Eating Frequency Is Higher in Weight Loss Maintainers and Normal-Weight Individuals than in Overweight Individuals

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ABSTRACT

Eating frequency has been negatively related to body mass index (BMI). The relationship between eating frequency and weight loss maintenance is unknown. This secondary analysis examined eating frequency (self-reported meals and snacks consumed per day) in weight loss maintainers (WLM) who had reduced from overweight/obese to normal weight, normal weight (NW) individuals, and overweight (OW) individuals. Data collected July 2006 to March 2007 in Providence, RI, included three 24-hour dietary recalls (2 weekdays, 1 weekend day) analyzed using Nutrient Data System for Research software from 257 adults (WLM n=96, 83.3% women aged 50.0±11.8 years with BMI 22.1±1.7; NW n=80, 95.0% women aged 46.1±11.5 years with BMI 21.1±1.4; OW n=81, 53.1% women aged 51.4±9.0 years with BMI 34.2±4.1) with plausible intakes. Participant-defined meals and snacks were ≥50 kcal and separated by more than 1 hour. Self-reported physical activity was highest in WLM followed by NW, and then OW (3,097±2,572 kcal/week, 2,062±1,286 kcal/week, and 785±901 kcal/week, respectively; $P<0.001$). Number of daily snacks consumed was highest in NW, followed by WLM, and then OW (2.3±1.1 snacks/day, 1.9±1.1 snacks/day, and 1.5±1.3 snacks/day, respectively; $P<0.001$). No significant group differences were observed in mean number of meals consumed (2.7±0.4 meals/day). Eating frequency, particularly in regard to a pattern of three meals and two snacks per day, may be important in weight loss maintenance.

The prevalence of overweight/obesity has reached epidemic levels in the United States, with >60% of adults being overweight (1). Although lifestyle interventions in successful in achieving weight loss, prevention of weight regain remains elusive (2). Therefore, it is important to identify factors that aid in successful weight loss maintenance.

Increasing the structure of the diet, in which procedures are put into place to help limit the amount and type of food consumed, appears to be important for successful weight loss maintenance (3). For example, a recent review of long-term lifestyle interventions to prevent weight regain after weight loss found that use of meal replacements, which control portion size and reduce variety in the diet, was related to weight loss maintenance (4). Research examining eating patterns of the National Weight Control Registry, a registry of more than 6,000 individuals who have lost and maintained a significant amount of weight loss (on average participants have lost 30 kg and kept it off for 5.5 years), has found that these individuals have a fairly structured diet: they regularly consume breakfast, have a consistent diet across weekdays and weekends, limit the variety of foods consumed, and report consuming close to five eating occasions per day (2,5,6).

Number of daily eating occasions—meals and snacks consumed per day—which is often reported as eating frequency, may be important in achieving a lower weight status (7,8). Eating more frequently may help to control hunger, which is believed to decrease the chance of overeating (9). Research investigating the relationship between eating frequency and weight has found mixed outcomes (10). Methodologic limitations in previous investigations, such as not examining the potential influence of physical activity (11) and including dietary underreporters in analyses (10), have been suggested as potential reasons for the unclear outcomes between eating frequency and weight.

The purpose of this study was to examine the relationship between eating frequency and weight loss maintenance. To achieve this purpose, comparisons between successful weight loss maintainers (WLM), normal weight (NW), and treatment-seeking overweight/obese (OW) individuals were made in the number of self-reported meals and snacks consumed per day. In addition, to account for potential confounding variables, physical activity was controlled for and under-reporters of dietary intake were excluded from this analysis. It was hypothesized that WLM and NW would have a greater eating frequency than OW.

METHODS

Participants

Participants for this secondary data analysis were part of two National Institutes of Health–funded investigations. Data for both investigations were collected between July 2006 and March 2007 in Providence, RI. The first was an 18-month randomized controlled trial examining the influence of a dietary variety prescription, which limited the variety of sweet and salty energy-dense foods consumed, on weight loss maintenance during a standard behavioral intervention. Baseline data from OW participants were obtained from this investigation. This trial was registered at ClinicalTrials.gov (NCT00328744). The second investigation was a cross-sectional study examining weight control behaviors of successful long-term WLM and NW controls. Data from WLM and NW were obtained from this study. Both studies were approved by the Institutional Review Board at the Miriam Hospital in Providence, RI. Written informed consent was obtained from all participants for the respective studies in which they were participants.

OW group participants were overweight and obese (body mass index [BMI] 27 to 45) individuals aged 21 to 65 years who could walk at least two blocks and regularly consumed at least five different sweet and salty energy-dense foods (assessed by a 1-week food record). Participants were ineligible if they reported major psychiatric diseases or organic brain syndromes, had a food allergy to commonly consumed foods, recently lost weight, took weight loss medication, were <6 months postpartum, currently breastfeeding, or planned to move out of the area during the time frame of the investigation. Baseline data from the randomized controlled trial were used in this investigation. Participants were not paid for baseline measures.

WLM and NW group participants were from the cross-sectional study in which participants were aged 18 years or older. WLM group participants were overweight/obese (BMI >25) at some point in their life, normal weight (BMI 19 to 24.9) at entry into the trial, had lost >10% of their maximum body weight and maintained that for at least 5 years, and were weight stable (±4.5 kg) within the previous 2 years. NW group participants were normal weight (BMI 19 to 24.9) at entry into the trial, never overweight or obese (BMI ≥25), and were weight stable (±4.5 kg) within the previous 2 years. Participants were located in all different parts of the United States, but predominantly participants were from New England (>70%), the same area as OW participants. Participants were paid $50 for assessments. Participants who had completed measures at approximately the same time period in which measures were collected from OW were included in this investigation.

Measures

For OW participants, all measures were collected at baseline, before randomization to the start of the intervention. For WLM and NW participants, all measures were administered at study enrollment. All variables, except for anthropometric measures, were measured identically in the two studies.

Self-reported information on age, sex, race/ethnicity, highest level of education, and marital status was collected from all participants. For OW, weight and height were measured and documented by trained and blinded assessors with an electronic digital scale (Healthometer Professional 597KL, Pelstar LLC, Bridgeview, IL) and a stadiometer (Seca 214, Seca North America, East Hanover, MD), respectively, according to standard procedures (12). Height and weight from WLM and NW was collected via self-report, which has been validated previously (13).

Self-reported physical activity was assessed using the Paffenbarger Activity Questionnaire (PAQ) (14) for all three groups. This questionnaire yields estimates of the total energy expended in physical activity per week. The PAQ has been shown to be significantly correlated with measures of cardiovascular fitness (15). Self-reported physical activity was used to help determine plausible dietary reporters and was included as a covariate in analyses to control for the effect of physical activity on eating frequency.

Dietary intake was assessed via three, random, nonconsecutive, 24-hour telephone dietary recalls (2 weekdays and 1 weekend day) for all three groups. Trained interviewers, blinded to group status, from the Cincinnati Center for Nutritional Research and Analysis at Children's Hospital Research Foundation of Cincinnati conducted interviews for both trials. Participants were given two-dimensional portion size estimation tools. Each 24-hour dietary recall was completed using the Nutrition Data System for Research software (version 2006, 2006, Nutrition Coordinating Center, University of Minnesota, Minneapolis).

The Goldberg cut-off equation (16) was used to identify under-reporters. The Goldberg equation assumes that energy intake equals energy expenditure, which can be calculated as basal metabolic rate×physical activity level, in weight stable individuals. Physical activity level, either 1.53 (inactive) or 1.76 (active), was coded for each participant based on energy expenditure from the PAQ (14) using guidelines from the joint report of the Food and Agriculture Organization/World Health Organization/United Nations University (17) and recommendations from the American College of Sports Medicine and the American Heart Association (18). A 99% confidence limit for reported energy intake:basal metabolic rate was calculated for each individual and those that were <99% confidence interval were classified as under-reporters (19).

Eating occasions were defined as any instance in which at least 50 kcal were consumed (food or drink). If two eating occasions were consumed within the same hour, they were combined and counted as one eating occasion. This method of calculating the number of eating occasions was based upon previous research (8). Meals and snacks were participant defined; however, only one eating occasion per day was counted as breakfast, lunch, or dinner, with the second reported same meal coded as a snack. Dietary recalls were reviewed twice by bachelor's degree– and master's degree–level nutrition-trained per-

Table 1. Baseline characteristics of participants in a cross-sectional study on eating frequency and weight status in three subgroups: weight loss maintainers, normal weight, and overweight

Characteristic	Weight loss maintainers (n=96)	Normal weight (n=80)	Overweight (n=81)
	←——— *mean± standard deviation* ———→		
Age (y)	50.0±11.8[xy]	46.1±11.5[x]	51.4±9.0[y]
Body mass index	22.1±1.7[x]	21.1±1.4[y]	34.2±4.1[z]
Self-reported physical activity (kcal/wk)	3,097±2,572[x]	2,062±1,286[y]	785±901[z]
	←——— *%* ———→		
Women	83.3[x]	95.0[x]	53.1[y]
Race			
American Indian	0	1.3	0
Asian	0	1.3	0
Black	3.1	0	3.7
White	91.7	95	95.1
Other	5.2	2.5	1.2
Hispanic			
Yes	2.1	2.5	3.7
No	97.9	97.5	96.3
Education			
High school	8.3	2.5	6.2
Vocational school	5.2	2.5	4.9
Some college	6.3	11.3	17.3
College graduate	28.1	40	33.3
Graduate school	52.1	43.8	38.3
Marital status			
Single	15.6	20	12.3
Married	67.7	70	66.7
Divorced	12.5	8.8	16
Separated	0	1.3	0
Widowed	4.2	0	4.9

[xyz]Values in a row that do not have a shared superscript (x, y, z) are significantly different ($P<0.05$).

sonnel. Discrepancies in coding were resolved by a doctoral-level registered dietitian.

Statistical Analysis

One-way analysis of variance and χ^2 tests examined differences in baseline characteristics in the groups as well as between under-reporters and plausible reporters. With under-reporters removed from the analysis, age and sex were significantly different between the groups and were used as covariates in subsequent analyses. Analyses of covariance were conducted to examine group differences in energy and percent energy from macronutrients consumed, and eating frequency variables (meals and snacks) consumed. These analyses were repeated with self-reported energy expenditure from physical activity as a covariate. For significant outcomes, post hoc comparisons with Bonferroni corrections were conducted. Relationships between the eating frequency variables and energy intake, self-reported energy expenditure from physical activity, and BMI for all participants combined were investigated using Pearson correlation coefficients. SPSS for Windows (version 17.0, 2008, SPSS Inc, Chicago, IL) was used to perform statistical analyses. Alpha level was set a priori at $P<0.05$.

RESULTS AND DISCUSSION

Baseline Characteristics

Only participants reporting plausible dietary intakes were included in all analyses (N=257; OW n=81, WLM n=96, and NW n=80). Baseline characteristics of the 257 participants by group are shown in Table 1. Groups were predominantly white (94.1%), non-Hispanic (97.3%), had some college education (89.9%), and married (68.1%). The OW group was older than the NW group ($P<0.01$) and had a lower ($P<0.001$) percentage of female participants than NW and WLM. BMI was significantly ($P<0.001$) different for all three groups. Energy expended from self-reported physical activity was also significantly different ($P<0.001$) between all three groups, with OW expending the least (785±901 kcal/week) and WLM expending the most (3,097±2,572 kcal/week).

Under-Reporters

Ten percent of participants were under-reporters, with OW having the largest percentage (OW n=16, 16.5%; WLM n=8, 7.7%; NW n=5, 5.9%; $P<0.05$). There were no baseline differences between under-reporters and plausible reporters among NW and WLM. In OW, under-report-

Table 2. Adjusted self-reported dietary intake in a cross-sectional study on eating frequency and weight status in three subgroups: weight loss maintainers, normal weight, and overweight					
Total daily intake	**Factors controlled**	**Weight loss maintainers (n=96)**	**Normal weight (n=80)**	**Overweight (n=81)**	***P* value[a]**
		← *mean± standard deviation* →			
Energy intake (kcal/d)	Age/sex	1,802±505[x]	1,900±426[xy]	2,020±559[y]	<0.05
	Age/sex/activity	1,780±539[x]	1,897±426[xy]	2,049±610[y]	<0.05
% Energy from fat	Age/sex	28.7±8.2[x]	33.0±8.3[y]	35.2±8.9[y]	<0.001
	Age/sex/activity	29.4±9.2[x]	33.1±8.3[y]	34.3±9.8[y]	<0.01
% Energy from carbohydrate	Age/sex	55.0±10.2[x]	49.8±10.1[y]	47.4±10.8[y]	<0.001
	Age/sex/activity	54.3±10.2[x]	49.7±10.1[y]	48.3±11.8[y]	<0.01
% Energy from protein	Age/sex	18.5±4.1[x]	16.2±4.6[y]	17.4±4.9[xy]	<0.01
	Age/sex/activity	18.6±5.1[x]	16.2±4.6[y]	17.4±4.9[xy]	<0.01
Meals	Age/sex	2.7±0.4	2.7±0.4	2.8±0.4	NS[b]
	Age/sex/activity	2.7±0.4	2.7±0.4	2.7±0.5	NS
Snacks	Age/sex	2.0±1.0[x]	2.3±1.1[x]	1.5±1.2[y]	<0.001
	Age/sex/activity	1.9±1.1[x]	2.3±1.1[y]	1.5±1.3[z]	<0.001

[a]*P* values are for the main effect of group.
[b]NS=not significant.
[xyz]Values in a row that do not have a shared superscript (x, y, z) are significantly different (*P*<0.05).

ers had a higher BMI then plausible reporters (36.9±3.8 vs 34.2±4.1, *P*<0.05).

Dietary Intake and Eating Frequency with Age and Sex as Covariates

Energy intake was higher in OW than WLM (2,020±559 kcal/day vs 1,802±505 kcal/day, *P* <0.05) (see Table 2 for adjusted means). WLM consumed a significantly lower percent energy from fat and a greater percent energy from carbohydrate than the other groups (see Table 2 for detailed results). There was no difference in the reported number of meals consumed between the groups (2.7±0.4 meals/day). Number of snacks reported was lower in OW than WLM (1.5±1.2 snacks/day vs 2.0±1.0 snacks/day, *P*<0.01) and NW (2.3±1.1 snacks/day, *P*<0.001).

Dietary Intake and Eating Frequency with Age, Sex, and Physical Activity as Covariates

Analyses of dietary intake controlling for age, sex, and self-reported physical activity were consistent with analyses reported above (see Table 2 for adjusted means). There was no difference in reported number of meals consumed between the groups. Snacks consumed per day were significantly (*P*<0.001) different between all three groups, with OW (1.5±1.3 snacks/day) consuming the least, WLM (1.9±1.1 snacks/day) in the middle, and NW (2.3±1.1 snacks/day) consuming the most.

Correlations between Eating Frequency Variables, Energy Intake, Physical Activity, and BMI

With all participants combined, a positive correlation was found between number of snacks and energy intake (r=0.18, *P*<0.01) and snacks and energy expenditure (r=0.13, *P*<0.05). BMI was negatively correlated with snacks (r=−0.20, *P*<0.01). No significant correlations were found for meals.

This study was the first to compare eating frequency between successful weight loss maintainers, normal weight, and overweight individuals. Findings indicated that WLM and NW had more frequent daily eating occasions than OW, due to a greater number of daily snacks consumed. Moreover, analyses across all three groups indicated that number of daily snacks consumed was negatively associated with BMI. These findings are consistent with previous cross-sectional studies that have found greater eating frequency related to lower BMI (7,8).

Although there was a difference in snacking between WLM and NW as compared to OW, the difference was fairly small (approximately 0.5 to 0.8 snacks/per day), and does not suggest a so-called grazing (eating every 2 to 3 hours) style of eating frequency in those with lower BMI. For WLM and NW, the eating pattern was consuming approximately three meals plus two snacks per day. This eating pattern is consistent with the only other published report of eating frequency in successful weight loss maintainers in which participants in the National Weight Control Registry reported consuming approximately five eating occasions per day (5). Therefore, it appears from observational research that this eating pattern may be beneficial for long-term weight loss maintenance.

The mechanisms by which increased eating frequency is associated with lower BMI and weight loss maintenance remain unclear. This study suggests that physical activity may be an important factor in the relationship between eating frequency and BMI. In this study when all groups were combined, greater frequency of snack episodes was associated with greater physical activity and energy intake, but a lower BMI. Thus, a higher level of activity may allow for maintenance of lower body weight despite greater energy intake from increased snack frequency. Clearly, as shown with the OW, a higher energy intake coupled with lower physical activity is not helpful with achieving a healthy weight or weight loss maintenance, whereas as demonstrated by the WLM, a lower energy intake combined with greater physical activity is helpful for achieving and maintaining weight loss. More research is required to understand the relationship between eating frequency, physical activity, weight status, and maintenance of weight loss, before clinical recommendations can be developed.

Limitations of this study include potential unmeasured differences between the groups as they were recruited for two different studies. However, the participants in these studies were recruited from the same geographical area and data were collected during the same time period, with most measures conducted identically in both studies. In addition, dietary intake and energy expenditure from physical activity were self-reported by all groups. Also, this was a cross-sectional study, and the generalizability of this study is limited by the primarily white, middle-class, middle-aged sample, as well as the treatment-seeking OW group.

CONCLUSIONS

This preliminary investigation suggests that eating more frequently, characterized by an eating pattern of approximately three meals and two snacks, was related to lower BMI and maintenance of weight loss. However, as this investigation also found that greater frequency of snack episodes were positively related both to energy intake and physical activity, additional research is needed to examine the role of eating frequency and physical activity in weight loss maintenance. Because greater eating frequency was associated with two different groups of normal weight individuals, further examination of this pattern as part of a dietary prescription for weight gain prevention and weight loss maintenance is warranted.

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References

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999-2008. *JAMA*. 2010;303:235-241.
2. Wing RR, Phelan S. Long-term weight loss maintenance. *Am J Clin Nutr*. 2005;82(suppl 1):S222-S225.
3. Lowe MR. Self-regulation of energy intake in the prevention and treatment of obesity: Is it feasible? *Obes Res*. 2003;11(suppl):S44-S59.
4. Brown T, Avenell A, Edmunds LD, Moore H, Whittaker V, Avery L, Summerbell C. Systematic review of long-term lifestyle interventions to prevent weight gain and morbidity in adults. *Obes Rev*. 2009;10: 627-638.
5. Klem ML, Wing RR, McGuire MT, Seagle HM, Hill JO. A descriptive study of individuals successful at long-term maintenance of substantial weight loss. *Am J Clin Nutr*. 1997;66:239-246.
6. Wyatt HR, Grunwald GK, Mosca CL, Klem ML, Wing RR, Hill JO. Long-term weight loss and breakfast in subjects in the National Weight Control Registry. *Obes Res*. 2002;10:78-82.
7. Holmback I, Ericson U, Gullberg B, Wirfalt E. A high eating frequency is associated with an overall healthy lifestyle in middle-aged men and women and reduced likelihood of general and central obesity in men. *Br J Nutr*. 2010;104:1065-1073.
8. Ma Y, Bertone ER, Stanek EJ, 3rd, Reed GW, Hebert JR, Cohen NL, Merriam PA, Ockene IS. Association between eating patterns and obesity in a free-living US adult population. *Am J Epidemiol*. 2003; 158:85-92.
9. Burley VJ, Paul AW, Blundell JE. Influence of a high-fibre food (myco-protein) on appetite: Effects on satiation (within meals) and satiety (following meals). *Eur J Clin Nutr*. 1993;47:409-418.
10. Bellisle F, McDevitt R, Prentice AM. Meal frequency and energy balance. *Br J Nutr*. 1997;77(suppl 1):S57-S70.
11. Duval K, Strychar I, Cyr MJ, Prud'homme D, Rabasa-Lhoret R, Doucet E. Physical activity is a confounding factor of the relation between eating frequency and body composition. *Am J Clin Nutr*. 2008;88:1200-1205.
12. Lohman TR, Roche, AF, Martorell R, eds. *Anthropometric Standardization Reference Manual*. Champaign, IL: Human Kinetics Books; 1988.
13. McGuire MT, Wing RR, Klem M, Lang W, Hill JO. What predicts weight regain in a group of successful weight losers? *J Consult Clin Psychol*. 1999;67:177-185.
14. Paffenbarger RS Jr, Wing AL, Hyde RT. Physical activity as an index of heart attack risk in college alumni. *Am J Epidemiol*. 1978;108:161-175.
15. Siconolfi SF, Lasater TM, Snow RCK, Carleton RA. Self-reported physical activity compared with maximal oxygen uptake. *Am J Epidemiol*. 1985;122:101-105.
16. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, Prentice AM. Critical evaluation of energy intake data using fundamental principles of energy physiology: 1. Derivation of cut-off limits to identify under-recording. *Eur J Clin Nutr*. 1991;45:569-581.
17. World Health Organization, the Food and Agriculture Organization of the United Nations, the United Nations University. *Joint FAO/WHO/UNU Expert Consultation on Human Energy Requirements.* Rome, Italy: Food and Agriculture Organization; 2001.
18. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116:1081-1093.
19. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake: Basal metabolic rate. A practical guide to its calculation, use and limitations. *Int J Obes Relat Metab Disord*. 2000;24:1119-1130.