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ORIGINAL ARTICLE

Ethnic disparities among food sources of energy and nutrients of public health concern and nutrients to limit in adults in the United States: NHANES 2003–2006

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Abstract

Background: Identification of current food sources of energy and nutrients among US non-Hispanic whites (NHW), non-Hispanic blacks (NHB), and Mexican American (MA) adults is needed to help with public health efforts in implementing culturally sensitive and feasible dietary recommendations.
Objective: The objective of this study was to determine the food sources of energy and nutrients to limit [saturated fatty acids (SFA), added sugars, and sodium] and nutrients of public health concern (dietary fiber, vitamin D, calcium, and potassium) by NHW, NHB, and MA adults.
Design: This was a cross-sectional analysis of a nationally representative sample of NWH (n = 4,811), NHB (2,062), and MA (n = 1,950) adults 19+ years. The 2003–2006 NHANES 24-h recall (Day 1) dietary intake data were analyzed. An updated USDA Dietary Source Nutrient Database was developed using current food composition databases. Food grouping included ingredients from disaggregated mixtures. Mean energy and nutrient intakes from food sources were sample-weighted. Percentages of total dietary intake contributed from food sources were ranked.
Results: Multiple differences in intake among ethnic groups were seen for energy and all nutrients examined. For example, energy intake was higher in MA as compared to NHB; SFA, added sugars, and sodium intakes were higher in NHW than NHB; dietary fiber was highest in MA and lowest in NHB; vitamin D was highest in NHW; calcium was lowest in NHB; and potassium was higher in NHW as compared to NHB. Food sources of these nutrients also varied.
Conclusion: Identification of intake of nutrients to limit and of public health concern can help health professionals implement appropriate dietary recommendations and plan interventions that are ethnically appropriate.

Keywords: *NHANES*; *energy intake*; *nutrients to limit*; *nutrients of public health concern*; *food sources*; *diverse ethnicities*

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In the United States, there is an overabundance of foods available, including healthy ones like whole grains, fruit, vegetables, low-fat dairy, and lean meats (1), but foods that is high in energy and nutrients to limit is also plentiful (2). To guide Americans in the selection and consumption of healthy foods, while not over-consuming energy and nutrients to limit, the Dietary Guidelines for Americans (DGA) (3), coupled with MyPlate (4) provides nutrient-dense food options and concomitant dietary patterns for a range of energy recommendations. Despite the recommendations of the DGA/MyPlate on the healthy foods available, most adults over-consume nutrient-poor, energy-dense foods and beverages with the consequence of not meeting the dietary recommendations for foods or nutrients (3, 5–8). On average, US adults fail to meet recommended intakes for dietary fiber, vitamin D, calcium, and potassium, and these have been identified as nutrients of public health concern (3). A total of 80–99% of Americans do not meet the recommendations for the nutrient-dense food groups which would help provide these nutrients – fruit, vegetables, whole grains, or reduced-fat dairy products (3, 7). Further, Americans also over-consume energy from saturated fatty acids (SFA), added sugars, solid fats, and sodium (3, 7, 9).

Some ethnic groups appear to find the recommendations of the DGA especially difficult to follow (5, 9–12).

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Using data from the National Health and Nutrition Examination Survey (NHANES) 2001–2004, Kirkpatrick et al. (10) showed that smaller proportions of non-Hispanic black (NHB) adults met the recommendations for whole fruit, total and other vegetables, total grains, and milk, when compared with non-Hispanic whites (NHW) and Mexican Americans (MA). Fewer MA adults met the recommendations for dark green or starchy vegetables, and oils compared with NHW and NHB. Although overall milk consumption was low, a greater proportion of NHW met the recommendations compared with the other two ethnic groups studied. Other studies have shown that all ethnic groups over-consumed energy from SFA (9) and solid fat (10), as well as absolute amounts of sodium (9).

Long-term over-consumption of energy, without a concomitant increase in energy expenditure, leads to overweight or obesity. There is a clear ethnic divide when considering the prevalence of obesity. Data from the 2011–2012 NHANES showed that 47.8, 42.5, and 32.6% of NHB, Hispanic American, and NHW adults, respectively, were obese (13). Obesity is associated with excess mortality and morbidity, especially as a risk factor for coronary heart disease (14), hypertension (14, 15), stroke (16), metabolic syndrome (17), and type 2 diabetes mellitus (18).

Failure to meet food, and consequently nutrient recommendations or exceeding recommendations for nutrients to limit, can lead to nutrient imbalances and increased risk of chronic disease (19–21). The lower intake of nutrients of public health concern (3) by NHB and MA and other Hispanics, as compared with NHW (9), may contribute, in part, to the disparities in diet-related diseases observed among these ethnic groups (22–25). It is likely that differential over- or under-consumption of some of these nutrients by different ethnic groups may partly explain the differences observed in the prevalence or incidence of obesity and other diet-related chronic diseases.

Understanding current food selections among the US populations, especially those at high risk for diet-related chronic diseases is critical for designing culturally specific strategies to help Americans meet nutrient recommendations while keeping within energy needs. A detailed list of the food sources of energy and nutrients among US adults used data from NHANES 2003–2006 has been published (8); however, that study did not examine NHW, NHB, and MA separately. The purpose of this study was to update and extend previous research by using nationally representative data from the NHANES 2003–2006 to examine food sources of energy and nutrients of public health concern or nutrients to limit that are over- or under-consumed by US NHW, NHB, and MA adults.

Methods

Population and dietary intake

Intake data from adults 19+ years of age (y) participating in the NHANES 2003–2006 who self-identified as NHW ($n = 4{,}811$), NHB ($n = 2{,}062$), or MA (1,950) (26, 27) were obtained from a single in-person 24-h dietary recall interview using an automated multiple-pass method (28, 29). Data from pregnant or lactating women ($n = 632$) or data judged incomplete or unreliable ($n = 71$) by the Food Surveys Research Group were excluded from these analyses. Descriptions of methods for the 24-h recalls have been described previously (3). The NHANES has strict protocols and approvals regarding human subjects (30). This research did not require institutional review board review, as it does not constitute original research on human subjects (31).

Food groupings and composition

The USDA Dietary Sources of Nutrients (DSN) database (32) was used to define food groups. The DSN database was originally developed for use with the Continuing Survey of Food Intake by Individuals 1994–1996. For this study, the DSN database was updated for application to more recent food consumption survey releases. The food grouping and disaggregation rules used to update the DSN database were similar to those methods reported by others who have described DSN in the American diet (33–35). The more than 130 DSN food groups were collapsed into 51 categories, as described previously and with a previously published table showing the food categories (8). This is an aggregation level consistent with that used by the USDA Food Surveys Research Group when defining food groups (36). Disaggregation of foods allows for a more accurate assessment of nutrients in food groups (35). Categories of food include survey foods or ingredients of recipes for home- or restaurant-prepared foods that were disaggregated. None of the baked goods (neither home-baked nor commercially prepared baked goods) and none of the manufactured foods were disaggregated.

If foods were not disaggregated in the DSN database, the Food and Nutrient Database for Dietary Studies (37) (FNDDS) codes were assigned to DSN food groups (FNDDS versions 2.0 and 3.0 were used in 2003–2004 and 2005–2006 NHANES, respectively). The ingredients of disaggregated survey food recipes (coded using the USDA Nutrient Database for Standard Reference [SR] food codes) were linked to the appropriate food composition databases using the SR-Link file of the FNDDS [versions 2.0 and 3.0 link SR releases 18 and 20, respectively (38)]. Recipe calculations were performed to determine proportions of the disaggregated survey foods assigned to the 51 DSN food groups. Ingredients of a recipe for a grain-based mixture such as spaghetti and meat sauce, for example, included spaghetti, tomato sauce/paste, carrots, onions, garlic, olive oil, ground meat, and cheese, which were each classed to respective DSN groups. Ingredients added in food preparation, such as salt added to the sauce, were disaggregated to separate the sodium that was added to the sauce from that occurs naturally in foods.

Statistical analyses

Analyses were conducted using SUDAAN 9.0.3 (2007; Research Triangle Institute, Research Triangle Park, NC). Appropriate weighting factors were used in analyses to adjust for oversampling of selected groups, survey non-response of some individuals, and day of the week the interview was conducted (39). Mean and standard errors of energy and nutrient intakes from the total diet and from each food group were determined using PROC DESCRIPT of SUDAAN. Using the mean intake data, the average percentage of total dietary intake of energy and nutrients contributed from each food grouping was calculated and tabulated in ranked order. Tests for comparisons of means of energy and nutrients among three ethnic groups were performed using Bonferroni's correction ($p < 0.05/3 = p < 0.0167$) to adjust the significance level for multiple comparisons.

Results

Energy and nutrients to SFA, added sugars, and sodium

NHB consumed less energy than MA; however, energy intake for NHW was not different from the other two ethnic groups (Table 1). MAs consumed more energy from grain products than NHW and NHB. In all ethnic groups, meat/poultry/fish (MPF) contributed the next highest percentage of energy: NHW, NHB, and MA. NHW had lower energy intake from MPF than NHB; however, there were no other differences. For NHW, energy intake from desserts and sweets ranked third and was significantly higher than that seen in NHB and MA. For NHB and MA, non-dairy beverages were the third ranking energy source and intake was significantly higher than that seen in NHW. Dairy products were the fifth highest source of energy for NHW and MA and the sixth highest for NHB; energy intake from dairy products was lowest in NHB. Energy intake from fruit and vegetables was low for all ethnic groups. The only difference was that NHW had a higher energy intake from vegetables than NHB.

Mean SFA intake was higher in NHW than NHB; however, neither was different from intake by MA (Table 2). For NHW, dairy products provided the highest number of grams of SFA in the diet; for NHB and MA, dairy products provided the second highest number of grams of SFA. Both NHW and MA consumed significantly more SFA from dairy products than NHB. For NHW, MPF provided the second highest number of grams of SFA in the diet; MPF was the highest source of grams of SFA in the diets of NHB and MA. NHW consumed significantly fewer grams of SFA from the MPF group than NHB, but not than MA. In all three ethnic groups, fats and oils contributed the third highest number of grams of SFA: NHW, NHB, and MA; NHW had the highest

Table 1. Mean energy (kJ) intake from disaggregated food groups, and ranked percentage contribution to daily energy intake: adults 19+ years by ethnic group

	Non-Hispanic white (NHW) ($n = 4,811$)		Non-Hispanic black (NHB) ($n = 2,062$)		Mexican American (MA) ($n = 1,950$)		p		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	9,310 ± 87	100.0	8,991 ± 146	100.0	9,587 ± 166	100.0	0.0601	0.1406	**0.0071**
Grain products	2,271 ± 29	24.4	2,224 ± 61	24.7	2,527 ± 61	26.4	0.4849	**0.0005**	**0.0009**
Vegetables	535 ± 14	5.7	478 ± 18	5.3	503 ± 28	5.2	**0.0129**	0.2987	0.4637
Fruit (includes fruit juice)[a]	356 ± 15	3.8	379 ± 21	4.2	428 ± 35	4.5	0.3877	0.0590	0.2226
Dairy products	924 ± 24	9.9	602 ± 27	6.7	875 ± 40	9.1	< **0.0001**	0.2795	< **0.0001**
Meat, poultry, fish	1,411 ± 31	15.2	1,658 ± 49	18.4	1,529 ± 60	16.0	< **0.0001**	0.0804	0.0940
Eggs, legumes, nuts, and seeds	435 ± 13	4.7	344 ± 19	3.8	558 ± 39	5.8	**0.0001**	**0.0032**	< **0.0001**
Fats and oils	809 ± 14	8.7	760 ± 23	8.5	678 ± 34	7.1	0.0709	**0.0003**	0.0440
Desserts and sweets	1,335 ± 33	14.3	1,150 ± 44	12.8	1,064 ± 48	11.1	**0.0007**	< **0.0001**	0.1816
Beverages	1,099 ± 31	11.8	1,305 ± 64	14.5	1,282 ± 58	13.4	**0.0040**	**0.0054**	0.7956
Other foods	135 ± 7	1.5	90 ± 6	1.0	144 ± 9.0	1.5	< **0.0001**	0.4229	< **0.0001**

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older ($n = 8,823$).

[a]Defined as 100% fruit juice.

Sample-weighted mean and standard error are estimated using SUDAAN.

$p < 0.0167$ Bonferroni corrected for three groups.

Values in bold face are significantly different.

Table 2. Mean saturated fatty acid (g) intake from disaggregated food groups, and ranked percentage contribution to daily saturated fatty acid intake: adults aged 19+ years by ethnic group

	Non-Hispanic white (NHW) (*n* = 4,811)		Non-Hispanic black (NHB) (*n* = 2,062)		Mexican American (MA) (n = 1,950)		*p*		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	28.8 ± 0.4	100.0	26.4 ± 0.6	100.0	26.9 ± 0.7	100.0	**0.0007**	0.0199	0.5979
Grain products	2.9 ± 0.1	10.0	3.3 ± 0.1	12.5	2.9 ± 0.1	10.9	**0.0042**	0.5471	0.0590
Vegetables	0.7 ± 0.1	2.3	0.7 ± 0.1	2.6	0.7 ± 0.1	2.5	0.5775	0.8737	0.7805
Fruit (includes fruit juice)[a]	0.1 ± 0.01	0.2	0.1 ± 0.01	0.2	0.1 ± 0.01	0.2	0.9666	0.0966	0.1154
Dairy products	7.1 ± 0.2	24.8	5.2 ± 0.2	19.7	7.2 ± 0.4	26.6	< **0.0001**	0.9590	< **0.0001**
Meat, poultry, fish	6.6 ± 0.2	23.1	7.9 ± 0.3	29.8	7.2 ± 0.4	26.6	**0.0002**	0.1908	0.1389
Eggs, legumes, nuts, and seeds	1.4 ± 0.04	5.0	1.2 ± 0.1	4.5	1.4 ± 0.1	5.2	**0.0002**	0.7704	0.0971
Fats and oils	5.5 ± 0.1	19.1	4.7 ± 0.2	17.8	4.1 ± 0.2	15.3	**0.0004**	< **0.0001**	0.0208
Desserts and sweets	4.2 ± 0.1	14.7	3.3 ± 0.1	12.3	3.1 ± 0.2	11.4	< **0.0001**	< **0.0001**	0.3734
Beverages	0.1 ± 0.01	0.2	0.02 ± 0.01	0.1	0.03 ± 0.01	0.1	**0.0015**	0.0801	0.3114
Other foods	0.2 ± 0.01	0.8	0.1 ± 0.02	0.5	0.3 ± 0.03	1.2	**0.0001**	0.0221	< **0.0001**

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older (*n* = 8,823).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p < 0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

intake of SFA from this food group. Desserts and grain products were also major contributors of SFA in the diet in all three ethnic groups.

The only significant difference in added sugars intake was that intake from NHW was lower than that of NHB (Table 3). For NHW, desserts and sweets contributed the highest number of grams of added sugars to the diet; for NHB and MA this food group contributed the second highest number of grams of added sugars. MA consumed the fewest number of grams from this food group when

Table 3. Mean added sugars (g) intake from disaggregated food groups, and ranked percentage contribution to daily added sugars intake: adults aged 19+ years by ethnic group

	Non-Hispanic white (NHW) (*n* = 4,811)		Non-Hispanic black (NHB) (*n* = 2,062)		Mexican American (MA) (*n* = 1,950)		*p*		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	80.7 ± 1.9	100.0	91.8 ± 3.1	100.0	86.6 ± 2.4	100.0	**0.0020**	0.0501	0.1781
Grain products	6.3 ± 0.2	7.8	6.3 ± 0.3	6.9	4.4 ± 0.3	5.0	0.9831	< **0.0001**	< **0.0001**
Vegetables	0.3 ± 0.02	0.4	0.4 ± 0.1	0.4	0.2 ± 0.04	0.3	0.4218	**0.0077**	**0.0072**
Fruit (includes fruit juice)[a]	1.0 ± 0.1	1.2	1.0 ± 0.2	1.1	1.3 ± 0.2	1.5	0.8886	0.1255	0.2658
Dairy products	1.9 ± 0.2	2.4	1.2 ± 0.2	1.3	2.0 ± 0.2	2.3	**0.0100**	0.9589	0.0206
Meat, poultry, fish	0.1 ± 0.01	0.1	0.2 ± 0.1	0.2	0.1 ± 0.03	0.1	0.1272	0.5549	0.0941
Eggs, legumes, nuts, and seeds	0.5 ± 0.1	0.6	0.4 ± 0.1	0.5	0.1 ± 0.03	0.1	0.7563	< **0.0001**	**0.0002**
Fats and oils	1.4 ± 0.1	1.8	1.2 ± 0.1	1.3	0.8 ± 0.1	1.0	0.1016	< **0.0001**	0.0290
Desserts and sweets	34.1 ± 0.9	42.3	32.2 ± 1.5	35.1	27.3 ± 1.2	31.6	0.2773	< **0.0001**	**0.0126**
Beverages	33.7 ± 1.5	41.7	48.0 ± 2.5	52.3	49.5 ± 1.8	57.2	< **0.0001**	< **0.0001**	0.6142
Other foods	1.4 ± 0.1	1.8	0.9 ± 0.1	1.0	0.8 ± 0.1	1.0	**0.0005**	**0.0002**	0.4523

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older (*n* = 8,823).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p < 0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

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compared with NHW and NHB. For NHB and MA, beverages contributed the highest number of grams of added sugars; for NHW, beverages contributed the second highest number of grams. Both NHB and MA consumed significantly more grams of added sugars from beverages than NHW.

NHW consumed significantly more sodium than NHB (Table 4). In all three ethnic groups, 'other foods' contributed the highest amounts of sodium to the diet, with MA consuming the highest amount from this food group compared with NHW or NHB. In all three ethnic groups, grain products were the next highest contributor of sodium to the diet, although no differences were observed among the groups. MPF was the third leading contributor of sodium to the diet. MA had the lowest intake from this group when compared with NHW and NHB.

Nutrients of public health concern

NHB had the lowest mean dietary fiber intake of all three ethnic groups, and MA had the highest of all groups (Table 5). Grain products contributed the most fiber to the diet of all three groups; MA had the highest dietary fiber intake from grain and NHB had the lowest. Vegetables provided the second highest source of dietary fiber. NHW consumed more dietary fiber from vegetables than NHB, but not more than MA; MA consumed more fiber from vegetables than NHB. For NHW and NHB, fruit provided the third highest source of fiber. NHW had higher dietary fiber intake from fruit than NHB; however, MA had the highest dietary fiber intake from fruit. MA consumed higher amounts of dietary fiber from eggs, legumes, nuts, and seeds than either NHW or NHB, which was the lowest.

Vitamin D intake (Table 6) was highest in NHW when compared with NHB or MA; NHB intake was not significantly different from MA intake. Dairy products were the principal source of vitamin D in the diet for all three ethnic groups, with NHB having the lowest intake; NHW intake was not different from MA intake. MPF was the next highest source of vitamin D in all three ethnic groups. Intake was lowest in MA; intake in NHW was not different from that of NHB.

Calcium intake (Table 7) was lowest in NHB; calcium intake was not different in NHW when compared with intake from MA. In all three ethnic groups, dairy products constituted the highest percentage contribution of calcium to the diet. NHW had the highest intake of calcium from dairy products and NHB had the lowest.

NHW intake of potassium was higher than NHB; no other significant differences were observed (Table 8). Vegetables were the highest ranking source of dietary potassium in the diet of NHW and MA; NHW consumed significantly more dietary potassium from vegetables than NHB. For NHB, MPF was the highest ranking source of dietary potassium; however, intake from MPF was not higher than NHW or MA. For MA, eggs, legumes, nuts, and seeds were a major source of potassium; intake of potassium in this group was higher than NHW and NHB. Grain products, fruit, dairy, and beverages also contributed relatively higher amounts of potassium to the diet in all three ethnic groups.

Table 4. Mean sodium (mg) intake from disaggregated food groups, and ranked percentage contribution to daily sodium intake: adults 19+ years by ethnic group

	Non-Hispanic white (NHW) (n = 4,811)		Non-Hispanic black (NHB) (n = 2,062)		Mexican American (MA) (n = 1,950)		p		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB v MA
Total (all food groups)	3565.3 ± 37.0	100.0	3285.1 ± 69.8	100.0	3437.2 ± 70.4	100.0	**0.0004**	0.1074	0.1250
Grain products	750.9 ± 13.7	21.1	730.8 ± 23.0	22.3	735.1 ± 23.6	21.4	0.4513	0.5615	0.8960
Vegetables	249.9 ± 7.9	7.0	186.9 ± 8.4	5.7	205.6 ± 11.3	6.0	< **0.0001**	**0.0013**	0.1835
Fruit (includes fruit juice)[a]	3.9 ± 0.2	0.1	4.3 ± 0.2	0.1	4.1 ± 0.5	0.1	0.2493	0.6998	0.7452
Dairy products	382.1 ± 10.1	10.7	261.9 ± 8.2	8.0	307.7 ± 23.3	9.0	< **0.0001**	**0.0034**	0.0637
Meat, poultry, fish	558.1 ± 16.1	15.7	597.1 ± 30.7	18.2	450.9 ± 34.3	13.1	0.2607	**0.0047**	**0.0015**
Eggs, legumes, nuts, and seeds	111.1 ± 5.1	3.1	93.0 ± 6.9	2.8	105.2 ± 7.4	3.1	0.0348	0.5138	0.2273
Fats oils	203.8 ± 6.5	5.7	165.1 ± 10.1	5.0	110.5 ± 6.9	3.2	**0.0012**	< **0.0001**	< **0.0001**
Desserts and sweets	169.3 ± 5.5	4.8	137.7 ± 5.9	4.2	128.8 ± 8.7	3.8	**0.0001**	**0.0001**	0.3927
Beverages	91.6 ± 3.5	2.6	87.3 ± 3.4	2.7	87.5 ± 4.6	2.6	0.3767	0.4810	0.9711
Other foods	1044.5 ± 18.5	29.3	1021.0 ± 22.6	31.1	1301.8 ± 41.1	37.9	0.4215	< **0.0001**	< **0.0001**

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older (n = 8,823).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p < 0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

Table 5. Mean dietary fiber (g) intake from disaggregated food groups, and ranked percentage contribution to daily dietary fiber intake: adults 19+ years by ethnic group

	Non-Hispanic white (NHW) ($n = 4{,}811$)		Non-Hispanic black (NHB) ($n = 2{,}062$)		Mexican American (MA) ($n = 1{,}950$)		p		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	15.9 ± 0.3	100.0	12.8 ± 0.3	100.0	19.1 ± 0.5	100.0	**< 0.0001**	**< 0.0001**	**< 0.0001**
Grain products	6.1 ± 0.1	38.2	5.0 ± 0.1	39.5	7.8 ± 0.3	40.6	**< 0.0001**	**< 0.0001**	**< 0.0001**
Vegetables	4.3 ± 0.1	26.8	3.5 ± 0.1	27.2	4.1 ± 0.2	21.4	**< 0.0001**	0.4142	**0.0032**
Fruit (includes fruit juice)[a]	1.8 ± 0.1	11.1	1.4 ± 0.1	11.0	2.1 ± 0.2	11.0	**0.0037**	0.0448	**0.0002**
Dairy products	0.2 ± 0.02	1.1	0.1 ± 0.01	0.6	0.1 ± 0.02	0.7	**0.0002**	0.2630	0.0414
Meat, poultry, fish	0.1 ± 0.01	0.7	0.1 ± 0.01	1.0	0.1 ± 0.01	0.4	0.6941	0.0318	0.0425
Eggs, legumes, nuts, and seeds	1.7 ± 0.1	10.9	1.3 ± 0.1	10.4	3.5 ± 0.2	18.1	**0.0165**	**< 0.0001**	**< 0.0001**
Fats and oils	0.03 ± 0.01	0.2	0.03 ± 0.01	0.2	0.02 ± 0.01	0.1	0.7624	0.1521	0.3281
Desserts and sweets	1.4 ± 0.04	8.7	1.0 ± 0.04	7.8	1.0 ± 0.1	5.0	**< 0.0001**	**< 0.0001**	0.5612
Beverages	0.03 ± 0.01	0.2	0.1 ± 0.01	0.8	0.1 ± 0.01	0.4	**< 0.0001**	**< 0.0001**	0.1518
Other foods	0.3 ± 0.02	2.1	0.2 ± 0.01	1.4	0.4 ± 0.03	2.2	**< 0.0001**	0.0512	**< 0.0001**

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older ($n = 8{,}823$).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p < 0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

Discussion

Faced with a high prevalence of overweight and obesity, and the difficulty balancing dietary recommendations with energy intake, it was important to identify principal food sources of energy and examine their potential nutrient contributions to the diet in different ethnic groups. This is the first study to examine specific foods and their contribution to energy, nutrients of public health concern, and

Table 6. Mean vitamin D (μg) intake from disaggregated food groups, and ranked percentage contribution to daily vitamin D: adults 19+ years by ethnic group

	Non-Hispanic white (NHW) ($n = 4{,}811$)		Non-Hispanic black (NHB) ($n = 2{,}062$)		Mexican American (MA) ($n = 1{,}950$)		p		
Food group	Mean ± SE	%	Mean ± SE	%	Mean ± SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	4.9 ± 0.1	100.0	3.8 ± 0.2	100.0	4.4 ± 0.1	100.0	**< 0.0001**	**0.0064**	0.0365
Grain products	0.3 ± 0.01	6.5	0.3 ± 0.02	7.4	0.3 ± 0.02	5.8	0.1606	0.0200	0.4184
Vegetables	0.01 ± 0.01	0.2	0.01 ± 0.01	0.2	0.01 ± 0.01	0.2	**0.0014**	**0.0091**	0.6550
Fruit (includes fruit juice)[a]	0.2 ± 0.01	3.1	0.2 ± 0.03	5.9	0.2 ± 0.02	4.3	0.0280	0.1241	0.3535
Dairy products	2.7 ± 0.1	54.5	1.4 ± 0.1	37.3	2.5 ± 0.1	56.8	**< 0.0001**	0.2422	**< 0.0001**
Meat, poultry, fish	1.1 ± 0.1	22.3	1.3 ± 0.2	34.6	0.8 ± 0.1	18.7	0.2085	**0.0042**	**0.0074**
Eggs, legumes, nuts, and seeds	0.2 ± 0.01	4.9	0.3 ± 0.01	7.1	0.4 ± 0.04	8.5	0.0461	**0.0003**	**0.0076**
Fats and oils	0.2 ± 0.01	3.3	0.1 ± 0.01	3.5	0.1 ± 0.01	2.6	**0.0021**	**< 0.0001**	0.0349
Desserts and sweets	0.1 ± 0.01	2.6	0.1 ± 0.01	2.6	0.1 ± 0.02	2.1	**0.0012**	0.0323	0.7502
Beverages	0.01 ± 0.01	0.01	0.01 ± 0.01	0.01	0.01 ± 0.01	0.01	N/A	N/A	N/A
Other foods	0.1 ± 0.02	2.6	0.1 ± 0.02	1.6	0.04 ± 0.01	1.0	0.0272	0.0016	0.3519

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older ($n = 8{,}823$).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p < 0.0167$ Bonferroni corrected for three groups.
N/A values result from a non-definable number due to division by zero.
Values in bold face are significantly different.

Table 7. Mean calcium (mg) intake from disaggregated food groups, and ranked percentage contribution to daily calcium: adults 19+ years by ethnic group

	Non-Hispanic white (NHW) ($n=1,998$)		Non-Hispanic black (NHB) ($n=2,390$)		Mexican American (MA) ($n=2,316$)		p		
Food group	Mean±SE	%	Mean±SE	%	Mean±SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	965.9±14.9	100.0	732.0±18.7	100.0	925.9±22.8	100.0	<**0.0001**	0.1422	<**0.0001**
Grain products	166.4±2.5	17.2	152.0±5.2	20.8	200.7±5.8	21.7	0.0116	<**0.0001**	<**0.0001**
Vegetables	48.4±1.0	5.0	43.7±1.9	6.0	48.2±2.8	5.2	0.0308	0.9522	0.1873
Fruit (includes fruit juice)[a]	34.4±2.1	3.6	43.7±4.1	6.0	45.8±3.7	5.0	0.0461	**0.0071**	0.6906
Dairy products	478.6±12.0	49.6	284.2±12.4	38.8	420.5±20.8	45.4	<**0.0001**	**0.0154**	<**0.0001**
Meat, poultry, fish	32.1±0.9	3.3	40.0±2.3	5.5	34.3±2.4	3.7	**0.0012**	0.3880	0.0870
Eggs, legumes, nuts, and seeds	25.4±0.8	2.6	22.8±1.1	3.1	40.8±2.9	4.4	0.0652	<**0.0001**	<**0.0001**
Fats and oils	13.6±0.7	1.4	8.3±0.8	1.1	7.1±0.8	0.8	<**0.0001**	<**0.0001**	0.2947
Desserts and sweets	75.1±2.7	7.8	53.7±2.0	7.3	46.2±2.9	5.0	<**0.0001**	<**0.0001**	0.0318
Beverages	70.6±3.1	7.3	72.5±5.0	9.9	68.4±3.7	7.4	0.7489	0.6438	0.5062
Other foods	21.2±3.2	2.2	11.1±1.5	1.5	13.8±1.1	1.5	**0.0045**	0.0311	0.1381

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older ($n=8,823$).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p<0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

nutrients to limit in three ethnic groups in the United States. This study, along with previous studies (8, 34, 35), showed that energy-dense, nutrient-poor foods were major contributors to dietary energy intake, making it difficult for individuals to achieve nutrient recommendations without exceeding energy limits. The study also showed significant differences in energy intake and in the food sources contributing to energy and nutrient intakes among NHB, NHW, and MA.

SFA intake exceeded the recommended less than 10% of total energy (40). In all three ethnic groups, dairy products and MPF were the two major sources of SFA in the

Table 8. Mean potassium (mg) intake from disaggregated food groups, and ranked percentage contribution to daily potassium intake: adults aged 19+ years by ethnic group

	Non-Hispanic white (NHW) ($n=1,998$)		Non-Hispanic black (NHB) ($n=2,390$)		Mexican American (MA) ($n=2,316$)		p		
Food group	Mean±SE	%	Mean±SE	%	Mean±SE	%	NHW vs NHB	NHW vs MA	NHB vs MA
Total (all food groups)	2812.0±28.8	100.0	2296.2±39.0	100.0	2788.4±57.7	100.0	<**0.0001**	0.7150	0.7150
Grain products	333.4±5.8	11.9	349.1±14.6	15.2	355.0±12.0	12.7	0.3178	0.1035	0.1035
Vegetables	590.3±10.9	21.0	448.4±15.6	19.5	581.0±24.0	20.8	<**0.0001**	0.7239	0.7239
Fruit (includes fruit juice)[a]	285.7±13.4	10.2	306.3±18.1	13.3	336.1±26.5	12.1	0.3586	0.0888	0.0888
Dairy products	386.6±12.2	13.8	213.5±12.1	9.3	342.4±14.9	12.3	<**0.0001**	0.0218	0.0218
Meat, poultry, fish	438.0±10.5	15.6	476.0±15.3	20.7	475.1±19.6	17.0	0.0398	0.0953	0.0953
Eggs, legumes, nuts, and seeds	144.4±6.3	5.1	118.9±7.9	5.2	255.8±18.0	9.2	0.0115	<**0.0001**	<**0.0001**
Fats and oils	33.0±1.1	1.2	22.4±1.4	1.0	21.0±2.2	0.8	<**0.0001**	<**0.0001**	<**0.0001**
Desserts and sweets	150.7±4.6	5.4	111.2±3.4	4.8	99.4±5.5	3.6	<**0.0001**	<**0.0001**	<**0.0001**
Beverages	364.5±7.3	13.0	196.8±8.1	8.6	211.5±11.0	7.6	<**0.0001**	<**0.0001**	<**0.0001**
Other foods	85.3±3.6	3.0	53.6±3.3	2.3	111.0±6.4	4.0	<**0.0001**	**0.0005**	**0.0005**

Source: NHANES, 2003–2006, Day 1, all aged 19 years and older ($n=8,823$).
[a]Defined as 100% fruit juice.
Sample-weighted mean and standard error are estimated using SUDAAN.
$p<0.0167$ Bonferroni corrected for three groups.
Values in bold face are significantly different.

diet, likely reflecting the choice of full-fat dairy products and fatty meats. In NHB, SFA from dairy products was lower than in NHW and MA; however, this is likely due to MA and NHB not consuming the recommended intake of dairy foods (41), rather than selection of low-fat options. Although the role of SFA in heart disease (42) and type 2 diabetes (43) has recently been questioned, it is still premature to change recommendations. However, the higher prevalence of these diseases in MA and NHB merits further study of dietary and other potential causes (44) so that ethnic-specific interventions can be devised to reduce the risk of chronic disease (45).

MA had the highest intake of fiber; however, mean intake of dietary fiber in each ethnic group was well below the recommended intakes for adults (46), although the results were not inconsistent with other studies (47). Although grain products were the highest contributor of dietary fiber to the diet, it is unlikely that the grains consumed by those participating in this study were whole grains since other studies have shown that intake of whole grains is very low (48). Fruit, vegetables, nut, and legumes were the other sources of fiber in the diet. Fruit contributed very little dietary fiber to any ethnic group, especially to the diets of NHB. The total fiber intake from fruit was less than that found in one medium apple (3.4 g) (36), suggesting that the fruit recommendation was not being met (6). Vegetables contributed more fiber than fruit to the diet; however, amounts were small, especially among NHB. Fiber intake from legumes was highest in MA, confirming results from a previous study that showed MA and other Hispanics (49) were more likely to consume legumes, a rich source of dietary fiber, than not. Part of the failure to meet the dietary fiber recommendations may be a lack of awareness of fiber-rich foods and of the dietary recommendations (5, 50). Cost may be another barrier to consumption of these healthy foods (51). Culturally sensitive interventions may help improve intake of these foods.

All three ethnic groups studied consumed less than half of the recommended intake of 10 μg of vitamin D/day (52) and less than the recommended intakes of 1,000–1,200 mg calcium/day (52). The nutrient contribution of milk and dairy products plays an important role in helping Americans meet recommendations for these nutrients and for potassium (53). Although all ethnic groups had average intakes below recommendations, NHB had the lowest intake of these nutrients. This confirms results from previous studies (54) and is likely the result of the low intake of milk and other dairy foods by NHB (10). A major barrier to dairy consumption among NHB and MA is actual or perceived lactose intolerance (41). Many adults who are lactose intolerant can consume up to one cup of milk at a time without symptoms (55); however, those that are lactose intolerant need to understand this and to understand the importance of dairy foods in the diet. Strategies are available to help those that are lactose intolerant or perceive themselves to be, to consume more dairy products (55). It is important to recognize that in addition to lactose intolerance that cultural food and dietary practices also contribute to low dairy intake (55); however, it is very difficult to meet the recommendations for vitamin D, calcium, and potassium without dairy foods in the diet.

Excess dietary sodium, especially when coupled with low potassium intake, has been linked with hypertension, cardiovascular disease, and osteoporosis (22, 56, 57). Mean sodium intakes were high in all ethnic groups, but were more than double the recommendation of 1,500 mg for NHB promulgated by the 2010 DGA (3). Control of sodium intake is critical since NHB adults have one of the highest prevalence rates for hypertension in the world, with more than 40% of NHB adults having hypertension (19). NHB adults also have a higher prevalence of stroke and stroke mortality than NHW (19). It is critical that individuals make good food choices to help reduce their risk of hypertension, and ultimately stroke and chronic kidney disease; the latter are also found disproportionally among NHB (19, 58). The fact that grain products were the leading source of dietary sodium in all three ethnic groups was not surprising, since bread has been shown to be a major contributor of sodium to the diet (8).

NHB also consumed less than half the recommended intake of potassium; although the NHW and MA consumed slightly more potassium, mean intake fell far short of the recommended level of 4,700 mg/day for adults (53). Food choices contributing to potassium included vegetables, meat, dairy, grains, and fruit; however, not enough of these foods was consumed and it was clear that recommendations for these food groups were not met. Reducing dietary sodium and increasing fruit, vegetables, and dairy products to increase potassium intake are major public health objectives (3). A Dietary Approaches to Stop Hypertension diet, high in potassium, calcium, and magnesium and low in sodium has been shown to be more effective in lowering blood pressure in NHB than in NHW (59).

Overall, nutrient intake of nutrients to limit and those of public health concern is poor, but intake of minorities is generally poorer than that of NHW. Questions not answered in this paper revolve the intake of Hispanics other than MA, the influence of acculturation (60, 61) on dietary intake, and barriers to intake for all ethnic groups. But what is clear is that ethnic interventions need to be designed to improve overall intake of all groups. Understanding of barriers and enabling factors to consumption of specific foods need further study to design these interventions.

Limitations

This study has a number of limitations. Food grouping can have a major influence on the ranked order of food groups; thus, caution is advised when comparing these data to previous reports if there were differences in the level of aggregation (i.e. the number of food groups) or disaggregation procedures used to include ingredients in food groups. Foods were grouped and the groups were collapsed, making it difficult to study the effect of specific foods by the different ethnic groups. Study outcomes are based on self-reported data that tend to underestimate energy intake (62). Another limitation is the possible under-reporting of food intake by some groups, including overweight and obese individuals which have been previously documented in other studies (63). A single day's intake is not representative of an individual's usual intake. However, the mean of the intake distribution drawn from a large, representative sample of a group is not affected by day-to-day variation, and since the contribution of food sources is based on mean intake data from NHANES, the use of a single 24-h recall was appropriate (64).

Further, because the food grouping in the USDA DSN database does not include ingredients of manufactured foods, disaggregated foods represent mixtures that are prepared from recipes. The USDA reduces the sodium content of mixtures if the respondent never, rarely, or occasionally uses salt in cooking, and the food was prepared at home; therefore, a large portion of the salt was added to recipes for foods prepared by restaurants, schools, and other establishments (data not shown). Finally, the updated vitamin D database that USDA released (65) was appropriate for use with the 2005–2006 NHANES dietary intake data; however, since vitamin D intake from foods consumed in 2003–2004 was determined using the updated food composition data, the 2003–2004 intake data may not have been representative of that time period. Any variation in food composition data affects the reliability of dietary intake estimation.

Conclusions

Meeting nutrient intake recommendations while staying within energy needs has proven to be challenging for many Americans, and as a result, individuals may be overweight or obese while being undernourished. This study suggested that nutrient intake by NHW, NHB, and MA could be improved by improving food choices. Ideally, foods containing a constellation of the nutrients of public health concern (3) should be selected without unduly increasing energy intake or contributing to intakes of added sugars, SFA, or sodium. Thus, consumption of whole grains, fruit, vegetables, and low-fat dairy should be increased, calling for profound changes in the diet of all three ethnic groups. Programs tailored to each ethnic group should be developed and provided to these groups. In these programs, specific barriers and enablers should be addressed to maximize their effectiveness.

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