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Original Research

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The objective of this investigation is to describe the associations of number of eating episodes and proportion of meals eaten away from home with total serum cholesterol. Data from 499 participants, recruited from a health maintenance organization in central Massachusetts, aged 20-70, were used for this analysis. Dietary information and total blood cholesterol were obtained at five sampling points (baseline and four consecutive quarters) during the one-year follow-up. A cross-sectional study was conducted. The results from the study do not support the hypothesis that the number of eating episodes per day is associated with total blood cholesterol. However, we noted that the mean concentration of total cholesterol decreased with increasing number of eating episodes among women, although the adjusted mean among three categories of number of eating episodes per day was not statistically significant. On the other hand, the results of our study suggest that increased frequency of meals (breakfast, lunch, or dinner) eaten away from home is positively associated with mean total blood cholesterol concentration. Furthermore, meals eaten away from home, especially breakfast and dinner, were significantly higher in total calories, and percent calories from total and saturated fat, but lower in percent calories from protein and carbohydrate, and grams of fiber, than corresponding meals eaten at home. We conclude that eating out may have adverse influences on blood lipids. Further research is needed to better understand the impact of eating away from home on blood lipids.
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Key Words: *eating patterns, epidemiology, diet, cholesterol*

INTRODUCTION

Small, short-term trials in healthy individuals with normal blood lipids have shown that increased frequency of eating may be associated with improved lipoprotein profiles.[1-9] Furthermore, there are plausible mechanisms by which increased eating frequency might reduce levels of total and LDL-cholesterol. One controlled trial[10] suggested that a short-term increase in the frequency of eating, with no change in energy intake, results in an acute reduction in postprandial blood glucose and insulin level. Reduction in insulin level may have direct influences on blood cholesterol through its regulation of hepatic cholesterol synthesis; however, the longer-term influences have not been studied and data from free living populations are limited. One study from a free living population in Norfolk, England[11] suggested that concentration of total cholesterol was negatively and consistently associated with frequency of eating. Results have shown a decrease of approximately 5% total cholesterol in subjects who eat six or more times a day compared with those who eat once or twice a day.[11] However, there is no report on the US population.

Data from the US Department of Agriculture's (USDA) 1995 Continuing Survey of Food Intakes by Individuals (CSFII) suggested that food eaten away from home is generally higher in fat, saturated fat, and lower in dietary fiber.[12] Higher intake of fat and saturated fat, and lower intake of dietary fiber lead to an increase in total and LDL cholesterol levels.[13-16] While theoretically plausible, the impact of eating away-from-home on blood cholesterol has not been documented.

The purpose of the present investigation is to examine the associations of eating frequency, and meals eaten away-from-home with levels of blood total cholesterol in free-living healthy adults.

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METHODS

Subject Recruitment and Study Design

The Seasonal Variation in Blood Cholesterol Levels Study (SEASONS) is funded by The National Heart, Lung, and Blood Institute (NHLBI), it was designed to describe and prospectively evaluate the nature and cause of seasonal variation in blood lipid levels. The major factors investigated were dietary fat, physical activity, exposure to light, psychological variables, weather patterns, and body weight.

Most SEASONS participants were recruited from among members of the Fallon Healthcare Systems, a health maintenance organization (HMO) in the central Massachusetts/Worcester area. Additional individuals of Hispanic descent, the largest minority community in Worcester, MA, were recruited from outside of the HMO population to increase the diversity of the SEASONS population. Individuals who were residents of Worcester County, aged 20 to 70 years, and who had telephone service were eligible to participate. In addition, individuals were eligible if they also were: 1) not taking cholesterol-lowering medications; 2) not actively 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 of chronic illness (e.g., cancer, renal disease, heart failure). Subjects were recruited into the study between December 1994 and February 1997 at a rate of approximately 25 subjects per month by Fallon system telemarketers and by a recruiter assigned specifically to recruit members of ethnic minority groups (who were not Fallon members). Each subject was compensated for his/her participation with a free portable blood pressure monitor and a monetary incentive for each completed clinic visit (maximum possible compensation: $70).

Approximately 5000 subjects were contacted to determine their interest in study participation. From this sample, 1254 met verbal eligibility criteria and consented to making a baseline appointment. Of these subjects, 427 (34%) failed to attend their first appointments and 140 (11%) did not meet the formal eligibility requirements for the study. The remaining 641 subjects (51%) completed the baseline questionnaire and 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 Center 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 clinic at the initial baseline interview and then every three months over the next year. Serum lipids and body weight were measured once per quarter and three 24-hour dietary recalls, including assessments of food intake on two weekdays and one weekend day, were completed each quarter. The times each individual went to bed at night and arose in the morning were also collected as part of a 24-hour physical activity recall, administered together with the diet recall. Therefore, a total of fifteen 24-hour diet and physical activity recalls were potentially available for each subject, with serum lipids and body weight each measured five times.

Of the 641 subjects formally entering the SEASONS study, twenty-four hour recall completion rates were high with 267 subjects (41.9%) having all fifteen 24-hour diet recalls, and 503 subjects (78.8%) having more than ten 24-hour diet recalls. One hundred thirty eight had fewer than ten 24-hour diet recalls and four subjects were working night shift (although individuals who worked night shift were excluded, we double checked eating time for breakfast, lunch, and dinner for study subjects to see whether it was correct). These 4 subjects were excluded from the present analyses. We also excluded subjects with fewer than ten diet recalls to achieve more highly reliable dietary information. These exclusions left 499 men and women with a total of 6,931 twenty-four-hour diet recalls available for analysis. The average number of recalls was 13.4 (SD=1.5) per subject and average number of lipid measures was 4.79 (SD=0.59) per subject.

Dietary Assessment

Randomly selected 24-hour dietary recalls, three (two weekdays and one weekend) in each quarter of follow-up, were employed to quantify dietary changes over time. Unannounced 24-hour diet recalls have emerged as a favored dietary assessment method to capture changes in behavior because the respondents only have to recall their previous day of dietary intake.[17,18] The short period of recall is thought to: minimize errors in recall (omission and/or intrusion),[19] eliminate error due to long-term averaging imposed by longer-term dietary assessments,[19] and minimize response-set biases in reporting of dietary intake (e.g., social desirability bias).[20] The 24-hour dietary recall data were collected using the Nutrition Data System (NDS) data entry and nutrient database software developed and maintained by the Nutrition Coordinating Center at the University of Minnesota, Mineapolis, MN.[21] Dietary variables considered in these analyses were total energy (kcal/day), % carbohydrate (expressed as a percentage of total energy intake), % protein, % total fat intake, % saturated fat and fiber (g/1,000kcal). In addition, daily averaged eating episodes and proportion of breakfast, lunch, and dinner eaten away from home for each subject were evaluated.

Blood Lipid Assessment

Fasting (> 12 hours) venous blood samples (10 mls) were obtained after sitting for 15 minutes. Blood plasma was harvested by low-speed centrifugation at 4° C, aliquoted into individual tubes, and quickly frozen to - 70° C. On a regular basis, plasma samples were packed in dry ice and shipped for analysis via overnight service to the Centers for Disease Control standardized laboratory at the University of Massachusetts at Lowell.[22] Total cholesterol was measured in plasma by enzymatic methods using a Beckman System 700 autoanalyzer.[23,24]

Physical Activity Assessment

Physical activity was assessed at the same time as the diet recalls. Unannounced telephone-administered 24-hour recall interviews of physical activity were conducted by trained

registered dietitians on two randomly selected weekdays and one randomly selected weekend day within the 4-week period surrounding each clinic visit. The 24-hour physical activity recall used in our study was adapted from methods developed for a seven-day recall of physical activity.[25] Specifically, subjects were asked to recall the number of hours they had slept the previous night, and the amount of time spent engaged in three types of activity (household, occupational, leisure-time). In addition, subjects were given a handout to familiarize themselves with the activity intensity classification system (light, moderate, hard, and very hard) to be employed during the interview and then asked to rate the intensity of all activities reported. The interviewers used a standardized interview script and entered the activity data directly into an EpiInfo database.[26] While the subject was still on the phone, interviewers checked that the total duration of activity reported in the 24-hour period was arithmetically correct and summed to no more than 24 hours.

We used methods described by Ainsworth and colleagues [27] to estimate total daily energy expenditure based on the reported time spent at each activity and activity intensity. A validity study was conducted in estimating short-term physical activity using 24-hour recalls.[28] Results showed that three 24HR of physical activity were observed to have a relative validity that was comparable to published data from other short-term activity assessments that also employed the Baecke Questionnaire and activity monitors as criterion measures.

Clinical Data

Data on demographic variables were collected by self-administered questionnaire at baseline (1st quarter). Smoking status was ascertained at baseline and in each quarter of follow up by self-administered questionnaire. Anthropometric data including height (m), waist and hip circumferences (cm) were measured at baseline and 12-months of follow-up. Body mass was measured at each clinic visit, with the subject removing his/her shoes and wearing minimal layers of clothing. Body mass index (BMI) was computed using the following formula: weight(kg)/height(m)^2. Subjects were classified as "overweight" if their BMI was equal to or greater than 25 kg/m^2 and as "obese" if their BMI was equal to or greater than 30 kg/m^2.[29]

Statistical Analysis

Daily average measure of eating episodes, total energy (kcal/day), percent calories from carbohydrate, protein, total fat intake, and saturated fat, and grams of fiber (g/1,000kcal) were derived from repeated 24-hour diet recall data and evaluated.

Previous studies have suggested that meal frequency may be associated with blood lipids. Though different definitions for meals and snacks have been used in previous studies, all definitions include consideration of the minimal time span between intakes and level of calorie intake. In order to more objectively classify eating frequency, we used the definition proposed by Gibney and colleagues,[30] which classified an eating episode as an event which provides at least 50 kcal (or 210KJ, in the form of food; it is equivalent to a half cup of Coke, one slice of bread, two cups of coffee with milk and sugar, or a quarter of a cup of cereal with milk) with a minimum time interval between episodes of at least 15 minutes. We then tallied the number of eating episodes for each study subject on each day. The average number of eating episodes from all completed 24HR for each subject was used for this analysis. Proportion of "breakfast", "lunch", and "dinner" eaten away from home were computed for each subject based on multiple 24 hour diet recalls. Breakfast, lunch, and dinner were determined based on self report. Total cholesterol was averaged for each subject from all 5 potential measurements.

The purpose of this analysis was to investigate whether aspects of eating patterns are associated with blood lipids. Although we have multiple measurements per subjects, there is a large within subject variation for dietary measures,[31] especially eating episodes, and proportion of meal eaten away from home.[32] Using the average of diet provides more precision, therefore, a cross-sectional analysis was conducted to investigate the association between eating patterns and total cholesterol. Linear regression models were used for the analysis, with total cholesterol fitted as the dependent variable.

The eating pattern parameters evaluated were daily average eating episodes and proportion of meals (breakfast, lunch, and dinner) eaten away from home. Covariates, including participants' demographic characteristics (e.g., age, gender, race/ethnicity and smoking status), total physical activity, and total caloric intake, were evaluated as potential confounders of the eating patterns and blood lipids relationship; variables that were significantly associated with total cholesterol at α=0.20 or had been associated with total cholesterol in previous studies were considered candidate variables to be entered into the final models, which include age, gender, race/ethnicity, obesity, cigarette smoking, physical activity, alcohol intake, caloric intake, % saturated fat and dietary fiber. This approach enabled the examination of the association between eating patterns and blood lipids independent of total energy intake, physical activity, and other covariates.

Additional analyses were conducted to compare meal contents eaten at home and away from home. Nutrient variables, including total energy (kcal/day), % carbohydrate (expressed as a percentage of total energy), % protein, % total fat intake, % saturated fat and fiber (g/1,000kcal), were estimated from a linear mixed model using SAS PROC MIXED [33] with a random intercept for each subject, and within-subject correlation was prescribed as compound symmetry. Analyses were conducted separately for breakfast, lunch, and dinner.

RESULTS

Descriptive characteristics of the SEASONS cohort were examined (**Table 1**). Briefly, at baseline, the average age of both men and women was approximately 48 yrs and their

average BMI's were 28.6 and 26.6 kg/m^2, respectively. Forty-eight percent of men and 33% of women were overweight (BMI 25-29.9 kg/m^2), and 27% and 17% were obese (BMI >=30 kg/m^2), respectively. Average total cholesterol was 219 mg/dl (SD=40). The study participants were predominantly white, married, educated, non-smokers, and employed in white-collar occupations (e.g., managerial, scientific, or office work).

Table 2 presents associations between participants' characteristics and total blood cholesterol. Increasing age was significantly associated with higher total cholesterol. BMI was also significantly associated with total cholesterol; overweight or obese subjects had higher total cholesterol than subjects with normal weight. Total cholesterol level did not statistically differ by gender, or by smoking status, physical activity level, and total energy intake.

The associations between average daily number of eating episodes and total cholesterol are presented in **Table 3**. Mean concentration of total cholesterol was not significantly different among three categories of eating episodes for the unadjusted and adjusted means. When analyses were stratified by gender, total cholesterol was shown to be similar for men among three categories of eating episodes for both the unadjusted and adjusted means. For women, although not statistically significant, mean concentration of total cholesterol decreased with increased eating episodes in a continuous relation. The total cholesterol for subjects with three or less eating episodes per day was 218 mg/dl, 211 mg/dl for 4 eating episodes, and 209 mg/dl for five or more episodes.

On average, subjects ate 18.9% of breakfast, 53.5% of lunch and 19.6% of dinner away from home. Associations between proportion of meals eaten away from home and participants' characteristics are examined and results are presented in **Table 4**. Briefly, factors associated with eating away from home are gender, race/ethnicity, age, educational levels, and occupation categories; subjects with younger age, male gender, non-white race, higher education and white collar occupations are more likely to eat out.

Table 5 presents nutrient density by meal type and meal place. Breakfasts or dinners eaten away from home were significantly higher in total calories, percentage of calories from total fat (% total fat), and % saturated fat, lower in % protein, % carbohydrate and fiber than breakfasts or dinners eaten at home. For example, breakfasts eaten away from home had 105 more kcal, 7% more fat, 2.8% more saturated fat and 2.2g/1000 kcal less fiber; while dinners eaten away from home had 194 more kcal, 3.5% more fat, and 0.7% more saturated fat than dinners eaten at home. Lunches eaten away from home were significantly higher in total calories and % total fat, but lower in % protein than lunches eaten at home.

Table 6 presents the relationship between the proportion of meals eaten away from home and total cholesterol. Two adjusted means are presented in the table. The first was adjusted for age, gender, race/ethnicity, obesity, cigarette smoking, and physical activity. The second was adjusted for the variables listed for the first mean, plus other dietary variables including alcohol intake, caloric intake, % saturated fat, and dietary fiber. Results showed that the two adjusted means for each category were very similar, and the decision was made to present the mean that was adjusted for all possible covariates. Increased proportion of breakfast eaten away from home was positively associated with total cholesterol. Subjects in the upper quartile for proportion of breakfast eaten away from home had total cholesterol 11 mg/dl higher than subjects in the 1st quartile. Similarly, increased proportion of lunches or dinners eaten away from home was also positively associated with increased total cholesterol. Subjects in the highest quartile for proportion of lunches eaten away from home had total cholesterol 19 mg/dl higher than subjects in the 1st quartile of the distribution. Subjects in the upper quartile for proportion of dinner eaten away from home had total cholesterol 11 mg/dl higher than subjects in the 1st quartile. We also stratified the analysis by gender, with the results showing that the differences of total cholesterol among the four categories of proportion were similar between men and women (P>0.05 for interaction term between gender and categories of meal proportion eaten away from home).

Adjusting for covariates including age, gender, race/ethnicity, BMI, cigarette smoking, and physical activity made the association between total cholesterol and eating patterns stronger. To investigate this, we fit a series of models adding each covariate individually to the base model of total cholesterol and eating patterns. The results suggested that race/ethnicity and BMI were the most important covariates that alter these associations.

DISCUSSION

The results from our study do not support the hypothesis that the number of eating episodes per day is associated with total blood cholesterol. However, we noted that the mean concentration of total cholesterol decreased with increasing number of eating episodes among women, although the adjusted mean among three categories of number of eating episodes per day was not statistically significant. On the other hand, the results of our study suggest that increased frequency of meals (breakfast, lunch, or dinner) eaten away from home was positively associated with mean total blood cholesterol concentration. Furthermore, meals eaten away from home, especially breakfast and dinner, were significantly higher in total calories, percent calories from total fat and saturated fat, but lower in percent calories from protein and carbohydrate, and grams of fiber, than corresponding meals eaten at home.

Results from previous studies suggest that the number of eating episodes per day may be causally associated with blood lipids. Insulin stimulates the activity of 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase, an enzyme that plays a pivotal role in regulating the synthesis of cholesterol in the liver. Several lines of evidence have shown that a low number of eating episodes is associated with

higher 24-hour insulin concentrations [1,3,6,7,34] when compared to a high number of eating episodes. Eating multiple, small meals suppresses hunger and decreases overall serum insulin concentration,[7] thereby lowering cholesterol production.

Several small, short-term trials in healthy individuals with normal blood lipids have demonstrated that increased frequency of eating may be associated with improved lipoprotein profiles.[1-9] Data from a free-living population in Europe [11] suggest that concentration of total cholesterol is negatively and consistently associated with frequency of eating. Our results suggest a similar trend. However, there are some differences between the European study and ours. First, we had a small sample size compared with the European study, so we may not have adequate power to detect the association between number of eating episodes and total cholesterol. In our study we observed a 4% reduction in total cholesterol among women reporting five or more episodes, compared with those reporting less than three eating episodes per day, although this did not reach statistical significance. This is similar to that reported in the European study: a 5% decrease in subjects who ate six or more times a day compared to those who ate once or twice a day. Second, eating episodes were measured quite differently: eating frequency was assessed by a simple question in the European study, while our measures were obtained from averaging up to fifteen 24-hour recalls performed during a one-year period, and therefore less subject to within person variation.

Table 1. Baseline Demographic Characteristics of Subjects (N=499), Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts, 1994-1998.

	%
Gender	
Male	50.3
Race	
White	87.7
Hispanic	7.2
Education	
High school or less	30.8
Post-high school	29.4
Bachelor degree or more	39.8
Smoking Status	
Yes	15.2
Occupational Category	
Unemployed/retired	21.8
Blue collar	13.5
Service work	27.3
White collar	37.4
Marital Status	
Married	78.1
Not married	21.9
Age (years)	
20-39	25.3
40-59	50.9
60-70	23.8
Body Mass Index Classification	
Normal Weight (17.1-24.9)	37.5
Overweight (25.0-29.9)	39.3
Obese (>=30.0)	23.2

Table 2. Mean Values of Blood Lipids for Participants' Characteristics Adjusted for Age and Gender, Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts (N=499), 1994-1998.

	n (%)	Total Cholesterol (mg/dl) Mean (SE)
Age ¶		
20-30	28 (5.61)	188 (7.21)
30-40	98 (19.64)	208 (3.85)
40-50	140 (28.06)	212 (3.22)
50-60	114 (22.85)	231 (3.57)
60-70	119 (23.85)	231 (3.50)
p-value*		<0.001
Gender ¥		
Male	251 (50.30)	216 (2.68)
Female	248 (49.70)	212 (2.62)
p-value		0.27
Race		
White	426 (87.65)	217 (2.31)
Others	60 (12.35)	205 (4.99)
p-value		0.046
Smoking Status		
Never	401 (86.98)	214 (2.25)
Ever	60 (13.02)	211 (5.16)
p-value		0.55
Physical Activity (MET-hr/day)		
Quartile 1 (5.6 Met-hr/day)§		216 (3.60)
2 (8.4)		212 (3.66)
3 (11.2)		212 (3.63)
4 (17.7)		215 (3.65)
p-value		0.8265
Total Energy Intake (Kcal/d)†		
Quartile 1		221 (3.62)
2		213 (3.55)
3		212 (3.60)
4		209 (3.58)
p-value		0.0960
Body Mass Index Classification		
Normal Weight (17.1-24.9)	180 (30.07)	204 (2.97)
Overweight (25.0-29.9)	203 (40.68)	218 (2.94)
Obese (>=30.0)	116 (23.25)	223 (3.65)
p-value		<0.001

*: P-value for test of adjusted mean difference across categories.
†: Sex-specific quartile cutpoints used. Median quartile values for men=1703, 2055, 2383, and 2836. Median quartile values for women=1259, 1486, 1724, and 2078.
§: Median values for Met-hr/day in each quartile.
¶: Adjusted for sex only.
¥: Adjusted for age only.

Table 3. Mean Values of Total Cholesterol (mg/dl) by Reported Daily Eating Episodes, Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts, 1994-1998.

	Total			Men			Women		
Average Daily Number of Eating Episodes	**n**	**Unadjusted**	**Adjusted†**	**n**	**Unadjusted**	**Adjusted‡**	**n**	**Unadjusted**	**Adjusted‡**
3 or less	141	221 (3.38)	216 (4.78)	81	224 (4.22)	219 (7.16)	60	217 (5.45)	218 (6.45)
4	264	218 (2.47)	213 (4.33)	128	220 (3.35)	219 (6.67)	136	215 (3.62)	211 (5.71)
5 or more	94	217 (4.13)	213 (5.18)	42	217 (5.85)	220 (8.87)	52	216 (5.85)	209 (6.80)
p-value§		0.66	0.81		0.60	0.99		0.99	0.50

†: Adjusted for age, gender, race/ethnicity, obesity, cigarette smoking, physical activity, alcohol intake, caloric intake, % saturated fat and dietary fiber.
‡: Adjusted for Age, Race/ethnicity, Obesity, Cigarette Smoking, Physical Activity, Alcohol Intake, Caloric Intake, % Saturated Fat and Dietary Fiber
§: P-value was from test of difference of means or adjusted means among subjects who ate 3 or less episodes, subjects who ate 4 episodes, and subjects who ate 5 or more episodes.

Table 4. Proportion of Meals Eaten Away from Home by Participants' Characteristics, Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts (N=499), 1994-1998.

	n (%)	Breakfast Mean (SE)	Lunch Mean (SE)	Dinner Mean (SE)
Age				
20-30	28 (5.61)	25.22 (3.56)	58.41 (4.54)	22.42 (3.15)
30-40	98 (19.64)	26.45 (1.90)	62.84 (2.42)	23.23 (1.68)
40-50	140 (28.06)	18.93 (1.59)	62.79 (2.03)	20.21 (1.41)
50-60	114 (22.85)	18.86 (1.77)	54.36 (2.25)	19.46 (1.56)
60-70	119 (23.85)	11.11 (1.73)	33.11 (2.20)	15.30 (1.53)
p-value*		<0.001	<0.001	0.0092
Gender				
Male	251 (50.30)	21.72 (1.33)	56.17 (1.73)	21.11 (1.18)
Female	248 (49.70)	16.00 (1.10)	50.90 (1.64)	18.09 (0.92)
p-value		0.001	0.03	0.04
Race				
White	426 (87.65)	17.80 (0.91)	52.57 (1.31)	19.76 (0.83)
Others	60 (12.35)	27.81 (2.86)	60.98 (3.05)	19.21 (2.06)
p-value		0.0002	0.02	0.81
Smoking Status				
Never	401 (86.98)	18.43 (0.96)	52.81 (1.31)	20.19 (0.85)
Ever	60 (13.02)	22.12 (2.80)	58.94 (3.23)	18.28 (2.38)
p-value		0.17	0.09	0.42
Education				
≤High school	152 (30.83)	19.61 (1.58)	48.93 (2.17)	15.98 (1.36)
Some college	145 (29.41)	20.63 (1.62)	54.05 (2.22)	19.39 (1.39)
≥Bachelor degree	196 (39.76)	17.29 (1.39)	56.80 (1.91)	22.63 (1.19)
p-value		0.27	0.02	0.001
Occupational Category				
White collar	185 (37.37)	20.22 (1.40)	61.28 (1.81)	22.84 (1.23)
Service work	135 (27.27)	21.08 (1.64)	58.33 (2.11)	17.71 (1.44)
Blue collar	67 (13.54)	23.76 (2.33)	55.15 (3.00)	18.26 (2.05)
Unemployed/retired	108 (21.82)	11.00 (1.84)	33.18 (2.30)	17.52 (1.61)
p-value		<0.0001	<0.0001	0.014

*: P-value for test of mean difference across categories using t-test or analysis of variance.

Table 5. Nutrient Density by Meal Type and Meal Place, Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts (N=499), 1994-1998.

	Number of Meals	Energy (kcal)	Total Fat (%)	Saturated Fat (%)	Protein (%)	Carbohydrate (%)	Fiber (g/1,000 kcal)
	n	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)
Breakfast							
At Home	5889	334 ± 7.2	21.9 ± 0.5	9.2 ± 0.3	12.5 ± 0.1	68.2 ± 0.5	12.1 ± 0.3
Away from home	1351	439 ± 9.4	28.9 ± 0.6	12.0 ± 0.3	11.8 ± 0.2	60.8 ± 0.6	9.9 ± 0.4
p-value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lunch							
At Home	2835	542 ± 10.7	31.4 ± 0.4	10.7 ± 0.2	18.3 ± 0.2	50.3 ± 0.5	9.4 ± 0.2
Away from home	3192	606 ± 10.4	32.6 ± 0.4	10.7 ± 0.2	17.5 ± 0.2	50.0 ± 0.5	9.3 ± 0.2
p-value		<0.001	0.001	0.8147	<0.001	0.5532	0.6795
Dinner							
At Home	5272	758 ± 11.7	31.2 ± 0.3	10.8 ± 0.1	20.4 ± 0.2	46.4 ± 0.4	9.3 ± 0.1
Away from home	1265	952 ± 15.6	34.7 ± 0.4	11.5 ± 0.2	18.8 ± 0.3	41.7 ± 0.5	7.6 ± 0.2
p-value		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 6. Mean Values of Total Cholesterol by Categories of Proportion of Meals Eaten Away from Home, Seasonal Variation of Blood Cholesterol Study, Worcester, Massachusetts, 1994-1998.

	Unadjusted	Adjusted¶	Adjusted§
Breakfast			
Quartile 1 (median=0% of breakfasts away from home)	216 (3.69)	209 (5.16)	206 (5.15)
2 (6.7%)	217 (3.60)	213 (5.17)	212 (5.13)
3 (18.2%)	223 (3.44)	222 (4.84)	219 (4.86)
4 (46.2%)	217 (3.64)	219 (4.65)	217 (4.74)
p-value‡	0.8155	0.0493	0.0488
Lunch			
Quartile 1 (median=15.1% of lunches away from home)	218 (3.63)	204 (5.08)	203 (5.06)
2 (45.5%)	219 (3.63)	216 (4.85)	213 (4.94)
3 (66.7%)	217 (3.53)	220 (4.71)	218 (4.72)
4 (83.3%)	227 (3.58)	226 (4.97)	222 (5.04)
p-value‡	0.6789	0.0001	0.0004
Dinner			
Quartile 1 (median=0% of dinners away from home)	213 (3.93)	209 (5.17)	207 (5.16)
2 (9.1%)	220 (3.42)	218 (4.55)	216 (4.57)
3 (20.0%)	220 (3.57)	219 (5.11)	216 (5.15)
4 (38.5%)	220 (3.49)	221 (4.90)	218 (4.99)
p-value‡:	0.1919	0.0264	0.0389

‡: P-value was from test of difference among means or adjusted means from whom the proportion of meals eaten away from home from 4 quartiles of the distribution.
¶: Adjusted for age, gender, race/ethnicity, obesity, cigarette smoking, and physical activity.
§: Adjusted for age, gender, race/ethnicity, obesity, cigarette smoking, physical activity, alcohol intake, caloric intake, % saturated fat and dietary fiber.

Results from our study indicate that meals eaten away from home were higher in total calories, percent calories from total fat and saturated fat, and lower in percent calories from protein and carbohydrates, and in grams of fiber than corresponding meals eaten at home. These results are similar to results from the US Department of Agriculture's (USDA) 1995 Continuing Survey of Food Intakes by Individuals (CSFII).[12]

Results from our study suggest that subjects who eat a larger proportion of meals away from home tend to have higher total cholesterol levels. This association was not significantly altered after controlling for covariates including total energy intake, and fat, saturated fat, and dietary fiber intake. This agrees with results reported by Jacobs,[35] in which he found no association between dietary fat and serum lipids in a cross-sectional analysis.

There are several theories as to explain the association between eating away from home and total cholesterol. First, dietary glycemic index (GI) and glycemic load (GL) could be different in foods eaten away from home, as several studies have shown an association of GI and GL with blood lipids.[36,37] Secondly, the "Western" diet, which is characterized by a higher intake of red and processed meat, high-fat dairy products, sugar-containing beverages, sweets and desserts, may be associated with a higher fasting insulin concentration than the "Prudent" diet (higher intake of fruit, vegetables, whole grains, and poultry).[38] Thus the "Western" diet affects blood lipids.[38] Finally, studies have shown that hydrogenated fat consumption affects blood cholesterol.[39,40]

Hydrogenated oils not only raise total cholesterol and LDL cholesterol levels but also are known to lower HDL cholesterol levels. As discussed by Willett,[41] most restaurants and fast food establishments prepare foods using hydrogenated oils (because when liquid oils are hydrogenated, the oils become more solid, more stable, and less greasy-tasting); most processed foods are also made with hydrogenated fat. The spread of fast food restaurants and processed foods all over the world has changed modern nutrition fundamentally. The influence begins early in childhood. Advertising concentrates on the selling of image over substance. However, fast foods and processed foods contain high levels of fat, especially trans fatty acids.[41] Higher consumption of trans fatty acids has been associated with a higher incidence of morbidity and mortality from coronary heart disease.[42-44]

In our study, the magnitude of the change in total blood cholesterol was a difference of 9 mg/dl (4%) between subjects reporting five or more episodes compared with subjects reporting fewer than 3 eating episodes per day. Looking at the quartile distribution, we found an 11 mg/dl difference in total blood cholesterol between subjects in the 1st quartile of the distribution of number of breakfasts or dinners eaten away from home and subjects in the 4th quartile of that distribution. This difference in cholesterol concentration is clinically relevant, since it is comparable to that achieved in clinical trials involving changes in dietary intake of fat and saturated fat,[45] as well as in controlled trials of eating frequency.[7] A 10mg/dl reduction in total cholesterol concentration has been associated with reductions in coronary heart disease ranging from 10% to 21% in observational studies and trials.[46, 47] If applied to the entire population, such a reduction may have a substantial impact, particularly in older people, who have higher absolute rates of heart disease.[48]

Since the study has a cross-sectional design, causality cannot be determined. Therefore, further investigation of this association in other populations using cohort studies or clinical trials is warranted. The relationship between total cholesterol and eating out might be explained by confounding factors. However, this association persisted after adjustment variables including age, gender, dietary intake, BMI, smoking status, physical activity and dietary intake, suggesting that the frequency of meals eaten away from home influences blood lipids through other mechanisms (e.g. hydrogenated fat), but we can not explain such mechanism in this study. Finally, there is a potential limitation in generalizing our study results. Participants in this study were highly motivated, ages between 20 and 70 years, predominantly well-educated, employed full time, and white.

In conclusion, the results of this study suggest that total blood cholesterol levels might be correlated with number of eating episodes per day, but the association did not achieve statistical significance. On the other hand, total blood cholesterol levels appear to be positively related with the frequency of meals eaten away from home. Further research is needed to better understand the role of eating away from home on blood lipids.

DISCLOSURE

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CONFLICT OF INTEREST

None.

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