistent with the hypothesis that increasing the number of eating episodes per day and eating breakfast were inversely associated with obesity and that eating breakfast or dinner away from home on a frequent basis may increase the risk of obesity. In addition to energy intake and nutrient composition, future studies of diet and obesity should also explore the frequency of eating and the location of meals.

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