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Food Security and Metabolic Syndrome in U.S. Adults and Adolescents: Findings From the National Health and Nutrition Examination Survey, 1999–2006

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Abstract

PURPOSE—We sought to examine the association of food security and metabolic syndrome in a representative sample of U.S. adults and adolescents. We hypothesized that compared with those in food-secure households, adolescents and adults living in food-insecure households would have increased odds of (MetS).

METHODS—Data from the National Health and Nutrition Examination Surveys from 1999 to 2006 were combined and analyzed cross-sectionally. Logistic regression was used to compute odds ratios and 95% confidence intervals (95% CI) in the association of household food security (fully food secure, marginal, low, and very low food security) and MetS.

RESULTS—Compared with those who were food secure, adults in households with marginal food security had 1.80-fold increased odds of MetS (95% CI, 1.30–2.49), and those with very low food security had a 1.65-fold increased odds of MetS (95% CI 1.12–2.42). There was no association with low food security. The association of marginal household food security and MetS was not significant in adolescents. In adults and adolescents, very low was food security not associated with increased odds of MetS compared with those who were food secure.

CONCLUSIONS—Members of households with marginal and very low food security are at increased risk of MetS. A mechanism may be that foods that are inexpensive and easily accessible tend to be energy dense and nutrient poor.

Keywords

Cross-Sectional Studies; Food Security; NHANES; Metabolic Syndrome

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INTRODUCTION

The clustering within individuals of risk factors for cardiovascular disease and diabetes comprises the metabolic syndrome. The metabolic syndrome is associated longitudinally with increased risk for cardiovascular disease and diabetes (1). In several studies, socioeconomic position (SEP), or where a person is oriented in his or her society's social hierarchy (often measured by education and a person's material resources), has been found to be associated with metabolic syndrome (2–5). However, the potential biologic mechanisms behind this association are unclear.

One possible explanation for the association between lower SEP and increased risk of metabolic syndrome is the environmental factors consequent to living at a lower SEP. Food insecurity, which is more prevalent among those living in poverty, may be one such factor. Food insecurity, or not having enough food for an active healthy life because of lack of resources, is a persistent problem in the United States. According to monitoring by the U.S. Department of Agriculture (USDA) using the Current Population Survey, 11.1% of households experienced food insecurity at some point during the year in 2007, and this level of food insecurity has been essentially stable for the previous 3 years (1). Furthermore, households with children were twice as likely to report food insecurity during at least part of the past year compared to households without children.

Food insecurity has been associated with a lack of home availability of nutritious; low-energy dense types of foods, such as fruits and vegetables in adolescents and adults; and also greater intakes of dairy and greater fat intakes among adolescents (6–8). Dietary patterns that are energy dense and low in fruits and vegetables have been found to be associated cross-sectionally with inflammation, obesity and metabolic syndrome (9–11). Thus, it follows that members of food-insecure households are at increased risk of unfavorable risk profiles. This work will be among the first to examine the cross-sectional association of food insecurity with metabolic syndrome in a representative sample of the U.S. population. We used data from the National Health and Nutrition Examination Survey (NHANES) for the years 1999 to 2006 to investigate the cross-sectional association of household food security with metabolic syndrome in Unites States adolescents and adults. We hypothesized that those who reported household food insecurity will have a greater odds of metabolic syndrome compared to those who reported residing in fully food secure households.

METHODS

Data Sources

We combined data from the 1999 to 2006 waves of the NHANES. To combine these data, we used the 4-year weights provided for 1999 to 2002 with the 2-year weights for both 2003 to 2004 and 2005 to 2006 to create an 8-year weight variable as per instructions provided on the CDC website (http://www.cdc.gov/nchs/tutorials/nhanes/SurveyDesign/Weighting/Task2.htm). We created separate weighting variables for adolescents and adults. In brief, NHANES is a cross-sectional, nationally representative survey of the non-institutionalized population administered by the National Center for Health Statistics (12). The NHANES 1999 to 2006 waves used multistage probability cluster sampling method with oversampling

of Mexican Americans, African Americans, and person older than 60 years of age. The survey comprised multiple components: a household interviewer-administered survey, a physical examination in a mobile exam center, and laboratory tests. Details of recruitment and data collection procedures have been previously published and are available on the CDC website (http://www.cdc.gov/nchs/about/major/nhanes).

Food Security Measures

The food security module used in NHANES is the Household Food Security Scale questionnaire developed by the USDA (13). The Household Food Security Scale measures the presence of food security at the household level during the past 12 months (13). We used the household food security measure, which has 18 items for households with children and 10 items for households without children (14). These questions refer to all members of the household, not just NHANES participants. Households were categorized by use of the NHANES suggested categories: fully food secure; marginally food secure; low food security; and very low food security.

Metabolic Syndrome Definitions

In adults, metabolic syndrome was defined by the use of criteria set forth by the National Cholesterol Education Program Adult Treatment Panel III (ATP III) (15). In short, the ATP III criteria are met by three of the following five: increased waist circumference (≥102 cm in men, ≥88 cm in women); triglycerides ≥ 150 mg/mL; high-density lipoprotein cholesterol (HDL-c) <40 mg/dL in men or <50 mg/dL in women); elevated blood pressure (≥130/85 mm Hg); or glucose >110 mg/dL (including diabetes). In adolescents, metabolic syndrome was defined using the age- and sex-specific criteria for each of the five ATP III components published in Jolliffe and Janssen (16).

Statistical Analysis

The study sample was stratified by age into two groups, adolescents (12–19 years) and adults (20 years or older), To be included in these analyses, we excluded pregnant women (n = 1350), those with missing data on household food security (n = 1061), missing data on metabolic syndrome components (n = 16, 945), or implausible values (n = 1147). It should be noted that metabolic syndrome components that are collected via laboratory examination are intentionally not collected on the on every NHANES subject. The final study population consisted of 3113 adolescents and 6138 adults.

SAS Version 9.1 software was used for all analyses (SAS Instituted, Cary, NC). Descriptive statistics, means, standard deviations, and percents were generated for each age group applying the calculated sampling weights (PROC SURVEYMEANS and PROC SURVEYFREQ). Differences across categories of household food security were tested by overall F-test. To ascertain the cross-sectional association of household food security and metabolic syndrome, logistic regression applying the sampling weights (PROC SURVEY-LOGISTIC) was used to compute odds ratios (ORs) and 95% confidence intervals (95% CI). Statistical models were adjusted for age, sex, race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic, and other race, including multirace), and household income ($0 to <$5,000, $500 to <$15,000, $15,000 to <$20,000, $20,000 to <

$24,999, $25,000 to <$35,000, $35,000 to <$45,000, $45,000 to <$55,000, $55,000 to < $65,000, $65,000 to <$75,000, or $75,000 or greater) in adolescents. For adults, models were further adjusted for educational attainment (less than high school, high school diploma, greater than high school) and smoking status (never, past and current). Additional models were examined to determine which individual components of the metabolic syndrome are more strongly associated with household food insecurity.

To address concerns of residual confounding by socioeconomic position by including household income in models, we conducted a sensitivity analysis stratified by poverty-income ratio (<1 and ≥1). The poverty-income ratio (PIR) is the ratio of a family's income to the U.S. Census Bureau's poverty threshold, which varies with the number and ages of family members and is revised yearly (17).

RESULTS

Descriptive characteristics for the study sample are shown in Table 1. Adults reporting food-secure households tended to be slightly older, and a greater percentage were non-Hispanic whites. Food-secure adults also reported greater educational attainment and were more likely to report vigorous physical activity in the last 30 days compared with adults in households with marginal food security, low, and very low food security. Of the metabolic syndrome measures, only systolic blood pressure was difference across categories of household food security. Adolescents from fully food-secure households were more likely to be non-Hispanic white and more likely to report vigorous physical activity in the last 30 days compared with adolescents in households with marginal food security, low, and very low food security. None of the metabolic syndrome measures differed significantly across categories of household food security.

The prevalence of metabolic syndrome components by household food security category is shown in Table 2. Adults from very low food-secure households were more likely to have abnormal glucose and HDL-c less than 40 mg/DL compared with other categories of household food security. Additionally, adolescents from very low food-secure households had more likely to have abnormal glucose. Adolescents from fully food-secure households were also less likely to meet metabolic syndrome criteria for waist circumference. Overall, adults and adolescents from marginally food-secure households were most likely to meet three or more metabolic syndrome criteria compared with other categories of household food security.

Odds ratios and 95% CIs in the association of household food security and metabolic syndrome are shown in Table 3. In Model 1, after adjusting for race/ethnicity, sex, and age, adults reporting marginal food security were 1.94-fold more likely to meet criteria for the metabolic syndrome compared with adults from fully food secure households. Adults from households with low and very low food security were 14% and 76% more likely to meet criteria for metabolic syndrome compared to adults from fully food secure households, respectively. After adjusting for Model 1 variables plus household income, education, and smoking status, the association of food security with metabolic syndrome was attenuated but remained significant in the marginal and very low food secure categories (OR 1.80 and 1.65,

respectively). In adolescents, there was no association between household food security and metabolic syndrome.

We conducted an additional analysis (data not shown) to examine the association of household food security with the individual components of the metabolic syndrome in adults. Compared with adults from fully food-secure households, those in marginally food-secure households were more likely to have high blood pressure (OR, 1.80; 95% CI, 1.36–2.39), whereas there was no association with low and very low household food security. Additionally, adults from very low food-secure households were more likely to have high glucose (OR, 1.46; 95% CI, 1.04–2.06), whereas there was no associated with marginal and low household food security. There was no association between household food security and other components of the metabolic syndrome, that is, waist circumference, triglycerides, and HDL.

We conducted a sensitivity analysis of the relationship of household food security and metabolic syndrome stratified by PIR (data not shown) to examine a possible limitation of our models, that is, that they may contain some residual confounding by socioeconomic position. In these analyses, among those with PIR ≥1 the association with metabolic syndrome was significant across all categories of household food security (2.15, 1.53, 2.75 for marginal, low, and very low household food security, respectively). Among those with PIR <1, marginal household food security was associated with metabolic syndrome (OR, 1.18; 95% CI, 1.18–2.74) only. There was no association between household food security and metabolic syndrome in adolescents regardless of PIR.

DISCUSSION

Our results demonstrate that compared with fully food-secure households, marginal and very low household food security were associated with increased odds of metabolic syndrome in a representative population of U.S. adults after multivariate adjustment. We did not observe an association of household food security with metabolic syndrome in adolescents.

Household food insecurity may be associated with some of the components of the metabolic syndrome. Other studies in which the authors used NHANES data found associations of mild food insecurity with diabetes and dyslipidemia in adults (18, 19). Recently, Seligman et al. (20) reported associations of food insecurity with dyslipidemia, hypertension, and diabetes. However, we did not find clear associations of household food security with the individual metabolic syndrome components, thus suggesting that it is the constellation of the cardiometabolic risk factors that is associated with food insecurity.

Several studies have found an association of food insecurity with overweight status in children and adults (6, 21–25). However, other studies have found no association between food insecurity and obesity and body mass index (26–28). A possible mechanism that may explain the paradoxical association of food insecurity with overweight is that foods that are inexpensive and easily accessible tend to be energy dense and have low nutritional value (29). Individuals living in food-insecure households tend to buy cheaper, calorically dense foods of low nutritional value (29, 30). For a food-insecure household, these foods may

seem attractive because they are inexpensive, convenient, have long shelf lives, and are more readily available in impoverished communities compared to healthful foods (31).

Living in environments lacking healthy foods has been associated with lower dietary quality (32, 33). Also, such dietary choices/patterns could allow individuals to be able to avoid hunger and maintain their caloric requirements. Unfortunately, these types of inexpensive foods may also be high in refined grains and added sugars, which contribute to hyperglycemia, high sodium, which may contribute to hypertension, and high in fats, which contribute to dyslipidemia (34). Consumption of energy dense foods has been associated with increased energy intakes and obesity (10).

An explanation for the association between very low household food security and metabolic syndrome may be that individuals living in food-insecure households do not necessarily experience food shortages at all times. Often these households face both periods when food is easily accessible and times when food is scarce. Individuals facing periodic food restriction may be in a habit of overeating during the times when food is available, for instance, after receiving a paycheck or food stamps, due to a concern about the future scarcity (30, 35). It has been hypothesized that the structure of certain government assistance programs may create a “food stamp cycle” where families have less food for the week and food is restricted before a monthly aid program is given out followed by overeating in the weeks immediately after the aid has been received (35). Those living in very low food-secure households may have not had enough to eat most of the time.

It is possible that extreme dietary behaviors of increased consumption of energy-dense foods are more pronounced in the marginal and very low categories of household food security compared with low household food security. Individuals in low food secure households may avoid the so-called “food stamp cycle” without increased energy intakes of high calorie foods. The low household food security category had the lowest proportion who met the criteria for waist circumference compared with all other categories and lower or comparable proportions who met the criteria for glucose, HDL-c and hypertension in adults.

We did not observe an association of food security and metabolic syndrome in adolescents. One explanation may be that food-insecure adolescents may have access to relatively healthy foods as part of school breakfast or lunch program that can supplement deficits in their at-home diet and reduce the stress of periodic shortages of food at home. Although previous research has shown that food insecure adolescents are more likely to have greater than 30% of their calories come from fat, other studies of both children and adolescents did not find food insecurity to be associated with a greater energy density diet or other nutritional outcomes (6, 10). Alternatively, this may reflect the resilience of youth because the detrimental effects of low-diet quality/poor dietary patterns may not have accumulated to levels that result in elevate risk factors.

Previously, it has been hypothesized that children may be somewhat protected from the adversity of food insecurity because adults in a household may sacrifice eating to prevent hunger in their children (35). A final possibility is that the cutoffs we used for adolescent metabolic syndrome were not ideal. Although we used the most commonly accepted criteria,

there is still disagreement on what is the best definition of metabolic syndrome for youth and the various cutoffs give rise to differing prevalence of metabolic syndrome (36).

Strengths and Limitations

Our study is limited by the cross-sectional nature of NHANES. We have no ability to determine whether household food insecurity preceded metabolic syndrome. However, there are few reasonable hypotheses that would have metabolic syndrome causing food insecurity. It has been hypothesized by Seligman et al. (18) that individuals with diabetes may preferentially allocate limited resources toward medical expenses rather than grocery bills, resulting in increased levels of food security, but metabolic syndrome is not a condition that would necessarily confer medical expenses. Thus, it seems unlikely that a similar shift in resource allocation could explain associations. This research is bolstered by other strengths of the NHANES design, including the large sample size, which is representative of U.S. adults and adolescents as well as the use of valid measures of food security and metabolic syndrome. However, on the basis of our lack of significant findings in the relatively small number of adolescents, we cannot rule out the null hypotheses that there is no association between household food security and metabolic syndrome. Additionally, given the comprehensive nature of the NHANES exam, we were able to adjust for many potential confounders of the association between household food security and metabolic syndrome.

Future Directions

Future research is needed at multiple levels and should examine factors at the individual level (dietary habits, nutrient intake), household level (food availability), and the environmental level (policies related to food security, food availability in a community). Policies and programs directed at food insecurity and their impact on eating patterns and misnutrition should be examined. Additionally, longitudinal studies are needed to examine the temporal relationship between food insecurity and metabolic syndrome as well as potential mediators in this relationship. These are important questions with relevance to public health interventions.

CONCLUSION

Despite the fact that the United States is one of the wealthiest nations in the world, household food insecurity continues to be prevalent. Our results demonstrate that food marginal and very low food security may be associated with cardiometabolic risk in adults. Further characterization of dietary patterns associated with household food insecurity as well as investigation into issues related to household food security may explain the association of food security with metabolic syndrome and identify opportunities for intervention.

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Selected Abbreviations and Acronyms

SEP	socioeconomic position
USDA	United States Department of Agriculture
NHANES	National Health and Nutrition Examination Survey
ATP III	Adult Treatment Panel III
HDL-c	high-density lipoprotein cholesterol
95% CI	95% confidence interval
PIR	poverty income ratio
OR	odds ratio

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TABLE 1

Characteristics of a representative population of U.S. adults and adolescents stratified by household food security status, NHANES 1999–2006[a]

	Full food security	Marginal food security	Low food security	Very low food security
Adults, 21 or more years, n	4892	450	536	260
Mean (SE) or %[b]				
Age, years[c]	47.6 (0.4)	41.7 (0.9)	40.3 (0.7)	41.1 (1.1)
Male, %[c]	50	43	48	49
Race/ethnicity, %[c]				
Mexican American	5	15	28	10
Other Hispanic	4	14	9	14
Non-Hispanic white	78	43	43	54
Non-Hispanic black	9	22	15	20
Other[d]	4	6	5	2
Educational attainment, %[c]				
Less than high school	15	35	39	40
High school diploma	25	27	26	28
Greater than high school	59	37	35	31
Current smoker, %[c]	19	32	29	48
Body mass index, kg/m sq[c]	27.7 (0.1)	29.4 (0.5)	8.1 (0.3)	28.3 (0.6)
Waist, cm	95.9 (0.3)	98.0 (1.2)	95.4 (0.9)	96.8 (1.7)
Triglycerides, mg/dL	1.18 (1.1)	126.0 (4.4)	124.8 (3.2)	129.0 (4.7)
Glucose, mg/dL	99.6 (0.4)	101.7 (1.7)	99.0 (1.0)	104.2 (1.8)
HDL, mg/dL	87.5 (2.3)	83.3 (4.0)	85.9 (3.9)	90.4 (4.9)
Systolic blood pressure, mg Hg[c]	122.2 (0.4)	123.6 (1.0)	119.3 (0.9)	121.3 (0.8)
Diastolic blood pressure, mg Hg	72.4 (0.2)	71.9 (0.6)	71.9 (0.5)	72.6 (0.6)
Adolescents 12–19 years,	2099	275	486	266
Age, years	15.7 (0.1)	15.4 (0.2)	15.2 (0.2)	15.3 (0.2)
% male[c]	50	40	56	50
Race/ethnicity, %[c]				
Mexican American	8	20	24	16
Other Hispanic	4	10	10	17
Non-Hispanic White	68	35	36	46
Non-Hispanic Black	11	31	23	28
Other[d]	8	3	7	3
Ever smoked, %	41	41	49	47
Body mass index, kg/m sq[c]	22.9 (0.2)	24.4 (0.6)	23.2 (0.4)	23.6 (0.5)
Waist, cm	80.2 (0.5)	82.8 (1.4)	80.6 (1.0)	81.9 (1.3)
Triglcyerides, mg/dL	88.6 (1.5)	94.5 (5.3)	86.0 (3.9)	90.3 (5.3)
Glucose, mg/dL	91.4 (0.4)	91.9 (0.7)	92.9 (1.2)	90.9 (0.7)

	Full food security	Marginal food security	Low food security	Very low food security
High-density lipoprotein, mg/dL	76.8 (2.2)	68.9 (2.7)	73.9 (3.1)	84.7 (3.9)
Systolic blood pressure, mg Hg	109.4 (0.3)	110.7 (0.7)	109.2 (0.8)	109.2 (0.8)
Diastolic blood pressure, mg Hg	64.7 (0.3)	63.3 (0.9)	64.6 (0.7)	63.4 (0.8)

Values are mean (SE) or %.

NHANES = National Health and Nutrition Examination Survey.

[a] NHANES mobile examination center weights and design corrections were applied.

[b] Column totals may not add up to 100% because of rounding.

[c] Indicates significant differences across household food security categories at the $p < .05$ level.

[d] Other race includes multiple races.

TABLE 2

Prevalence of metabolic syndrome components in a representative sample of U.S. adolescents and adults, NHANES 1999–2006[a]

Percent exceeding cutoff[b]	Full food security	Marginal food security	Low food security	Very low food security
Adults, n	4892	450	536	260
Waist, % ≥102 cm in men or ≥ 88 cm in women	62	67	57	61
Triglycerides, ≥ 150 mg/mL	28	29	31	30
Glucose, % >110 mg/dL	36	26	36	39
High-density lipoprotein, % <40 mg/dL in men or <50 mg/dL in women	22	35	22	29
High blood pressure, % ≥130/85 mm Hg[c]	41	28	28	38
Meeting three or more metabolic syndrome criteria, %[c]	30	47	27	35
Adolescents	2099	275	486	266
Waist[c]	18	31	22	26
Triglycerides	12	14	11	13
Glucose	9	11	11	13
High-density lipoprotein	75	64	78	78
High blood pressure	7	13	10	7
Meeting three or more metabolic syndrome criteria, %	5	5	8	6

NHANES = National Health and Nutrition Examination Survey.

[a] NHANES mobile examination center weights and design corrections were applied.

[b] For adolescents cut-off criteria for each of the five items vary by age and sex.

[c] Indicates differences across household food security categories are significant at the $p < .05$ level.

TABLE 3

Odds ratios (ORs) and 95% confidence intervals (95% CI) for the cross-sectional association of household food security and metabolic syndrome in US adults and adolescents, NHANES, 1999–2006[a]

	Full food security	Marginal food security	Low food security	Very low food security
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Adults				
Model 1	1.00 (REF)	1.94 (1.41–2.65)	1.14 (0.93–1.40)	1.76 (1.25–2.47)
Model 2	1.00 (REF)	1.80 (1.30–2.49)	1.03 (0.83–1.29)	1.65 (1.12–2.42)
Adolescents				
Model 1	1.00 (REF)	1.04 (0.38–2.86)	1.49 (0.79–2.82)	1.18 (0.47–2.95)
Model 2	1.00 (REF)	0.94 (0.35–2.51)	1.12 (0.57–2.17)	0.89 (0.35–2.23)

NHANES = National Health and Nutrition Examination Survey.

Model 1 was adjusted for race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic, and other race including multi race), sex, and age.

Model 2 was adjusted for race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican-American, other Hispanic, and other race including multi race), gender, age, household income ($0 to <$5,000, $500 to <$15,000,$15,000 to <$20,000, $20,000 to <$24,999, $25,000 to <$35,000, $35,000 to <$45,000, $45,000 to <$55,000, $55,000 to <$65,000, $65,000 to <$75,000, or $75,000 or greater), smoking status (never, past, current), and education (less than high school, high school diploma, greater than high school in adults only).

[a]NHANES mobile examination center weights and design corrections were applied.