Associations Among Food Insecurity, Academic Performance, and Weight Status in Primary Schoolchildren in Tehran, Iran: A Cross-sectional Study

Saeed Esfandiari, MSc; Nasrin Omidvar, PhD; Hassan Eini-Zinab, PhD; Aazam Doustmohammadian, PhD; Zeynab Amirhamidi, MSc

ABSTRACT

Objective: To examine the associations among household food insecurity (FI), academic performance, and weight status in urban primary schoolchildren.

Design: Cross-sectional study.

Setting: Primary schools in Tehran, Iran.

Participants: A total of 803 students (419 boys and 384 girls), aged 10–12 years, were recruited from 43 primary schools.

Main Outcome Measures: Levels of FI were measured using a locally validated, 18-item household food security survey module. Academic performance was assessed by 152 teachers through a specifically designed, 20-scale questionnaire. Standard anthropometric measurements were also taken.

Analysis: Linear and multinomial regressions were conducted.

Results: At the household level, FI was associated with poorer grades in all subjects studied (except for social science in FI without hunger) ($P < .05$). At the child level, a significant association was observed between low food security and poorer grades in all subjects studied, whereas for very low food security, this relationship was significant only for mathematics, reading, and science ($P < .05$). Food insecurity without hunger (odds ratio = 2.56; 95% confidence interval, 1.05–6.23) and low food security (odds ratio = 4.41; 95% confidence interval, 1.58–12.23) were associated with overweight only in girls.

Conclusions and Implications: The findings confirm the need for policies and programs to improve students' dietary quality and food security to improve their health as well as educational attainment. Future research is needed to explore further the association between food security and academic performance.

Key Words: food insecurity, body weight, academic performance, primary schoolchildren (*J Nutr Educ Behav*. 2018;50:109–117.)

INTRODUCTION

Food insecurity (FI) refers to "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to obtain food in socially acceptable ways."[1] Food insecurity is a multidimensional phenomenon associated with developmental adverse outcomes and a persistent public health concern in both developed and developing countries.[2] The relatively high prevalence of different FI levels in Iran has made its alleviation a priority of national development programs.[3] Based on a recent study, about 49% of Iranian households experience some degree of FI.[4]

Children need consistent access to an adequate quantity of high-quality food for optimal physical, social, and cognitive growth; therefore, they are considered a group vulnerable to FI. Based on epidemiologic studies, FI in children is associated with poor academic achievement and school engagement, grade repetition, absenteeism, tardiness, anxiety, aggression, psychosocial dysfunction, and difficulty in getting along with peers.[5-8] In addition, children in food-insecure households are more

Department of Community Nutrition, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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Address for correspondence: Nasrin Omidvar, PhD, Department of Community Nutrition, Faculty of Nutrition Sciences and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, 7th West Hafezi St., Farahzadi Blvd., Shahrak-e Gharb, Tehran 1981619573, Iran; Phone: +(98 21) 22360658; Fax: +(98 21) 22360660; E-mail: nomidvar@yahoo.com

at risk of being neglected by their parents in providing adequate health and nutritional and emotional care.[9,10] Findings on the association between FI and poorer academic performance were different based on the severity of FI and academic subjects (mathematics, reading, etc). In 1 study, this association was observed only in marginal but not severe FI,[11] whereas a longitudinal study showed that FI was associated with poor scores in reading but such an association was not observed in mathematics.[12] On the other hand, a possible paradoxical association between FI and childhood obesity was suggested.[13] Plausible mechanisms to explain this association include changes in food choices and consumption patterns in food-insecure children.[14] As a coping strategy, food-insecure children tend to consume less expensive, energy-dense foods; overeat when foods are available; and have low physical activity.[15] Most studies conducted to examine the association between FI and obesity were carried out in the US. Results of these studies were inconsistent: some showed a positive association,[12,15-17] others showed no association,[18-21] and yet others reported an inverse association between obesity and FI in children.[22,23]

In Iran, child obesity is a growing public health problem. According to the Childhood and Adolescence Surveillance and Prevention of Adult Noncommunicable Disease survey,[24,25] in 2010, overweight/obesity in 10- to 18-year-old children was 18.2% and increased to 21.5% in 2012. The authors undertook the current study to explore the association between FI at the household and child levels with academic performance and weight status in fifth- and sixth-grade students in the city of Tehran, the capital of Iran.

METHODS
Sampling and Data Collection

This cross-sectional study was carried out in fifth- and sixth-grade primary schoolchildren in the city of Tehran. A total of 186,761 children were eligible to participate, 803 of whom took part in the study (419 boys and 384 girls). Data were collected from October, 2015 to March, 2016. The researchers applied multistage systematic cluster sampling in 3 stages to select districts, schools, classes, and children. The general office of education in Tehran classifies its 19 educational districts into 3 socioeconomic levels: affluent, semiaffluent, and deprived. In the first stage of the study, 9 districts (3 from each of the 3 socioeconomic areas) were selected by weighting districts according to their students' population density. Then the researchers selected public and private schools from these 9 districts by weighting them according to the number of students in the schools. In the third stage, fifth- and sixth-grade students were randomly selected from each school.

A team of 7 trained nutritionists collected data. A supervisor ensured consistency during the data collection process. The participant and their parents received a full verbal and written explanation of the purpose of the study and a consent form to sign. All data were collected in the schools. Parents were invited to complete food security (FS), socioeconomic, and demographic questionnaires through face-to-face interviews. In some cases in which parents were unable to attend in schools (because of child care needs, illness, work constraints, etc), telephone interviews were employed. The ethical committee of the National Nutrition and Food Technology Research Institute approved the study protocol.

Measurements

Household FS status. The researchers measured household FS status using a locally validated,[26] 18-item US Department of Agriculture Household Food Security Survey Module, which was designed to capture experiences associated with inadequate quality and quantity of the household food supply within the past 12 months.[1] Based on the scale, households were categorized as FS (raw score of 0–2), FI without hunger (raw score of 3–7), FI with moderate hunger (raw score of 8–12), and FI with severe hunger (raw score of 13–18). Because of the prevalence of each category, the categories of FI with moderate and severe hunger were grouped together.

Child-level FS status. The last 8 items of the US Department of Agriculture Household Food Security Survey Module referred to FI in households with children. The items were applied to all children in the household. The categories of children's FS based on the scale were: high or marginal FS (raw score of 0–1); low FS (LFS) (raw score of 2–4); and very low FS (VLFS) (raw score of 5–8).[27] Mothers were asked child-level questions with regard only to the child who was included in the study, not all children within the household.

Children's weight status. For each child, standing height (in centimeters) and weight (in kilograms) were measured twice. Two digital scales (model number 63200, Soehnle, Backnang, Germany) were used to measure weight to the nearest 0.1 kg. The scales were placed on a metal platform. Each day before starting weight measurements, scales were calibrated using a predefined weight; this was repeated after every 20 samples. A tape measure was used to measure standing height to the nearest 0.1 cm. The tape measure was set vertically against the wall, 50 cm above the floor. A big, flat, set square was used to make a right angle with the wall to ensure that height was measured accurately. Children were asked to remove shoes and bulky clothes before measurements. Body mass index (BMI) was calculated as weight (in kilograms) divided by the square of height (in meters). The BMI Z-score for age and sex was calculated based on World Health Organization Child Growth Standards software (AnthroPlus, World Health Organization, Geneva, Switzerland, 2007). Children's weight status was reported in 4 categories: thin (Z-score: <2 SD), normal (Z-score: ≥–2 SD and ≤1 SD), overweight (Z-score: >1 SD and ≤2 SD), and obese (Z-score: >2 SD). Girls were asked whether they had reached menarche; weight status was reported as pre-menarche or post-menarche.

Academic performance. The researchers collected data on academic performance with an author-designed questionnaire that was completed by the student's teacher. Because children's final grades were not available at the time, this pretested, self-administered questionnaire was developed and used based on teachers' assessments of children's performance in class and with

Table 1. Food Security, Weight, and Academic Performance in Iranian Primary Schoolchildren (n = 749)

Characteristics	All	Boys	Girls
Household food security status, n (%)			
FS	563 (75.2)	281 (71.1)	282 (73.4)
FI without hunger	131 (17.5)	88 (22.3)	43 (12.1)
FI with hunger	55 (7.3)	26 (6.6)	29 (8.2)
Child FS status, n (%)[a]			
FS	622 (83.0)	326 (82.5)	296 (83.6)
Low FS	105 (14.0)	64 (16.2)	41 (11.6)
Very low FS	22 (2.9)	5 (1.3)	17 (4.8)
Z-score for BMI, n (%)			
Thin	15 (1.9)	9 (2.1)	6 (1.6)
Normal	382 (47.6)	186 (44.4)	196 (51.0)
Overweight	214 (26.7)	97 (23.2)	117 (30.5)
Obese	192 (23.9)	127 (30.3)	65 (16.9)
BMI, kg/m^2 (mean ± SD)	20.5 ± 4.4	20.7 ± 4.6	20.2 ± 4.1
Pre-menarche	–	–	19.8 ± 4.1
Post-menarche	–	–	22.0 ± 4.0
Academic performance score (0–20) (mean ± SD)[b]			
Mathematics	15.2 ± 4.5	14.6 ± 4.9	15.8 ± 3.8
Reading	17.3 ± 3.3	16.8 ± 3.9	17.8 ± 2.6
Science	16.7 ± 3.8	16.3 ± 4.2	17.2 ± 3.2
Spelling	17.8 ± 3.2	17.3 ± 3.7	18.3 ± 2.4
Composition	17.2 ± 3.3	16.7 ± 3.8	17.8 ± 2.6
Social science	17.0 ± 3.8	16.7 ± 4.2	17.3 ± 3.4

BMI indicates body mass index; FI, food insecurity; FS, food security.
[a]Defined based on the last 8 items of the US Department of Agriculture's Household Food Security Survey Module (FS: raw score of 0–1; low FS: raw score of 2–4; very low FS: raw score of 5–8); [b]Measured based on teacher's assessment of child's performance in class and with regard to midterm grades.

regard to midterm grades. To ensure validity and consistency of academic performance, 2 approaches to assessment were used and compared: qualitative and quantitative. A total of 152 teachers (66 and 86 in girls' and boys' schools, respectively) from 42 schools evaluated students in mathematics, reading, science, spelling, composition, and social science using 2 scales: (1) quantitatively on a scale of 0–20, based on grades attained in class, and (2) qualitatively on a scale of 1–7 (1 = very good; 7 = very weak), based on a general assessment of teachers about the student. Teachers were instructed on how to fill out the questionnaire.

Study covariates. Covariates included age, birth order (<2 or ≥2), family size (<4, 4, or >4), puberty stage for girls (pre-menarche or post-menarche), father's age tertile (T1: age 30–40 years; T2: age 41–45 years; or T3: age ≥46 years), mother's age tertile (T1: age 23–35 years; T2: age 36–40 years;

or T3: age ≥41 years), ethnicity (Fars, Azeri, Fars-Azeri, or others),[28] parents' education (illiterate or ≤5 years of school; 6–9 years of school or diploma; or associate's degree or higher), father's job position (worker, employee, self-manager, high-rank employee, or retired), mother's employment (housewife or work outside home), other income source of family members (yes or no), house ownership status (owner, tenant, mortgage, or other), and have financial support source (yes or no). Children's physical activity was measured by a locally validated version of the Child and Adolescent International physical activity questionnaire[29] through a face-to-face interview with children.

Statistical Analysis

Data are presented as means and SDs for continuous variables and frequencies and percentages for categorical vari-

ables. Normality of distribution was evaluated using Kolmogorov–Smirnov test. The researchers used Pearson's chi square goodness of fit test to evaluate differences between qualitative variables. One-way ANOVA was used to evaluate differences between continuous variables in >2 groups. Pearson correlation test was used to examine the correlation between 2 academic performance scales in all classes studied. Initial analysis determined whether children with FS status who were missing data differed from children with complete data with regard to demographic and socioeconomic status. Variables identified as predicting missing data were included in the analysis as covariates.

The authors used linear regression to test associations of FI categories with academic performance. Multinomial logistic regression was used to estimate the association between household FI status and BMI categories. To reduce the possibility of spurious associations between variables, the authors controlled associations for individual, parental, and household variables. Two models were used for analysis: (1) 1 without imputing controls, and (2) 1 controlling for grade, sex, birth order, family size, ethnicity, parents' highest education, father's job post position, mother's employment, other family members' source of income, status of house property, source of financial protection, physical activity, and menstruation. $P < .05$ was considered statistically significant. All statistical analyses were conducted using Statistical Package for the Social Sciences software version 16, (SPSS, Inc, Chicago, IL, 2007).

RESULTS
Characteristics of Study Participants

At the household level, the prevalence of FS, FI without hunger, and FI with hunger was 75.2%, 17.5%, and 7.3%, respectively. At the child level, the prevalence of FS was higher and 16.9% of participants were food insecure. Based on BMI Z-score for age and sex, >50% of children were overweight and obese, which differed with sex (23.2% and 30.2% for boys and 30.5% and 16.9% for girls); 1.9% of children were thin. Mean BMI of

Table 2. Demographic Characteristics by Food Security Status for Iranian Children at Household and Child Levels

Demographic Characteristics	All (n = 749) n	%	Household Level of Food Security Status				Child Level of Food Security Status			
			FS n (%)	FI[1] Without Hunger n (%)	FI With Hunger n (%)	P*	FS[2] n (%)	Low FS[3] n (%)	Very Low FS[4] n (%)	P*
Overall	749	–	563 (75.2)	131 (17.5)	55 (7.3)		622 (83.0)	105 (14.0)	22 (2.9)	
Grade	749	–				.31				.11
5	391	52.2	282 (72.1)	75 (19.2)	34 (8.7)		318 (81.3)	62 (15.9)	11 (2.8)	
6	358	47.8	281 (72.1)	56 (15.6)	21 (5.9)		304 (84.9)	43 (12)	11 (3.1)	
Puberty stage	354	–				.53				.39
Pre-menarche	285	80.5	230 (80.7)	32 (11.2)	23 (8.1)		242 (84.9)	30 (10.5)	13 (4.6)	
Post-menarche	69	19.5	52 (75.4)	11 (15.9)	6 (8.7)		54 (78.3)	11 (15.9)	4 (5.8)	
Birth order	747	–				.13				.23
<2	407	54.8	318 (78.1)	63 (15.5)	26 (6.4)		347 (85.3)	50 (12.3)	10 (2.5)	
≥2	340	45.2	244 (71.8)	68 (20.0)	28 (8.2)		274 (80.6)	55 (16.2)	11 (3.2)	
Father's age tertile, y	739	–				.27				.46
T1: 30-40	285	38.1	208 (73.0)	54 (18.9)	23 (8.1)		229 (80.4)	46 (16.1)	10 (3.5)	
T2: 41-45	252	33.5	191 (75.8)	47 (18.7)	14 (5.6)		216 (85.7)	31 (12.3)	5 (2.0)	
T3: 46≤	202	28.4	159 (78.7)	26 (12.9)	17 (8.4)		170 (84.2)	25 (12.4)	7 (3.5)	
Mother's age tertile, y	744	–				.43				.68
T1: 23-35	270	36.3	202 (74.8)	50 (18.5)	18 (6.7)		226 (83.7)	38 (14.1)	6 (2.2)	
T2: 36-40	285	38.3	207 (72.6)	56 (19.6)	22 (7.7)		231 (81.1)	43 (15.1)	11 (3.9)	
T3: 41≤	189	25.4	150 (79.4)	25 (13.2)	14 (7.4)		161 (85.2)	23 (12.2)	5 (2.6)	
Ethnicity	747	–				.01				<.001
Fars	415	55.6	332 (80.0)	60 (14.5)	23 (5.5)		366 (88.2)	41 (9.9)	8 (1.9)	
Azeri	208	27.8	147 (70.7)	40 (19.2)	21 (10.1)		162 (77.9)	38 (18.3)	8 (3.8)	
Fars-Azeri	47	6.3	36 (76.6)	6 (12.8)	5 (10.6)		39 (83.0)	5 (10.6)	3 (6.4)	
Other	77	10.3	47 (61.0)	24 (31.2)	6 (7.8)		54 (70.1)	20 (26.0)	3 (3.9)	

FI indicates food insecurity; FS, food security.
*Significant at $P < .05$ for chi-square tests of independence.

pre-menarche and post-menarche girls was significantly different ($P < .05$).

Data on academic performance were available for 753 children. Qualitative and quantitative scores for all subjects studied were highly correlated ($r ≥ 0.88$); therefore, the quantitative scale (score of 0–20) was included in the analysis (Table 1).

Association Between Socioeconomic and Demographic Characteristics With FS Status

Tables 2 and 3 list background characteristics of the children who were studied. There was a strong significant association among household FS status and school status, family size, parents' education, father's job position, and house ownership status ($P < .001$), as well as financial support source and ethnicity ($P < .05$). At the child level, FS status was associated with school status, parents' education, father's job position, house ownership status, ethnicity ($P < .001$), family size, and mother's employment ($P < .05$).

Association Between Academic Performance and FS Status

Multiple linear regressions were used to estimate the association between household and child-level FI status and academic performance (Table 4). Food insecurity was strongly associated ($P < .05$) with academic performance in mathematics, reading, science, spelling, and social science. Only composition grades and the category of VLFS were not associated, compared with those who were food secure in both adjusted and unadjusted models.

The adjusted model showed an inverse but significant association between FI without hunger and academic performance in all subjects studied, except for social science; the highest $β$ observed was in mathematics ($β = –1.78$; $P < .001$) and the lowest was in spelling ($β = –.88$; $P = .007$). Also, FI with hunger was inversely associated with grades attained in all subjects; the highest $β$ was in mathematics ($β = –1.98$; $P = .003$) and the lowest was in composition ($β = –.94$; $P = .05$). The adjusted model showed that at the child level, LFS and VLFS were associated with lower academic achievement. This association was significant between LFS and all grades attained in all subjects studied, whereas for VLFS it was significant only for mathematics, reading, and science (adjusted multivariate coefficient [R^2] = 0.13, 0.12, and 0.10, respectively) but not for spelling, composition, and

Table 3. Socioeconomic Characteristics by Food Security Status for Iranian Children at Household and Child Levels

Socioeconomic Characteristics	All (n = 749) n	%	Household Level of Food Security Status				Child Level of Food Security Status			
			FS n (%)	FI Without Hunger n (%)	FI With Hunger n (%)	P*	FS n (%)	LFS n (%)	VLFS n (%)	P*
School status	749					<.001				<.005
Governmental	648	86.5	471 (72.7)	123 (19.0)	54 (8.3)		626 (81.2)	100 (15.4)	22 (3.4)	
Nongovernmental	101	13.5	92 (91.1)	8 (7.9)	1 (1.0)		96 (95.0)	5 (5.0)	0	
Family size	746	–				<.001				.01
<4	161	20.1	120 (81.1)	21 (14.2)	7 (4.7)		131 (88.5)	14 (9.5)	3 (2)	
4	467	58.4	343 (78.0)	70 (15.9)	27 (6.1)		371 (84.3)	59 (13.4)	10 (2.3)	
>4	172	21.5	98 (62.0)	40 (25.3)	20 (12.7)		118 (74.7)	32 (20.3)	8 (5.1)	
Father's education	738	–				<.001				<.001
Illiterate or ≤5 y	76	10.7	27 (35.5)	30 (39.5)	19 (25)		38 (50.0)	33 (43.4)	5 (6.6)	
6–9 y or diploma	337	50.3	276 (73.2)	73 (19.4)	28 (7.4)		306 (81.2)	56 (14.9)	15 (0.4)	
Associate's degree or higher	285	39.0	254 (89.1)	24 (8.4)	7 (2.5)		270 (94.7)	13 (4.6)	2 (0.7)	
Mother's education	744	–				<.001				<.001
Illiterate or ≤5y	83	10.9	32 (38.6)	31 (37.3)	20 (24.1)		46 (55.4)	30 (36.1)	7 (8.4)	
6–9 y or diploma	432	58.1	322 (74.5)	81 (18.8)	29 (6.7)		357 (82.6)	62 (14.4)	13 (3.0)	
Associate's degree or higher	229	31.0	205 (89.5)	19 (8.3)	5 (2.2)		215 (93.9)	12 (5.2)	2 (0.9)	
Father's job position	726	–				<.001				<.001
Worker	102	13.6	48 (47.1)	36 (35.3)	18 (17.6)		59 (57.8)	37 (36.3)	6 (5.9)	
Employee	300	41.9	239 (79.7)	51 (17.0)	10 (3.3)		263 (87.7)	30 (10.0)	7 (2.3)	
High-rank employee	133	17.9	121 (91)	9 (6.8)	3 (2.3)		126 (94.7)	5 (3.8)	2 (1.5)	
Retired	17	2.6	14 (82.4)	1 (5.9)	2 (11.8)		15 (88.2)	2 (11.8)	0	
Self-employed	174	24	131 (75.3)	27 (15.5)	16 (9.2)		145 (83.3)	24 (13.8)	5 (2.9)	
Mother's employment	744	–				.17				.05
Working	152	79.4	123 (80.9)	21 (13.8)	8 (5.3)		135 (88.8)	12 (7.9)	5 (3.3)	
Housewife	592	20.6	436 (73.6)	110 (18.6)	46 (7.8)		483 (81.8)	92 (15.5)	17 (2.9)	
Other income source of family members	735	–				.98				.78
No	694	92.5	523 (75.4)	121 (17.4)	50 (7.2)		578 (83.3)	96 (13.8)	20 (2.9)	
Yes	41	5.9	30 (73.2)	7 (17.1)	4 (9.8)		33 (80.5)	7 (17.1)	1 (2.4)	
House ownership status	748	–				<.001				<.001
Owner	397	53.4	328 (82.6)	54 (13.6)	15 (3.8)		353 (88.9)	37 (9.3)	7 (1.8)	
Tenant	34	4.4	29 (85.3)	5 (14.7)	0		32 (94.1)	2 (5.9)	0	
Mortgage	241	32.7	147 (61.0)	57 (23.7)	37 (15.4)		169 (70.1)	58 (24.1)	14 (5.8)	
Other	76	9.6	59 (77.6)	14 (18.4)	3 (3.9)		68 (89.5)	7 (9.2)	1 (1.3)	
Source of financial support	748	–				.02				.36
No	731	97.8	554 (75.8)	126 (17.2)	51 (7.0)		610 (83.4)	100 (13.7)	21 (2.9)	
Yes	17	2.2	9 (52.9)	4 (23.5)	4 (23.5)		12 (70.6)	4 (23.5)	1 (5.9)	

FI indicates food insecurity; FS, food security.
*Significant at $P < .05$ for chi-square tests of independence.

social science (adjusted R^2 = 0.10, 0.09, and 0.10, respectively).

Associations Between Weight Status, FS Status, and Academic Performance

Data on FS status were available for 749 children. In the multinomial regression, the association between household FI without hunger and overweight was statistically significant for girls (odds ratio = 2.56; 95% confidence interval, 1.05–6.23) compared with those from food-secure households (Table 5). A significant association was also observed for the child-level FI scale between LFS and overweight in girls (odds ratio = 4.41; 95% confidence interval, 1.58–12.23) compared with those of food-secure girls. In boys, no associations were found between household and child-level FS status and weight status and between weight status and academic performance.

DISCUSSION

Results from the current study indicated that FI was strongly associated with lower academic performance in children. Food insecurity without

Table 4. Beta Coefficient and P for Association Between Household- and Child-Level Food Insecurity Status and Academic Performance in Mathematics, Reading, Science, Spelling, Composition, and Social Science

Food Security Status[c]	Mathematics		Reading		Science		Spelling		Composition		Social Science	
	β (P)[a]	Adjusted β (P)[b]	β (P)	Adjusted β (P)	β (P)	Adjusted β (P)	β (P)	Adjusted β (P)	β (P)	Adjusted β (P)	β (P)	Adjusted β (P)
Household level FS status												
FS (reference)												
FI without hunger	−2.59 (<.001)	−1.78 (<.001)	−1.71 (<.001)	−1.08 (.001)	−1.75 (<.001)	−.97 (.01)	−1.50 (<.001)	−.88 (.007)	−1.69 (<.001)	−1.04 (.002)	−1.48 (.001)	−.71 (.06)
FI with hunger	−3.37 (<.001)	−1.98 (.003)	−2.09 (<.001)	−1.13 (.02)	−2.72 (<.001)	−1.54 (.007)	−2.12 (<.001)	−1.05 (.03)	−2.15 (<.001)	−.94 (.05)	−2.72 (<.001)	−1.29 (.02)
Adjusted R²	0.07	0.13	0.05	0.10	0.05	0.10	0.05	0.10	0.05	0.09	0.04	0.09
Child-level FS status												
FS (reference)												
Low FS	−3.14 (<.001)	−1.74 (<.001)	−1.94 (<.001)	−.88 (.01)	−2.34 (<.001)	−1.17 (.006)	−2.07 (<.001)	−1.07 (.003)	−2.46 (<.001)	−1.31 (<.001)	−2.52 (<.001)	−1.28 (.003)
Very low FS	−3.08 (.001)	−2.40. (.01)	−2.00 (.004)	−1.89 (.009)	−2.43 (.002)	−1.85 (.02)	−1.55 (.02)	−1.30 (.06)	−.58 (.40)	−.40 (.57)	−1.79 (.02)	−1.53 (.06)
Adjusted R²	0.06	0.12	0.04	0.10	0.05	0.10	0.05	0.10	0.06	0.09	0.05	0.10

FI indicates food insecurity; FS, food security; R², multivariate coefficient.

[a]Row model without control for confounders; [b]Adjusted for school status (governmental and nongovernmental), grade, sex, birth order, family size, ethnicity, parents' education, father's job position, mother's employment, other source of income of family members, house ownership status, source of financial support, and physical activity; [c]Multiple linear regression models to estimate association between household- and child-level FI status and academic performance.

Note: Data were significant at P < .05.

hunger and LFS at both the household and child levels were associated with overweight in girls. The association between FI and academic performance remained highly significant even after controlling for known confounders. Only VLFS was not associated with composition scores before and after the researchers controlling for known confounders. This finding was consistent with reports of significant associations between FI and academic performance in children.[5,6,12,30] Alaimo et al[6] analyzed data from the third National Health and Nutrition Examination Survey and found a significant association between FI and low test scores for arithmetic, letter–word, and passage comprehension.

Ahmad Bawadi et al[30] reported a significant association between FI and impaired academic performance in children aged 11–16 years in Jordan. In a longitudinal study[12] on 21,000 kindergarten children who were followed up to third grade, FI predicted poor academic performance; however, over time, persistence of FI was only associated with lower reading scores in girls compared with food-secure ones. In the Early Childhood Longitudinal Study,[11] kindergarten children who faced marginal FI had lower math scores, but this association was not observed in households with severe FI.

Three mechanisms were suggested to explain how FI may be associated with academic performance. First, FI can result in compromised dietary quality or quantity. Food insecurity is shown to be related to lower fruit, vegetable, and nutrient intake and higher intake of carbohydrates.[31,32] Themane et al[33] found a negative association between malnutrition and educational achievement. Malnutrition negatively affects speed, fine motor skills, and coordination. Furthermore, malnutrition affects cognitive development and leads to poor behavioral performance.[34] Children who experienced hunger or were at risk of hunger were absent from school more days than were other children and also had higher rates of tardiness. Suspension from school in food-insufficient teenagers occurred almost 3 times more than that in food-sufficient teenagers.[6]

The second possible mechanism is the indirect association between FI and emotional well-being. Children in food-insecure households are at

Table 5. Relative Risk Ratios and 95% CI for Association Between FS Status and Body Mass Index Z-Score for Age Categories for Iranian Children

	Boys				Girls			
	Unadjusted Relative Risk Ratio (95% CI)		Adjusted Relative Risk Ratio (95% CI)[b]		Unadjusted Relative Risk Ratio (95% CI)		Adjusted Relative Risk Ratio (95% CI)[c]	
Food Security Status[a]	Overweight	Obese	Overweight	Obese	Overweight	Obese	Overweight	Obese
Household-level FS status								
FS (reference)								
FI without hunger	1.02 (0.57–1.82)	0.59 (0.32–1.10)	0.96 (0.46–1.98)	0.80 (0.37–1.69)	1.57 (0.77–3.18)	1.34 (0.52–3.40)	2.56 (1.05–6.23)*	1.63 (0.45–5.80)
FI with hunger	0.65 (0.20–2.11)	1.27 (0.52–3.08)	0.34 (0.06–1.79)	2.63 (0.80–8.65)	0.46 (0.16–1.28)	0.95 (0.33–2.71)	0.87 (0.23–3.30)	0.55 (0.11–2.63)
Child-level FS status								
FS (reference)								
Low FS	0.88 (0.44–1.76)	1.03 (0.80–2.24)	0.81 (0.33–1.97)	1.69 (0.73–3.89)	1.94 (0.93–4.03)	1.85 (0.74–4.60)	4.41 (1.58–12.23)*	2.00 (0.53–7.62)
Very low FS	0.98 (0.08–10.98)	1.68 (0.23–12.16)	0.72 (0.05–10.05)	2.75 (0.25–29.50)	0.45 (0.12–1.66)	0.61 (0.13–2.86)	0.85 (0.18–3.94)	0.18 (0.01–1.99)

95% CI indicates 95% confidence intervals; FI, food insecurity; FS, food security.
[a]Multinomial logistic models compared weight category with nonobese group/food secure category; [b]Adjusted for school status (governmental and nongovernmental), grade, birth order, family size, ethnicity, parents' education, father's job position, mother's employment, other source of income of family members, house ownership status, source of financial support, and physical activity; [c]Also adjusted for menstruation; *Significant at $P < .05$.

risk for experiencing considerable psychological and emotional distress.[5] Emotional distress has the potential to reduce schoolwork through its effects on children's attention and motivation; furthermore, children who experience levels of emotional distress may experience more difficulties in the school environment.[35] The third possible mechanism is related to parent–child interactions. Food insecurity is associated with decreased household sensitivity to children's need.[10] Adults in food-insecure households are significantly more likely to exhibit less positive parenting practices ($P = .04$) such as less response to distress and less sensitivity to their children's cues, social-emotional growth, and cognitive growth than are other adults.[9] Children in food-insecure households are usually cared for by mothers who have poor self-control and exhibit depressive and antisocial tendencies and live in families that provide less structure and nurturance.[7,36]

Based on the results of this study, household FI without hunger and LFS in children were associated with overweight only in girls. Results of previous studies on the relationship between FI and weight status were inconsistent. Almost all studies that examined FI and obesity in children were carried out in the US, where the relationship between children's weight status and FI is likely to be complex because eligible households receive food through the *Supplement Nutrition Assistance Program* and children consume reduced-price or free food.[18] The association between FI and child overweight in the current study was consistent with findings from other studies.[12,15-17] In a study conducted on 8- to 16-year-old non-Hispanic white children from the third National Health and Nutrition Examination Survey, Alaimo et al[15] reported that girls with food insufficiency were almost 3.5 times more likely to be overweight (BMI for age, >85th percentile). In the longitudinal study carried out on children from kindergarten to third grade, Jiyot et al[12] reported an association between FI and increase in BMI for girls but not boys.

A review of studies that examined the relationship between FI and overweight or obesity in children suggested that the prevalence of overweight was relatively higher in food-insecure children.[37] The findings of the current

study indicated that FI at the household and child levels was associated with overweight in girls. Sociocultural factors may explain the different effects of FI in boys and girls. Studies suggested that girls have little decision-making power and less social freedom; as a result, boys are more buffered from the consequences of FI than are girls.[38]

The current study had limitations. The cross-sectional nature of the study made it impossible to establish a causal relationship. This also limited the possibility of observing the metabolic adjustments that may have occurred as a result of FS, which may have led to obesity. Also, in this study, household- and child-level FI data were obtained through interviews with mothers; however, children in this age group may have been able to access food outside the home about which mothers were unaware.[19] The possibility of bias owing to the use of a tape measure to determine height was another limitation.

IMPLICATIONS FOR RESEARCH AND PRACTICE

The developmental consequences of household FI in children are not well established. The association of FS status with academic performance and body weight in children may differ in different communities. Therefore, the findings may serve to provide evidence regarding the relationship of FI with obesity and academic performance, specifically in developing countries that were examined by few studies. To explore clear associations between FI and developmental consequences, studies and new approaches are needed. For instance, measuring the impact of national programs such as the School Milk Program in Iran on children's academic performance can serve as an opportunity to explore such associations. In any case, the results suggest the need for nutrition and educational supplemental programs for low-income and food-insecure students to provide them with equal opportunity.

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CONFLICT OF INTEREST

The authors have not stated any conflicts of interest.