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How much of racial/ethnic disparities in dietary intakes, exercise, and weight status can be explained by nutrition- and health-related psychosocial factors and socioeconomic status among US adults?

Youfa Wang, MD, MS, PhD[*] and **Xiaoli Chen, MD, PhD**
Center for Human Nutrition, Department of International Health, Johns Hopkins Bloomberg School of Public Health

Abstract

Large disparities exist in obesity and other chronic diseases across racial/ethnic and socioeconomic status (SES) groups in the US. This study examined how much of racial/ethnic differences in diet, exercise, and weight status could be explained by nutrition- and health-related psychosocial factors (NHRPF) and SES among US adults. Nationally representative data of 4,356 US adults from the 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII) and the Diet and Health Knowledge Survey (DHKS) were used. NHRPF were assessed using 24 questions and related index scores. Dietary intakes were assessed using two non-consecutive 24-hour dietary recalls. The US Department of Agriculture (USDA) 2005 Healthy Eating Index (HEI) was applied to evaluate diet quality. Body mass index (BMI) was calculated based on self-reported weight and height. SES was assessed using education and household income. Americans with higher SES had better NHRPF and HEI. There were some but small racial/ethnic differences in NHRPF including making food choices and awareness of nutrition-related health risks. Multivariable linear and logistic regression models revealed some racial/ethnic differences in diet, exercise, and BMI, but few of these disparities was explained by NHRPF, while SES explained some. The odds ratio of BMI≥25 for non-Hispanic Blacks comparing with Whites decreased by 38% after SES was adjusted for. For exercise, we found a smaller change (9.5%) in the racial/ethnic differences when controlling for SES. In conclusion, these NHRPF may explain very few, but SES may contribute some of the racial/ethnic disparities in diet, exercise, and weight status in the US.

Keywords

race; ethnicity; psychosocial; nutrition; diet; exercise; body mass index; obesity

[*]Corresponding author Youfa Wang, MD, MS, PhD Associate Professor of International Health and Epidemiology Center for Human Nutrition, Room E2546 Department of International Health Johns Hopkins Bloomberg School of Public Health 615 North Wolfe Street, Baltimore, MD 21205 Tel: 410-502-3102, ywang@jhsph.edu.

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There is no conflict of interest.

INTRODUCTION

In the US, large health disparities exist across racial/ethnic and socioeconomic status (SES) groups regarding obesity and many other chronic diseases (1). A good understanding of the determinants of health disparities is critical to help develop related interventions to eliminate health disparities, which is a national priority (2, 3). Some previous studies have suggested significant racial/ethnic differences in eating behaviors that are independent of SES (4). African Americans may face more negative chronic health condition trajectory compared with their white counterparts (5, 6). Racial/ethnic disparity in obesity in the US may be attributed to racial/ethnic disparity in SES (5), while our previous research suggests ethnic-, sex-, and age- differences in the SES-obesity associations (7-9). Furthermore, only a small proportion of the racial/ethnic differences in body weight may be explained by SES (7-9).

We and others hypothesized that the between-group differences in nutrition- and health-related psychosocial factors (NHRPF) including nutrition knowledge and beliefs (NKB) are important contributors to the large racial/ethnic and SES differences observed in US adults' dietary intakes, exercise, and obesity. Some previous research has found positive associations of good nutrition knowledge, self-efficacy, and beliefs with desirable diet and health outcomes (10-13). However, to our knowledge, no studies have examined whether NHRPF and SES could explain the ethnic disparities in diet, exercise, and obesity in the US.

Using nationally representative data, we examined whether and how much of the racial/ethnic differences in US adults' dietary intakes, exercise, and weight status may be explained by NHRPF and SES. We also tested how much of the racial/ethnic disparities in weight status could be explained by the differences in diet and exercise participation.

METHODS

Study design and subjects

A nationally representative multi-stage stratified sample of 16,103 non-institutionalized persons aged 0 to 90 years residing in the US participated in the US Department of Agriculture (USDA) Continuing Survey of Food Intakes by Individuals (CSFII) 1994-96 (14). Of the 16,103 CSFII 1994-96 participants, 9,872 adults aged 20 years and older provided one to two days of dietary intake information in 24-hour recalls conducted 3-10 days apart. The 24-hour recalls utilized an automated 5-stage multiple-pass approach (15). Demographic, socioeconomic, and lifestyle data were collected for all CSFII participants.

One adult aged 20 years or older per household who participated in CSFII completed the Diet and Health Knowledge Survey (DHKS). They were asked about their self-perceptions of the adequacy of intake levels of nutrients and other dietary components, awareness of diet-health relationships, perceived importance of following dietary guidance for specific nutrients and other dietary components, behaviors related to fat and food safety, knowledge about food sources of fats and cholesterol, and self-perceptions about weight status (16).

Of these, 5765 completed the DHKS. Ninety DHKS participants who provided only one 24-hour recall were excluded. Also excluded were 1,319 participants over age 65 years. These participants were excluded to help obtain a sample of relatively healthy individuals with no potentially special dietary needs. Our analyses included a final sample of 4, 356 individuals (2,219 men and 2,137 women) aged 20-65 years.

Key measures and study variables

Nutrition- and health-related psychosocial factors (NHRPF)—Study participants answered 24 questions regarding NHRPF. Based on their answers, we assigned scores for

each question and then created related several index scores to summarized answers to a set of related questions for each category of NHRPF, respectively.

1) Nutrition knowledge and beliefs (NKB): Each subject was asked about his/her NKB using 11 questions. We calculated an overall NKB score (range: 11-44) to summarize subjects' answers to these questions. A high total score indicated a better NKB.

2) Consideration of key factors affecting food choices: Subjects were asked 6 questions to identify factors they considered important when buying foods, including safety, taste, ease of preparation (convenience), how well the food keeps (freshness), nutrition, and food price. We computed a total score for considerations of food choices (range: 6-24). The higher the score was, the more considerations of high food quality that the subject took.

Furthermore, we evaluated subjects' consideration about the importance of nutrition at food purchase using one question. Subjects who answered 'very important' were categorized as 'nutrition important' group. They were compared with the others.

3) Awareness of nutrition-related health risks: Subjects were asked to respond "yes" or "no" to a question about whether they had heard about any health problems caused by unhealthy eating, such as eating too much fat, salt, cholesterol or sugar, but not enough fiber or calcium. This was evaluated by counting the number of 7 health problems caused by unhealthy eating of which subjects were aware (range: 0-7). The higher the number, the better awareness of health risks subjects had. Subjects were further categorized in the "awareness" group if they were aware of all 7 of these health risks, vs. the other subjects who were less aware.

4) Overall NHRPF score: We created several indices to summarize these NHRPF: Those who had higher NKB (score ≥ median of NKB score); more food choice consideration (food choice score ≥ median), and awareness of the 7 nutrition-related health risks ("awareness" group) were categorized as the "good NHRPF" group, while the others were treated as the "poor NHRPF" group. Note that we only counted the importance of nutrition once when creating the NHRPF index.

5) Intention to improve diet: Subjects were also asked to identify whether they thought about their current diet habits and would be willing to make changes: "The things that I eat and drink are healthy, and there is no reason for me to make changes." Their intention to make changes was assessed by using a 4-point Likert scale ("strongly disagree," "somewhat disagree," "somewhat agree" and "strongly agree"). For our analyses, subjects who answered "strongly disagree" or "somewhat disagree" were grouped as "intention to improve diet" and those reporting "strongly agree" or "somewhat agree" served as the reference group (no intention to improve diet).

The Cronbach's α coefficients were 0.86 for NKB (0.86 for NH Whites or for Blacks; 0.85 for Hispanics; 0.87 for "others"), and 0.74 for awareness of nutrition-related health risks (NH Whites: 0.74; NH Blacks or Hispanics: 0.73; others: 0.79). Overall, the internal consistency reliability of NHRPF measures in this study was acceptable.

Dietary intakes and exercise participation—Based on responses which uncovered types of foods consumed during the two survey days along with their portion sizes, nutrient intakes were calculated by the USDA. Averaged dietary intakes of foods and nutrients from the 24-hour recalls were used. To assess the overall quality of diet, we applied the USDA's new 2005 Health Eating Index (HEI), which has been described elsewhere (17, 18). The HEI was revised to reflect the 2005 Dietary Guidelines for Americans, and consists of 12

components. The HEI ranged 0 to 100 (best). High diet quality was defined as HEI ≥ 80th percentile.

Exercise participation was evaluated by asking one question: "How often do you exercise vigorously enough to work up a sweat?". Those who answered 'rarely or never' were categorized as 'no exercise participation', while subjects who reported regularly exercising were treated as 'exercise participation' group.

Weight status—Body mass index (BMI, kg/m^2) was calculated based on self-reported weight and height. Overweight was defined as 25≤BMI<30; and obesity, BMI≥30.

Sociodemographic characteristics—Based on self-reported information, subjects were grouped as non-Hispanic (NH) Whites, NH Blacks, Hispanics, and others. SES was assessed using education and household income: a) Education: based on "< high school" (< 12 years), "high school" and "> high school"; and b) Household income levels: based on poverty income ratio (PIR): 0-130% (poor, eligible for food stamps), 131-350% (middle income), and ≥ 350% (high income).

Other covariates—(1) Comorbidity: Subjects were reported whether they had chronic diseases diagnosed by their doctors, including diabetes, high blood pressure, heart disease, cancer, osteoporosis, high blood cholesterol, and stroke; (2) Self-rated health: This was assessed based on the following question: "In general, would you say that your health is 1) excellent; 2) very good; 3) good; 4) fair; 5) poor." Subjects with answers of "fair" or "poor" were categorized as being in "fair/poor health" group; (3) Survey year; (4) Geographic region (Northeast, Midwest, South and West); and (5) Degree of urbanization of the geographical area (metropolitan statistical area-central city, suburban, and rural).

Statistical analysis

Our independent variables were NHRPF and SES, while dependent variables included HEI (continuous variable), high diet quality (categorical variable: HEI≥80th vs. HEI<80th percentile) exercise participation (categorical variable: yes vs. no), BMI (continuous variable), overweight/obesity (categorical variable: BMI≥25 vs. BMI<25), and obesity (BMI≥30), respectively. Note that diet and exercise participation became covariates when we studied the changes in the racial/ethnic differences in weight status.

First, we evaluated internal consistency reliability of NHRPF measures (e.g., NKB, food choices score, and awareness of nutrition-related health risk score) by calculating Cronbach's α coefficient (19). The coefficients were 0.86 for NKB (0.86 for NH Whites or Blacks; 0.85 for Hispanics; 0.87 for "others"), 0.55 for food choices (NH Whites or Blacks: 0.52; Hispanics: 0.63; others: 0.63), and 0.74 for awareness of nutrition-related health risks (NH Whites: 0.74; NH Blacks or Hispanics: 0.73; others: 0.79). Overall, the internal consistency reliability of NHRPF measures was acceptable. Second, using the analysis of variance (ANOVA) and χ^2 tests, we tested the differences in the NHRPF index and the individual NHRPF factors and HEI by sociodemographic characteristics.

Third, multivariable linear and logistic regression models were fit to examine whether and how much of the racial/ethnic differences in diet, exercise, and weight status could be explained by NHRPF or SES. In particular, we assessed how the estimated racial/ethnic effects (ie, beta and R^2 in linear regression models and odds ratio (OR) in logistic regression models) would change if NHRPF and SES were included in the models vs. not. The base model included the following variables: survey year, sex, age, education, income, region, urbanization, comorbidity, and self-rated health. In further analysis, we added NHRPF to the models to examine the racial/ethnic differences in diet, exercise, and BMI that could be

explained by NHRPF. We suspected that the differences would become smaller after NHRPF was included.

Furthermore, using multivariable linear regression models, we tested how much of the racial/ethnic disparities in BMI could be explained by diet and exercise. By using normal weight (BMI < 25) as the reference, we fit multinomial logistic regression models for overweight (BMI: 25-29.9) and obesity (BMI≥30). We included survey year, sex, age, education, income, region, urbanization, comorbidity, self-rated health, and NKB in our base models. We then added HEI, energy, exercise to the model to examine the changes in beta or OR.

In all of the multivariate analysis, survey year, age, sex, region, degree of urbanization, chronic disease, and self-rated health were considered as potential confounders. All analysis was conducted using survey-related commands in SAS (version 9.2; SAS Institute, Inc., Cary, North Carolina) to take complex sampling design into account to produce nationally representative estimates and correct estimates of standard errors (SE). Statistical significance was set at $P<0.05$.

RESULTS AND DISCUSSION

Table 1 shows that women, older Americans, those with higher SES (high education or high income), and people with comorbidities had better NHRPF and HEI (all $P<0.001$). There were some but small racial/ethnic differences in NHRPF. NH Whites reported better awareness of nutrition-related health risks (score±SE: 6.04±0.04) than NH Blacks (5.58±0.10), Hispanics (5.49±0.11), and other racial/ethnic group (5.78±0.15) ($P<0.001$). Overall, these NHRPF factors showed desirable associations with healthy eating as indicated by HEI (data not shown in tables).

How much of the racial/ethnic differences in diet, exercise, and BMI could be explained by NHRPF or SES?

In general, compared to NH Whites, NH Blacks had higher BMI and lower HEI, and were less likely to participate in exercise, while Hispanics had better HEI (data not shown in tables). The racial/ethnic differences in diet and BMI changed little after controlling for NHRPF (**Table 2, part A**), but changed some if SES was controlled for (**Table 2, part B**). Once SES was controlled for, the Black-White differences in HEI became smaller, while the White-Hispanic differences became greater. Our linear regression models indicated that the Black-White difference in BMI became smaller (β±SE: 2.07±0.40 vs. 2.26±0.40; % change in beta was small, -8%) if SES were controlled for (e.g., the subjects had similar SES), and our logistic regression models showed similar patterns for overweight and obesity (**Table 2, part B**). After controlling for education and income in the multivariable models, the percent change in beta of HEI (-3.38±0.77 vs. -4.80±0.81, respectively) was 30% for NH Blacks vs. Whites. The OR of overweight and obesity (BMI≥25) for NH Blacks comparing with NH Whites changed by 38% after education and income were adjusted for in the model (OR (95% CI): 1.48 (0.96, 2.29) vs. 2.38 (1.66, 3.40)). For exercise participation, we found a smaller change (10%) in the racial/ethnic differences (NH Blacks vs. Whites) when controlling for SES (0.69 (0.49, 0.96) vs. 0.63 (0.45, 0.89)).

How much of the racial/ethnic differences in weight status were explained by diet and exercise?

The estimated racial/ethnic differences (NH Blacks vs. Whites) in BMI and obesity changed little (% changes in beta or OR were <-3%) after diet and exercise were controlled for (**Table 3**). Similar results were found for Hispanics vs. Whites. It was likely due to the fact

that some overweight and obese subjects might have changed their diet and exercise (what observed in the survey) and due to potential measurement errors.

Our study based on US nationally representative data showed several important findings, which could help enhance the understanding of the complex factors that affect disparities in diet, exercise and obesity across ethnic and SES groups. Our results provided mixed evidence regarding our original hypothesis that NHRPF could help explain some of the ethnic differences in diet, exercise and obesity. We found that the racial/ethnic differences in diet and BMI changed little after controlling for NHRPF in our models.

SES played a more important role than NHRPF to explain the ethnic differences in these outcomes. In our study, the percentage change in HEI was 30% for NH Blacks vs. Whites after controlling for SES. The risk of overweight and obesity for NH Blacks comparing with NH Whites changed by 38% after controlling for education and income, e.g., the black-white difference was reduced by 38%. These findings differ from findings from a recent study. The Exploring Health Disparities in Integrated Communities (EHDIC) study conducted in Southwest Baltimore, Maryland, compared to national data of National Health Interview Survey and found no racial/ethnic disparities in obesity among poor, urban women sharing the same social context (20). The study included 449 black women and 322 white women living in the same social context with similar low income. In our study, the SES factors only explained less than 40% of the black-white difference in obesity.

Ours and previous findings suggest that disparities in obesity in the US are not predominantly due to individual psychosocial differences regarding these selected NHRPF factors, but may be more affected by their broader social environments. Poor-quality retail food environments in disadvantaged areas, in conjunction with limited individual economic resources, contribute to increased risk of obesity within ethnic minorities and socioeconomically disadvantaged populations (21).

The R^2 in our models show that the many variables we included could only explain a very small proportion (10-20%) of the variations in BMI and HEI, which are likely due to the complex factors that affect BMI and HEI and due to potential measurement errors in these outcomes.

Two main limitations of this study are that only self-reported weight and height were collected in CSFII, and it is based on cross-sectional surveys. The study also has several important strengths including that nationally representative data collected from a large sample with rich data regarding NHRPF were used; and we created a set of index scores to measure NHRPF and used the USDA new HEI to assess overall dietary quality.

CONCLUSIONS

These US national survey data show that few of racial/ethnic differences in diet, exercise, and weight status were explained by health- and nutrition-related psychosocial factors, which is different from what we have expected, but SES explained considerable proportion, eg, 30% of the black-white difference in dietary quality and about 40% in overweight and obesity prevalence. However, the reduction in the white-black disparity for exercise participation was small (10%). The underlying causes of ethnic disparities in health related behaviors such as eating and excise and obesity in the US are complicated. More well-designed studies with vigorous and comprehensive assessment of related factors are needed to help advance the understanding. Such knowledge is needed to help develop evidence-based national policies and programs to eliminate health disparities.

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Table 1

Nutrition and health-related psychosocial factors (NHRPF) and healthy eating index (HEI), by sociodemographic characteristics[a]

Characteristic		NKB score[b]		Nutrition important[c]		Food choice[d]		Awareness[e]		Better NHRPF[f]		HEI	
	N	Mean	SE[g]	%	SE	Mean	SE	Mean	SE	%	SE	Mean	SE
Sex													
Men	2219	35.50	0.23***	52.83	1.73***	16.52	0.05***	5.72	0.05***	15.41	1.00***	50.69	0.36***
Women	2137	37.70	0.17	69.25	1.36	16.97	0.04	6.11	0.04	26.82	1.34	53.85	0.5
Age (yrs)													
20-34	1165	35.56	0.26***	54.65	1.67***	16.52	0.07***	5.64	0.06***	13.96	1.22***	50.44	0.65***
35-49	1507	37.04	0.20	62.09	1.59	16.86	0.05	6.04	0.04	23.42	1.63	52.16	0.47
50-65	1684	37.54	0.21	69.55	1.57	16.91	0.05	6.15	0.04	28.59	1.65	55.23	0.43
Race/ethnicity													
NH White	3285	36.67	0.19	58.40	1.20***	16.65	0.05**	6.04	0.04***	21.78	0.87	52.28	0.4***
NH Black	512	36.34	0.32	71.39	3.26	17.26	0.13	5.58	0.10	20.96	3.06	47.60	0.55
Hispanic	411	36.77	0.46	71.58	3.29	16.92	0.18	5.49	0.11	17.93	2.21	54.36	1.02
Other	148	36.11	0.65	58.42	6.53	16.69	0.28	5.78	0.15	20.33	4.72	59.29	1.69
Education													
<High school	731	35.71	0.37***	66.03	3.67	16.91	0.08	5.17	0.10***	10.72	1.18***	49.41	0.64***
High school	1552	36.03	0.29	60.17	1.90	16.70	0.08	5.69	0.05	18.46	1.21	49.91	0.49
>High school	2073	37.20	0.17	60.78	1.17	16.75	0.06	6.24	0.03	25.43	1.21	54.50	0.41
Income													
Low	1079	36.18	0.29*	64.83	2.58	16.75	0.09	5.39	0.06***	12.90	1.49***	49.49	0.75***
Middle	1543	36.40	0.23	61.94	1.45	16.75	0.06	5.85	0.05	20.07	1.60	50.97	0.46
High	1734	36.95	0.20	59.41	1.50	16.76	0.05	6.15	0.05	24.94	1.31	54.37	0.45
Comorbidity													
0	2830	36.28	0.22***	58.88	1.21***	16.70	0.04*	5.83	0.04***	18.94	1.14***	51.80	0.41***
1	951	37.27	0.18	64.63	1.88	16.86	0.07	6.12	0.05	24.89	1.95	52.94	0.59
≥2	575	37.88	0.42	72.08	2.75	16.96	0.12	6.17	0.07	31.29	3.35	54.80	0.73

[a]Controlled for complex survey design. Values are shown as mean (SE) or proportion (SE). P value from ANOVA and/or $\chi 2$ test for continuous and categorical variables, respectively.

[b] NKB=Nutrition knowledge and beliefs; consisting of 11 questions as “To you personally, is it very important (score: 4), somewhat important (score: 3), not too important (score: 2), or not at all important (score: 1) to consume the following nutrients or foods at appropriate levels: salt/sodium, saturated fat, fiber, cholesterol, fruits and vegetables, sugar, dairy products, etc?” The higher the score, the better nutrition kowledge and beliefs (range: 11-44).

[c] Subjects’ consideration about the importance of nutrition at food purchase was assessed by asking “When you buy food, how important is nutrition?” Response ‘very important’ was categorized as ‘nutrition important’ group, while subjects with other responses served as as the reference group.

[d] Food choice: Subjects took considerations of 6 key factors affecting food choices, including food safety, nutrition, price, freshment, convenience, and taste. The higher the score, the more consideration in buying food (score range: 6-24).

[e] Awareness: Subjects were aware of the number of 7 health problems caused by unhealthy eating behaviors, such as fat, cholesterol, sodium, fiber, and calcium. The higher the number, the more awareness of health risks.

[f] Summarized from high NKB (score ≥ median), more food choice consideration (score ≥ median), and awareness of health risks.

[g] SE=standard error

* P<0.05

** P<0.01

*** P<0.001

Table 2

Comparisons of estimated racial/ethnic differences in diet quality, exercise participation, and weight status with and without adjustment for nutrition-and health-related psychosocial factors (NHRPF) or socioeconomic status (SES)

Characteristic	Non-Hispanic Black[a]		Hispanic[a]		
A. Comparison of with and without adjustment for NHRPF[b]					
Linear regression models	Beta (SE[c])	% change[b]	Beta (SE)	% change[b]	*R2*
HEI [d]					
Model 1	-3.37 (0.80)**	-	3.85 (0.92)**	-	0.15
Model 1+NKB[e]	-3.38 (0.77)**	0.30	3.71 (0.87)**	-3.64	0.16
Model 1+Nutrition important[f]	-3.82 (0.83)**	13.35	3.26 (0.92)**	-15.32	0.17
Model 1+Food choice[g]	-3.44 (0.79)**	2.08	3.77 (0.91)**	-2.08	0.15
Model 1+Awareness[h]	-3.15 (0.75)**	-6.53	4.00 (0.89)**	3.90	0.16
Model 1+Intention to improve diet[i]	-3.48 (0.78)**	3.26	3.56 (0.93)**	-7.53	0.16
Model 1+NKB+Nutrition important+Awareness	-3.59 (0.78)**	6.53	3.35 (0.86)**	-12.99	0.19
Model 1+NHRPF[j]	-3.47 (0.78)**	2.97	3.76 (0.91)**	-2.34	0.15
BMI [k]					
Model 1	2.07 (0.41)**	-	0.71 (0.63)	-	0.11
Model 1+NKB[e]	2.07 (0.40)**	0.00	0.72 (0.63)	1.41	0.11
Model 1+Nutrition important[f]	2.12 (0.40)**	2.42	0.77 (0.65)	8.45	0.11
Model 1+Food choice[g]	2.08 (0.42)**	0.48	0.72 (0.63)	1.41	0.11
Model 1+Awareness[h]	2.07 (0.40)**	0.00	0.71 (0.63)	0.00	0.11
Model 1+Intention to improve diet[i]	2.13 (0.39)**	2.90	0.86 (0.62)	21.13	0.12
Model 1+NKB+Nutrition important+Awareness	2.11 (0.40)**	1.93	0.77 (0.65)	8.45	0.11
Model 1+NHRPF[j]	2.08 (0.40)**	0.48	0.72 (0.63)	1.41	0.11
Logistic regression models	OR[l] (95% CI[m])	% change[b]	OR (95% CI)	% change[b]	

Characteristic	Non-Hispanic Black[a]		Hispanic[a]	
High HEI (HEI≥80th)				
Model 1	0.56 (0.31, 1.03)	-	1.74 (1.16, 2.62)*	-
Model 1+NKB[e]	0.55 (0.30, 0.99)*	-1.79	1.69 (1.14, 2.50)*	-2.87
Model 1+Nutrition important[f]	0.51 (0.28, 0.96)**	-8.93	1.57 (1.03, 2.38)*	-9.77
Model 1+Food choice[g]	0.55 (0.30, 1.01)	-1.79	1.70 (1.14, 2.52)*	-2.30
Model 1+Awareness[h]	0.57 (0.31, 1.05)	1.79	1.78 (1.18, 2.68)*	2.30
Model 1+Intention to improve diet[i]	0.55 (0.30, 0.99)*	-1.79	1.65 (1.09, 2.48)*	-5.17
Model 1+NKB+Nutrition important+Awareness	0.52 (0.28, 0.96)**	-7.14	1.57 (1.04, 2.37)*	-9.77
Model 1+NHRPF[j]	0.55 (0.30, 1.00)*	-1.79	1.23 (1.15, 2.59)*	-29.31
Exercise participation				
Model 1	0.69 (0.49, 0.97)*	-	0.84 (0.57, 1.24)	-
Model 1+NKB[e]	0.69 (0.49, 0.96)**	0.00	0.83 (0.55, 1.25)	-1.19
Model 1+Nutrition important[f]	0.65 (0.46, 0.92)**	-5.80	0.81 (0.54, 1.21)	-3.57
Model 1+Food choice[g]	0.67 (0.48, 0.93)**	-2.90	0.84 (0.57, 1.26)	0.00
Model 1+Awareness[h]	0.70 (0.49, 0.98)*	1.45	0.84 (0.57, 1.25)	0.00
Model 1+Intention to improve diet[i]	0.68 (0.48, 0.95)*	-1.45	0.83 (0.56, 1.22)	-1.19
Model 1+NKB+Nutrition important+Awareness	0.66 (0.46, 0.93)**	-4.35	0.81 (0.53, 1.23)	-3.57
Model 1+NHRPF[j]	0.69 (0.49, 0.96)*	0.00	0.83 (0.56, 1.24)	-1.19
BMI≥25				
Model 1	2.35 (1.62, 3.39)**	-	1.48 (0.96, 2.27)	-
Model 1+NKB[e]	2.35 (1.63, 3.40)**	0.00	1.48 (0.96, 2.29)	0.00
Model 1+Nutrition important[f]	2.38 (1.64, 3.47)**	1.28	1.50 (0.96, 2.34)	1.35
Model 1+Food choice[g]	2.30 (1.57, 3.36)**	-2.13	1.46 (0.94, 2.24)	-1.35
Model 1+Awareness[h]	2.35 (1.62, 3.39)**	0.00	1.48 (0.96, 2.29)	0.00

Characteristic	Non-Hispanic Black[a]		Hispanic[a]		
Model 1+Intention to improve diet[i]	2.43 (1.70, 3.49)**	3.40	1.59 (1.02, 2.46)*	7.43	
Model 1+NKB+Nutrition important+Awareness	2.38 (1.64, 3.47)**	1.28	1.51 (0.96, 2.37)	2.03	
Model 1+NHRPF[j]	2.34 (1.62, 3.38)**	-0.43	1.47 (0.96, 2.26)	-0.68	
B. Comparison of with and without adjustment for SES [n]					
Linear regression models	Beta (SE)	% change[n]	Beta (SE)	% change[n]	*R2*
HEI					
Model 2	-4.80 (0.81)***	-	2.29 (0.86)*	-	0.125
Model 2+Income	-3.97 (0.84)***	-17.29	3.09 (0.88)**	34.93	0.136
Model 2+Education	-3.77 (0.73)***	-21.46	3.40 (0.85)***	48.47	0.156
Model 2+Income+Education	-3.38 (0.77)***	-29.58	3.71 (0.87)***	62.01	0.159
BMI					
Model 2	2.26 (0.40)***	-	0.90 (0.58)	-	0.106
Model 2+Income	2.18 (0.41)***	-3.54	0.82 (0.60)	-8.89	0.107
Model 2+Education	2.08 (0.40)***	-7.96	0.73 (0.62)	-18.89	0.111
Model 2+Income+Education	2.07 (0.40)***	-8.41	0.72 (0.63)	-20.00	0.111
Logistic regression models	OR (95% CI)	% change[n]	OR (95% CI)	% change[n]	
High HEI (HEI≥80th)					
Model 2	0.47 (0.26, 0.84)**	-	1.44 (1.01, 2.06)*	-	
Model 2+Income	0.53 (0.29, 0.96)**	12.77	1.65 (1.14, 2.39)*	14.58	
Model 2+Education	0.50 (0.28, 0.91)**	6.38	1.57 (1.07, 2.31)*	9.03	
Model 2+Income+Education	0.55 (0.30, 0.99)*	17.02	1.69 (1.14, 2.50)*	17.36	
Exercise participation					
Model 2	0.63 (0.45, 0.89)*	-	0.73 (0.49, 1.09)	-	
Model 2+Income	0.66 (0.47, 0.92)*	4.76	0.76 (0.52, 1.13)	4.11	
Model 2+Education	0.68 (0.48, 0.96)*	7.94	0.82 (0.54, 1.25)	12.33	

Characteristic	Non-Hispanic Black[a]		Hispanic[a]	
Model 2+Income+Education	0.69 (0.49, 0.96)*	9.52	0.83 (0.55, 1.25)	13.70
Overweight/obesity (BMI≥25)				
Model 2	2.38 (1.66, 3.40)**	-	1.52 (1.02, 2.24)*	-
Model 2+Income	2.43 (1.69, 3.50)**	2.10	1.55 (1.03, 2.35)*	1.97
Model 2+Education	2.26 (1.58, 3.25)**	-5.04	1.44 (0.95, 2.19)	-5.26
Model 2+Income+Education	1.48 (0.96, 2.29)**	-37.82	1.48 (0.96, 2.29)	-2.63

[a] Non-Hispanic white served as the reference group.

[b] Model 1 adjusted for survey year, sex, age, education, income, region, urbanization, comorbidity, and self-rated health. Change in beta or odds ratio (%) from model 1.

[c] SE=standard error

[d] HEI=Health Eating Index

[e] NKB=Nutrition knowledge and beliefs; consisting of 11 questions as “To you personally, is it very important (score: 4), somewhat important (3), not too important (score: 2), or not at all important (score: 1) to consume the following nutrients/foods at appropriate levels: salt/sodium, saturated fat, fiber, cholesterol, fruits and vegetables, sugar, dairy products, etc?” The higher the score, the better nutrition kowledge and beliefs (range: 11-44).

[f] Subjects’ consideration about the importance of nutrition at food purchase was assessed by asking ‘When you buy food, how important is nutrition?’ Response ‘very important’ was categorized as ‘nutrition important’ group, while subjects with other responses served as the reference group.

[g] Food choice: Subjects took considerations of 6 key factors affecting food choices, including food safety, nutrition, price, freshment, convenience, and taste. The higher the score, the more consideration in buying food (score range: 6-24).

[h] Awareness: Subjects were aware of the number of 7 health problems caused by unhealthy eating behaviors, such as fat, cholesterol, sodium, fiber, and calcium. The higher the number, the more awareness of health risks.

[i] Intention to improve diet was assessed by asking subjects whether they thought about their current diet habits and if they would be willing to make changes: “The things that I eat and drink are healthy, and there is no reason for me to make changes.” Subjects who answered “strongly disagree” or “somewhat disagree” were grouped as “intention to improve diet” and those reporting “strongly agree” or “somewhat agree” served as the reference group (no intention to improve diet).

[j] NHRPF summarized from high NKB (score>=median), more food choice consideration (score≥median), and awareness of health risks.

[k] BMI=body mass index

[l] OR=odds ratio

[m] CI=confidence interval

[n] Model 2 adjusted for survey year, sex, age, region, urbanization, comorbidity, self-rated health, and NKB. Change in beta or OR (%) from model 2.

* $P<0.05$

** $P<0.01$

*** $P<0.001$.

Table 3

Changes in the estimated racial/ethnic difference in weight status with and without adjustment for diet and exercise participation[a]

Characteristic	Non-Hispanic Black		Hispanic		
A. Linear regression models	Beta (SE)	% change[b]	Beta (SE)	% change[b]	R2
BMI					
Model 1	2.07 (0.40)*	-	0.72 (0.63)	-	0.11
Model 1+ HEI	2.04 (0.40)*	-1.45	0.75 (0.63)	4.17	0.11
Model 1+Energy	2.06 (0.41)*	-0.48	0.71 (0.63)	-1.39	0.11
Model 1+Exercise	2.06 (0.40)*	-0.48	0.71 (0.64)	-1.39	0.11
Model 1+HEI+Exercise	2.04 (0.40)*	-1.45	0.74 (0.64)	2.78	0.11
Model 1+Energy+Exercise	2.05 (0.41)*	-0.97	0.70 (0.63)	-2.78	0.11
B. Multinomial regression models	OR (95% CI)	% change[b]	OR (95% CI)	% change[b]	
Overweight (BMI: 25-29.9)					
Model 1	1.90 (1.31, 2.75)**	-	1.53 (1.04, 2.25)*	-	
Model 1+HEI	1.89 (1.30, 2.73)**	-0.53	1.54 (1.05, 2.26)*	0.65	
Model 1+Energy	1.89 (1.31, 2.74)**	-0.53	1.54 (1.04, 2.26)*	0.65	
Model 1+Exercise	1.90 (1.31, 2.77)**	0.00	1.54 (1.05, 2.26)*	0.65	
Model 1+HEI+Exercise	1.89 (1.31, 2.74)**	-0.53	1.54 (1.05, 2.27)*	0.65	
Model 1+Energy+Exercise	1.90 (1.31, 2.75)**	0.00	1.54 (1.05, 2.27)*	0.65	
Obesity (BMI≥30)					
Model 1	3.29 (2.09, 5.18)***	-	1.39 (0.71, 2.75)	-	
Model 1+HEI	3.24 (2.09, 5.04)***	-1.52	1.43 (0.73, 2.80)	2.88	
Model 1+Energy	3.27 (2.08, 5.15)***	-0.61	1.39 (0.71, 2.73)	0.00	
Model 1+Exercise	3.25 (2.08, 5.08)***	-1.22	1.38 (0.70, 2.73)	-0.72	
Model 1+HEI+Exercise	3.20 (2.07, 4.96)***	-2.74	1.41 (0.72, 2.78)	1.44	

Characteristic	Non-Hispanic Black		Hispanic	
Model 1+Energy+Exercise	3.23 (2.06, 5.04)***	-1.82	1.38 (0.70, 2.72)	-0.72

[a] Non-Hispanic white served as the reference group. Model 1 adjusted for survey year, sex, age, education, income, region, urbanization, comorbidity, self-rated health, and nutrition knowledge and beliefs.

[b] Change in beta or OR (%) from model 1.

* P<0.05

** P<0.01

*** P<0.001.