Food Insecurity Is Positively Related to Overweight in Women[1,2]

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ABSTRACT Although individuals with poor food security might be expected to have reduced food intake, and thus reduced body fat and less likelihood of being overweight, these associations have not been adequately studied. The purpose of the current study was to examine the relationship between food insecurity and overweight as measured by body mass index (BMI) using data from the nationally representative 1994–1996 Continuing Survey of Food Intakes by Individuals (CSFII). Overweight was defined as BMI >27.3 kg/m^2 for women and 27.8 kg/m^2 for men. Food insecurity was related to overweight status for women ($n = 4509$, $P < 0.0001$), but not for men ($n = 4970$, $P = 0.44$). Excluding the 11 severely insecure women, the prevalence of overweight among women increased as food insecurity increased, from 34% for those who were food secure ($n = 3447$), to 41% for those who were mildly food insecure ($n = 966$) and to 52% for those who were moderately food insecure ($n = 86$). Food insecurity remained a significant predictor of overweight status, after adjustment for potentially confounding demographic and lifestyle variables ($P < 0.01$). In a logistic regression analysis, mildly insecure women were 30% more likely to be overweight than those who were food secure [odds ratio (OR) 1.3, $P = 0.005$]. Thus, food insecurity had an unexpected and paradoxical association with overweight status among women with a higher prevalence of overweight among the food insecure, and a resulting potential for increased incidence of obesity-related chronic diseases. Given that the rates of both overweight and food insecurity are on the rise, this research area warrants further investigation. J. Nutr. 131: 1738–1745, 2001.

KEY WORDS: • *overweight* • *obesity* • *food security* • *food insecurity* • *food insufficiency* • *humans*

An estimated 11.9% of U.S. households experienced food insecurity in 1995 (1), making it a concern to nutritionists, legislators and other policy makers (2). Among these food-insecure households, 34.9% showed evidence of moderate or severe hunger (1). Some in the United States, particularly policy makers, have doubted the existence of food insecurity in lower income population groups because of the high rates of overweight seen in these groups (3). Definitions and examples of key words used in this paper appear in **Figure 1**.

As expected, researchers have found that food insecurity was related to income level. Low income families were far more likely to experience food insecurity than other families (4–6). Although poverty in the United States rarely leads to clinical manifestations of malnutrition, poverty was a significant predictor of hunger and food insecurity (7). In addition, adults from low income families were more likely to be overweight than other adults (8–10). The prevalence of obesity [defined as body mass index (BMI)[4] ≥30 kg/m^2] increased from 12% in 1991 to 17.9% in 1998 (11).

Because overweight is usually thought to be associated with excessive food intake (9), and hunger with an inadequate food supply (1,5,7), thinking in terms of excess body weight and an inadequate food supply in the same individual connotes a paradox (12). Consequently, it would be easy to understand why policy makers and politicians might discredit the possibility of insufficient food supplies in impoverished families with overweight members.

The suggestion of a relationship between hunger and obesity in the United States was first proposed in a case study in 1994 (12). Dietz suggested that "food choices or physiologic adaptations in response to episodic food shortages could cause increased body fat." He recommended confirmation of this hypothesis with research examining the relationship of overweight and food insecurity in large cross-sectional and prospective studies (12).

Although individuals with poor food security might be expected to have reduced food intake, and thus reduced body fat and less likelihood of being overweight, these associations have not been adequately studied. To our knowledge, only one study examined the relationship and that was in a group of 193

[1] Presented in preliminary form at Experimental Biology 2000, April 14–19, San Diego, CA [Townsend, M., Love, B., Achterberg, C. & Murphy, S.P. Obesity among food insecure women: a paradox? FASEB J. 14:4, Mar 15, 2000. A731.]

[2] Funded in part by a grant from USDA, Economic Research Service, Contract/Grant # U.S. Department of Agriculture 43–3AEM-6–8010.

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[4] Abbreviations used: BMI, body mass index; CSFII, Continuing Survey of Food Intakes by Individuals; OR, odds ratio.

Manuscript received 21 September 2000. Initial review completed 24 October 2000. Revision accepted 22 March 2001.

Term	Definition	Example
Food security	• Access by all people at all times to enough food for an active, healthy life. It includes at a minimum: 1) the ready availability of nutritionally adequate and safe foods, and 2) an assured ability to acquire acceptable foods in socially acceptable ways (41)	
Food insecurity	• Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain abillity to acquire acceptable foods in socially acceptable ways (41)	• 4th week in food stamp cycle when food supplies are inadequate
Food restriction	• Externally imposed restriction of intake due to lack of access to foods or foods of choice (involuntary)	• 4th week in food stamp cycle when food supplies are inadequate
	or	
	• Self-imposed reduction of energy intake (voluntary), also called *dieting* to lose weight (29)	• Dieting for weight maintenance or weight loss
Disinhibition	• Release from the cognitive suppression of eating that occurs in response to the presence of palatable food or other disinhibiting stimuli (42) • Uncontrollable eating of large amounts of food. Overeating that occurs in the absence of hunger and has been linked to binge eating (43)	• Binging (usually of highly palatable foods) • Gorging of food when not hungry
Disordered eating	• The umbrella term for eating problems related to excessive weight management. It encompasses both cognitive and behavioral aspects of excessive weight management.	• Any of the following: fear of weight gain, obsession with body weight, distorted body image, purging behaviors with laxatives or diurctics, binge eating

FIGURE 1 Definitions and examples of key words related to food insecurity.

women in rural New York State (13). Those researchers suggested that at least some of the effects of lower income on higher adiposity were mediated through food insecurity. They proposed that, in the food insecure, the influence on body weight was composed of two opposing influences, i.e., the first, promotion of weight gain and the second, weight loss. First, food insecurity influenced weight gain by causing disordered eating patterns. Second, food insecurity affected weight status and promoted weight loss. The first pathway predominated in the mildly food insecure, whereas the second pathway predominated in the severely food insecure (13).

Because being overweight is usually associated with a plentiful food supply and being underweight with hunger (12), we suggest that this paradigm requires reexamination. The purpose of this paper is to examine the relationship between food insecurity and overweight status.

The following questions are addressed: Is there overweight in the United States among the food insecure? What is the prevalence of overweight among this food-insecure group? Is there more overweight among the food insecure than the general population? Is there more overweight among food-insecure low income women? Is there more overweight among food-insecure food stamp recipients? Is food insecurity a predictor of overweight?

To our knowledge, this study is the first to explore the food insecurity/overweight relationship using a nationally representative sample of the U.S. population.

SUBJECTS AND METHODS

To document the existence and prevalence of overweight among the food insecure in the United States, we used data from the Continuing Survey of Food Intakes by Individuals (CSFII). We examined the overweight/food insecurity relationship among the general population, the low income population and among food stamp recipients.

Sample and sampling frame. The CSFII employed a stratified multistage probability design to obtain representative samples of U.S. households (14). The surveys consist of partial probability samples of households in the 48 contiguous states. Institutionalized and homeless persons were not included. Data from the 1994, 1995 and 1996 CSFII were combined for this study, to yield a sufficient sample of women who self-identified as food insecure. A final sample was generated to meet the following criteria: ≥20 y old, reported height and weight available, income data available, nonpregnant and nonlactating. The final sample included 4537 women and 5004 men.

Conceptual model. The conceptual model that guided this study was theory-informed and is shown in **Figure 2**. The variables in the model are of interest because of the hypothesized relationships to food insecurity or BMI. Bronfenbrennner's *Ecology of Human Development* (15,16) guided the conceptualization with its emphasis on all factors affecting one another in a child's life. Applied to this research, all factors, including food insecurity, influence body weight. Included in the model are two demographic (age and ethnicity), three socioeconomic (education, income and occupation), two government assistance (welfare status and food stamps), three environmental (household size, urbanization and region of country) and five lifestyle (vigorous exercise, television time, percentage of dietary energy as fat, percentage of dietary energy as saturated fat and total energy intake) variables. According to this model, food insecurity influences overweight directly as well as indirectly through lifestyle factors. Furthermore, food insecurity is influenced by age, income, education, occupation, household size, welfare status and food stamp status. Ethnicity, region and urbanization variables were included in the model to ensure that these did not confound any relationships examined.

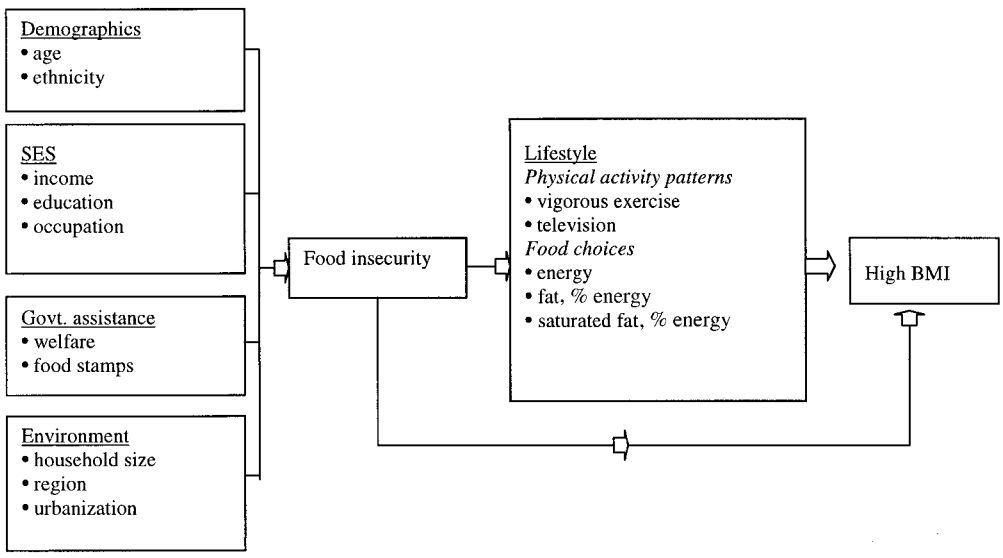

FIGURE 2 Conceptual framework of food insecurity and its relation to overweight. SES, socioeconomic status; BMI, body mass index.

TABLE 1

Food insecurity question, response elements, identifier, sample size, percentage overweight, and income as percentage of poverty level for women[1,2]

	Identifier term	*n* (sum of weights)	Overweight %	Household income as % of poverty level[3] ($\bar{x} \pm$SD)
Q: Which of the following statements best describes the food eaten in your household in the last 3 mo?				
• Enough of the kinds of food we want to eat.	No food insecurity	3447 (3513)	34[b]	373 ± 236[a]
• Enough but not always the kinds of food we want to eat.	Mild insecurity	966 (915)	41[a]	253 ± 194[b]
• Sometimes not enough to eat.	Moderate insecurity	86 (71)	52[a]	112 ± 119[c]
• Often not enough to eat.	Severe insecurity	11 (8)	20[4 a,b]	114 ± 69[c]
Overweight, % (for sample)			36	
$\bar{x} \pm$SD poverty, % (for sample)				344 ± 234
Total for sample		4509 (4507)		
P-value			<0.0001	<0.0001

[1] Frequencies and means are weighted to adjust for the intentional oversampling of some groups and the nonresponse of some individuals.
[2] Values in a column without a common letter differ, $P < 0.05$.
[3] The poverty levels for a family of 4 in the 48 contiguous states in 1994, 1995 and 1996 are $14,800, 15,150 and 15,600, respectively (22, 23, 24).
[4] Proportion is not significantly different from any of the other groups due to very low sample size and unequal distribution in the clusters.

Survey measures. The independent variable, food insecurity, was based on one question with four response elements as shown in **Table 1**. Sample size for each response category, sum of weights, percentage overweight and the mean income as a percentage of poverty are provided in the table. In addition, an identifier term for each response category is noted. This self-reported hunger measure was found to be valid (2,17,18) and reliable (2).

Dependent variable. The dependent variable was BMI, which was computed as weight (kg) divided by height squared (m^2) and adjusted as described below. The rationale for classification of BMI categories was an adaptation of criteria recommended in the consensus statement of the 1985 NIH Development Conference on the Health Implications of Obesity (19). The overweight cut-off points were defined as 27.3 kg/m^2 for women and 27.8 kg/m^2 for men and coincided with the 85th percentile for overweight from the second National Health and Nutrition Examination Survey. New federal guidelines for the classification of overweight and obesity in adults were published in June 1998 by the National Heart, Lung and Blood Institute (20). Use of these guidelines dramatically increased the prevalence of overweight as defined by BMI of 25.0 kg/m^2. We have chosen to use the earlier criteria for this study to identify a subset of individuals who are clearly overweight. The obesity cut-off point, 30 kg/m^2, was not defined as the outcome measure, because the numbers of obese men and women in the moderately and severely insecure categories were too low to be able to estimate associations with confidence. Furthermore, the self-reported weights and heights were adjusted to better estimate measured weights and measured heights using the equations developed by Michael Rowland (21). Separate equations for men and women were applied to the self-reported data to adjust for underreporting of weight and overestimation of height, as follows:

$$\text{Estimated measured weight (male)} = -4.1259 + 1.0185 \cdot \text{self-reported weight}$$

$$\text{Estimated measured weight (female)} = -3.1974 + 1.0438 \cdot \text{self-reported weight} - 0.0175 \cdot \text{age}$$

$$\text{Estimated measured height (male)} = 7.1987 + 0.8865 \cdot \text{self-reported height} + 0.0222 \cdot \text{age} - 0.0004 \cdot \text{age}^2$$

$$\text{Estimated measured height (female)} = 7.4583 + 0.8745 \cdot \text{self-reported height} + 0.0424 \cdot \text{age} - 0.0007 \cdot \text{age}^2$$

where height is in inches, weight in pounds and age in years.

Other independent variables. The *income* variable, based on household income as a percentage of poverty level for the corresponding years of the survey (22–24), was divided into four ordinal categories. The first group, 0–185% of poverty, was intended to capture adults receiving government aid including the Women, Infants and Children's Supplemental Nutrition Program (WIC) serving families to 185% of poverty. An *ethnicity* variable was created as follows: Caucasian, African American, Hispanic, Asian American, Native American and other non-Hispanic ethnicities. The last three categories were collapsed into the *other* category for the regression analyses (Table 3).

The *occupation* variable was a condensation of 16 occupational categories of employment and unemployment into the following six categories: professional/technical/managerial; blue collar/service; clerical/sales; homemaker; retired; and other (not employed, including students). The *region of the country* was represented by the Northeast, Midwest, South and West. The *urbanization* variable had three categories, i.e., central city, suburban and rural. The *household size* variable had 4 categories, i.e., 1, 2, 3 and ≥4 persons in the household. A four-category ordinal variable for *vigorous exercise* was created in response to the question "How often do you exercise vigorously enough to work up a sweat?" The *television/video* variable was based on the question "How many hours did you watch television or videotapes yesterday?" which was asked on two occasions. **Table 2** gives a complete list of all variable categories.

Dietary intake data were based on responses to one or two 24-h dietary recalls. Two days of recalls were reported by 95% of the sample. The dietary data were converted to nutrient intakes by USDA/ARS using nutrient composition data from the USDA Nutrient Database for Individual Intake Surveys (25). The *dietary fat* and *dietary saturated fat* variables represented percentages of energy intake

TABLE 2

Overweight prevalence among women and for three food insecurity categories[1]

	Overweight prevalence			
	All	No insecurity	Mild insecurity	Moderate insecurity
		% (*n*)		
Poverty, %				
0–185	43.8 (1326)	41.1 (837)	48.3 (421)	51.5 (61)
186–320	36.5 (1088)	35.6 (862)	39.8 (218)	—
321–500	33.2 (1044)	32.3 (870)	38.0 (173)	—
>500	26.7 (1049)	26.6 (943)	26.3 (103)	—
Education				
≤11th grade	49.8 (749)	46.8 (519)	57.2 (195)	63.3 (29)
High school graduate	38.8 (1588)	37.1 (1207)	44.3 (352)	39.7 (28)
1–3 y college	31.5 (1056)	29.8 (846)	37.7 (201)	—
≥4 y college	24.9 (1066)	25.4 (905)	22.2 (157)	—
Age, *y*				
20–34	25.7 (1337)	23.7 (961)	29.1 (342)	49.2 (32)
35–44	33.2 (963)	30.8 (740)	41.5 (206)	31.4 (16)
45–59	41.6 (1068)	39.6 (866)	50.4 (188)	53.2 (12)
≥60	43.8 (1139)	40.8 (945)	57.7 (179)	84.2 (12)
Ethnicity				
Caucasian	33.0 (3423)	31.7 (2735)	37.4 (643)	49.5 (43)
Hispanic	38.4 (353)	37.0 (247)	40.9 (88)	47.3 (17)
African American	57.1 (549)	55.0 (389)	62.2 (147)	—
Asian American	5.2 (130)	2.3 (112)	23.9 (18)	—
Native American	64.5 (23)	53.7 (13)	—	—
Other	20.7 (27)	19.5 (17)	—	—
Food stamps				
Yes	51.8 (386)	48.4 (204)	53.7 (147)	68.3 (31)
No	34.1 (4105)	32.8 (3293)	39.6 (768)	39.2 (40)
Welfare (AFDC)				
Yes	48.1 (208)	45.9 (106)	46.9 (84)	69.4 (17)
No	35.0 (4217)	33.3 (3350)	41.6 (808)	44.2 (52)
Fat, % *energy*				
<27.2	32.3 (1130)	29.6 (915)	42.0 (193)	64.1 (18)
27.2–33.1	34.1 (1125)	33.4 (840)	35.9 (266)	43.6 (19)
33.2–38.1	37.8 (1123)	36.5 (892)	44.1 (212)	26.1 (18)
>38.1	38.3 (1129)	35.5 (865)	46.3 (244)	75.8 (16)
Saturated fat, % *energy*				
<8.75	31.9 (1322)	29.9 (1058)	39.6 (237)	47.3 (25)
8.75–11	36.0 (1132)	34.8 (890)	39.9 (223)	47.8 (18)
11–13.2	39.1 (986)	37.3 (753)	44.1 (222)	—
>13.2	36.5 (1067)	34.3 (812)	43.8 (233)	52.4 (19)
Total energy				
1st quartile	36.7 (1126)	34.7 (845)	42.8 (259)	49.3 (18)
2nd quartile	36.5 (1127)	32.8 (899)	50.7 (204)	55.7 (21)
3rd quartile	37.3 (1123)	35.6 (883)	42.1 (224)	70.8 (14)
4th quartile	32.0 (1131)	31.9 (885)	32.4 (228)	33.4 (18)
Vigorous exercise				
Rarely/Never	41.2 (1951)	39.4 (1524)	46.7 (387)	62.9 (37)
1–4 times/mo	33.6 (665)	32.8 (506)	36.2 (144)	32.7 (14)
2–4 times/wk	29.4 (1019)	27.4 (811)	37.6 (204)	—
5–7 times/wk	31.7 (861)	29.1 (666)	41.0 (176)	42.3 (16)
TV/video, *h/d*				
<1	27.1 (1406)	26.5 (1117)	29.5 (268)	32.0 (18)
1–2	33.6 (1150)	30.9 (922)	42.9 (205)	54.6 (22)
2–4	41.1 (1272)	40.3 (989)	43.2 (265)	63.7 (16)
>4	46.3 (677)	41.9 (482)	57.5 (177)	58.6 (16)

[1] Data meet assumptions of normalacy for the estimated prevalences. The severely insecure category was not included because assumptions of normalacy were invalid. AFDC, Aid to Families with Dependent Children.

from fat and saturated fat and were divided into approximate quartiles. The *energy* variable was total energy intake in kJ. Because energy needs were confounded by height, the influence of height was removed by regressing energy on height, and residuals were calculated for each subject. The residuals were then divided into quartiles, i.e., the quartile cut-off values are −1615, −239.3 and + 1282.0 kJ.

Statistical analysis. Differences among food-insecurity categories with respect to overweight prevalence and mean incomes were examined with ANOVA and Tukey's test for pairwise differences using a significance level of $P < 0.05$ (Table 1). Contingency tables were calculated to assess the bivariate associations between food security and the various demographic and dietary variables using the χ^2 test (Table 2).

TABLE 3

Logistic regression model predicting overweight in women (n = 4431)[1,2]

	Parameter estimate	SE	OR[3]	95% CI	*P*-value
Intercept	−0.4746	0.0726			<0.0001
Food insecurity					
Mild	0.2459	0.0877	1.3	(1.08, 1.52)	0.0050
Moderate	0.4251	0.2720	1.5	(0.90, 2.61)	0.1180
Severe	−0.9384	1.0103	0.39	(0.05, 2.83)	0.3530
Ethnicity					
Hispanic	0.3286	0.1477	1.4	(1.04, 1.86)	0.0261
African American	0.8451	0.1128	2.3	(1.87, 2.90)	<0.0001
Other	−0.7688	0.2290	0.46	(0.30, 0.73)	0.0008
Age, *y*					
35–44	0.5122	0.1032	1.7	(1.36, 2.04)	<0.0001
45–59	0.9350	0.1015	2.5	(2.09, 3.11)	<0.0001
≥60	0.7972	0.1050	2.2	(1.81, 2.73)	<0.0001
Education					
≤11th grade	0.4836	0.1269	1.6	(1.27, 2.08)	<0.0001
High school graduate	0.2141	0.1015	1.2	(1.02, 1.51)	0.0348
Some college	0.1337	0.1060	1.1	(0.92, 1.41)	0.2074
Food stamps					
Yes	0.3220	0.1308	1.38	(1.07, 1.78)	0.0139
Vigorous exercise					
Rarely/never	0.2701	0.0972	1.3	(1.08, 1.59)	0.0054
1–4 times/mo	0.2416	0.1231	1.3	(1.00, 1.62)	0.0497
2–4 times/wk	0.1029	0.1104	1.1	(0.89, 1.38)	0.3514
Television + video, *h/d*					
1–2	0.2990	0.0942	1.36	(1.13, 1.62)	0.0015
2–4	0.4977	0.0911	1.64	(1.38, 1.95)	<0.0001
>4	0.5276	0.1103	1.75	(1.42, 2.15)	<0.0001

[1] The reference woman is Caucasian and food sufficient with the following other characteristics: 20–34 y old, college graduate, watches <1 h of television + video per day, has a diet <27.2% dietary energy as fat and exercises vigorously 5–7 times per week.
[2] Income was included in the model as a continuous variable.
[3] OR, odds ratio; CI, confidence interval.

Multivariate modeling was approached in three ways. In the first two, parsimonious models were sought using the General Linear Model procedure in SAS (Statistical Analysis System, Release 7.0 for Windows; SAS Institute, Cary, NC) to determine which variables best predict overweight. Stepwise techniques were used to develop a categorical model using the sample weights and random cluster effect described below. Initially, all main effects were entered into the model, and nonsignificant variables were removed in a backward stepwise fashion. Then, all two-way interactions of the significant main effects were added to the model and nonsignificant interactions were removed in a backward fashion. Similarly, all three- and four-way interactions were added to the model and removed in a backward fashion. In the final models, variables that did not make a meaningful contribution to explaining the variance in overweight were removed. The level of significance was 0.05 based on type III sum of squares.

Because food insecurity was closely related to income, we performed another analysis adjusting for income as a continuous, rather than as a categorical variable.

In the third approach, further analysis was conducted with a logistic regression model to predict the probability of being overweight (**Table 3**). Significant variables from the previous model were chosen as initial predictors. All variable categories were entered as dummy variables to magnify the prediction capabilities of the model for each variable category. Nonsignificant interaction terms were removed to create the final model. The level of significance was 0.05. Because group proportions of overweight were generally between 0.2 and 0.8, the General Linear Model procedure to obtain adjusted means was performed. A weighting variable was applied to all analyses to adjust for the intentional oversampling of some groups and the nonresponse of some individuals—variable wt3d1, provided in the data files (26). Additionally, 86 sample clusters were identified (based on CSFII variables *varstrat* and *varunit*, which provided geographic information for the surveyed households) and were included in the multivariate models as random effects to avoid the problem of cluster differences being misidentified as differences due to other demographic variables. Where necessary, cluster was nested within factors such as region and urbanization; however, most variables such as age and ethnic group had several variable categories represented within each cluster. Analyses were repeated using the SurveyReg procedure of SAS 8.1, which adjusts for the clustered sample design. The findings were essentially unchanged and thus we have chosen to present the results from the GLM procedure.

RESULTS

In bivariate analysis, food insecurity was related to overweight status for women ($P < 0.0001$, $n = 4509$) as shown in Table 1, but no relationship was observed for men ($P = 0.44$, $n = 4970$). This observation was consistent with studies that have examined socioeconomic status and overweight by gender (8,10). Because there was a gender × food insecurity interaction with this dataset, the remaining analyses focused on women.

Each food insecurity response category is shown in Table 1 by prevalence of adjusted overweight and by mean household income stated as a percentage of poverty level. Of the 966 women (915 weighted) reporting mild food insecurity, 41% were overweight compared with 34% of the food-secure population ($P < 0.05$). The moderate food insecurity category of 86 women at 52% overweight was significantly different from the food secure. Food security was related to income with a dose-response effect for three categories (Table 1). The food

secure had a higher income than the mildly and moderately insecure groups ($P < 0.0001$). Furthermore, the mildly insecure had a higher income than the moderately insecure ($P < 0.0001$).

Food insecurity was related to a number of independent variables in bivariate analyses (not shown in table) as follows: income ($P < 0.001$), education ($P < 0.001$), occupation ($P < 0.001$), region of the country ($P = 0.002$), urbanization ($P = 0.009$), ethnicity ($P < 0.001$), age ($P < 0.001$), household size ($P < 0.001$), welfare status ($P < 0.001$), food stamps ($P < 0.001$), total energy intake ($P = 0.003$) and television viewing ($P = 0.002$). Food insecurity was not significantly related to energy from dietary fat or saturated fat ($P > 0.05$).

Prevalence of overweight for 11 variables is shown in Table 2. The prevalence of overweight was highest for those in the lowest income category (43.8%), with an educational level of ≤11th grade (49.8%), who ate a diet ≥38.1% in fat energy (38.3%), who rarely/never exercised vigorously (41.2%) and who watched television >4 h/d (46.3%). The majority of African Americans and Native Americans, and food stamp recipients reported being overweight (57.1, 64.5 and 51.8%, respectively). Among the lowest income group, the prevalence of overweight among the food secure was 41.1%, the mildly insecure, 48.3%, and the moderately insecure, 51.5%. The prevalence of overweight among the mildly and moderately insecure groups was significantly higher than for the food secure. The fourth category of food insecurity was not included in these analyses because only 11 women reported they "*often* did not have enough to eat."

Because the low income category included a broad range of incomes, 0–185% of poverty, we examined individuals at the lower end of that group, i.e., recipients of food stamps. Among the food stamp population, rates of overweight for the secure, mildly insecure and moderately insecure were 48.4, 53.7 and 68.3%, respectively, and exhibited a positive linear relationship similar to that of the low income group. The prevalence of overweight among the moderately insecure food stamp recipients was significantly higher than for the mildly insecure and the food secure.

For most variables, trends were seen across the food insecurity categories for the prevalence of overweight (Table 2). A dose-response effect was seen for 26 of the 31 variable categories with data for three variable categories of food security. For these variable categories, the trend in overweight increased with the degree of insecurity. The prevalence of overweight for the mildly insecure was greater than for the food secure for 38 of the 40 variable categories with data.

Because the three multivariate models provided support for the same inferences regarding the overweight/food insecurity relationship, the first two models are reported briefly (data not shown), whereas the third model, the logistic regression, is reported in detail (Table 3). In the first model, the 15 variables in the conceptual framework (Fig. 2) were entered into the ANOVA model as independent variables along with food insecurity. Food insecurity continued to be important in predicting overweight ($P < 0.01$). Thus, food insecurity was a contributor to overweight over and above the effect of income. In the second model, the mean BMI for the food secure was significantly different from the mean BMI for the food insecure when controlling for the same demographic and lifestyle variables ($P < 0.0001$).

Because income and food insecurity were correlated, the same analysis was repeated with income as a continuous variable. The food insecurity variable continued to be significant ($P < 0.0001$) when the model was adjusted for income as a continuous variable.

In the third multivariate model, logistic regression was used to predict the probability of a woman being overweight (Table 3). The six significant main effects remaining in the final ANOVA model were entered into the logistic regression model. Although income was not a significant main effect, it was included in the model as a continuous variable. Women at the intercept had the following baseline characteristics: Caucasian race, food secure, 20–34 y old, college educated, watched television/video <1 h/d and vigorously exercised 5–7 times a week. Mildly insecure women were 30% more likely to be overweight than those who were food secure [odds ratio (OR) 1.3, $P = 0.005$]. African-American race emerged as the greatest single predictor of overweight (OR 2.3, $P < 0.0001$). Other variable categories that were significant predictors of overweight but with smaller OR were Hispanic ethnicity, high school education or less, >35 y old, television/video viewing >1 h/d, receiving food stamps and exercising ≤4 times per month.

DISCUSSION

We intentionally chose the construct *food insecurity*, not *food insufficiency*, as an independent variable. Thus, the 966 women in Table 1 who had sufficient food but worried about having enough, were counted among the *food insecure* in this study. Worrying that food will run out can be considered *food insecurity*, but not *food insufficiency*, and we wished to examine the full range of *food insecurity* in our analyses.

These results confirm that food insecurity for women was related to overweight in this study. Using a large national sample, a paradox emerged. The prevalence of overweight was lower among the two extremes of food insecurity (Table 1), i.e., the food secure and the severely insecure, although likely for two very different reasons. Among food-secure women, food intake may be *voluntarily* restricted to prevent weight gain or maintain weight (27). Among the severely food insecure, food intake may be *involuntarily* restricted due to insufficient resources to access food (2). The mildly food insecure had a higher mean BMI than women who self-identified as food secure. In addition, overweight occurred among mild and moderate levels of food insecurity, a finding similar to that of the study of 193 women by Frongillo and colleagues (13). Taken together, these results suggest that overweight is related to involuntary, temporary food restriction.

One possible explanation for the high prevalence of overweight among food stamp recipients involves a food acquisition cycle (28). Abundant food supplies may be available the first 3 wk of the month, followed by 1 wk without food stamps or money when food selection is limited. Then, when money and food stamps are restored at the first of the food stamp month, food-insecure families may overeat highly palatable and rich foods. This cycle may synchronize with food stamp distribution, suggesting a "food stamp cycle" hypothesis. Furthermore, this behavior could be reminiscent of binge eating, also known as disinhibition in the psychology literature (27,39). Binge eating can result in weight gain (27,29,31, 37,38). Thus, overeating by food-insecure families when palatable food is plentiful, i.e., when food stamps or money for food is available, followed by a short period of involuntary food restriction, followed by overeating, could be a pattern that results in gradual weight gain over time.

Although the "food stamp cycle" hypothesis has yet to be tested, a limited number of human and animal studies provide evidence for it. These studies show that food deprivation in humans (30–33) and animals (34–36) and food restriction in children (12,37–39) produce a tendency toward binge eating

behaviors when a plentiful food supply is available. If food deprivation/restriction occurs among food-insecure food stamp recipients, it is probably not long term, but episodic. We suggest that externally imposed food restriction, i.e., involuntary, as would occur when a family runs out of food stamps and money at the end of the month, may lead during time of plenty to overeating, binge eating and disregard for internal satiety cues. Future research should include an exploration of this hypothesis.

The finding of a gender difference in the food insecurity/overweight relationship is noteworthy and two possible explanations are offered. Women may be more sensitive to the social pressures to be thin than men and therefore, may have a lower threshold for detecting an overweight/food insecurity relationship. Yet at extremes, male conscientious objectors overate after severe food restriction in the well-known Minnesota study conducted during World War II (31,32). Only a few of the food-insecure respondents in the CSFII dataset were severely insecure. Another explanation might be that food-insecure women were often heads of households with children, whereas men reporting food insecurity were often alone. Consequently, the gender comparison might be inappropriate.

Limitations and alternate interpretations. Although this study sample was representative of the adult U.S. population, a number of study limitations should be considered. First, because of the cross-sectional design, any inferences regarding cause and effect must be made with caution and should be considered preliminary. Use of secondary data presented certain difficulties. Analyses were limited to the topics, wording of questions and variables in the survey instrument. For example, variables of interest such as parity, marital status, disordered eating patterns including disinhibition and family medical history were not available in the dataset.

Validation studies of all CSFII items have not been reported, making interpretation of some results problematic. For example, it was not known how respondents define "vigorous exercise to work up a sweat." All data were self-reported, introducing a variety of social response biases. In the case of the self-reported heights and weights, however, these biases were reduced by a correction factor (21). In addition, the homeless, who were more likely to be food insecure, were not sampled. Systematic error may have occurred in the four response elements to the food insecurity question (Table 1) by categorizing women to groups incorrectly. In the future, this error will be minimized by the replacement of the CSFII items with the 18-item Core Food Security Module, which carefully identifies the severity of the food insecurity (1,40). Another concern is that food-insecure women may be fearful of answering honestly because honest responses might be perceived as justification for removal of children from their care. Last, it is feasible that the food insecurity/overweight relationship could be attributable entirely, or in part, to variables not in the model, such as psychosocial factors, e.g., knowledge about maintaining a normal body weight, attitudes about body weight, perceived control of body weight, social support, health awareness and/or health beliefs.

The data for the severely insecure were problematic. Assumptions of normalcy were not valid for the 11 women in this category of food insecurity. It is very likely that these women have health issues overriding those of food such as mental illness and drug and alcohol abuse. Although results are provided for this category of food insecurity, they should be interpreted with extreme caution.

This study demonstrated that overweight exists among the food insecure. Moreover, it was more prevalent among the food insecure than the food secure and among insecure food stamp recipients than among other food stamp recipients. After controlling for relevant variables in multivariate models, food insecurity continued to be significantly and independently related to overweight status.

Given that the rates of both obesity (11) and food insecurity (1,3) are on the rise, this is an important topic for further investigation. The finding that food insecurity had unexpected and paradoxical consequences in this study, i.e., higher rates of overweight, and consequently, the potential for increased incidence of obesity-related chronic diseases, must be addressed.

In addition, there are public policy implications for USDA's food assistance and poverty programs, particularly the food stamp program. According to Dietz (12), confirmation of these findings would suggest that the prevalence of obesity among low income groups may require increased food supplementation in the form of food stamps to achieve a more uniform pattern of food intake. Consequently, elaboration of the food insecurity/overweight relationship would allow for better intervention designs.

ACKNOWLEDGMENTS

The authors are grateful to Madeleine Sigman-Grant, Nutrition Specialist, University of Nevada, Las Vegas, and Patricia Crawford, Nutrition Department, UC Berkeley, for their insightful comments on the manuscript.

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