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Food Insecurity Is Not Associated with Childhood Obesity as Assessed Using Multiple Measures of Obesity[1–3]

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Abstract

There has been extensive previous research examining the connection between obesity and food insecurity, 2 serious nutrition challenges facing low-income children in the US. All of this work used BMI to categorize a child as obese. Although BMI is one way to categorize the obesity status of a child, other measures have not been used to understand the connection between food insecurity and obesity. In response, this study used multiple measures of obesity taken from the 2001 to 2004 NHANES. The sample included 2516 children between the ages of 8 and 17 y in households with annual incomes <200% of the poverty line. Within this sample, 36.6% of children were in food-insecure households. The prevalence of obesity depended on the measure employed (BMI, waist circumference, triceps skinfold thickness, trunk fat mass, body fat), with prevalence rates ranging from 15.4 to 44.8%. Logistic regression models estimated the probability of a child being obese using multiple measures of obesity conditional on food-insecurity status and other covariates. The results indicated that food-insecure children were no more likely to be obese than their food-secure counterparts across all measures of obesity. This relationship held after controlling for other factors and examining subpopulations based on race/ethnicity, gender, and race/ethnicity and gender. These results suggest that efforts to alleviate food insecurity and childhood obesity will work independently. J. Nutr. 139: 1173–1178, 2009.

Introduction

The problem of pediatric obesity in the United States has been well documented (1,2). As measured by BMI, recent estimates indicate that almost 1 in 5 children are considered obese (1). Both genetic (3,4) and environmental (5–7) factors contribute to the energy imbalance that leads to obesity. Another public health concern in the US is food insecurity. A household is considered food insecure if it does not have the financial means to access enough food for all household members to sustain active, healthy living (8). Approximately 1 in 5 children in the US lives in a food-insecure household as measured via the USDA Core Food Security Module (CFSM)[6] with substantially higher rates for those below the poverty line (8). Both obesity and food insecurity have been shown to lead to a plethora of medical problems for children (9–15).

Research on the relationship between food insecurity and childhood obesity has lead to mixed results. Some studies have found a positive relationship (16–19), others have found no relationship (10,20–25), others have found a negative relationship (26–28), and 1 study found that the relationship depended on whether self-reported or measured heights and weights were used (29). Food insecurity has also been found to influence obesity through its interaction with stress (30,31) and with depression, parenting, and infant feeding (32). This work has used a variety of data sets and methods. Common to all these studies is the use of a child's BMI to delineate whether he or she is obese, overweight, healthy weight, or underweight.

The central advantage of using BMI to establish the weight status of a child is that, compared with other measures of obesity, stature and weight are considered the easiest and most reliable measures to obtain across the wide range of settings in which routine preventive screenings are conducted (33). A key disadvantage is that excessive body fatness is the pathology associated with obesity and it cannot be measured directly using BMI insofar as BMI does not distinguish between mass in the form of fat, lean tissue, or bone (33,34). Additionally, gender- and age-specific BMI-derived guidelines are confounded by the onset of puberty (34) and are not appropriate for children with contractures or deformities (33). Therefore, scientists argue that multiple measures of childhood obesity should be assessed (34–36).

In addition to BMI not presenting a full picture of obesity, research has shown that connections between obesity and child

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[3] Supplemental Table 1 is available with the online posting of this paper at jn.nutrition.org.
[6] Abbreviations used: CFSM, Core Food Security Module; TSF, triceps skinfold; WC, waist circumference.
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health outcomes differ if alternative measures of obesity are used. For example, compared with BMI, waist circumference (WC) and waist:height ratios were better predictors of cardiovascular disease risk factors (37), WC and hypertiglyceridemic waist phenotype were better predictors of metabolic syndrome (38,39), and fat mass was more closely associated with physical activity (40). Moreover, the distribution of obesity within populations (e.g. by race and by sex) differs depending on which measure of obesity is used (41–44). Just as relationships between obesity and health outcomes differ by choice of measure, the same may be true for the relationship between childhood obesity and food insecurity.

Within the obesity literature, there is no consensus on which measure of obesity is preferable in all instances (45). As a consequence, we used a wide variety of measures [BMI, WC, triceps skinfold (TSF), trunk fat mass, percentage of body fat] and their respective obesity cutoffs. We analyzed these relationships for children between the ages of 8 and 17 y with data from the 2001–2004 NHANES.

Methods

Participants

Participants were from the 2001–2004 waves of the NHANES, which is a program of studies conducted by the National Center for Health Statistics, CDC (46) to assess the health and nutritional status of adults and children in the United States. NHANES examines a nationally representative sample of ~5000 persons each year, about one-half of whom are children (46). The NHANES samples examined for these analyses were limited to households < 200% of the poverty line, because food insecurity is rare among households above this threshold (8). The resulting sample included 2516 children (1239 girls, 1277 boys) between the ages of 8 and 17 y.

Measures

Classification of weight status. All physical assessments of the child (e.g. height, weight, WC) were measured by a trained technician in the NHANES mobile examination center. We derived 5 indicators of obesity from this information. In each instance, if a child was not classified as obese, we referred to the child as being nonobese. First, BMI (kg/m^2) was calculated from the child's weight and height and mapped into a percentile using age- and sex-specific reference values obtained from CDC growth charts for the US (47). A child was classified as obese if his or her BMI was ≥ the 95th percentile. Second, WC was measured at just above the uppermost lateral border of the right ilium at the end of a normal expiration. A child was classified as obese if his or her WC was ≥ the 90th percentile reference value for their age and sex in models for the full population or by gender, and their age, sex, and race in models by race (48). Third, TSF thickness was determined at the midpoint between the acromion and olecranon process on the posterior surface of the right arm with a Lange caliper. A child was classified as centrally obese if his or her TSF was ≥ the 95th percentile reference value for their age and sex in models for the full population or by gender, or age, sex, and race in models by race (49,50). Fourth, trunk fat mass was determined using dual-energy X-ray absorptiometry. The trunk included the thoracic and lumbar spine, and left and right ribs and pelvis. A child was classified as obese if his or her trunk fat mass was greater than or equal to established age-sex reference values for identifying high trunk fat mass (51). Our final indicator of obesity was percentage of whole-body fat measured via whole-body dual-energy X-ray absorptiometry scans taken with a Hologic QDR-4500A fan-beam densitometer. Hologic software version 8.26:a3* was used to administer all scans. For the scans, children wore disposable paper gowns, removed all objects that would interfere with obtaining an analyzable scan image, and were positioned supine on the tabletop with their feet in a neutral position and hands flat by their side (52). A child was classified as obese if his or her percentage of body fat was ≥ the 95th percentile reference value for their age and sex (34).

Food insecurity. Food insecurity was measured using the same methodology employed by the USDA, a well-established and reliable methodology that has been used in the official classifications of food insecurity since the mid-1990s (8). Defined over a 12-mo period, a series of 18 questions taken from the CFSM was posed to NHANES mothers; the full set of questions can be found in **Supplemental Table 1**. As done with the official measures (8), a household with ≤2 affirmative responses to the CFSM was categorized as food secure and a household with ≥3 affirmative responses was categorized as food insecure.

Confounders. Several demographic characteristics were included as covariates in the multivariate analyses. Each has been related to children's weight status and the food insecurity status of the child's household (10,16–32). These cofounders included the child's age (y), race/ethnicity (Hispanic of any race, non-Hispanic Black, non-Hispanic White, other), gender, and annual household income divided by the poverty line.

Statistical analyses

Descriptive statistics were calculated for the total sample, by race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic), by gender, and by race/ethnicity and gender. Comparisons between the obesity statuses of food-insecure and food-secure children were made for each of the obesity measures. To test for the statistical significance of differences, χ^2 tests were used. Logistic regression models were estimated to assess the association between childhood obesity and food insecurity, controlling for other factors (i.e. the list of confounders above). The bivariate comparisons and logistic regression models were conducted on the full sample and subsamples of non-Hispanic White children, non-Hispanic Black children, Hispanic children, girls, and boys. We further estimated the logistic regression models for each of the race/ethnicity categories separately for girls and boys (i.e. White non-Hispanic girls, Black non-Hispanic girls, Hispanic girls, White non-Hispanic boys, Black non-Hispanic boys, and Hispanic boys). As described above, when race-specific obesity cutoffs were available, we used these in our subsample analyses. In light of the oversampling of Hispanics and non-Hispanic Blacks in the NHANES, we used the sampling weights supplied by the NHANES for all estimations (48). All analyses were conducted using Stata Version 10 for Windows (53).

Results

The sample when weighted was 44% non-Hispanic White, 22% non-Hispanic Black, and 26% Hispanic (**Table 1**). Fifty-two percent of the children were males and the mean age of the child was 12 y. The mean income:poverty line ratio was 1.04. Regarding our key variables of interests, nearly 37% of the households were food insecure and for the 5 measures of childhood obesity, the range of obese children varied from 15 to 45%. Specifically, 18% of children were considered obese via BMI assessments, 21% via WC, 15% via TSF thickness, 30% via trunk fat mass, and 45% via body fat. Along with the proportions defined as obese differing markedly by obesity measure, there were also differences within measures by race/ethnicity and by gender.

Next, we broke down food insecurity status by whether a child was obese or not obese according to the 5 measures of obesity noted above (**Table 2**). Bivariate χ^2 results for the entire sample and for each of the subsamples showed that food-insecure children were no more likely to be obese than their food-secure counterparts across the 5 measures of obesity. It should be noted, however, that food insecurity and obesity often coexist in low-income children, because, depending on the obesity measure and subsample assessed, 12–57% of food-insecure children were also obese.

We used logistic regressions to control for other factors. The association between food insecurity and obesity was nonsignificant at usual confidence levels for the sample of all children for all 5 measures of obesity (**Table 3**). The nonsignificance of the relationship between food insecurity and obesity also held when

TABLE 1 Descriptive statistics of children and adolescents aged 8–17 y in households with annual incomes less than 200% of the poverty line[1,2]

	All	White, non-Hispanic	Black, non-Hispanic	Hispanic	Girls	Boys
n (unweighted)	2516	391	983	1124	1239	1277
Food insecure, *%*	36.60	33.21	37.13	45.09	34.27	38.72
Measures of obesity, *% above cutoff*						
BMI	18.27	17.72	19.31	17.95	16.17	20.18
WC	20.88	24.28	15.68	20.10	21.95	19.91
TSF thickness	15.42	17.14	18.15	13.52	12.22	15.32
Trunk fat mass	29.78	30.81	23.13	33.73	26.92	32.37
Body fat	44.83	44.81	33.69	54.49	48.63	41.39
Measures of body size						
Height, *cm*	153.31 ± 0.46	153.35 ± 0.86	154.60 ± 0.51	152.40 ± 0.66	152.02 ± 0.54	154.47 ± 0.73
Weight, *kg*	51.66 ± 0.52	51.21 ± 0.95	52.75 ± 0.61	51.80 ± 0.82	50.99 ± 0.62	52.26 ± 0.80
BMI, *kg/m²*	21.35 ± 0.14	21.14 ± 0.25	21.47 ± 0.17	21.66 ± 0.22	21.62 ± 0.19	21.12 ± 0.20
WC, *cm*	74.71 ± 0.39	75.41 ± 0.73	72.22 ± 0.45	75.88 ± 0.60	75.09 ± 0.50	74.36 ± 0.58
TSF thickness, *mm*	15.68 ± 0.22	16.00 ± 0.42	14.83 ± 0.27	16.09 ± 0.31	17.87 ± 0.29	13.69 ± 0.30
Trunk fat mass, *kg*	6.31 ± 0.11	6.44. ± 0.21	5.29 ± 0.13	6.78 ± 0.19	7.13 ± 0.16	5.58 ± 0.15
Body fat, *%*	29.31 ± 0.23	29.66 ± 0.44	27.02 ± 0.28	30.17 ± 0.35	32.82 ± 0.28	25.31 ± 0.32
Non-Hispanic White, *%*	44.00	100.00	0.00	0.00	44.74	44.23
Non-Hispanic Black, *%*	22.42	0.00	100.00	0.00	22.84	22.03
Hispanic, *%*	26.41	0.00	0.00	100.00	27.64	25.31
Other, *%*	7.15	0.00	0.00	0.00	5.76	8.41
Child is male, *%*	52.45	52.74	51.56	50.25	0.00	100.00
Age, *y*	12.20 ± 0.08	12.19 ± 0.16	12.14 ± 0.09	12.32 ± 0.12	12.31 ± 0.11	12.10 ± 0.12
Income:poverty line ratio	1.04 ± 0.01	1.12 ± 0.03	0.89 ± 0.02	1.01 ± 0.03	1.06 ± 0.02	1.02 ± 0.02

[1] Values are means ± SE or percent.
[2] Data were weighted using sampling weights provided by NHANES (46).

we limited the sample to non-Hispanic Whites, non-Hispanic Blacks, and Hispanics, as well as by girls and boys. In addition, when we assessed the association between food insecurity and obesity status for race by gender subgroups (e.g. White non-Hispanic girls) (results not tabulated), all relationships were nonsignificant across all subgroups for all 5 measures of obesity.

Discussion

Food insecurity and childhood obesity were not associated for children between the ages of 8 and 17 y in households with incomes <200% of the poverty line. This was true when we examined the full sample and when we broke down the sample by gender, race/ethnicity, and gender and race/ethnicity. These

TABLE 2 Obesity status for food-secure compared with food-insecure 8- to 17-y-old children and adolescents assessed using various measures of obesity[1]

	Proportion obese					
	n	BMI	WC, *cm*	TSF thickness, *mm*	Trunk fat mass, *kg*	Body fat, *%*
All						
Food secure	1518	0.174	0.202	0.152	0.286	0.440
Food insecure	998	0.197	0.221	0.159	0.319	0.462
White non-Hispanic						
Food secure	261	0.173	0.226	0.173	0.309	0.454
Food insecure	130	0.186	0.235	0.177	0.307	0.435
Black non-Hispanic						
Food secure	615	0.194	0.172	0.154	0.229	0.335
Food insecure	368	0.191	0.175	0.131	0.234	0.340
Hispanic						
Food secure	582	0.171	0.189	0.137	0.308	0.521
Food insecure	466	0.190	0.215	0.133	0.373	0.574
Girls						
Food secure	748	0.149	0.211	0.118	0.263	0.483
Food insecure	491	0.186	0.236	0.131	0.281	0.492
Boys						
Food secure	770	0.199	0.193	0.184	0.308	0.399
Food insecure	507	0.206	0.209	0.181	0.349	0.438

[1] Data were weighted using sampling weights provided by NHANES (46).

TABLE 3 Risk of obesity status as a function of food insecurity status and other covariates for 8- to 17–y-old children and adolescents assessed using various measures of obesity[1,2]

	BMI	WC	TSF thickness	Trunk fat mass	Body fat
Food insecure					
All	1.137	1.136	1.070	1.121	1.051
	(0.840 1.539)	(0.848 1.523)	(0.754 1.519)	(0.858 1.465)	(0.821 1.346)
White non-Hispanic	0.894	0.931	0.871	0.826	0.887
	(0.490 1.631)	(0.550 1.577)	(0.458 1.658)	(0.494 1.380)	(0.550 1.429)
Black non-Hispanic	1.050	1.225	0.856	1.132	1.050
	(0.731 1.510)	(0.828 1.812)	(0.587 1.248)	(0.803 1.596)	(0.779 1.415)
Hispanic	1.142	1.206	0.969	1.314	1.197
	(0.729 1.789)	(0.793 1.832)	(0.579 1.621)	(0.873 1.977)	(0.835 1.717)
Girls	1.251	1.153	1.331	1.101	1.020
	(0.829 1.889)	(0.784 1.696)	(0.791 2.241)	(0.744 1.630)	(0.720 1.443)
Boys	1.043	1.112	0.949	1.151	1.066
	(0.679 1.601)	(0.723 1.713)	(0.594 1.520)	(0.796 1.663)	(0.749 1.516)

[1] Values are logit regression odds ratios (95% CI).

[2] Data were weighted using sampling weights provided by NHANES (46). Other covariates in the model were race/ethnicity (except for samples of White non-Hispanic, Black non-Hispanic, and Hispanic), gender (except for samples of girls and boys), age, and the ratio of income:poverty line.

results are consistent with recent findings of no relationship between food insecurity and childhood obesity (10,20–24). We emphasize that our results held across a wide array of obesity measures. Previous findings of no relationship between food insecurity and childhood obesity were based only on the BMI of the child. Our results demonstrate that the findings from these previous studies may also be robust to other obesity measures.

Despite finding no association between food insecurity and childhood obesity, an important point (and paradox) still remains: food insecurity and overweight coexist in low-income children. In our sample, depending on the obesity measure, 12–57% of food-insecure children were obese. The possible reasons why food-insecure children are also obese may include overconsumption of cheaper, energy-dense foods (54,55), overeating during times when food is more plentiful (56), metabolic changes to ensure a more efficient use of energy (57), different standards of what constitutes an adequate diet (58), parents overprotecting their children by giving them more food than needed when food is available (59), and the mother being food insecure during pregnancy (60).

Low-income, food-insecure children may be obese due to other factors associated with residing in a low-income household. As noted in the annual reports on food insecurity in the United States (8), households with lower incomes (vs. those with higher incomes), households headed by a Black non-Hispanic or Hispanic person (vs. households headed by a White non-Hispanic person), and households headed by a single person (vs. households headed by a married couple) are all more likely to be food insecure. These are all factors that have been associated with childhood obesity (1,61–65).

Four limitations of this study and subsequent directions for future research warrant mention. First, we were unable to examine associations with food insecurity specifically for the child in question. As the availability of food to eat may vary among the members in a household, analyses testing the relationship between food insecurity and weight status for a particular child are needed (22,31). Second, compared with other data sets, the NHANES more precisely measures the physical characteristics of children, but it does not have as rich a set of socioeconomic confounders and income is not as precisely measured. Future researchers on this topic may wish to use other data sources with richer sets of possible cofounders. To the best of our knowledge, a data set that provides measures of the physical characteristics of children as precise as those in the NHANES and also has a rich set confounders does not exist for the US. Third, we have not made any causal claims about the relationship between food insecurity and childhood obesity. Future researchers may wish to utilize data sets and empirical models that allow for establishing causality. Fourth, we did not consider the potential effect of dietary intake and physical activity on childhood obesity. Future work might consider how the interaction of these factors is associated with food insecurity and childhood obesity.

In conclusion, we emphasize policy implications of our work. Alleviating food insecurity and childhood obesity have been priorities among policymakers. Policymakers have tools to address these issues. Chief among food programs is the Food Stamp Program. Previous work has presented some evidence that food stamps help to alleviate food insecurity (66–70). Along with food stamps, policymakers can use other programs such as the National School Lunch Program, the Temporary Assistance to Needy Families program, and the Earned Income Tax Credit to aid low-income families in meeting the food needs of their children. Regarding childhood obesity, school fitness programs and, more broadly, nutrition and wellness programs have had some success in combating child weight issues. Our findings that food insecurity and obesity are not associated mean that policymakers can address the dual problems of alleviating food insecurity and childhood obesity without worrying about possible negative spillovers from one to the other.

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