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Dietary energy density predicts women's weight change over 6 y[1], [2], [3]

Jennifer S Savage, **Michele Marini**, and **Leann L Birch**
[1]Center for Childhood Obesity Research (JSS, MM, and LLB), the Department of Nutritional Sciences (JSS and LLB), and the Human Development and Family Studies (LLB), The Pennsylvania State University, University Park, PA

Abstract

Background—Dietary energy density (ED) is positively associated with energy intake, but little is known about long-term effects on weight change.

Objective—We assessed whether dietary ED predicts weight change over 6 y among a sample of non-Hispanic, white women.

Design—Participants were part of a 6-y longitudinal study (*n* = 186), assessed at baseline and biennially. ED (in kcal/g) was calculated from the energy content of all foods (excluding beverages) with the use of three 24-h recalls. Height and weight were measured in triplicate to calculate body mass index (BMI; in kg/m^2). Repeated measures (PROC MIXED) were used to examine the influence of ED on weight change, before and after adjusting for initial weight status. Food choices were examined among subjects consuming low-, medium-, and high-ED diets at study entry.

Results—ED did not change across time for a subject. ED was positively associated with weight gain and higher BMI over time; this association did not vary by BMI classification. Food group data showed that, compared with women consuming higher-ED diets, women consuming lower-ED diets reported significantly lower total energy intakes and consumed fewer servings of baked desserts, refined grains, and fried vegetables and more servings of vegetables, fruit, and cereal. Women consuming lower-ED diets ate more meals at the table and fewer meals in front of the television.

Conclusions—Findings indicate that consumption of a lower-ED diet moderates weight gain, which may promote weight maintenance. Consuming lower ED diets can be achieved by consuming more servings of fruit and vegetables and limiting intake of high-fat foods.

INTRODUCTION

The prevalence of overweight has increased dramatically in recent years; ≈ 60% of adult men and women in the United States are now overweight or obese (1). This increasing prevalence reflects, in large part, weight gain that occurs during adulthood. Longitudinal

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[3]Address reprint requests to LL Birch, Department of Human Development and Family Studies, 129 Noll Laboratory, University Park, PA 16802. llb15@psu.edu.

The author's responsibilities were as follows—LLB: contributed to the study design; JSS participated in data collection; all authors contributed to the conceptual approach, statistical analyses, interpretation of the results, and manuscript preparation. None of the authors had a financial or personal conflict of interest studies estimate that, on average, adults gain 0.5–1.0 kg/y (2–5), which, over time, increases overweight prevalence and the risk of many leading causes of morbidity and mortality, including diabetes mellitus, coronary heart disease, and stroke (6). To reduce energy intake and prevent weight gain, the World Health Organization (6), the US Department of Health and Human Services, and the US Department of Agriculture (7) recommend consuming low–energy-dense foods. Energy density (ED) is defined as the amount of dietary energy in a given weight of food (ie, kcal/g).

Diets lower in ED can be achieved by increasing consumption of fruit and vegetables and reducing fat intake (8, 9). Results of laboratory-based studies, manipulating the ED of foods by altering fat and water content, show that, because persons consume a consistent weight of food across ED manipulations, they consume more energy when presented with higher ED foods than with similar foods of lower ED (10–13). Three clinical trials designed to test the effectiveness of consuming low-ED foods on weight loss showed that modest dietary ED reductions were associated with long-term weight loss (14–16), and cross-sectional studies show that lower ED is associated with lower weight status (17–20). Only one longitudinal study, to date, has examined the influence of ED on subsequent weight change, which showed mixed results (21): ED was positively associated with weight gain in obese women, but it was inversely associated with weight gain in normal-weight women. In summary, little is known about the long-term effect of ED on weight change and, in particular, on unintentional weight gain among free-living women.

The main purpose of the present study was to examine the relation of ED to weight change over time among free-living women, with the use of longitudinal data. A secondary aim was to describe differences in patterns of dietary intake among women with diets differing in ED, including information on food group intake, meal frequency, and the contexts in which eating occurred at study entry. An understanding of how different food choices and the overall ED of a women’s diet influence weight change has important implications for the development of recommendations to prevent unintentional weight gain over time. On the basis of previous research (11, 14, 20, 22), we hypothesized that *1*) ED would be a significant predictor of weight and weight change over time; *2*) ED of the diet would be positively associated with total energy intake; and *3*) women reporting low-ED diets would be consuming higher quality diets that would include more fruit, vegetables, and whole grains than women reporting high-ED diets.

SUBJECTS AND METHODS

Subjects

Participants included 192 non-Hispanic white women living in central Pennsylvania recruited as part of a longitudinal study designed to examine parental influences on girls’ growth and development; the sample was not recruited based on weight status or concern about weight. Families with age-eligible female children within a 5-county radius were identified with the use of available marketing information (Metromail Inc, Chicago, IL). These families received mailings that provided information about the study and were recruited with the use of follow-up phone calls. Eligibility criteria focused on the daughters’ characteristics, including the absence of severe food allergies or chronic medical problems affecting food intake and the absence of dietary restrictions involving animal products. There were no exclusion criteria for mothers. Only data for mothers are considered in this study. At study entry, participants included 192 women, of whom 183, 177, and 168 women were reassessed at year 2, year 4, and year 6, respectively, representing an 88% retention rate. Attrition was primarily due to family relocation outside the study area. Women who were missing body weight data at years 2 through 6 were excluded from all longitudinal analyses, resulting in a final sample of 186 women. No significant difference was found between the initial weight status or ED of participants missing body weight data (*n* = 6) and of participants remaining in the study through year 6. Among the final sample of 186 women, 3 women (1.6%), 9 women (5%), and 18 women (10%) were missing dietary ED data at year 2, year 4, and year 6, respectively.

Design and procedures

Data were collected on 4 occasions across a 6-y period, with 2-y intervals between assessments. At each time of assessment, women completed a series of self-report questionnaires during a scheduled visit to the laboratory. The Pennsylvania State University Institutional Review Board approved all study procedures, and mothers provided consent for their family's participation in the study before the initiation of data collection.

Measures

Background characteristics—Women completed a background questionnaire, developed in our laboratory, that assessed family background characteristics, including combined family income and mothers' and fathers' years of education. Participants chose from 4 income categories: <$20 000/y, $20 000–$35 000/y, $35 000–$50 000/y, or ≥$50 000/y. For education, women indicated whether they had the following degrees or diplomas: high school, associate's, technical or vocational school, bachelor's, master's, PhD, MD, JD, or other.

Weight status and body mass index—Height and weight measurements were assessed in triplicate at each occasion by a trained staff member following the procedure outlined by Lohman et al (23). Participants were dressed in light clothing and measured without shoes in the morning. Height was measured in triplicate to the nearest 0.1 cm with the use of a stadiometer (Shorr Productions stadiometer; Irwin Shorr, Olney, MD). Weight was measured in triplicate to the nearest 0.1 kg with the use of an electronic scale (Seca Electronic Scale; Seca Corp, Birmingham, United Kingdom). Average height and weight were used to calculate body mass index (BMI; in kg/m^2). Recommendations made by the World Health Organization were used to classify women as overweight (BMI ≥ 25) (24).

Energy intake for 24 h—Twenty-four-hour recall interviews were conducted by telephone at the Dietary Assessment Center at the Pennsylvania State University at each occasion by trained staff with the use of the computer-assisted NUTRITION DATA SYSTEM FOR RESEARCH (NDS-R) software (database version 4.01_30; Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN). The NDS-R software itself provides a structured, guided, controlled platform in which questions and probes are standard, and the process of conducting the 24-h recall is standard. The NDS-R time-related database updates analytic data while maintaining nutrient profiles true to the bastion used for data collection. The NDS-R is updated annually. Furthermore, interviewers were required to complete 40 h of intensive training and are subject to reliability tests. To assess reliability, a nutritionist administers 3 standard dietary recalls in a mock telephone interview to all newly trained interviewers. Reliability among interviewers is based on interclass correlation of ≥0.95 (25). Women provided three 24-h recalls by telephone within a 2–3-wk period, including 2 weekdays and 1 weekend day. These dates were randomly selected, and recalls were conducted from June through October. Participants were mailed a poster depicting 2-dimensional representations of food portions (2D Food Portion Visual; Nutrition Counseling Enterprises, Framingham, MA) as a visual aid for estimating amounts of food eaten (26).

ED (in kcal/g) was calculated from the three 24-h recalls, with the use of energy content of all foods, excluding all beverages, for each subject at all 4 time points. Beverages were omitted based on previous findings indicating that the inclusion of beverages may diminish associations with outcome variables because of the increased day-to-day variance within individual respondents (27). To calculate ED, energy and gram intakes for each eating occasion were summed for each of the 3 d. Next, total energy intake from the food consumed for each of the 3 d was divided by the total weight of food consumed for each of the 3 d. For each participant, a mean ED value was derived by taking the average of the 3 daily ED values at the 4 time points.

Food group and subgroup data were averaged across 3 d to obtain an estimate of the number of servings reported consumed based on the *Dietary Guidelines for Americans* (7) and the US Department of Agriculture Food Guide Pyramid guidelines (28). Mixed dishes were disaggregated into the corresponding components, and the sum of the weights (in g) of the components was used to calculate the number of servings for each food group. Finally, at time 2, interviewers were instructed to ask participants "Where did you eat each meal?" (ie, in front of the television, at a table, etc). These data were used to determine the specific location of each meal.

Statistical analyses

Data were analyzed with the use of the SAS software (version 9.1, 2001; SAS institute, Cary, NC) (29). Descriptive information was generated for all variables of interest. Each outcome variable was assessed for normality.

Longitudinal analyses—For the primary analyses of interest, a mixed-modeling approach (PROC MIXED) was used to assess the effects of ED on body weight and BMI change over 6 y. Mixed modeling is a useful tool for analyzing repeated measures over time, and a main advantage is its ability to retain cases with ≥1 missing data points (30). Determination of model fit was based on several criteria: *1*) model convergence,*2*) a positive definite G matrix, and *3*) statistical fit comparison based on the Akaike Information Criteria (31). For the models predicting weight status (in kg), a compound symmetry covariance matrix was selected, as determined by the aforementioned model fit criteria; main effects of time, ED, and an ED-by-time interaction were tested before (model 1) and after adjusting for initial BMI, dietary fiber intake, and caloric beverage intake (model 2). For model 3, the main effect of BMI classification [normal weight (BMI < 25) compared with over-weight and obese (BMI > 25), the interaction between BMI classification, ED, and time, and all lower order (2–factor) interactions were considered. Finally, for the models predicting BMI change over time, an unstructured covariance matrix provided the best fitting model; similar predictors were tested before (model 4) and after (model 5) adjusting for initial weight status. In all models, inclusion of the interaction of ED by time provided a test of the major hypothesis, because a significant interaction effect provides evidence for a differential pattern of change over time for women consuming diets varying in ED.

Cross-sectional analyses—To address the second aim of the study and to further explore differences in dietary patterns among women whose diets differed in ED, analysis of variance with Tukey's honestly significant difference post hoc tests were examined at study entry. Tertile cutoffs were used to classify women by the ED of their diet (low, medium, or high). Low-, medium-, and high-ED diets were defined by mean daily ED values <1.5 kcal/g, 1.5–1.85 kcal/g, and >1.85 kcal/g, respectively. Specifically, analyses tested for differences in energy intake, food group intake, meal frequency, and the contexts in which eating occurred. *P* values < 0.05 were considered significant.

RESULTS

Descriptive characteristics

Mean (±SD) age of women at study entry was 35.7 ± 4.7 y, ranging from 24.1 to 46.6 y. Women were in general well-educated with a mean of 14.6 ± 2.2 y of education. Approximately an equal proportion of families at entry into the study reported incomes <$35 000, between $35 000 and $50 000, and >$50 000. The sample was, on average, slightly overweight (BMI: 27.0 ± 6.2). Of the 183 participants, 105 (57%) were classified as overweight (BMI ≥ 25) at baseline.

Longitudinal analyses: repeated-measures mixed-effect models

On average, women gained weight across the 6-y period (3.73 ± 7.8 kg). Descriptive statistics for all predictor and outcome variables at each occasion are shown in Table 1. Mixed-model analysis with the use of random coefficients showed that both weight (70.43 + 1.21 kg × years; $P < 0.001$) and BMI (26.09 + 0.45 × years; $P < 0.001$) increased significantly over time, such that 66% of women gained weight from baseline to year 6. Similar analyses showed that ED (1.68 + 0.01 × years; $P = 0.47$) remained stable over time.

Association of ED with body weight and weight gain over time—In model 1, the predictive model for body weight (in kg), results of the mixed-model analyses showed a significant main effect of time ($P < 0.001$), indicating a general trend for women to gain weight over time. A significant main effect of ED ($P < 0.05$) was observed such that women with higher ED had higher weight at all time points. Finally, a significant interaction between ED and time was evident ($P < 0.01$). Therefore, a woman's pattern of weight gain depended on ED group membership. For example, women consuming higher ED diets (ED ≥ 1.85 kcal/g), on average, gained 6.4±6.5 kg over 6 y, whereas women consuming lower ED diets (ED ≤1.5 kcal/g) only gained 2.5 ± 6.8 kg. Women consuming intermediate-ED diets (ED: 1.5–1.85 kcal/g) gained 4.8 ± 9.2 kg. In model 2, similar results emerged after adjusting for initial BMI (data not shown). Model 2 was also tested, including dietary fiber and caloric beverage intake as covariates. Although dietary fiber and caloric beverage intakes were not significant predictors of weight change, similar results emerged for ED (data not shown). Therefore, ED predicts weight change over and above the effect of consuming diets differing in fiber and caloric beverage intakes.

In model 3, we tested a 3-factor interaction (after including all relevant main effects and 2-factor interactions) to examine whether the association between ED and time would vary across normal and overweight women (BMI classification). However, the 3-factor interaction was not significant, indicating no effect of BMI classification on the effect of ED on weight change. Thus, overweight women consuming higher ED diets did not gain significantly more weight over time than did normal-weight women on higher ED diets. Therefore, the model was reduced to only consider the 2-factor interactions and main effects. A significant interaction was observed between BMI classification and time such that overweight women increased in weight at a greater rate over time than did normal-weight women ($P < 0.001$). In addition, a significant interaction was identified between ED and time ($P < 0.01$); as ED increased, weight increased over time. Finally, no significant interaction was observed between ED and BMI classification. Therefore, the association between ED and weight did not vary by BMI classification.

Association of ED with BMI and BMI change over time—In model 4, when the predictive model for BMI was considered, results showed a significant main effect of time ($P < 0.001$) and ED ($P < 0.05$). A significant interaction between ED and time was also evident ($P < 0.01$). Thus, a women's pattern of BMI change over time depended on the ED group. For example, BMI increased 2.5 units among women consuming higher ED diets, whereas BMI only increased 0.9 units over 6 y for women reporting lower ED diets. Similar results emerged after adjusting for initial BMI (model 5). In addition, when including BMI classification in the model, results were in agreement with model 2, predicting weight gain (in kg) (data not shown).

Cross-sectional analyses: differences among ED groups

Because ED did not vary across time, women were grouped by ED at baseline, and differences among the ED groups in energy and macronutrient intake, food choices, and meal location were examined. These analyses provide information on how dietary choices result in ED differences, which were associated with differences in weight change.

As shown in Table 2, women with a lower ED diet consumed a greater weight of food than did women in the high-ED diet group ($P < 0.0001$) but had lower energy intakes. Women consuming the lowest energy-dense diet consumed ≈ 225 kcal/d less than women in the high-ED group ($P < 0.01$). Energy intakes from caloric beverages did not differ by ED group, which further supports the exclusion of beverages when calculating ED. In addition, dietary ED was positively associated with the percentage of energy from fat and negatively associated with the percentage of energy from of carbohydrate and fiber intakes. No differences in protein intake were noted across the ED groups.

Food choices—As shown in Figure 1, dietary ED was linked to specific patterns of food consumption. Following the Food Guide Pyramid, the foods were aggregated into 6 major US Department of Agriculture food groups. Women in the high-ED group reported consuming significantly more servings from the grain, meats, and fats groups than did the lower ED group, whereas the low-ED group consumed significantly more servings from the vegetable and fruit groups than did the high-ED group. Specifically, the lower ED group reported consuming ≈5 servings (2.5 cups) of fruit and vegetables, whereas the lower ED group consumed an estimated 2.7 servings or 1.35 cups. No group differences were observed for servings of dairy or sweets.

Grain subgroup intakes are shown in Figure 2; women in the high-ED group reported consuming significantly more servings than did the low-ED group from the bread and baked desserts subgroups but significantly fewer servings from the cereal sub-group. For whole compared with refined grains, women consuming the high-ED diet consumed significantly fewer servings of whole grains than did women in the low-ED group (0.7 servings/ d compared with 1.1 serving/d), but they 7 also reported consuming more servings of refined grains (5.0 servings/d compared with 3.9 servings/d). With respect to reported intake from the vegetable group, the high-ED group reported consuming significantly more servings of the french fry and potato chip subgroup than did the low-ED group, whereas the low-ED group ate significantly more servings of the dark green, yellow, and red vegetable subgroup (Figure 3).

Meal frequency and location—Dietary ED was not associated with the total number of eating occasions over 3 d (Table 2). However, women consuming the high-ED diet reported eating significantly more meals and snacks in front of the television as well as eating fewer dinners at the table as a family.

DISCUSSION

Data from this longitudinal study were used to examine the association between ED and weight change over time among free-living women, while also providing information on food and macronutrient selection patterns of women consuming diets varying in ED. These data indicate that during the 6-y period, on average, women gained 3.7 kg or ≈5% of their initial body weight. Differences in dietary ED were associated with differences in weight gain; women consuming higher ED diets over this period gained nearly 3 times as much weight as did women on lower ED diets. Results extend previously reported relations between ED and weight status observed in cross-sectional (18–20) and intervention (14, 15) studies. It is also important to note that ED did not change across time for a subject. Together, these findings provide evidence that long-term consumption of a lower ED diet moderates weight gain and promotes weight maintenance. Consistent with previous findings (22), women consuming lower ED diets had higher quality diets, which included more fruit, vegetables, and whole grains than did women with higher ED diets.

In support of our first hypothesis, dietary ED was a significant positive predictor of weight gain before and after adjusting for initial weight status. On average, over 6 y women consuming lower ED diets gained 2.5 kg or ≈3.4% of their initial body weight, whereas women consuming higher ED diets gained 6.4 kg or ≈8.5% of their initial body weight. Previous literature indicates that the weight gain by women on higher ED diets may be substantial enough to cause negative shifts in metabolic indicators of cardiovascular health and metabolic syndrome components, including blood pressure and concentrations of triglycerides, fasting glucose, and cholesterol (32–35). It is important to note that women consuming lower ED diets still gained weight over time, albeit less than the women consuming higher ED diets. Lower ED diets were effective at moderating, but not preventing, weight gain. One potential explanation for this finding is that women consuming low-ED diets were not eating enough servings of water-rich foods. Moreover, the positive association between ED and weight gain did not differ for normal-weight and overweight women. Thus, reducing ED has important public health implications in both normal-weight and overweight women.

As hypothesized, and consistent with previous research (11, 20, 22), women with lower ED diets reported consuming lower energy intakes, but consumed more food, by weight, compared with women with higher ED diets. This finding confirms that eating a low-ED diet allows a person to eat fewer calories but more food. Thus, prescribing diet plans that advise women to consume low–energy-dense foods, by increasing their intake of water-rich food sources such as fruit and vegetables may moderate weight gain and serve as a more effective weight maintenance strategy than dieting, which may promote weight gain (36–39). In addition, dietary ED was positively associated with the percentage of energy from fat and negatively associated with the percentage of energy from carbohydrate; however, there was no difference in the percentage of energy from protein. Our findings are consistent with those of Bell et al (11) who varied the ED of foods by 30% over 2 d and found that participants failed to compensate for changes in ED by altering the amount (weight) of food consumed; thus, significantly more energy was consumed in the higher ED condition. Similarly, cross-sectional data from the third National Health and Nutrition Examination Survey show that ED was positively associated with total energy and fat intakes and inversely associated with the weight of food consumed and carbohydrate intake (40).

In support of our third hypothesis, we observed that women reporting low-ED diets consumed higher quality diets than women reporting high-ED diets. Specifically, compared with women with higher ED diets, women with lower ED diets consumed more servings of vegetables, fruit, cereal, and whole grains and fewer servings of baked desserts and fried vegetables. ED was also inversely associated with fiber intake; however, only 4% of women reported consuming >25 g fiber/d. These findings are consistent with Ledikwe et al (22) who explored associations between ED and diet quality in a nationally representative sample and found that, compared with adults consuming higher ED diets (ED > 2.0 kcal/g), a higher percentage of adults with lower ED diets (ED < 1.6 kcal/g) consumed cereal, fruit, vegetables, and grains and a lower percentage consumed baked goods and fried potatoes. Together, these findings provide evidence that lower ED diets can be achieved through dietary patterns consistent with the *Dietary Guidelines for Americans*(7). However, it is important to note that women in the present study are not meeting recommendations to consume a total of 4.5 cups of fruit and vegetables (2 cups of fruit and 2.5 cups of vegetables) per day, based on a 2000-kcal diet. For example, women with low-ED diets only consumed 1 cup of fruit/d and 1.5 cups of vegetables/d. Moreover, consumption of whole-grain foods fell well below current recommendations to consume 3 ounces/d; the low-ED group only consumed 1.1 ounces/d. Thus, population-based efforts are needed to encourage fruit, vegetable, and whole-grain intakes based on evidence that meeting dietary guidelines ensures nutrient adequacy and decreases the risk of chronic diseases (7).

This study is not without limitations. This sample was racially and demographically homogenous and included only women, which prevents us from generalizing to men or to other racial and socioeconomic groups. Another potential limitation is the use of self-reported dietary recall data. On the basis of previous studies suggesting that overweight women are more likely to selectively underreport intakes of energy-dense, nutrient-poor foods perceived as unhealthy such as high-fat foods (41), ED estimates may be lower than actual intakes. However, if this is the case, it is likely that underreporting by obese women would actually weaken associations between ED and weight status, suggesting that our findings may actually underestimate the magnitude of the association between ED and weight gain. Thus, additional research is warranted to explore how reporting accuracy influences calculations of dietary ED and associations with weight status over time.

To date, the present study is the first to describe differences in meal location and frequency among free-living non-Hispanic white women with diets differing in ED. Women consuming lower ED diets reported eating fewer meals and snacks in front of the television and more dinners as a family at the table, although ED groups did not differ in the total number of eating occasions. The findings suggest that, among these women, television viewing was associated with intake of high– energy-dense foods, whereas eating meals as a family was associated with consumption of lower ED foods. Thus, ED may be a marker for unhealthy dietary and lifestyle patterns. Fitzpatrick et al (42) found that eating dinner as a family was positively associated with serving fruit and vegetables; however, this association decreased when the television was on during dinner. Similarly, a recent study found that watching television increased the amount of high-density, palatable, familiar foods eaten by adults (43). These findings suggest particular eating contexts, such as eating in front of the television, may promote weight gain. However, the underlying mechanism linking television viewing and weight status remains unclear.

In conclusion, our findings provide evidence that dietary ED is positively associated with weight gain over time among free-living women over a 6-y period, showing that diets lower in ED can moderate weight gain among normal-weight and overweight women. These results support recommendations by the World Health Organization (6) and *Dietary Guidelines for Americans* (7) to decrease ED as a means to prevent weight gain and obesity. Lower ED diets were achieved through dietary patterns consistent with *Dietary Guidelines for Americans* (7) to consume more servings of fruit and vegetables and to limit the intake of high-fat foods such as baked goods and fried vegetables. Therefore, decreasing ED by increasing fruit and vegetable consumption may be an effective weight maintenance strategy among free-living women. This strategy may be particularly effective at preventing obesity because consuming lower ED diets allows a person to consume a greater weight of food while decreasing total energy intake. However, our findings showed that even women who were consuming lower ED diets were not generally successful in maintaining weight at initial values across the 6-y period or in meeting the recommendations of the *Dietary*

Guidelines for Americans (7) for the number of daily servings of fruit and vegetables, suggesting the need for additional dietary guidance focused on providing effective strategies for reducing dietary ED.

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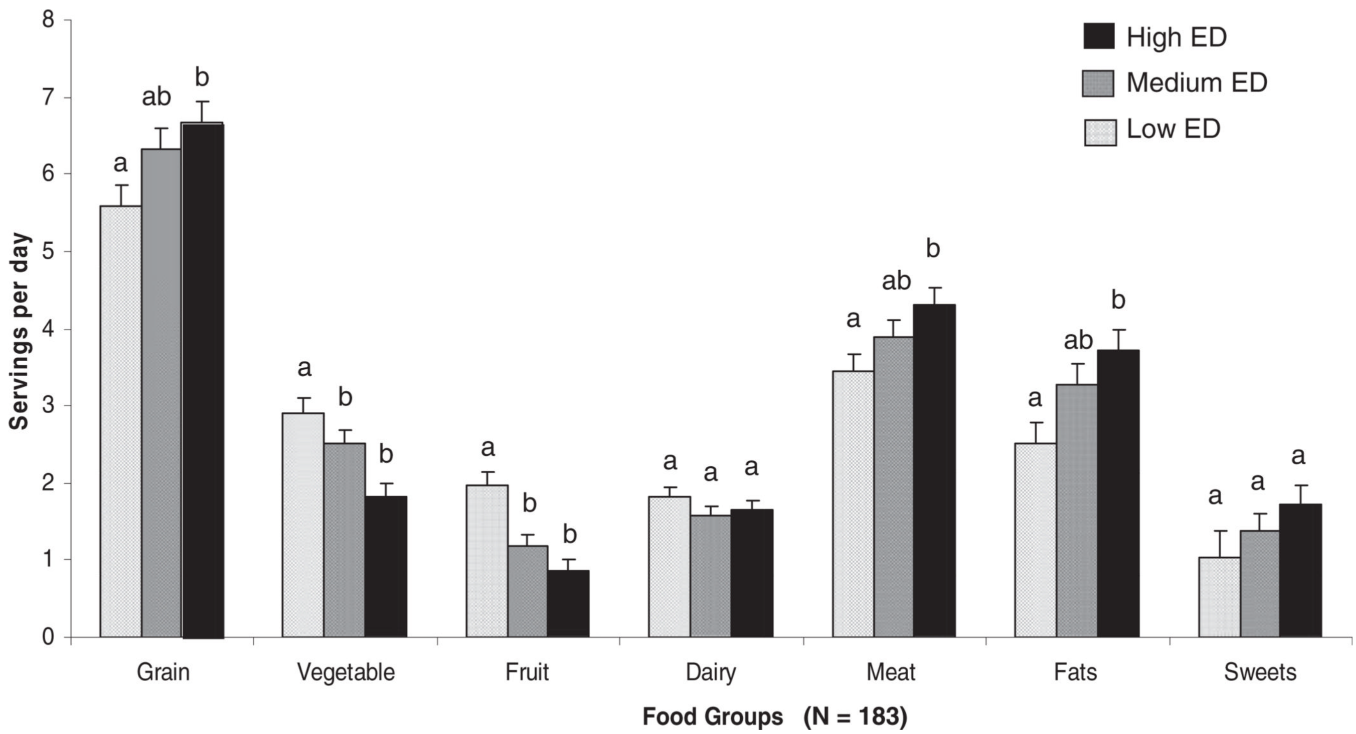

FIGURE 1.

Food group servings per day ($\bar{x} \pm$ SD) are based on the average of three 24-h dietary recalls by energy density (ED) group (n = 183). ED groups were identified by using tertile cutoffs: low-, medium-, and high-ED diets were defined by ED values <1.5 kcal/g, 1.5–1.85 kcal/g, and >1.85 kcal/g, respectively. Data were analyzed by ANOVA; different superscript letters within food groups indicate significant differences among ED groups ($P < 0.05$, Tukey's honestly significant difference comparison).

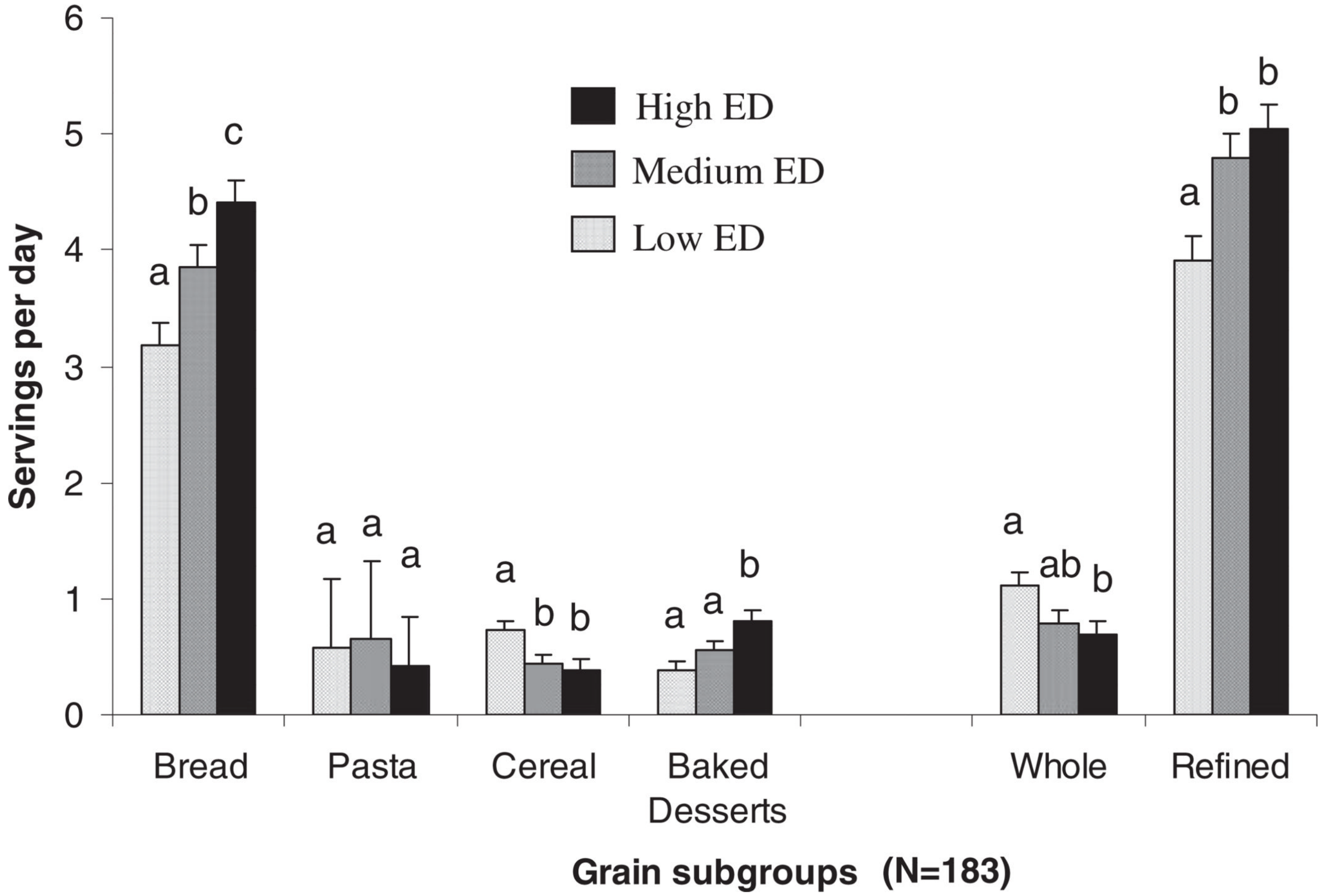

FIGURE 2.
Grain subgroup servings per day ($\bar{x} \pm$ SD) are based on the average of three 24-h dietary recalls by energy density (ED) group ($n = 183$). ED groups were identified by using tertile cutoffs: low-, medium-, and high-ED diets were defined by ED values <1.5 kcal/g, 1.5–1.85 kcal/g, and >1.85 kcal/g, respectively. Data were analyzed by ANOVA; different superscript letters within grain subgroups indicate significant differences among ED density groups (P <0.05, Tukey's honestly significant difference comparison).

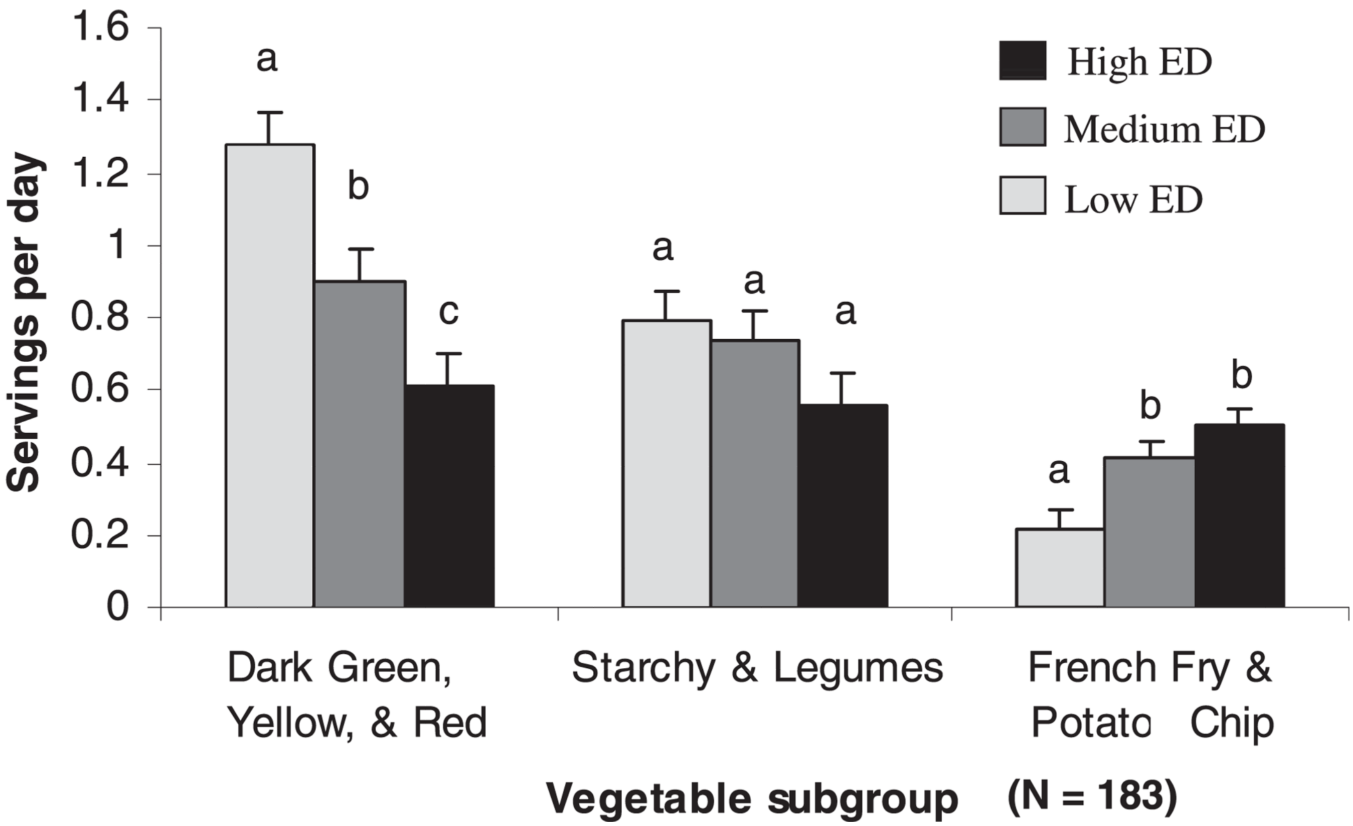

FIGURE 3.

Vegetable subgroup servings per day ($\bar{x} \pm$ SD) are based on the average of three 24-h dietary recalls by energy density (ED) group ($n = 183$). ED groups were identified by using tertile cutoffs: low-, medium-, and high-ED diets were defined by ED values <1.5 kcal/g, 1.5–1.85 kcal/g, and >1.85 kcal/g, respectively. Data were analyzed by ANOVA; different superscript letters within vegetable subgroups indicate significant differences among ED groups ($P <$ 0.05, Tukey's honestly significant difference comparison).

TABLE 1

Mean weight status and energy density characteristics of study sample

	Baseline (n = 193)	Year 2 (n = 183)	Year 4 (n = 177)	Year 6 (n = 168)	P[1]
Weight (kg)					<0.0001
$\bar{x}$	72.6	74.3	75.1	76.4	
SD	16.6	16.8	17.8	18.3	
Range	46–142	46–139	46–153	47–147	
BMI (kg/m^2)					<0.0001
$\bar{x}$	26.9	27.5	27.8	28.3	
SD	6.2	6.3	6.5	6.7	
Range	18.1–53.5	18.4–52.3	18.6–57.6	18.7–55.4	
Energy density (kcal/g)[2]					0.55
$\bar{x}$	1.7	1.7	1.7	1.7	
SD	0.4	0.4	0.4	0.4	
Range	0.95–2.85	0.98–2.93	0.97–2.97	0.77–3.09	

[1] $P < 0.05$ (mixed-model ANOVA) was considered significant.

[2] Calculated from food only (excludes beverages) based on 3 dietary recalls at each year.

TABLE 2

Cross-sectional analyses of energy density (ED) diets based on three 24-h dietary recalls at study entry[1]

	Total sample (*n* = 183)	**Low ED (*n* = 61)**	**Medium ED (*n* = 63)**	**High ED (*n* = 59)**
ED (kcal/g)[2]	1.7 ± 0.4	1.3 ± 0.2[a]	1.7 ± 0.1[b]	2.1 ± 0.2[c]
Food intake (g/d)	879 ± 275	1022 ± 332[a]	864 ± 203[b]	751 ± 205[c]
Energy intake				
Total energy intake (kcal/d)	1639 ± 421	1514 ± 437[a]	1649 ± 394[a,b]	1737 ± 409[b]
Food intake (kcal/d)	1443 ± 391	1336 ± 426[a]	1450 ± 340[a,b]	1545 ± 382[b]
Beverage intake (kcal/d)	189 ± 135	178 ± 136	198 ± 136	192 ± 134
Fat (% of energy)	31.8 ± 6.8	27.7 ± 6.1[a]	31.6 ± 6.5[b]	36.3 ± 5.9[c]
Carbohydrate (% of energy)	53.0 ± 8.3	56.3 ± 8.4[a]	54.1 ± 6.5[a]	48.5 ± 8.0[b]
Protein (% of energy)	15.6 ± 3.2	16.4 ± 3.6	15.1 ± 2.8	15.2 ± 3.1
Fiber (g)	13.6 ± 5.4	13.6 ± 4.4[a]	15.6 ± 6.4[a,b]	11.7 ± 4.6[b]
Total number of eating occasions on 3 d	12.7 ± 2.9	13.0 ± 2.9	12.5 ± 2.3	12.6 ± 3.3
Location of eating occasions on 3 d[3]				
Snacks eaten at TV (%)	23.8 ± 26.6	15.5 ± 17.6[a]	26.0 ± 26.7[a,b]	28.1 ± 31.4[b]
Eating occasions at TV (%)	11.1 ± 12.6	7.4 ± 9.4[a]	12.2 ± 12.5[a,b]	13.0 ± 14.5[b]
No. of breakfasts eaten at table on 3 d	1.8 ± 1.0	2.0 ± 0.9	1.8 ± 1.0	1.6 ± 1.2
No. of lunches eaten at table on 3 d	1.6 ± 1.0	1.7 ± 1.0	1.8 ± 1.0	1.5 ± 0.9
No. of dinners eaten at table on 3 d	2.4 ± 0.8	2.6 ± 0.6[a]	2.4 ± 0.8[a,b]	2.2 ± 0.8[b]

[1] $\bar{x}$ ± SD; *n*=183. TV, television viewing. ED groups were identified by using tertile cutoffs: low-, medium-, and high-ED diets were defined by ED values <1.5 kcal/g, 1.5–1.85 kcal/g, and > 1.85 kcal/g, respectively. Values in a row with different superscript letters are significantly different for groups, $P < 0.05$(ANOVA).

[2] Calculated from food only (excludes beverages).

[3] Location of meals eaten was assessed at year 2.