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Association of Eating Frequency with Body Fatness in Pre- and Postmenopausal Women

Mary Yannakoulia, Labros Melistas,* Eleni Solomou,* and Nikos Yiannakouris†*

Abstract

YANNAKOULIA, M., LABROS MELISTAS, ELENI SOLOMOU, AND NIKOS YIANNAKOURIS. Association of eating frequency with body fatness in pre- and postmenopausal women. *Obesity*. 2007;15:?–?.

Objective: To examine associations between eating frequency (EF) and body fatness in pre- and postmenopausal women, after excluding potential low-energy reporters.

Research Methods and Procedures: This was a cross-sectional study of 64 pre- and 50 postmenopausal non-low-energy-reporting free-living women (age, 24 to 74 years; BMI, 18.5 to 38.6 kg/m^2). BMI and percentage body fat were assessed by DXA. EF and energy, and macronutrient intake were assessed by 3-day food record. Physical activity level and energy expenditure were assessed by self-reported questionnaire. AQ: A

Results: No association between EF and adiposity indices was detected in premenopausal women. In contrast, EF was positively correlated with percentage body fat in postmenopausal women ($r = 0.30$, $p = 0.03$). EF was positively correlated with total energy intake in both groups and with total energy expenditure in premenopausal women only ($r = 0.34$, $p = 0.02$). Multivariate analysis revealed that, in postmenopausal women, EF was a significant predictor of body fatness (standardized $\beta = 0.41$, $p = 0.01$).

Discussion: Frequent eating was not found to be related to adiposity in premenopausal women, but it was associated with increased body fat in postmenopausal women. Possible explanations could be that the frequent eating is not associated with a physically active lifestyle in postmenopausal women or that frequent eating predisposes women after menopause to a higher energy intake by increasing food stimuli and rendering it more difficult for them to control energy balance.

Key words: eating behaviors, energy intake, energy expenditure, adiposity, menopause

Introduction

Obesity is becoming a global epidemic, with harmful health, psychosocial, and economic effects (1,2). Several studies have been conducted so far to identify dietary factors that contribute to a positive or a negative energy balance. Among others, a nibbling or a grazing meal pattern has been associated with leanness (3), although the results have not been consistent so far. Some early studies revealed an inverse relationship between overall eating frequency (EF)[1] and adiposity (4–6), whereas others could not detect any association (7,8). It has been proposed that frequent eating may improve body weight management by facilitating control of hunger and, thus, improving energy compensation (9). Drummond et al. (10) showed that EF was inversely related to body weight status in men but not in women. In women, there was no evidence of energy compensation because EF was positively correlated with energy intake (EI). Furthermore, positive correlation with energy expenditure (EE) at leisure time postulates that women balance the higher EI associated with high EF by greater EE from physical activity, sufficient to prevent changes in body weight. Fn1

Several aspects of the relationship between EF and adiposity, however, remain unclear. In women, in particular, the absence of association needs to be further explored by also considering the influence of other factors predisposing women to overweight. Menopause transition possibly affects BMI, body fatness, and body fat distribution in midlife (11–13), although it has been suggested that this is a chro- AQ: B

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Departments of *Nutrition and Dietetics and †Home Economics and Ecology, Harokopio University, Athens, Greece.
Address correspondence to Nikos Yiannakouris, Department of Home Economics and Ecology, Harokopio University, El. Venizelou 70, Athens 17671, Greece.
E-mail: nyiannak@hua.gr

[1] Nonstandard abbreviations: EF, eating frequency; EI, energy intake; EE, energy expenditure; LER, low-energy reporter; BMR, basal metabolic rate; HAPAQ, Harokopio Physical Activity Questionnaire; PAL, physical activity level; TEE, total EE; EE_{home}, EE spent at home; EE_{work}, EE spent at work; $EE_{leisure}$, EE spent at leisure time.

nological rather than a hormonal effect (14), which may be exacerbated by concomitant decreases in physical activity. Sternfeld et al. (15) concluded that regular physical activity could help to mitigate the tendency for weight gain and adverse changes in body composition accompanying menopause transition. If, indeed, EF is related to physical activity in women and physical activity compensates for the adverse effect of the positive correlations between EF and EI on body weight, it would be interesting to investigate whether such associations also exist in postmenopausal women who generally exhibit decreases in EE. Therefore, the aim of the present study was to examine associations between EF and indices of adiposity in postmenopausal women, after accounting for confounding factors such as physical activity. Furthermore, to obtain more robust data, we identified low-energy reporters (LERs) and excluded them from further analysis, as has been previously recommended (9). Dietary under-reporting has been suggested to obscure associations between feeding frequency and body weight or fatness (3). Given the increased prevalence of under-reporting among overweight subjects, one may speculate that inclusion of under-reporters or LERs could create false negative correlations between EF and body fatness or even mask positive associations.

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Research Methods and Procedures

Subjects

For this study, we consecutively enrolled 220 healthy women (mean age, 48.2 ± 12.2 years). Women were recruited through local advertisement for an osteoporosis prevention program. After being informed of the purpose and procedures of the study, all subjects signed an informed consent form. The study protocol was approved by the Ethics Committee of Harokopio University. Blood samples were drawn in fasting condition between 8:30 AM and 10:30 AM; serum was immediately frozen at −80 °C until biochemical analysis. Data on general health status, medication, and duration and intensity of smoking were collected using an interviewer-administered questionnaire. Menstruation status was also recorded; women were classified as premenopausal if they had regular menses, perimenopausal if they were suffering from irregular menses, and postmenopausal if they had ceased menstruating for at least 12 months.

Anthropometry and Body Composition

Anthropometric and body composition measurements were performed with the subject wearing light clothing, without shoes. For all subjects, body weight and height were measured by the same observer using a scale and a wall-mounted stadiometer to the nearest 0.5 kg and 0.5 cm, respectively. BMI was computed as weight (in kilograms) divided by height (in meters) squared. Waist circumference (centimeters) was measured in the middle between the 12th rib and the iliac crest and hip circumference (centimeters) around the buttocks, at the level of the maximum extension. The waist-to-hip ratio was then calculated.

DXA was used as a reference method for the assessment of body composition. Soft tissue composition was determined using a DXA total body scanner (Model DPX+; Lunar Corp., Madison, WI) and the Lunar software 4.7e. Anthropometric and body composition measurements were performed in all study participants by one trained investigator (L.M.).

Dietary Assessment

Dietary intake was assessed using 3-day food records. Subjects were asked to record the type and amount of food and beverage consumed for 2 consecutive weekdays and 1 weekend day. Clear instructions were given to them on how to record the quantity of food eaten using standard household measures (cups, tablespoons, etc.). Food intake data were analyzed for energy and macronutrients using the Nutritionist V Diet Analysis software (FirstDataBank Inc., San Bruno, CA) as modified for the Greek population (16,17). Food records were also used to calculate the average number of eating episodes per day, i.e., EF. An eating episode was defined as any eating occasion when food or drink was taken. The definition of an eating episode included also alcoholic drinks, soft drinks, or coffees and teas eaten in the absence of food (i.e., a cup of coffee with milk and sugar or a coke was an eating episode). If two eating episodes occurred within a 15-minute period or less, they counted as a single episode. A greater time period resulted in two separate eating episodes.

For the assessment of under-reporting, the ratio of the EI/basal metabolic rate (BMR) was determined for each individual. BMR was estimated using the Schofield equations for the prediction of BMR (18), adopted by the 2004 Food and Agriculture Organization/World Health Organization/United Nations University report (19). Participants with EI/BMR <1.04 were classified as energy under-reporters or LERs based on the cut-off limits developed by Goldberg et al. (18). Normal-energy reporters or non-LERs were participants with EI/BMR ≥1.04.

Physical Activity Assessment

Assessment of physical activity was performed through a brief self-reported questionnaire [the Harokopio Physical Activity Questionnaire (HAPAQ)], which collects the previous week's self-reported physical activity (20). HAPAQ examines the time spent in light-, moderate-, and high-intensity activities and also requires sleeping to be recorded. The questionnaire is based on the metabolic equivalents of all activities of the previous week, including activities at work, leisure time, and rest or sleep, thus allowing the prediction of mean daily EE. The metabolic equivalents of various activities were obtained from Ainsworth et al. (21). HAPAQ has been validated against the RT3 triaxial accelerometer. Specifically, daily EE obtained from HAPAQ was significantly correlated with accelerometer measures (r = 0.80, $p < 0.001$). Physical activity level (PAL) and total EE (TEE) were estimated, as well as EE spent at home (EE_{home}), at work (EE_{work}), and at leisure time ($EE_{leisure}$). AQ: D

Statistical Analysis

Continuous variables are presented as mean values ± standard deviation, and categorical variables are presented as absolute and relative frequencies. Associations between categorical variables were tested by the use of χ^2 test. Correlations between study parameters were evaluated by calculation of the Pearson correlation coefficient for the normally distributed variables and the Spearman correlation coefficient for skewed variables. Comparisons between normally distributed continuous variables and groups of the participants were performed by the use of Student's t test, after testing for equality of variances and normality of the dependent outcome. For skewed variables, the non-parametric Mann-Whitney test was used. The Shapiro-Wilk test was applied to assess normality. Multiple regression analysis was then applied to evaluate the explanatory ability of various characteristics of the participants in relation to the investigated outcome (percentage body fat), after adjusting for potential confounders, and interactions using likelihood ratio tests. The results from the regression models are presented as standardized β coefficients. A step-wise procedure was applied to estimate the final model. The SPSS/PC statistical program (version 11.0 for Windows; SPSS, Inc., Chicago, IL) was used for all of the statistical calculations. All reported p values are based on two-sided tests.

Results

From the study population, 6.8% (n = 15) of the women were on a weight-reducing diet and were, therefore, excluded from the analysis. The mean value of EI/BMR for the remaining sample (n = 205) was 1.15 ± 0.37, and LERs represented 42% of the population. LERs (n = 86), compared with non-LERs (n = 119), were older (50.1 ± 12.6 vs. 46.8 ± 11.6 years, p = 0.04) and had higher BMI (30.2 ± 5.3 vs. 26.1 ± 4.6 kg/m^2, $p < 0.001$), percentage body fat (42.7 ± 5.9% vs. 37.6 ± 7.7%, $p < 0.001$), and waist-to-hip ratio (89.7 ± 12.2 vs. 80.9 ± 12.2, $p < 0.001$). With regard to their dietary intake, LERs reported a higher percentage of energy provided by protein (18.0 ± 3.7% vs. 15.5 ± 3.2%, $p < 0.001$), and fewer eating episodes per day (4.8 ± 1.3 vs. 5.7 ± 1.3, $p < 0.001$) than non-LERs.

Data from the 119 women reporting valid dietary intakes were considered for further analysis. According to their menstruation status, 64 women were premenopausal, five were perimenopausal, and 50 were postmenopausal. Due to their small number, perimenopausal women were excluded from the analysis below. Descriptive characteristics of the subjects are shown in Table 1. Postmenopausal women had T1 higher mean BMI values and percentage body fat than premenopausal women. Total EI, and macronutrient composition of the diet, were not different between the two groups, apart from percentage of energy derived from fat, which was lower in postmenopausal women. EF was similar between the two groups (premenopausal, 5.9 ± 1.4 eating episodes/d; postmenopausal, 5.4 ± 1.0 eating episodes/d, p = 0.10) and was TEE (2351 ± 489 kcal and 2383 ± 474, respectively, p = 0.60); however, premenopausal women had higher PAL compared with postmenopausal ones (1.54 ± 0.19 vs. 1.44 ± 0.19, p = 0.01).

Correlation coefficients between EF and body composition, dietary intake, and EE are shown in Table 2. EF was T2 found to be associated with percentage body fat (r = 0.30, p = 0.03) and total EI (r = 0.26, p = 0.05) in postmenopausal, but not premenopausal, women. In addition, post- AQ: E menopausal women with higher EF (above the median) exhibited significantly higher percentage body fat compared with those with lower EF (below the median), after controlling for age and EE (43.5 ± 1.1% vs. 37.8 ± 1.2%, p = 0.002). In premenopausal women, EF was strongly related to total EI (r = 0.53, $p < 0.001$); moderate associations were also found with TEE (r = 0.34, p = 0.02) and EE_{home} (r = 0.37, p = 0.01). Further adjustment for age, BMI, or percentage body fat did not substantially change the abovementioned correlations, apart from the one between EF and TEE in premenopausal women that became non-significant.

Age and dietary, and physical activity correlates of body fatness were further explored in a multivariate model. Stepwise multiple regression analysis revealed the statistically significant factors associated with percentage body fat in premenopausal women (adjusted R^2 = 0.22), namely EE_{home} (β = 0.52, p = 0.001) and $EE_{leisure}$ (β = −0.28, p = 0.05). In postmenopausal women, EF (β = 0.41, p = 0.01) and EE_{home} (β = 0.39, p = 0.01) were the significant predictors of body fatness, explaining 24% of the variance in percentage body fat. These data indicate that an increase of one eating episode in the daily EF would correspond to an increase in percentage body fat by 2.5% (after adjusting for potential confounders such as age, EE, and EI).

Discussion

The results of the present study confirm and expand previous findings on the associations between EF and indices of obesity in women. In premenopausal women, frequent eating was associated with high EI but also with high EE, especially EE_{home}. This may at least partly explain the absence of correlation between EF and body weight or body fatness in women, as has been previously proposed (10). Interestingly, we found that in postmenopausal women, EF was positively correlated with body fatness. Furthermore, in

Table 1. Characteristics of the study population by menstruation status*

	Premenopausal women (n = 64)	Postmenopausal women (n = 50)	p
Age (years)	38.6 ± 7.7 (24 to 51)	57.5 ± 6.2 (46 to 74)	<0.001
Weight (kg)	64.7 ± 11.1 (47.4 to 95.6)	69.9 ± 11.8 (48.0 to 97.5)	0.008
BMI (kg/m^2)	24.4 ± 4.5 (18.5 to 38.6)	28.0 ± 4.0 (21.6 to 37.6)	<0.001
BMI distribution (%)			
BMI < 25	62.5	24.0	
25 ≤ BMI < 30	26.6	46.0	
BMI ≥ 30	10.9	30.0	<0.001
Percentage total body fat	34.9 ± 7.9 (21.3 to 55.1)	40.8 ± 6.1 (26.0 to 51.2)	<0.001
Waist circumference	76.6 ± 8.1 (64.0 to 101.0)	86.1 ± 10.6 (68.0 to 116.0)	<0.001
Waist-to-hip ratio	0.75 ± 0.04 (0.65 to 0.88)	0.80 ± 0.06 (0.65 to 0.96)	<0.001
EI (kcal/d)	1949 ± 445 (1318 to 3508)	1838 ± 321 (1317 to 2714)	0.293
Percentage energy from			
Protein	15.5 ± 3.2 (9.3 to 23.5)	15.8 ± 3.0 (9.0 to 20.7)	0.624
Carbohydrate	40.3 ± 6.7 (23.9 to 56.6)	42.5 ± 7.6 (29.8 to 68.3)	0.101
Fat	44.2 ± 5.7 (32.2 to 61.1)	41.8 ± 7.2 (24.7 to 56.4)	0.042
Alcohol	1.6 ± 2.6 (0 to 9.3)	1.9 ± 3.3 (0 to 19.7)	0.942
Number of eating episodes (per day)	5.9 ± 1.4 (2.7 to 10.0)	5.4 ± 1.0 (3.3 to 8.7)	0.102
TEE (kcal/d)	2351 ± 489 (1661 to 4200)	2383 ± 474 (1681 to 3666)	0.599
PAL	1.54 ± 0.19 (1.16 to 2.04)	1.44 ± 0.19 (1.17 to 1.98)	0.006

EI, energy intake; TEE, total energy expenditure; PAL, physical activity level.
* Mean values and standard deviation are presented (range in parentheses).

a multivariate model controlling for physical activity, EF was a significant predictor of body fatness. Hence, in postmenopausal women, no physiological advantage associated with frequent eating that could improve body weight control was found.

One possible explanation could be that frequent eating is not associated with a physically active lifestyle in postmenopausal women, contrary to what was previously suggested for athletes and a group of men and women from Scotland (9,22). Decreases in resting metabolic rate and physical activity might be accelerated during menopausal years (23). This decline in EE, without a proportional reduction in EI, may constitute one of the factors affecting changes in body composition and fat distribution that accompany menopause transition. Our data support this hypothesis because no correlation was found between EF and EE in postmenopausal women; in addition, postmenopausal women had lower PAL compared with premenopausal women.

On the other hand, it is possible that frequent eating predisposes women after menopause to a higher EI by increasing food stimuli and rendering the control of energy balance more difficult for them. Kirk (9) suggested that overweight middle-aged women with high dietary restraint may be more likely to show poor compensation in response to increased snacking. Hormonal influences could also be involved because leptin levels, corrected for fat mass, were found to significantly decline in women post-menopause (24). Furthermore, preliminary evidence from rats showed that estrogen deficiency resulted in impaired central leptin sensitivity and overproduction of neuropeptide Y; and, thus, food intake was less suppressed (25). In the same study, ovariectomy was also associated with a decrease in spontaneous physical activity, supporting the hypothesis that in the ovarian hormone-deficient state, there is no compensation for EI by relevant changes in EE.

Because postmenopausal women had, on average, higher body fat compared with premenopausal women, it is possible that the associations between EF and adiposity observed in postmenopausal women are due to increased adiposity. However, we did not find an indication that the relation of EF with body fatness is influenced by the degree of adiposity because no differences in correlations between EF and percentage body fat were observed across subgroups of women with different body fat levels (data not shown).

Table 2. Correlation coefficients between EF (number of eating episodes per day) and body composition, dietary, and EE variables

	Premenopausal women	Postmenopausal women
BMI	0.16	0.16
Percentage body fat	0.17	0.30*
Waist circumference	0.11	0.08
Waist-to-hip ratio	0.15	−0.16
EI	0.53‡	0.26*
Percentage of energy from		
Protein	−0.12	0.01
Carbohydrate	−0.08	−0.05
Fat	−0.09	0.08
Alcohol	0.20	−0.16
TEE	0.34*	0.12
EE_{home}	0.37†	0.04
EE_{work}	0.01	0.14
$EE_{leisure}$	−0.01	0.09
PAL	0.11	−0.05

EF, eating frequency; EE, energy expenditure; EI, energy intake; TEE, total EE; EE_{home}, EE spent at home; EE_{work}, EE spent at work; $EE_{leisure}$, EE spent at leisure time; PAL, physical activity level.
* $p \leq 0.05$.
† $p \leq 0.01$.
‡ $p \leq 0.001$.

Not surprisingly, EF in postmenopausal women was correlated only with percentage body fat and not with BMI. Despite the numerous advantages of BMI and its widespread use in clinical practice for obesity assessment, it may be less predictive of body fatness in certain subgroups of a population than in others. The strength of the correlation between percentage body fat and BMI is influenced by age, sex, and ethnicity (26–28). Research evidence also suggests that in peri- and postmenopausal women, BMI does not accurately reflect body fatness (29,30). Blew et al. (31) proposed that current BMI-based classifications for obesity could be misleading based on the proposed standards for percentage body fat. The potential decreases in bone and skeletal mass observed in the postmenopausal years and concomitant increases in adiposity may change the relationship between BMI and body fatness from that observed in premenopausal years. Data from our sample confirm this because the correlation coefficient between BMI and percentage body fat was 0.92 in premenopausal women, whereas in postmenopausal women, the correlation coefficient dropped to 0.82 (data not shown). Consequently, we used percentage body fat as an obesity index in the multivariate analysis.

The percentage of under-reporting in our sample was 42%. (One of three premenopausal and almost one-half of postmenopausal women were LERs.) This figure, higher than what was previously found in the general Greek population (32), may evoke some concern on potential bias in food reporting. However, it was not surprising considering that our sample consisted mostly of middle-aged, overweight, or obese women. Research evidence indicates a higher proportion of LERs among female, older, and overweight subjects (33). In support of that, we found that LERs were older and heavier and had more central fat than women reporting valid dietary intakes. Furthermore, it has recently been found that under-reporting is quite prevalent among postmenopausal women, who, on average, and similarly to our findings, under-reported their EI by 37% on a 7-day dietary record and by 42% on a food frequency questionnaire (34). Exclusion of LERs from our data analysis provides confidence on the validity of the associations studied. Unreliable dietary data with low recorded eating frequencies are suggestive of non-reporting of certain eating occasions (35). Indeed, fewer eating episodes per day were recorded for LERs in this study compared with non-LERs. Snacks, in particular, are prone to under-reporting (36,37), a fact that would strongly intrude on the validity of the associations between meal patterns and health outcomes.

Some limitations should be recognized in the present study. As a cross-sectional study, confounding factors may always exist, and hypotheses stated should be addressed in future clinical trials. Furthermore, assessment of EE was performed through a simple questionnaire and not by gold standard techniques, such as doubly labeled water or heart rate monitors. Therefore, we did not use EE values from the physical activity questionnaire for the assessment of low-energy reporting. The latter was estimated by applying BMR prediction equations and the Goldberg cut-off points, which are based on an assumed PAL requirement of 1.55 (18). This approach has been adopted by several investigators for exploring factors associated with low-energy reporting or adjusting data before analysis (33,38), despite the fact that its ability to detect bias may not be perfect at an individual level. Black (38) notes that a PAL of 1.55 is possibly a conservative estimate and assumes a sedentary lifestyle; she proposes, therefore, the assignment of subjects to low-, medium-, and high-activity levels based on measures of EE by more sophisticated techniques rather than simple questionnaires and, then, the application of different cut-off values at each level. Given that we evaluated physical activity by questionnaire, and we examined a rather sedentary population (>75% of the subjects had a PAL <1.55), we used with relative confidence the Goldberg cut-off points that were based on a sedentary PAL and the predicted BMR values by the Schofield equations.

In conclusion, no association was found between EF and body fatness in premenopausal women, whereas in postmenopausal women, a positive correlation was detected. Further research is needed to explore the effect of EF on specific food group consumption in postmenopausal women, as well as the relation of EF with parameters of eating behavior, such as dietary restraint and external eating. For the time being, the most appropriate public health advice for weight management of postmenopausal women is to increase their physical activity to balance their dietary intake.

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