Food Insecurity and Its Association With Central Obesity and Other Markers of Metabolic Syndrome Among Persons Aged 12 to 18 Years in the United States

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Context: Food insecurity is a preventable health threat and may precipitate central obesity and metabolic syndrome in children and adolescents in the United States.

Objective: To examine (1) health by household food security status; and (2) differences and prevalence of central obesity among persons aged 12 to 18 years in the United States.

Methods: The National Health and Nutrition Examination Survey was administered to a cross-sectional sample of persons aged 12 to 18 years in 1999 to 2006. Controlling for age, race/ethnicity, and sex differences in mean obesity and chronic disease factors across levels of food insecurity (analysis of covariance [Bonferroni post hoc] and ORs [logistic regression analyses]) were examined, as were differences in the rates of risk factors (χ^2 statistics).

Results: A total of 7435 participants were analyzed. Those from marginally food secure (n=751) and low–food secure (n=1206) (population size estimate, 26,714,182) households were significantly more likely than their high–food secure counterparts (n=4831) to be overweight (*P*=.036) (OR, 1.44), and those from marginally food secure households were 1.3-times more likely to be obese (*P*=.036). Nearly 25% of respondents from marginally food secure, low–food secure, and very low–food secure (n=647) households reported central obesity (*P*=.002), which was 1.4 to 1.5 times more likely than those from high–food secure households. Participants from high–food secure households had significantly higher mean high-density lipoprotein values (*P*=.019). Risk factors indicative of metabolic syndrome were present in 3.1%.

Conclusion: Household food insecurity was associated with an increased likelihood of being overweight and having central obesity. Limitations included the use of cross-sectional data and some self-reported data and the inability to control for all moderating variables in obesity and overall health status.

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Food insecurity, defined as lacking access to food for an active, healthy life, is a preventable health threat. Yet, deprivation in basic access to food still exists in the United States and affects 14.3% of all households and 19.5% of households with children.[1-2] Severely low levels of food security among children has almost doubled from 2003 to 2013.[2]

Food insecurity is important to primary care osteopathic physicians because it can lead to physical impairments related to insufficient food (eg, illness and fatigue), psychological issues caused by lack of access to food (eg, feelings of constraints to go against held norms and values and stress), and sociofamilial disturbances (eg, modification of eating patterns

and related ritual and distortion of the means of food acquisition and management).[3,4] For children and adolescents in the United States, some studies have shown food insecurity to be positively related to being overweight and obese[5-9] and having lower dietary quality (ie, less healthy food selections and a greater likelihood for nutrient inadequacies).[8,10-15] Yet, the evidence remains conflicted about the relationships between food insecurity and obesity

Using National Health and Nutrition Survey Examination (NHANES) data,[16] the objectives of the present study were to examine health markers by household food security status and the differences and prevalence of central obesity in the United States among persons aged 12 to 18 years. We hypothesized that household food insecurity rates would be associated with increased likelihood of being overweight, having central obesity, and having poorer health.

Methods

We used public NHANES data obtained between 1999 and 2006.[16] Inclusion criteria were participants aged 12 to 18 years with waist circumference (WC) data, which is typically used to measure central obesity, in addition to data for at least 2 more parameters included in the International Diabetes Federation (IDF) criteria for diagnosis of metabolic syndrome in children and adolescents.[17] Women who were pregnant at the time of data collection were excluded. The protocol for the present study was approved by the National Center for Health Statistics' Research Ethics Review Board. The present study was exempt from institutional review board approval at Ohio University and The Ohio State University because the data are publicly available. Demographic data for the present study were collected through NHANES' in-home interviews. Dietary intake, laboratory results, health history questionnaires, and physical examination data were collected from the scheduled visits to the NHANES mobile examination center.

NHANES In-Home Interview

Data on age, race/ethnicity, sex, household income, and food security status were collected during the interviews. An adult in each participant's household also responded to the US Household Food Security Survey Module questions, which comprised 18 items. Affirmative responses were used to compute scale scores for household food security status.[1] *Table 1* summarizes the food security status categories.

NHANES Mobile Examination Center Visit

Anthropometric and laboratory data collected during the mobile examination center visit were used to assess the prevalence of central obesity and risk for chronic disease and metabolic syndrome. Age in months, height, sex, WC, and weight were exported to Epi Info (version 3.3.2; US Centers for Disease Control and Prevention) to generate age- and sex-specific body mass index (BMI)-for-age percentiles based on the 2000 Centers for Disease Control and Prevention growth charts.[18] Weight status was categorized using the following criteria of BMI-for-age and sex percentile: underweight (<fifth percentile), normal weight (≥fifth to <85th percentile), overweight (≥85th to <95th percentile), and obese (≥95th percentile). Central obesity was defined by WC with race-specific values; however, central obesity was also considered to be present if the BMI was greater than 30 kg/m².[17] To adjust for the varying criteria for WC values by age and sex, a proportion of the measured WC value to the threshold value was computed for comparison of numeric data.

Metabolic syndrome was determined using the criteria set forth by the IDF.[17] Diagnostic criteria required WC greater than the 90th age- and sex-specific percentile and any 2 of the following: (1) low high-density lipoprotein (HDL) (<40 mg/dL); (2) elevated blood pressure (≥130/85 mm Hg); (3) elevated blood glucose (≥100 mg/dL); or (4) elevated triglycerides (TG) (≥150 mg/dL). Data were coded for the presence of each

Table 1.
Food Security Categories of US Households With Persons Aged 12 to 18 Years[1-2]

Category	Definition
High food security	No indications of food access problems or limitations
Marginally food security	1 to 2 indications of food access problems or limitations, typically of anxiety over food insufficiency or shortage of food in the household; little or no indication of changes in diet or food intake are reported
Low food security	3 to 5 indications of reduced quality, variety, or desirability of diet; little or no indication of changes in diet or food intake are reported
Very low food security	6 to 10 indications of multiple indications of disrupted eating patterns and reduced food intake

of the risk factors and metabolic syndrome. Other health measures examined were glycosylated hemoglobin, total cholesterol, and low-density lipoprotein (LDL). A fast of at least 6 hours was required for all health parameters.

Statistical Analysis

Analyses were performed using SPSS statistical software (version 18.0; IBM Corp). All data were presented as unweighted sample size and weighted population percentage. Differences in the mean obesity and chronic disease factors across levels of food insecurity (categorical variable) were performed using analysis of covariance with Bonferroni post hoc comparison, controlling for age, race/ethnicity, and sex. Differences in the prevalence of risk factors and metabolic syndrome were examined using χ^2 statistics. Logistic regression analyses were also performed to generate ORs, controlled for age, race/ethnicity, and sex. All analyses were performed using the sampling weights, which correct for the oversampling of target populations to create a nationally representative sample and produce sample-specific SEs for statistical testing.

Results

Of 7701 participants obtained from the NHANES data[16] obtained between 1999 and 2006, 7435 had food security data and were included in the present study. Of the participants, 3822 of 7435 (51.4%) were boys, and 3613 (48.6%) were girls. Of 7435 participants, 4610 (62.0%) were non-Hispanic white, 2366 (14.2%) were non-Hispanic black, 2579 (10.8%) were Mexican American, 283 (6.2%) were other Hispanic, and 307 (6.7%) were other race or multiracial. The percentages of each race/ethnic group were weighted; using the sample sizes to calculate percentages did not yield an accurate distribution. The mean (SD) age of the participants was 14.9 (.06) years.

Table 2 summarizes the mean differences in health measures by household food security, and *Table 3* presents the proportion and likelihood of participants to present with markers of chronic disease. We found no significant differences in mean BMI-for-age percentiles by household food security status (*P*=.087; *Table 2*); however, participants from marginally food secure and low–food secure households were significantly more likely than their high–food secure counterparts to be overweight (OR, 1.44), and those from marginally food secure households were 1.3 times more likely to be obese (*P*=.036; *Table 3*).

Significant differences in central obesity were evident among levels of food security status. Participants from low– or very low–food secure households had a significantly higher mean percentage of WC thresholds (*P*<.001; *Table 2*). Nearly a quarter of participants from marginally food secure, low–food secure, and very low–food secure households presented with central obesity, which was 1.4 to 1.5 times more likely than participants from high–food secure households (*P*=.002; *Table 3*).

No statistically significant differences were found in mean levels of blood glucose, total cholesterol, and TG, and blood pressure across levels of household food security. Participants from high–food secure households had significantly higher mean HDL values compared

with those from marginally food secure, low–food secure, and very low–food secure households (*P*=.019; *Table 2*). The low HDL risk factor was the most prevalent risk factor in all participants, but prevalences were not significantly different by food security status (*Table 3*). Relatively few of the participants (2.8%-7.3%) presented with the glucose (n=243), TG (n=368), or blood pressure markers (n=387). Overall, 3.1% (n=246) of all participants presented with the WC marker and at least 2 additional markers indicative of metabolic syndrome *(Table 3)*.

Discussion

Because food insecurity is a preventable health threat, primary care osteopathic physicians in the United States must understand the relationship of central obesity, food insecurity, and metabolic syndrome in children and adolescents in light of obesity in these age groups.[19-22] Data from the present study indicated that household food security is associated with decreased risk for being overweight and having central obesity among children and adolescents. Participants from high–food secure and marginally food secure households had a lower prevalence of obesity than the national average level of 18.4%.[23] Conversely, those from low–food secure and very low–food secure households were significantly more likely to present as overweight and obese and had a prevalence of obesity greater than the national average level of 18.4%.[23] These data conflict with those of other studies,[3,24-30] indicating that further research is needed to elucidate the consistency and magnitude of the problem.

To delay or prevent the development of overt disease, physicians must identify patients at risk for metabolic disorders before clinical manifestations emerge.[17,31-39] In the present study, participants from marginally food secure, low–food secure, and very low–food secure households were found to be more likely to be centrally obese than their high–food secure counterparts. Because central obesity is a prerequisite for metabolic syndrome, this finding may foretell that children and adolescents from households characterized as marginally food secure, low–food secure, and very low–food secure are at greater risk for metabolic syndrome than those from fully food secure households. Until the relationship of food insecurity on child and adolescent weight status is fully clarified, the potential for the development of obesity-related metabolic syndrome among this age group is unclear.

Metabolic syndrome prevalence in the present study was lower than the national level. According to Cook et al,[40] 1 million persons aged 12 to 19 years in the United States were estimated to have metabolic syndrome, or 4.2% overall (6.1% of boys; 2.1% of girls) from 1988 to 1994. The prevalence of metabolic syndrome has since increased among US children and adolescents and is particularly prevalent (>30%) in overweight children and adolescents.[41] A possible reason for this difference is that Cook et al[40] used the modified National Cholesterol Education Program Adult Treatment Panel III criteria, whereas we used IDF criteria. The samples were also in different age groups, and the periods of the studies were different. The trends of metabolic syndrome among children and adolescents should be explored using a consistent definition of metabolic syndrome.

Because participants from high–food secure households have greater levels of physical activity, fewer resource constraints, or live in neighborhoods with more infrastructure,[42] they have significantly higher HDL levels than those from households with food security who may live in neighborhoods that could be unsafe or isolated, limiting physical activity.[43] Participants from high–food secure households may also have diets that avoid inexpensive high-fat, high-sugar, and energy-dense foods. Although results from the present study indicate that there is a statistically significant difference, the clinical importance of that difference is questionable.

Participants from high–food secure households and low–food secure households had no significant

Table 2.
Health Measures for US Persons Aged 12 to 18 Years by Household Food Security Status[a] (N=7435)

Risk Factor	Mean Total	High Food Security (n=4831 [75.9%])	Marginally Food Security (n=751 [7.1%])	Low Food Security (n=1206 [10.8%])	Very Low Food Security (n=647 [6.2%])	*P* Value
BMI-for-age percentile	63.1	62.6 (61.10-64.0)	66.1 (61.10-71.10)	66.2 (63.40-69.10)	65.4 (61.20-69.70)	.087
Cholesterol, mg/dL	160	160 (159.0-162.0)	162 (158-167)	158 (155.0-161.0)	161 (155.0-166.0)	.624
Diastolic blood pressure, mmHg	61	61.1 (60.40-61.90)	60.4 (59.20-61.50)	61.7 (60.50-62.80)	59.5 (57.50-61.60)	.233
Glucose, mg/dL	86.4	86.4 (85.90-86.80)	86.7 (85.30-88.0)	85.9 (85.0-86.80)	86.8 (85.50-88.0)	.551
Glycosylated hemoglobin, %	5.13	5.14 (5.12-5.16)	5.14 (5.11-5.17)	5.14 (5.10-5.17)	5.32 (5.07-5.58)	.338
HDL, mg/dL	50.5	51.2 (50.80-51.70)	49.6 (48.30-51.0)	49.7 (48.70-50.70)	49.8 (48.40-51.10)	.019
LDL, mg/dL	90.4	90.5 (88.80-92.30)	94.5 (89.60-99.30)	89.9 (86.20-93.70)	87.6 (83.0-92.30)	.204
Metabolic syndrome risk factors, No.	0.42	0.33 (0.30-0.36)	0.41 (0.30-0.51)	0.42 (0.34-0.50)	0.49 (0.39-0.60)	.018
Systolic blood pressure, mmHg	109	109 (108.0-109.0)	109 (108.0-111.0)	109 (108.0-110.0)	110 (108.0-111.0)	.502
Triglyceride, mg/dL	84.5	82.6 (79.20-86.0)	84.2 (76.0-92.40)	82.6 (76.60-88.60)	90.9 (82.0-99.70)	.444
Waist circumference[b]	88.5	87.9 (87.20-88.60)	87.9 (88.60-92.80)	90.4 (89.0-91.90)	91.1 (88.90-93.30)	<.001

[a] Data are given as mean (95% CI) unless otherwise indicated. Nonoverlapping CIs represent significant differences (*P*<.05).
[b] Percent of age- and sex-specific threshold criteria for the waist circumference risk factor.

Abbreviations: BMI, body mass index; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

differences in mean diastolic blood pressure, LDL, systolic blood pressure, TG, and total cholesterol by household food security status, which are consistent with findings in adults.[7] Future studies should focus on children and adolescents to further explore these trends because women from marginally food secure homes are at greater risk for abnormal levels of LDL cholesterol and TG:HDL cholesterol ratio.[44]

Several factors may account for the differences seen in the present study compared with national estimates. The national estimates for food insecurity are determined using Current Population Survey (CPS) data of a nationally representative sample,[45] and we used NHANES data, which are taken from a nationally representative sample.[46] More specifically, the NHANES data represent a sample of individuals instead of households, but the main food security measure is at the household level. If person-weighted statistics in the CPS for the same period are compared, the data are similar (M. Nord, oral/written communication, July 2010). In principle, the NHANES is nationally representative when weighted; therefore, the CPS and the NHANES

Table 3.
Percentage and Likelihood of Persons Aged 12 to 18 Years Having Risk Factors for Chronic Disease by US Household Food Security Status (N=7435)

Risk Factor	Total No. (%)	High Food Security[b]		Marginal Food Security		Low Food Security		Very Low Food Security		*P* Value
		No. (%)	OR (95% CI)	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)	
Blood pressure	199 (5.1)	139 (4.9)	1.0 (Referent)	21 (3.8)	0.83 (0.54-1.28)	28 (4.6)	0.99 (0.54-1.81)	11 (7.3)	1.49 (0.94-2.34)	.308
Central obesity	82.9 (19.2)	516 (17.6)	1.0 (Referent)	87 (25.4)	1.52 (1.08-2.15)	140 (23.8)	1.42 (1.11-1.80)	86 (24.7)	1.51 (1.10-2.08)	.002
Glucose	114 (3.4)	73 (2.8)	1.0 (Referent)	7 (3.1)	1.01 (0.55-1.86)	22 (3.7)	1.20 (0.73-1.97)	12 (5)	1.74 (0.78-3.85)	.592
HDL	1267 (31.9)	825 (28.1)	1.0 (Referent)	130 (31.4)	1.27 (0.94-1.72)	208 (33)	1.42 (1.09-1.84)	104 (31.2)	1.33 (1.02-1.73)	.297
Metabolic syndrome	144 (3.1)	86 (2.8)	1.0 (Referent)	15 (3.7)	1.41 (0.78-2.52)	28 (3.3)	1.25 (0.79-1.98)	15 (5)	1.84 (1.19-2.84)	.082
Overweight[b]	677 (32.7)	396 (30.5)	1.0 (Referent)	56 (40.5)	1.44 (1.12-1.87)	120 (40.6)	1.44 (1.13-1.84)	55 (38)	1.33 (0.98-1.79)	.001
Obese[b]	794 (16.8)	496 (15.5)	1.0 (Referent)	92 (21.3)	1.32 (1.01-1.74)	130 (20.3)	1.24 (0.98-1.59)	76 (21.6)	1.38 (1.04-1.84)	.036
Triglyceride	236 (6.3)	142 (5.3)	1.0 (Referent)	24 (6)	1.41 (0.62-3.23)	48 (5.6)	1.27 (0.82-1.99)	22 (6.3)	1.38 (0.86-2.23)	.970

[a] High food security serves as the reference group to which the other groups are compared for likelihood to present with the risk factor.
[b] Overweight was defined as greater than or equal to 85th percentile and obesity was defined as greater than 95th body mass index–for-age percentile.

Abbreviation: HDL, high-density lipoprotein.

should be in rough agreement. Yet, use of the NHANES data may account for differences seen. In addition, participants aged 12 to 18 years were included in the present study. The national estimates for households with children include persons aged 18 years or under. Older children may be at greater risk for food insecurity,[47] which also may account for our results.

The present study had several limitations. First, the assessment of cross-sectional data cannot determine a causal relationship. Our data represent participant characteristics from a snapshot in time. Second, inherent self-reporting and recall bias may have occurred because some NHANES data are self-reported (eg, household food security status). Third, some laboratory values for markers of chronic diseases were not collected after an ideal 8- to 12-hour fast, which limited our ability to precisely detect the presence of risk; however, nonfasting data were carefully assessed to provide conservative estimates of disease risk. Fourth, data availability limited the analyses conducted, and all moderating variables in obesity and overall health status for which could not be controlled. Finally, the analyses associated with the present study were conducted before the reallocation of oversampled populations in 2006, and the newer samples lack the sample size to conduct such analyses.

Conclusion

Household food insecurity was associated with an increased likelihood for being overweight and having central obesity among the 12- to 18-year age group. Improving access to adequate nutrient-dense, culturally and individually desirable foods obtained by socially acceptable means, for an active and healthy life may be the best preventive measure especially during formative childhood and adolescent years. Primary care osteopathic physicians, in collaboration with registered dietitians and other members of the health care team, should focus on

nutrition assessment and education efforts to address the potential ramifications of food insecurity on dietary habits and should identify strategies and resources to promote optimal nutritional status on limited resources. Future studies in this population should explore any differences in risk for obesity and metabolic syndrome by age, race/ethnicity, and sex as well as the relationship between food insecurity and diabetes and cardiovascular disease. Studies should also focus on interventions to improve food security among children and adolescents.

Author Contributions

Drs Holben and Taylor provided substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; Drs Holben and Taylor drafted the article or revised it critically for important intellectual content; Drs Holben and Taylor gave final approval of the version of the article to be published; and Drs Holben and Taylor agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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