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Are Energy Dense Diets Also Nutrient Dense?

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Abstract

Objective—Some beverages are nutrient dense, but they are often excluded from nutrient density calculations. The purpose of this study was to assess whether the energy-nutrient association changed when beverages were included in these calculations.

Design—Applying a cross-sectional design, a 24-hour dietary recall was collected on each participant.

Subjects/Setting—440 young adults (ages 19–28 years) in Bogalusa, Louisiana participated in this study.

Statistical Analysis—Mean nutrient intakes and food group consumption were examined across the energy density (ED) tertiles using two calculation methods: one with food and all beverages (excluding water) (ED1) and one including food and only energy containing beverages (ED2). Regression models were used and multiple comparisons were performed using the Tukey-Kramer procedure. A p-value < 0.05 was considered to be significant.

Results—With increasing ED, there was a significant increase in the consumption of total meats (ED1 $p < 0.05$; ED2 $p < 0.01$). In contrast, there was a significant decrease in consumption of fruits/juices (ED1 $p < 0.01$; ED2 $p < 0.0001$), vegetables (ED1 $p < 0.01$; ED2 $p < 0.05$), beverages (both $p < 0.0001$) and total sweets with increasing ED (both $p < 0.0001$). There was a significantly higher mean intake of total protein (grams) (ED2 $p < 0.0001$), amino acids (ED1 histidine/leucine $p < 0.05$; ED2 $p < 0.0001$), and total fat (grams) (ED1 $p < 0.0001$; ED2 $p < 0.0001$) with higher ED compared to lower ED. The percent energy from protein (ED1 $p < 0.05$; ED2 $p < 0.0001$), total fat (both $p < 0.001$) and saturated fatty acids (both $p < 0.0001$) significantly increased and the percent energy from carbohydrate (both $p < 0.0001$) and sucrose (both $p < 0.0001$) significantly decreased with increasing ED.

Conclusion—This study suggests that ED may influence the ND of the diet depending on whether energy containing beverages are included or excluded in the analysis.

Keywords

energy density; nutrient density; dietary intake; young adults

INTRODUCTION

The 2005 Dietary Guidelines for Americans (DGA) were designed to reduce the risk of chronic disease and to help individuals meet nutrient requirements by promoting consumption of nutrient dense foods while limiting energy intakes. Studies suggest that, by decreasing energy dense foods in the diet, total energy intake decreases [1–6] and diet quality improves [1,2]. Encouraging foods low in energy density (ED), including those with high fiber or water content and those with modest fat content, may be a useful strategy for individuals who are trying to lose weight or maintain current weight [7–10].

The current recommended food patterns [11] emphasize the consumption of low energy dense foods to meet nutrient needs without exceeding energy requirements [12]. Nutrient density (ND) is a central concept of the 2005 DGA [12], and is generally defined as kilocalories per 100 grams of food. Energy density may be calculated by a variety of methods, which may include all food and beverages or may limit beverages to certain types or exclude them altogether [13]. Whatever the method of calculation, ED refers to the amount of energy in a given weight of food and/or beverages (kcal/g) [12], and depends on the fat, fiber, and water content of the food [7]. ED based on food only and no beverages has been linked to higher weight status in population-based epidemiologic studies [1,2,14] and longitudinal studies [8–10]. The relationship between ED and ND has been studied previously. Ledikwe and colleagues [1] examined associations between ED and ND, but the ED calculations excluded all beverages including nutrient dense beverages such as milk from the calculation of ED. Another study examined energy dense diets that included nutrient rich beverages relative to nutrient density, although that study did not specifically examine nutrient intakes of fat-soluble vitamins, fatty acids, or amino acids [2].

The high energy content of fat influences the ED of foods. Low-fat intakes have been associated with lower energy intakes [15,16], possibly because of a reduction in ED. Most studies have shown that low fat intakes did not compromise nutrient intakes [15,17,18]. Yet, a few studies have shown that low fat intakes resulted in nutrient shortfalls in a free living population [16, 19]. Fats supply essential fatty acids and serve as a carrier for the absorption of the fat-soluble vitamins. It is reasonable to assume that diets low in ED are low in fat content, thus may also be lower in the fat soluble vitamins and essential fatty acids. The present study was undertaken to examine whether energy dense intakes were also nutrient dense, with special emphasis on fatty acids, fat-soluble vitamins, and amino acids based on consumption patterns of young adults in Bogalusa, Louisiana.

MATERIALS AND METHODS

Population

The Bogalusa Heart Study (BHS) is an epidemiologic investigation of cardiovascular risk-factor variables and environmental determinants in a biracial (Black/White) pediatric population that began more than 20 years ago. The study design, participation, and protocols are described in detail elsewhere [20–22].

The observations presented here were collected during a major follow-up survey (1988–1991) of the BHS Post-High School Cohorts, young adults 19 to 28 years of age ($\bar{x}$ age = 23 years). Individuals selected to participate in the dietary recall interview were from the 1963, 1966, and 1968 birth cohorts. Individuals in these cohorts originally participated in a dietary recall interview as 10-year-olds in the 1973–1974, 1976–1977, or 1978–1979 BHS surveys, respectively. Of the 533 individuals in these birth cohorts who were screened in 1988–1991, 95% consented to participate also in the dietary recall interview. From a total of 504 young adults, 64 were excluded from the analyses either because they were pregnant or reported an

energy intake less than 600 kcal/day or more than 4000 kcal/day for females or greater than 4200 kcal/day for males [23]. Experimental plans, procedures, and consent forms for this study were reviewed and approved by the Tulane University Medical Center Ethics and Research Committee. Subjects provided written informed consent prior to participating in this study.

Dietary Methodology

Dietary Methodology of the BHS has been published previously [24]. Briefly, the 24-hour dietary recall method was used with young adults. Participants were asked by a rigorously trained interviewer to recall all foods and non-water beverages consumed in the previous 24-hour period. This included foods and beverages that they took “a bite” or “sip” of. Quality controls included a standardized protocol, graduated food models for quantification, a product identification notebook, family recipe collection, and the Extended Table of Nutrient Values (ETNV) database for nutrient composition analysis. All interviewers participated in rigorous training sessions and pilot studies before the field surveys to minimize interviewer effects. Duplicate recalls were obtained from a 10% random subsample to assure reliability [24].

Nutrient Database

The ETNV originated in the early 1960s as one of the first nutrient databases in the United States [25]. The ETNV was the database used in the long-term Bogalusa Heart Study. In 1993, the ETNV, a mainframe designed computerized nutrient database system, was changed to a PC-based system [26]. At the time of this study, the ETNV included 5000 core foods, beverages, and recipes, with values for 97 dietary components, including alcohol. The data bank was a flexible system permitting continuous updating of existing values and additions of new single or composite foods. Periodic updates were made to the ETNV to reflect nutrient changes in food products. Nutrient values included USDA data, manufacturers' information, and recipe calculation by ingredients.

Food Sources

The food grouping scheme was designed as an adjunct to the Tulane University Medical Center Nutrition data system. All foods or entries (core and recipe) appearing in the ETNV and containing the food type identifying the group, *e.g.*, cheese, as a major ingredient, were included in the food group list. Twenty-one major food groups were established and based, where feasible, on similar source characteristics. For example, “fruit and fruit juices” formed one major group, and “rice, biscuits, and cereals” were another. Composite food items such as recipes were assigned to food groups according to primary ingredients. If no single type of food (other than water) accounted for at least 60% of the weight, the item was classified as a mixed dish.

Calculation of Energy and Nutrient Densities

Energy Density was defined as kilocalories per 100 grams of food/beverage consumed [12]. The sample was divided into tertiles based on ED. ED was calculated two ways in the analyses: energy density with food and all beverages (sweetened and unsweetened; excluding water intake) (ED1) and energy density with food and energy containing beverages (excluding unsweetened beverages) (ED2). Beverages with < 10 kcals/100g (diet drinks) were excluded from computing the ED2 variable. These two calculation methods have been used in a similar analyses conducted with a nationally represented United States population [13]. Nutrient Density was defined as mean nutrient intake per 100 grams of food/beverage consumed. Since we were interested in ND, beverages containing valuable nutrients (*e.g.*, milk, 100% fruit juice) along with nutrient poor beverages (*e.g.*, sweetened beverages) were included in the calculations (ED1). ED1 included carbonated beverages, coffee, tea, fruit flavored drinks (Hi-

C, grape drink, lemonade, orange drink), and Kool-Aid. ED2 included only sweetened beverages, all diet beverages were excluded.

Statistical Analysis

Mean 24-hour intake of energy and of selected nutrients were divided into tertiles according to tertiles of ED. Due to small numbers, the twenty-one food groups were collapsed into ten larger food categories. Mean nutrient intakes and food group consumption were examined across the tertile cut-points: 1st, < 33.2%; 2nd, 33.2–66.6%; and 3rd > 66.6%. Differences in demographic characteristics across the tertiles were examined using ANOVA. Independent χ^2 was used to test for any significant differences with regard to categorical variables. Regression models (Procedural General Linear Model in Statistical Analysis Software), adjusted for age, gender, race, race by gender, total energy intake, and body mass index (BMI), were used to identify differences in intakes of selected nutrients per 100 grams of food consumed. Percent of energy from macronutrients was also examined. The Tukey-Kramer test was used to detect pairwise differences. Linear contrast coefficients were used to test the trend of nutrient intake across the tertiles of energy density. Residual analyses indicated no variation in the regression models. A p-value < 0.05 was considered to be significant. All statistical analyses were performed using SAS (Version 9.1.3, SAS institute, Inc., Cary, NC).

RESULTS

Demographics of the Sample

The sample consisted of 440 young adults 19–28 years of age ($\bar{x}$ age = 23 years); 70% white, and 60% females (Table 1). There were approximately 147 individuals in each of the energy density tertiles. There was no significant difference by gender or age across the tertiles. The mean energy density (ED1) in tertile 1 was 74 ± 13 , 108 ± 8 in tertile 2, and, 151 ± 32 in tertile 3. Similar results were found for ED2. Significantly more whites than blacks consumed a diet low in ED. The mean energy intake (kcal) significantly increased with increasing ED. The mean energy intake in ED tertile 1 was 1903 kcal, 2196 kcal for ED tertile 2, and 2393 kcal in ED tertile 3. Similar demographic results were shown for ED2.

Food Group Consumption (gram amount) by Energy Density Tertiles

The mean gram consumption of food groups by ED tertiles is presented in Table 2. With increasing ED, there was a significant increase in consumption of total meats. In contrast, there was a significant decrease in consumption of fruits/juices, vegetables, beverages and sweets (*i.e.*, candy and desserts) with increasing ED. These results for ED1 remained after removing unsweetened beverages from the definition (ED2).

Percentage of Energy from Macronutrients by Energy Density Tertiles

The percentage of energy from macronutrients by ED tertiles is presented in Table 3. The percentage of energy from protein, total fat and saturated fatty acids significantly increased with increasing ED. In contrast, the percentage of energy from total carbohydrate and sucrose significantly decreased with increasing ED. These results for ED1 remained after removing unsweetened beverages from the definition (ED2).

Nutrient Density (per 100 grams of food/beverages consumed) by Energy Density Tertiles

The mean intake of nutrients per 100 grams of foods/beverages consumed by ED tertiles is presented in Table 4. For ED2, there was a significant increase in intake of total protein, amino acids, total fat, saturated and polyunsaturated fatty acids, and five fatty acids (linoleic, linolenic, oleic, palmitic, stearic) with increasing ED. In contrast, there was a significant decrease in

intake of carbohydrate, total sucrose and total sugar with increasing ED. For ED1, these trends were similar with the exception of the amino acids.

The mean intake of vitamins and minerals per 100 grams of foods/beverages consumed by ED tertiles was also examined (data not shown). For ED2, there was a significant increase in mean intake of vitamin E and a significant decrease in mean intake of vitamin C with increasing ED. For ED1, the results were similar in addition to a decrease in mean intakes of magnesium and potassium with increasing ED.

DISCUSSION

The 2005 Dietary Guidelines Advisory Committee (DGAC) concluded that eating foods of low ED may be a helpful strategy to reduce energy intake when trying to maintain or lose weight [12]. At the same time, the 2005 DGAC encouraged the consumption of nutrient dense foods within and among the major food groups. Although it is intuitively appealing that low energy dense intakes would also have a higher nutrient density, very little research has been conducted to examine this question. Most studies have focused on the consumption of energy dense, nutrient-poor foods on dietary intakes [27–29].

Data from this study suggest that intakes of energy dense foods and beverages may have both positive and negative outcomes on food group consumption and nutrient intakes. Individuals who had high ED intakes had increased intakes of total energy, total fat, and saturated fatty acids. The increased consumption of energy dense foods was reflected in increased consumption of total meats and a decreased consumption of fruits/juices, vegetables, beverages and total sweets. In contrast, there was a significantly higher mean intake of total protein, all types of fats, amino acids, and essential fatty acids.

Some of the results of this study are contrary to those reported previously [1], using data from a nationally represented sample of adults. In that study [1], ED was calculated based on foods only and excluded all beverages. Adults with a low energy dense diet had higher intakes of total protein, vitamins A, E, C, and B6, folate, iron, calcium and potassium. Similar to our findings, adults who consumed a high energy dense diet consumed more total energy and total fat. The impact of ED on intakes of amino acids and fatty acids was not studied. The consumption of beverages was higher in the high energy dense diets which is opposite of what we found.

A major reason for the discrepancy in the findings is the method that was used to define ED. In this study, ED was operationalized two ways: 1) the number of kilocalories per 100 grams of all foods and beverages (except water) consumed (ED1) and 2) the number of kilocalories per 100 grams of foods and beverages (excluding unsweetened beverages and water) consumed (ED2). We included energy-containing beverages in our calculation of ED because these beverages, such as milk and fruit juice, contribute significant amounts of important nutrients to the diet. In the other study [1], ED was based on kilocalories divided by the total weight of the food consumed, excluding all beverages such as milk, 100% juice, and soda. The results suggest that ED may influence the ND of the diet depending on the type of beverages included or excluded in the analyses.

The generally accepted definition for ED has been kilocalories/100 grams of food consumed [12]. The primary methodological difference in calculations involve whether beverages should be included or excluded in the calculations. Values for ED reported in the literature have been calculated by a variety of methods and include only food or food and varying combinations of beverages, such as: all beverages, all beverages excluding water, and all energy-containing beverages [13]. That study showed that ED, determined by eight calculation methods, varied by gender, age and race/ethnicity [13]. The authors concluded that investigators examining ED

may have to use several calculation methods to better understand the influence of different types of beverages on energy intake. The authors recommended that future work was needed to better understand the best way to deal with beverages when investigating ED. It is for these reasons that ED was determined by using two calculation methods in this study. Unfortunately, a calculation method including food only was not possible based on the structure of the food groups in this study. This is a limitation of this study, but the results are still useful in assessing the definition of ED as it relates to dietary intake. The two calculation methods used to define ED have their limitations. The lack of water data confounds ED calculations based on foods and combinations of beverages. Individuals consuming water will have spuriously high ED values. This is likely a considerable proportion of the population, as data from a recent nationally representative survey found that 87% of the United States population drink water [30]. However, 19% of water intake is water contained in food [12]. One would think if water consumption was deleted from the calculation of ED, the amount of water in food should also be taken out of the equation. A further limitation of the chosen calculation methods is that beverages may have a disproportionate influence on ED values when included along with foods to calculate ED. Beverages have substantial influence on ED values because most beverages have an ED that is considerably lower than the ED of most foods [13]. The beverage intake data in this study suggest that the stratification of the data in ED tertiles was greatly influenced by beverage intake. The extent to which total beverage intake contributed to nutrient intake is less clear.

Excluding beverages from the calculation of ED when determining nutrient intake and diet quality is problematic. The diet includes both beverages and foods; thus, to best examine nutrient intake of the typical American diet with regard to ED, the total diet of a free-living population should be examined. By excluding beverages from the definition of ED, a restricted picture of the diet is created, and therefore the energy and nutrient density of the diet is incomplete. Beverages such as 100% fruit juice and milk are ND beverages contributing valuable nutrients to the diet, if they are excluded from the analyses, the nutrient contribution of these foods in the ED categories may be underestimated. It makes sense that an ED diet is high in fat content, thus the fat soluble vitamins and essential fatty acids should also be higher compared to the lower ED diet. However, Ledikwe JH *et al.* [1] found that the high ED diets were higher in fat but lower in the fat soluble vitamins. In our study, we found very little differences in intakes of vitamins and minerals across the ED groups.

Our study does have some limitations. Since our study was a cross-sectional design, causal inferences cannot be made. Further, our findings may be specific to the young adults of Bogalusa and may not be representative of national findings. The dietary data are based on one 24-hour dietary recall which may not be reflective of usual dietary intakes. However, the sample size was large enough to characterize group intakes. The dietary data are over ten years old; however, they do provide an indication on the relationship between energy and nutrient dense intakes. The data used in this study were collected in 1989–1991 and may not be reflective of today's marketplace. However, it is acceptable to use long-term epidemiologic studies to address specific research questions. For example, in the past five years approximately 41 scientific papers were published using data from the Continuing Survey for Individual Intakes (CSFII 1989, 1991; 1994–1996, 1998). One of these papers included the widely cited study that determined ED using eight calculation methods [13].

The nutrient database used in this study (*i.e.*, ETNV) reflected the foods and beverages consumed by young adults in 1989–1991 and may not be representative of the fortified beverages available today. Thus, a similar study is needed using more current intake data on young adults. Finally, water as a beverage was not assessed nor included in the ED calculation. This limitation is also shared by other large surveys, such as the National Health And Nutrition Examination Survey.

Despite these limitations, ED diets appear to be also ND based on the increased fat content that contains essential fatty acids and vitamin E. The increased amount of meat consumed increased the amino acids that were higher with increased ED diets. These results are intriguing and are not consistent with other studies. Thus, more studies are needed to confirm these findings.

CONCLUSION

There are several implications of these findings for health practitioners and scientists. For practitioners, the data suggest that promoting the consumption of foods that are less energy dense may come with subtle consequences in overall dietary intake of nutrients often forgotten or seen less significant in the diet. Moreover, promoting less energy dense foods may indirectly result in very low fat intakes which have been shown to result in adverse changes in high density lipoprotein cholesterol and triglycerides [31]. For scientists, the definition of energy density is not as straight forward as it may seem and more research is needed to validate an appropriate definition. To date, there is no consensus on a standard calculation method for ED.

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Table 1

Demographic Characteristics for Energy Density Tertiles of Young Adults: BHS (1989–91)

	ED1 [§]			ED2 [§]			Total
	Tertile1	Tertile2	Tertile3	Tertile1	Tertile2	Tertile3	
Energy Density (kcal/100 gm)	74.8 ± 1.0	M ± SE 108 ± 0.7	151 ± 2.7 ^d	79.7 ± 1.1	M ± SE 115 ± 0.7	170 ± 3.8 ^d	M ± SE —
Energy (kcal) ²	1920 ± 70.0	2252 ± 64.9	2405 ± 64.0 ^d	1998 ± 68.9	2290 ± 65.4	2326 ± 65.8 ^c	—
Tertiles	146 (33.2)	n (%) 147 (33.4)	147 (33.4)	146 (33.2)	n (%) 147 (33.4)	147 (33.4)	n (%) 440 (100)
Age (years)	23.5 ± 0.2	23.5 ± 0.2	23.3 ± 0.2	23.5 ± 0.2	23.6 ± 0.2	23.2 ± 0.2	23.4 ± 0.1
Gender							
Males	59 (13)	55 (13)	65 (15)	67 (15)	57 (13)	55 (13)	179 (41)
Females	87 (20)	92 (21)	82 (18)	79 (18)	90 (20)	92 (21)	261 (59)
Race ³							
Blacks	23 (5) ^a	49 (11) ^c	62 (14) ^c	29 (7) ^a	52 (11) ^c	53 (12) ^c	134 (30)
Whites	123 (28) ^a	98 (22) ^{ac}	85 (20) ^c	117 (27)	95 (22)	94 (21)	306 (70)
Race by Gender ⁴							
Black Males	11 (3)	21 (5)	24 (5)	14 (3)	22 (5)	20 (5)	56 (13)
White Males	48 (11)	34 (8)	41 (9)	53 (12)	35 (8)	35 (8)	123 (28)
Black Females	12 (3) ^a	28 (6) ^{ac}	38 (9) ^c	15 (3) ^a	30 (7) ^{ac}	33 (8) ^c	78 (18)
White Females	75 (17) ^a	64 (15) ^{ac}	44 (10) ^c	64 (15)	60 (14)	59 (13)	183 (42)

Means with the same letter in their superscripts do not differ significantly from one another with $p < .01$.[§] ED1 = all foods and beverages without alcoholic beverage; ED2 = excluded no caloric or less than 10 kcal/g beverages.¹ Unadjusted mean and standard error.² Adjusted for age, race BMI, and race by gender only.³ ED1 overall $p < .0001$, ED2 overall $p < .01$.⁴ ED1 overall $p < .0001$, ED2 overall $p < .05$.

Table 2

Mean Food Group Consumption (grams) by Energy Density Tertiles of Young Adults: BHS (1989–91)

Food Groups (gm)	ED1 [§]					ED2 [§]				
	Tertile1 (n = 146)	Tertile2 (n = 147)	Tertile3 (n = 147)	Tertile1 (n = 146)	Tertile2 (n = 147)	Tertile3 (n = 147)	Tertile1 (n = 146)	Tertile2 (n = 147)	Tertile3 (n = 147)	Tertile1 (n = 146)
Beverages	1432 ± 51.7	M ± SE 810 ± 47.4	530 ± 47.4 ^d	1321 ± 52.8	769 ± 50.0	618 ± 50.0 ^d				
Condiments	6.4 ± 1.5	9.2 ± 1.3	12.4 ± 1.3 ^b	8.1 ± 1.4	8.8 ± 1.3	11.6 ± 1.4				
Dairy	163 ± 23.1	238 ± 21.2	125 ± 21.2	170 ± 22.4	227 ± 21.2	126 ± 21.4				
Breads/Grains	194 ± 12.9	196 ± 11.8	165 ± 11.8	185 ± 12.5	194 ± 11.8	174 ± 11.9				
Meats	214 ± 13.7	215 ± 12.5	251 ± 12.5 ^a	206 ± 13.1	217 ± 12.4	258 ± 12.5 ^b				
Fats/Oils	25.1 ± 3.4	23.8 ± 3.1	25.7 ± 3.1	26.3 ± 3.3	18.9 ± 3.1	29.7 ± 3.1				
Salty Snacks	9.3 ± 2.6	14.6 ± 2.4	14.7 ± 2.4	7.5 ± 2.5	13.7 ± 2.3	17.5 ± 2.4 ^b				
Sweets	1288 ± 58.2	796 ± 53.4	591 ± 53.4 ^d	1377 ± 51.6	803 ± 48.8	462 ± 49.3 ^d				
Fruits/Juices	145 ± 21.3	109 ± 19.6	63 ± 19.6 ^b	138 ± 20.6	106 ± 19.5	68.0 ± 19.7 ^d				
Vegetables	180 ± 15.1	168 ± 13.8	116 ± 13.8 ^b	168 ± 14.6	161 ± 13.9	130 ± 14.0 ^a				

[§] ED1 = all foods and beverages without alcoholic beverage; ED2 = excluded no caloric or less than 10 kcal/g beverages.

^{||} Least-square means and standard error (M ± SE) from regression models adjusted for age, race, gender, kilocalories, BMI, and race by gender.

Linear Trend:

^a p < 0.05,

^b p < 0.01,

^c p < 0.001,

^d p < 0.0001.

Percentage of Energy from Macronutrients by Energy Density Tertiles of Young Adults: BHS (1989–91)

Macronutrients (%)	ED1 [§]			ED2 [§]		
	Tertile1	Tertile2	Tertile3	Tertile1	Tertile2	Tertile3
Protein		M ± SE			M ± SE	
Total Fat	12.6 ± 0.4	13.2 ± 0.4	13.8 ± 0.4 ^d	11.7 ± 0.4	13.1 ± 0.4	14.7 ± 0.4 ^d
Saturated Fatty Acids	29.0 ± 0.8	36.1 ± 0.7	41.6 ± 0.7 ^d	28.6 ± 0.7	36.4 ± 0.7	42.5 ± 0.7 ^d
Total Carbohydrate	9.3 ± 0.4	11.7 ± 0.4	12.9 ± 0.3 ^d	9.3 ± 0.4	11.8 ± 0.3	13.1 ± 0.3 ^d
Total Sucrose	55.5 ± 1.0	49.4 ± 1.0	43.9 ± 0.9 ^d	56.7 ± 0.9	49.3 ± 0.9	42.2 ± 0.9 ^d
	17.8 ± 0.9	12.5 ± 0.9	11.3 ± 0.8 ^d	17.6 ± 0.9	13.2 ± 0.8	10.4 ± 0.9 ^d

[§] ED1 = all foods and beverages without alcoholic beverage; ED2 = excluded no caloric or less than 10 kcal/g beverages.

^{||} Least-square means and standard error (M ± SE) from regression models adjusted for age, race, gender, BMI, and race by gender.

Linear Trend:

^a p < 0.05,

^b p < 0.01,

^c p < 0.001,

^d p < 0.0001.

Table 4

Mean Nutrient Intake by Energy Density Tertiles of Young Adults: BHS (1989–91)

Nutrients	ED1 [§]			ED2 [§]		
	Tertile1	Tertile2	Tertile3	Tertile1	Tertile2	Tertile3
Energy Density (kcal/100 gm) ²		M ± SE ¹			M ± SE ¹	
Energy (kcal) ³	74.8 ± 1.0	108 ± 0.7	151 ± 2.7 ^d	79.7 ± 1.1	115 ± 0.7	170 ± 3.8 ^d
Total Protein (g)	1920 ± 70.0	2252 ± 64.9	2405 ± 64.0 ^d	1998 ± 68.9	2290 ± 65.4	2326 ± 65.8 ^c
Amino Acids (g)	68.5 ± 2.4	71.9 ± 2.2	74.5 ± 2.2	63.5 ± 2.2	71.6 ± 2.1	79.7 ± 2.1 ^d
Histidine	1.9 ± 0.1	2.0 ± 0.1	2.2 ± 0.1 ^d	1.8 ± 0.1	2.0 ± 0.1	2.3 ± 0.1 ^d
Isoleucine	3.0 ± 0.1	3.2 ± 0.1	3.3 ± 0.1	2.8 ± 0.1	3.2 ± 0.1	3.6 ± 0.1 ^d
Leucine	5.1 ± 0.2	5.5 ± 0.2	5.6 ± 0.2 ^d	4.7 ± 0.2	5.5 ± 0.2	6.0 ± 0.2 ^d
Lysine	4.6 ± 0.2	4.8 ± 0.2	5.1 ± 0.2	4.2 ± 0.2	4.8 ± 0.2	5.4 ± 0.2 ^d
Methionine	1.5 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	1.3 ± 0.1	1.6 ± 0.1	1.8 ± 0.1 ^d
Phenylalanine	2.8 ± 0.1	3.1 ± 0.1	3.1 ± 0.1	2.6 ± 0.1	3.1 ± 0.1	3.3 ± 0.1 ^d
Tryptophan	0.8 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	0.7 ± 0.0	0.8 ± 0.0	0.9 ± 0.0 ^d
Tyrosine	2.4 ± 0.1	2.5 ± 0.1	2.6 ± 0.1	2.2 ± 0.1	2.5 ± 0.1	2.7 ± 0.1 ^d
Valine	3.3 ± 0.1	3.6 ± 0.1	3.6 ± 0.1	3.1 ± 0.1	3.6 ± 0.1	3.9 ± 0.1 ^d
Total Fat (g)	71.6 ± 2.0	87.2 ± 1.8	102 ± 1.8 ^d	71.3 ± 1.8	87.8 ± 1.7	104 ± 1.7 ^d
Animal Fat	39.6 ± 2.2	45.7 ± 2.0	50.2 ± 2.0 ^c	38.9 ± 2.1	46.7 ± 2.0	50.4 ± 2.0 ^d
Vegetable Fat	15.1 ± 1.7	18.8 ± 1.6	25.7 ± 1.6 ^d	14.1 ± 1.7	19.9 ± 1.6	26.1 ± 1.6 ^d
Saturated Fatty Acids	23.4 ± 1.0	28.4 ± 0.9	31.7 ± 0.9 ^d	23.2 ± 0.9	28.6 ± 0.9	32.2 ± 0.9 ^d
Monounsaturated Fatty Acids	25.5 ± 0.9	30.2 ± 0.8	35.1 ± 0.8 ^d	25.1 ± 0.9	30.6 ± 0.8	35.7 ± 0.8 ^d
Polyunsaturated Fatty Acids	14.3 ± 0.9	17.9 ± 0.8	21.8 ± 0.8 ^d	14.3 ± 0.8	18.2 ± 0.8	22.0 ± 0.8 ^d
Fatty Acids (g)						
Arachidonic	0.3 ± 0.1	0.3 ± 0.1	0.5 ± 0.1	0.3 ± 0.1	0.3 ± 0.1	0.5 ± 0.1
Linoleic	12.2 ± 0.8	15.4 ± 0.7	19.2 ± 0.7 ^d	12.2 ± 0.8	15.8 ± 0.7	19.2 ± 0.7 ^d
Linolenic	1.1 ± 0.1	1.3 ± 0.1	1.4 ± 0.1	1.1 ± 0.1	1.3 ± 0.1	1.5 ± 0.1 ^b
Myristic	1.7 ± 0.1	2.1 ± 0.1	2.1 ± 0.1 ^a	1.7 ± 0.1	2.1 ± 0.1	2.2 ± 0.1
Oleic	23.6 ± 0.8	28 ± 0.8	32.4 ± 0.8 ^d	23.2 ± 0.8	28.1 ± 0.7	33.1 ± 0.7 ^d
Palmitoleic Acid	1.1 ± 0.1	1.3 ± 0.1	1.4 ± 0.1 ^b	1.1 ± 0.1	1.4 ± 0.1	1.3 ± 0.1
Palmitic	13.3 ± 0.5	16.3 ± 0.5	18.6 ± 0.5 ^d	16.3 ± 0.5	18.6 ± 0.5 ^d	
Stearic	6.1 ± 0.3	7.3 ± 0.2	8.3 ± 0.2 ^d	6.0 ± 0.3	7.3 ± 0.2	8.5 ± 0.2 ^d
Cholesterol (g)	0.3 ± 0.0	0.3 ± 0.0	0.3 ± 0.0	0.2 ± 0.0	0.3 ± 0.0	0.3 ± 0.0
Total Carbohydrate (g)	288 ± 5.6	265 ± 5.1	236 ± 5.1 ^d	294 ± 5.1	265 ± 4.9	227 ± 4.9 ^d
Total Sucrose (g)	94.8 ± 5.1	64.5 ± 4.7	58.3 ± 4.7 ^d	93.2 ± 4.9	68.3 ± 4.7	53.8 ± 4.7 ^d
Total Sugar (g)	160 ± 6.0	129 ± 5.5	111 ± 5.5 ^d	169 ± 5.4	132 ± 5.1	95.9 ± 5.2 ^d
Starch (g)	72.9 ± 3.2	87.6 ± 2.9	78.2 ± 2.9	72.0 ± 3.1	84.6 ± 2.9	82.1 ± 2.9
Fiber (g)	12.1 ± 0.5	11.9 ± 0.5	10.2 ± 0.5 ^b	11.5 ± 0.5	11.6 ± 0.5	10.8 ± 0.5

[§]ED1 = all foods and beverages without alcoholic beverage; ED2 = excluded diet or less than 10 kcal/g beverages.

¹Least-square means and standard error (M ± SE) from regression models adjusted for age, race, gender, kilocalories, BMI, and race by gender

²Unadjusted mean and standard error.

³Adjusted for age, race BMI, and race by gender only.

Linear Trend:
^a p < 0.05,
^b p < 0.01,
^c p < 0.001,
^d p < 0.0001.