Research Article

iMedPub Journals
www.imedpub.com

Journal of Food, Nutrition and Population Health
ISSN 2577-0586

2021
Vol.5 No.8:73

Association of Diet Quality Indices with Household Food Insecurity in Iranian Obese People

Abdurahman AA[1]*, L Azadbakhat[1,2], Shivappa N[3,4], J Hebert[3,4], Abshirini M[5], Qorbani M[6,7] and Dorosty AR[1]

1 Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran
2 Diabetic Research center, Endocrine and Metabolism clinical sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
3 Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, SC 29208, USA
4 Connecting Health Innovations LLC, Columbia, SC 29201 USA
5 Department of Nutrition, Science and Research, Islamic Azad University, Tehran, Iran
6 Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran
7 Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

***Corresponding author:**
Abdurahman AA

baharafenu@gmail.com

Tel: +98 21 889 555 69-Ext. 120

Department of Community Nutrition, School of Nutritional Sciences and Dietetics, Tehran University of Medical Sciences, Tehran, Iran

Citation: Abdurahman AA, Azadbakhat L, Shivappa N, Hebert J, Abshirini M, et al. (2021) Association of Diet Quality Indices with Household Food Insecurity in Iranian Obese People. Vol.5 No.8:73.

Abstract

Background: Little evidence is existing about the association between dietary inflammatory index (DII®) and Alternative Healthy Eating Index (AHEI) as a diet quality index with food insecurity (FI). The aim of the present study was to determine the association of diet quality indices (DII and AHIE) with household FI in Iranian obese people.

Method: A cross-sectional study was conducted among 300 obese people aged 19-59 years in Tehran from July to October 2017. DII scores were computed based on the overall inflammatory properties of dietary components using dietary intake assessed by a valid and reliable 168 items food frequency questionnaire. Diet quality was measured using the Alternate Healthy Eating Index-2010 (AHIE-2010). FI was measured using an adapted household food security status questionnaire.

Results: The prevalence (95% confidence interval) of FI was 44% (38-49), with 39.7% of households experiencing FI without hunger, 3.0% FI with moderate hunger, and 1.3% FI with severe hunger. In multivariate model, subjects in the last quartile of DII had higher odds of FI compared to the first quartile [AOR = 3.3 (95% CI =1.6-7.1), p-trend = 0.004]) Moreover, those who were in the last quartile of AHEI had lower odds of FI compared to the first quartile [AOR = 0.3 (95% CI: 0.1-0.6), p trend = 0.001].

Conclusions: Household food insecurity positively associated with a pro-inflammatory DII score among obese people in Iran. Improving the food and nutrition security of obese people may be a strategy to reduce obesity-related chronic conditions in this group of people.

Keywords: Dietary Inflammatory Index; food insecurity; Diet quality; household; Iran

Received: August 10, 2020, **Accepted:** August 25, 2021, **Published:** September 01, 2021

Introduction

Food insecurity is the state of being deprived of consistent access to a sufficient quantity of affordable, nutritious food [1]. Food insecurity appears to be an achieved process that results in compromises on food quality and followed by food quantity [2]. It denotes to limited or uncertain ability to obtain nutritionally appropriate food. Food insecurity has been shown to have a positive association with obesity and chronic diseases [3]. Food insecurity was prevalent in Iran, according to a recent meta-analysis nearly one-half of the households (49%) experienced food insecurity [4]. Evidence from epidemiological studies demonstrated a relationship between food insecurity and diet quality [5, 6].

Previous studies have shown that food insecurity may lead to inadequate dietary intakes and nutrient deficiencies [7-9]. Moreover, observational studies suggested that food insecurity may be associated with chronic disease in low-income adults, including cardiovascular disease (CVD), type 2 diabetes, overweight and obesity [10,11]. A recent review article [12] also demonstrated that household food insecurity significantly increased the odds of type 2 diabetes in adults. This is due to the fact that nutrient-dense foods, such as fruits and vegetables, are often more expensive and less available in lower-income neighborhoods in comparison to processed foods [13]. Therefore, food insecure individuals adhere to this unhealthy eating behavior which subsequently leads to an increased total energy intake, which can lead to the accumulation of visceral fat, and later chronic disease outcome. According to a recent study, although, the price of vegetables in Iran is not as expensive as that of developed countries, people prefer to consume other calorie dense foods than healthy foods [14].

Most chronic diseases could involve inflammation; therefore, one of the proposed dietary indices that can assess this inflammation is the dietary inflammatory index (DII®). DII measures the inflammatory potential of a diet based on the overall inflammatory properties of dietary components. Consequently, our hypothesis was that higher DII scores (more pro-inflammatory diet) might be associated with increased food insecurity.

Although recently Bergmans RS, et al. [15] explored the association between food insecurity and DII, the report has been limited to those with lower-income US adults. To our knowledge, no studies have been examined the association between household food insecurity and DII among obese people in Iran. Since obesity is a risk factor for obesity-related chronic conditions, an assessment of the distribution and relationship of household food security status with DII among obese people can have wide-ranging public health benefits to design the most effective strategies to improve the food and nutrition security situation of this group of people. Therefore, the aim of the present study was to determine the association of household food insecurity with dietary inflammatory index in Iranian obese people.

Material and Methods

Data for this study were collected from a cross-sectional study using a random sample of 300 Tehrani obese individuals in the South area of Tehran from July to October 2017. Using a stratified random sampling technique ten public health canters were selected from 33 public health centres found at the Southern area of Tehran. Followed by a probability proportional to their population obese people were randomly selected from the sampling frame of a telephone directory database from the nearby health centre. Finally, study participants were recruited via a phone call to come to the nearby cluster. When there were two eligible obese individuals in the household, only one person was invited randomly. In case, there was no eligible person in the selected household, the next household was contacted. Inclusion criteria were as follows: age between 19-59 years, had BMI of ≥ 30 kg/m2 and lived in the area for 6 months and more. Enough sample size was calculated based on WHO estimated the prevalence of obesity in adults of Iran (26.1%) [16]. Ethics Committee of Tehran University of Medical Sciences (TUMS) approved the study (Ethical Approval code: IR.TUMS.VCR.REC.1396.2157). All participants completed a written informed consent before entering the study.

Dietary Intake Assessment

Dietary intake of participants was assessed using a validated 168-item semi-quantitative FFQ [17]. The FFQ consisted of a list of foods with standard serving sizes. Participants were asked to report their frequency and amount of each food item consumed during the previous year. Portion sizes of the consumed foods were converted to grams using household measurements [18]. Nutritionist IV software was used for the nutrient analysis of the diets. The database of this software was modified for Iranian foods. Then, all items were converted to daily intakes of grams. Dietary data from the FFQ were used to calculate the DII.

Dietary inflammatory index

DII was calculated using the method proposed by Shivappa N, et al. [19] by which the design and development of these method have been described elsewhere [19]. The goal for developing the DII score was to measure the inflammatory potential of a diet based on the overall inflammatory properties of dietary components. The details of development of DII is described by Shivappa, et al. elsewhere [19]. High sensitivity CRP measurements were used to examine construct validity of the DII in a longitudinal cohort using multiple (up to 15) 24-hour dietary recall interviews and up to five 7-day dietary recalls. The DII was subsequently validated in four studies among different populations with a variety of inflammatory biomarkers (i.e., interleukin, IL-6, hs-CRP, fibrinogen, homocysteine and TNF-α) [20-25]. In this updated version of the DII, 1,943 articles were reviewed and scored. Forty-five food parameters, including foods, nutrients, and other bioactive compounds, were identified based on their inflammatory effect on six specific inflammatory markers, including CRP, IL-1β, IL-4, IL-6, IL-10 and tumor necrosis factor (TNF)-α. A regionally representative world database representing diet surveys from 11 countries was used as a comparative standard for each of the 45 parameters (i.e. foods, nutrients, and other food components). Intake values from this database were used to calculate the DII scores. This is explained in more detail in the DII Methods paper [19]. Briefly, a standard mean for each parameter from the representative world database was subtracted from the actual individual exposure and divided by its standard deviation to generate Z scores. These Z scores were converted to proportions (thus minimizing effects of outliers/right- skewing). These values were then doubled and 1 was subtracted to achieve symmetrical distribution with values centered on 0. The resulting value was then multiplied by the corresponding inflammatory score for each food parameter and summed across all food parameters, to obtain the overall DII score. Using the FFQ, we calculated the DII based on energy-adjusted intake of the 32 single food parameters of the 45 possible food parameters that were available from the FFQ using the energy density approach, which calculated the DII per 4184

kJ (1000 kcal) of energy [26]. Positive values represent a pro-inflammatory diet, whereas negative values represent an anti-inflammatory diet. DII scores range from -8.87 (maximally anti-inflammatory) to 7.98 (maximally pro-inflammatory).

Food Insecurity Measurement

Household food insecurity was measured using the validated 18 items household food security status (HFSS) questionnaire for Iran [27]. The food security score of each participant was calculated by its standard method according to the number of positive responses in this questionnaire [28]. Based on the USDA cut off, subjects were divided into 4 groups: Food Secure (scored 0-2.2), food insecure without hunger (scored 2.4-4.4), food insecure with moderate hunger (scored 4.7-6.4), and food insecure with severe hunger (scored more than 6.6). The HFSS score was constructed by adding the total values of the 18 questions food security scale values ranging from 0.0 to 9.3, with higher numbers representing a greater level of food insecurity. However, in the present study for the regression analysis, we had merged food insecurity with moderate and severe hunger groups into one group, food insecurity with hunger because the number of participants in these categories was very small.

Assessment of covariates

Covariates for the present study were identified using the existing knowledge base, including the investigative team's knowledge and published literature, and included BMI, demographic, socioeconomic status, and health habit information variables including age, sex, physical activity level (measured as light, moderate, and vigorous physical activity), and history of chronic disease (yes/no). BMI was categorized in to three groups; Obese I (BMI 30.00-34.99 kg/m^2), Obese II (BMI 35.00-39.99 kg/m^2), and Obese III (BMI ≥40 kg/m^2).

Statistical analyses

Normal distribution of continuous variables was checked by Kolmorov-Smirnov test. Categorical and continuous variables were presented as a number (percentage) and mean (SD), respectively. Association of categorical variables with household food insecurity were assessed using $\times^2$ test. The ANOVA test was used to compare continuous variable with normal distributions across food security status. The Kruskal-Wallis test, the non-parametric test that is equivalent of the one-way ANOVA, was used. Additionally, the linear association of DII quartile with continuous variables was assessed using ANOVA test of linearity. Multinomial logistic regression models were applied to find determinates of outcome variables (household food insecurity) using univariate and multivariate models. In the multivariate model, we included those variables that were significantly associated with the outcome variables at the $p \leq 20$ level in the univariate model [29]. Association between independent variables with household food insecurity was assessed using univariate and multivariate binary logistic regression. Results of binary and multinomial logistic regression was presented as odds ratios (OR) with 95% confidence intervals (CI). Quartile of DII was considered as continuous and categorical variable. In the categorical form of DII quartile, we compared fourth quartile with the first quartile in all analysis and in the continuous form, OR was calculated for per quartile increment. P-values <0.05 was considered as statistically significant. All analyses were performed using Stata (release 11.2 for Windows, Stata Corp LP).

Results

The sample was predominantly female with average age and BMI of 42.9 years and 34.2 kg/m^2, respectively. The majority of the household head was male. Around 68% of participants were unemployed, and 58% of the participants were physically inactive. Food secure households tend to have completed educational level more than and equal to high school, and food insecure without hunger participants tend to be older. The average DII score was -0.33 ranging from a minimum of -4.42 to a maximum of 3.34. There were significant differences among household food security status by age, educational level; socioeconomic status, physical activity level, and DII score. However, food security status did not vary by sex of household head, occupation, marital status and BMI among groups (**Table 1**).

The prevalence of FI in 300 households was 44%, with 39.7% of households experiencing FI without hunger, 3.0% FI with moderate hunger, and 1.3% FI with severe hunger. Compared with participants in the first quartile (i.e. most anti-inflammatory), those in the fourth quartiles (most pro-inflammatory) of DII score was more likely to be FI (51% vs 25%, p=.001), and participants in the lowest quartiles of DII score had a higher prevalence of food security. There was a significant trend observed in the prevalence of household FI with increasing quartiles of DII score (**Figure 1**).

Kruskal-Wallis results indicated that significant differences were observed on the intake of components of DII score among household food security status, except for anti-inflammatory food parameters, i.e. vitamin A, vitamin B6, vitamin C, vitamin D, and pro-inflammatory food parameter, Iron. Compared to the two levels of food security, i.e. food secure and food insecure with hunger, those with food insecure without hunger had a lower intake of several anti- and pro-inflammatory food parameters (**Table 2**).

A multinomial logistic regression was performed to model the relationship between household FI and the DII score. The analysis showed that FI without hunger was positively associated with higher DII quartile (Q4) [AOR = 3.3 (95% CI =1.6-7.1), p trend = 0.004). Similarly, FI without hunger was positively associated with DII score (continues) [AOR = 1.5 (95% CI: 1.2-1.9). However, FI without hunger was negatively associated with greater adherence to higher AHEI-2010 score [AOR = 0.3 (95% CI: 0.1-0.6), p trend = 0.001] after adjusting for potential covariates (**Table 3**).

Discussion

The results of the present cross-sectional study showed that food insecurity significantly associated with higher DII score. Precisely, food insecure household without hunger was positively associated with higher DII score (most pro-inflammatory) independent of a wide range of potential confounders. Moreover, food insecure household without hunger was inversely associated with greater adherence of higher AHEI-2010 among obese individuals. These

Table 1. Comparison of socio-demographics and socio-economic characteristics between the different categories of Food security status.

Characteristics	All (n=300)	Food security status				*p*
		Food secure (n=168)	Food insecure without hunger (n=119)	Food insecure with moderate hunger (n=9)	Food insecure with severe hunger (n=4)	
Continues variable[a]						
Age (year)	42.9± 10.9	40.9±10.6	45.7±10.6	41.4±12.5	41.0±11.5	0.003
DII Score	-0.33±1.60	-0.59±1.67	0.09±1.39	-0.93±1.93	-0.49±.93	0.002
AHEI-2010 Score	66.1± 10.5	67.8± 10.3	62.9 ±9.5	75.9 ±14.1	68.2± 10.1	<0.001
BMI (kg/m2)	34.2±3.9	34.2±3.9	34.2±3.8	34.5±4.4	32.6±2.8	0.87
Categorical variables[b]						
Sex, % female	254(84.7)	147(87.5)	95(79.8)	8(88.9)	4(100.0)	0.26
Sex of household head, % male	272(90.7)	156(92.8)	105(88.2)	7(77.8)	4(100.0)	0.27
Educational level, % ≥ high school	209(69.7)	123(73.2)	81(68.1)	3(33.3)	2(50.0)	0.05
Occupation, % unemployed	205(68.3)	122(72.6)	72(60.5)	8(88.9)	3(75.0)	0.08
Marital Status						0.27
Single	23(7.7)	10(5.9)	13(10.9)	0(0.0)	0(0.0)	
Married	261(87.0)	151(89.9)	99(83.2)	7(77.8)	4(100.0)	
Divorced	1(0.3)	1(0.6)	0(0.0)	0(0.0)	0(0.0)	
Widowed	15(5.0)	6(3.6)	7(5.9)	2(22.2)	0(0.0)	
Physical Activity Level						0.003
Low PA	174(58.0)	93(55.3)	80(67.2)	1(11.1)	0(0.0)	
Moderate PA	116(38.7)	69(41.1)	36(30.2)	7(77.8)	4(100.0)	
High PA	10(3.3)	6(3.6)	3(2.5)	1(11.1)	0(0.0)	
Socio-Economic Status						0.002
Lower SES	68(22.7)	41(24.4)	18(15.1)	6(66.7)	3(75.0)	
Middle SES	165(55.0)	87(51.8)	75(63.0)	2(22.2)	1(25.0)	
Higher SES	67(22.3)	40(23.8)	26(21.8)	1(11.1)	0(0.0)	
DII quartiles						0.003
Q1	75(25.0)	56(33.3)	16(13.4)	3(33.3)	0(0.0)	
Q2	75(25.0)	42(25.0)	28(23.5)	2(22.2)	3(75.0)	
Q3	75(25.0)	33(19.6)	39(32.8)	3(33.3)	0(0.0)	
Q4	75(25.0)	37(22.0)	36(30.2)	1(11.1)	1(25.0)	
AHEI-2010 Quartiles						0.001
Q1	81(27.0)	34(20.2)	45(37.9)	1(11.1)	1(25.0)	
Q2	72(24.0)	44(26.2)	28(23.5)	0(0.0)	0(0.0)	
Q3	76(25.3)	41(24.4)	31(26.0)	2(22.2)	2(50.0)	
Q4	71(23.7)	49(29.2)	15(12.6)	6(66.7)	1(25.0)	

[a]For continues variables *p* Values were obtained by ANOVA and values are presented as means ±SD
[b]For categorical variables *p* values were obtained by chi-squared test and values are presented as n (percent)

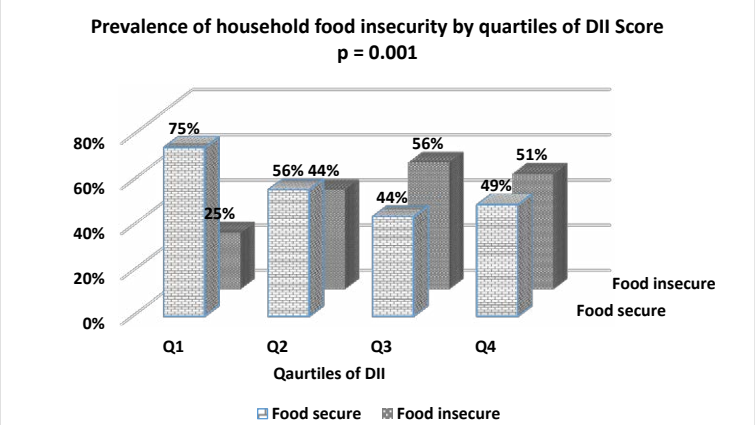

Figure 1 Prevalence of household food insecurity by quartiles of DII score among study participants.

Table 2. Median and Inter-quintile range (IQR) for DII score components by food security status among study participants.

DII Component	Food secure (n = 168)		Food insecure without hunger (n = 119)		Food insecure with hunger (n = 13)		p
	Median	IQR	Median	IQR	Median	IQR	
Total energy (kcal)	2787.7	3488.0	2226.4	2811.3	2853.7	3395.4	<0.001
Carbohydrate (g)	352.7	441.2	296.9	353.1	384.3	429	<0.001
Protein (g)	85.2	103.2	77.9	89.6	83.2	91.4	0.005
Fat (g)	118.3	148.2	88.6	118.9	109.9	162.3	<0.001
Fiber (g)	52.3	71.3	39.6	51.0	55.5	78.1	<0.001
Cholesterol (mg)	201.2	300.9	192.9	293.8	123.5	204.1	0.02
Saturated fat (g)	32.4	46.7	22.9	36.8	28.2	44.0	<0.001
MUFA (g)	42.9	52.7	31.3	42.3	42.8	62.8	<0.001
PUFA (g)	26.8	35.8	17.5	27.0	30.9	44.2	<0.001
n-3 PUFA (g)	1.5	2.2	1.0	1.7	1.1	1.9	<.001
n-6 PUFA (g)	0.02	0.05	0.04	0.09	0.00	0.01	0.01
Niacin (mg)	24.7	29.8	22.7	25.7	25.6	30.1	0.01
Riboflavin (mg)	2.1	2.7	1.9	2.1	2.1	2.5	<0.001
Thiamin (mg)	2.2	2.8	1.8	2.2	2.4	3.2	<0.001
Vitamin A, RAE (ug)	658.4	951.1	626.5	769.1	562.4	892.8	0.09
Vitamin B6 (mg)	1.8	2.2	1.8	2.0	1.8	1.9	0.18
Vitamin B12 (ug)	3.6	5.5	2.9	4.3	2.5	5.7	0.002
Vitamin C (mg)	117.8	173.0	109.9	155.2	98.5	195.9	0.49
Vitamin D (ug)	1.8	2.6	1.6	2.6	1.1	2.2	0.29
Vitamin E (mg)	17.6	31.2	12.7	20.4	31.5	44.2	<0.001
Iron (mg)	34.1	46.8	33.9	52.2	48.9	55.0	0.58
Magnesium (mg)	464.3	576.7	388.1	471.7	463.9	601.7	0.002
Zinc (mg)	12.9	15.9	11.0	13.2	12.6	15.1	<0.001
Folate (ug)	633.2	729.2	553.4	649.1	625.8	745.4	<0.001
Selenium (mg)	133.9	178.1	114.2	138.2	157.1	193.0	<0.001

The median and interquartile range (IQR) for continuous variables
[P]Values were obtained by Kruskal-Wallis rank test

Table 3. Odds ratios and 95% confidence intervals for the association between household food insecurity with dietary inflammatory index and AHEI-2010 Score estimated by multinomial logistic regression.

	Quartiles of DII [†]				DII quartile (per one quartile) [‡]
	Q1	Q2	Q3	Q4	
	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	AOR (95% CI)	
HFI status					
FI without hunger	1	2.2(1.0-4.7)*	3.9(1.9-8.4)*	3.3(1.6-7.1)*	1.5(1.2-1.9)*
FI with hunger	1	1.8(0.4-8.8)	1.1(0.4-8.7)	0.6(0.1-4.6)	0.8(0.5-1.5)
	Quartile of AHEI-2010[†]				**AHEI-2010 quartile (per one quartile) [‡]**
HFI status					
FI without hunger	1	0.4(0.2-0.9)	0.5(0.3-1.1)	0.3(0.1-0.6)*	0.7(0.6-0.9)*
FI with hunger	1	1.4(0.2-8.2)	1.4(0.2-8.6)	1.6(0.3-9.3)	1.5(0.8-2.8)

Model (AOR): Adjusts for age, sex, education status, occupation and socioeconomic status.
Note: Reference category for Household food security status is food secure; and for DII score quartile 1.
Abbreviations: HFI- Household food security status, FI- Food insecure, DII- Dietary inflammatory index, AHEI-2010 Alternate health eating index.
*Significant association (p<.05)
†DII/AHEI-2010 quartiles considered as categorical variable, ‡ DII/AHEI-2010 quartiles considered as continuous variable.

results support the hypothesis that food insecurity status may influence the inflammatory pathways which associated with chronic disease due to diet quality [30].

The possible mechanisms that determined food insecurity lead to obesity and obesity-related chronic diseases were that individuals with scare resource are limited in their food choices, and they usually adhere to unhealthy eating behavior such as consuming processed foods, which are inexpensive and highly accessible [31]. In addition, individuals living in food insecure household consume less fruit and fewer vegetable than their food secure counterparts do. Furthermore, food insecure individuals are worried about feeding themselves and/or families

adequately, which can increase stress, anxiety, and depression level [32]. Subsequently, these factors may contribute to an increased intake of total energy, which can result in the accumulation of visceral fat, and subsequent chronic disease outcome [33].

Although food insecurity is prevalent in Iranian households, the reported rate of food insecurity in the present study was less than that of studies using similar categories of food security status for the period 2014 to 2017 (44% in our sample vs. 54.4%-65.2% in the metropolitan Tehran) [34-37]. The possible reasons for the variation in the prevalence of food insecurity reported in different studies are socioeconomic, social and cultural differences between participants, type of participants included in the study and area of the study. The economic crisis and rapid increase in food prices may also contribute to this variation in the previous studies. Inconsistent to our findings, previous studies have shown that food insecurity has been associated with age, educational level, socioeconomic status, employment status, and physical activity level [27,35,38].

Several studies showed that food insecurity inversely associated with diet quality indices, i.e. Health eating index-2005 (HEI-2005), AHEI-2010 scores, dietary diversity score, and adherence to Mediterranean diet score [39-41]. These results are consistent with our findings that food insecure without hunger negatively associated with higher AHEI-2010 score. Food insecure household less likely to consume healthy diets such as fruits, vegetables, whole grains, chicken, meat, and fish, but consumed a greater percentage of energy from energy-dense foods than food secure households consumed [41-45]. However, in NHANES 1999-2008 cross-sectional study of pregnant women, no association was found between household food insecurity and dietary quality measured by Alternate Healthy Eating Index modified for Pregnancy (AHEI-P) [46]. Similarly, in the Mississippi Delta study, after controlling for potential confounders no association observed between household food insecurity and healthy eating index [6]. These discrepancies accounted for the different methods for measuring household food security status, variability on the sample size and study population included, differences on the tool used for gathering dietary information.

The results of the current study, differences in mean intake of DII score components among the food security status, are similar to those of Bergmans RS, et al. [15]. In their study, compared with food secured households, those in low or very low food security status consumed low vitamin A, vitamin B6, and vitamin C. Similarly, Kim HJ, et al. [44] revealed that mean daily intakes of vitamins and minerals, as well as weekly consumption frequencies of fruits and vegetables, were significantly lower in food insecure adults compared with food secure households. Fruit and vegetables are very rich in anti-oxidants and other anti-inflammatory phytochemicals. Fruits and vegetables are good sources of vitamins and used as the components of the anti-inflammatory food parameters. Low intake of these anti-inflammatory food parameters and higher consumption of the pro-inflammatory food parameters may contribute to the observed association. Thus, the optimal consumption of fruits and vegetables may contribute to the decreased risk of obesity and its related complications.

The findings of a significant association between household FI and DII in this study confirmed those of Bergmans RS, et al. [15] who assessed the associations between food security status and dietary inflammatory potential within lower-income adults. Their results revealed that household in very low food security status has been associated with higher DII (pro-inflammatory) score [15]. Previous epidemiological studies also have shown that food insecurity has been associated with increased inflammation, which increases the odds of obesity and obesity-related chronic diseases [3,30,41]. Findings also demonstrated that food insecurity has been associated with higher BMI, lower quality of life, lower self-efficacy, and depressive symptoms [3,40,47].

The present study had some limitations, which should be considered when interpreting the results. First, the study could not determine causality due to the cross-sectional nature of the study. Therefore, a direct causal inference could not be made. Second, because participants were asked to report their frequency and amount of each food item consumed during the previous year using FFQ; although it has been validated, there might have been recalling bias. However, to minimize any errors, an experienced nutritionist interviewed participants.

In conclusion, the results of the present study present food insecurity significantly associated with higher DII score. Indeed, food insecure household without hunger was positively associated with most pro-inflammatory DII score compared with food secure households independent of a wide range of potential confounders. Additionally, food insecure obese individuals scored lower AHEI-2010 than food secure adults. These findings highlight the need for a greater focus on advocacy and policy action to increase social supports and improve food and nutrition security of obese Iranian people. In addition, interventions are warranted to improve the dietary quality of obese people by promoting optimal consumption of healthy foods, with increasing the intake of fruits and vegetables. Further longitudinal research is needed to better understand the underlying biological mechanisms for the association of food insecurity with diet quality and inflammation.

References

1 Anderson SA (1990) Core indicators of nutritional state for difficult-to-sample populations. J Nutr 120, 1557-1599.

2 Summit WF (1996) Rome Declaration on World Food Security and World Food Summit Plan of Action: FAO.

3 Nikniaz L, Tabrizi JS, Sadeghi-Bazargani H et al. (2017) Food insecurity increases the odds of obesity among Iranian women: A population-based study of northwestern Iran. Nutr Diet 74, 454-459.

4 Student MBP, Shadi Abdi B (2016) Prevalence of Food Insecurity in Iran: A Systematic Review and Meta-analysis. Arch Iran Med 19, 288.

5 Kirkpatrick SI, Tarasuk V (2008) Food insecurity is associated with nutrient inadequacies among Canadian adults and adolescents. J Nutr. 138, 604-612.

6 Champagne CM, Casey PH, Connell CL et al. (2007) Poverty and food intake in rural America: diet quality is lower in food insecure adults in the Mississippi Delta. J Am Diet Assoc 107, 1886-1894.

7 Hasan-Ghomi M, Mirmiran P, Asghari G et al. (2015) Food security is associated with dietary diversity: Tehran Lipid and Glucose Study. Food Nutr Res 2, 11-18.

8 Alaimo K, Olson CM, Frongillo Jr EA et al. (2001) Food insufficiency, family income, and health in US preschool and school-aged children. Am J Public Health 91, 781.

9 Kaiser LL, LAMP CL, JOHNS MC et al. (2002) Food security and nutritional outcomes of preschool-age Mexican-American children. J Am Diet Assoc 102, 924-929.

10 Dorosty AR (2016) Food Insecurity and Chronic Diseases: The Editorial. Food Nutr Res 3, 1-2.

11 Eshraghian M, Siassi F, Jazayeri G (2007) Obesity and food security in Yazd primary school students. Tehran University Medical Journal TUMS Publications 65, 68-76.

12 Abdurahman AA, Chaka EE, Nedjat S et al. (2018) The association of household food insecurity with the risk of type 2 diabetes mellitus in adults: a systematic review and meta-analysis. Eur J Nutr, 1-10.

13 Connell CL, Zoellner JM, Yadrick MK et al. (2012) Energy density, nutrient adequacy, and cost per serving can provide insight into food choices in the lower Mississippi Delta. J Nutr Educ Behav. 44, 148-153.

14 Rouhani MH, Larijani B, Azadbakht L (2016) Are the price patterns of cardioprotective vs. unhealthy foods the same? A report from Iran. ARYA Atheroscler 12, 172-179.

15 Bergmans RS, Palta M, Robert SA et al. (2018) Associations between Food Security Status and Dietary Inflammatory Potential within Lower-Income Adults from the United States National Health and Nutrition Examination Survey, Cycles 2007 to 2014. J Acad Nutr Diet 118, 994-1005.

16 Region EM (2016) Framework for health information systems and core indicators for monitoring health situation and health system performance: Geneva (Switzerland): World Health Organization.

17 Mirmiran P, Hosseini Esfahani F, Azizi F (2009) Relative validity and reliability of the food frequency questionnaire used to assess nutrient intake: Tehran Lipid and Glucose Study. Iranian Journal of Diabetes and Lipid Disorders 9, 185-197.

18 Morgan KJ, Zabik ME, Stampley GL (1986) The role of breakfast in diet adequacy of the US adult population. J Am Coll Nutr 5, 551-563.

19 Shivappa N, Steck SE, Hurley TG et al. (2014) Designing and developing a literature-derived, population-based dietary inflammatory index. Public Health Nutr 17, 1689-1696.

20 Shivappa N, Steck SE, Hurley TG et al. (2014) A population-based dietary inflammatory index predicts levels of C-reactive protein in the Seasonal Variation of Blood Cholesterol Study (SEASONS). Public Health Nutr 17, 1825-1833.

21 Tabung FK, Steck SE, Zhang J et al. (2015) Construct validation of the dietary inflammatory index among postmenopausal women. Ann Epidemiol 25, 398-405.

22 Wirth MD, Shivappa, N., Davis, L. et al. (2016) Construct validation of the Dietary Inflammatory Index among African Americans. J Nutr Health Aging 21, 1-5.

23 Wirth MD, Burch J, Shivappa N et al. (2014) Association of a Dietary Inflammatory Index with Inflammatory Indices and Metabolic Syndrome among Police Officers. J Occup Environ Med. 56, 986-989.

24 Ramallal R, Toledo E, Martinez-Gonzalez MA et al. (2015) Dietary Inflammatory Index and Incidence of Cardiovascular Disease in the SUN Cohort. Plos One 10.

25 Shivappa N, Hebert JR, Rietzschel ER et al. (2015) Associations between dietary inflammatory index and inflammatory markers in the Asklepios Study. Br J Nutr 113, 665-671.

26 Willett WC, Howe GR, Kushi LH (1997) Adjustment for total energy intake in epidemiologic studies. Am J Clin Nutr 65, 1220-1228.

27 Mohammadi F, Omidvar N, Houshiar-Rad A et al. (2012) Validity of an adapted Household Food Insecurity Access Scale in urban households in Iran. Public Health Nutr 15, 149-157.

28 Bickel G, Nord M, Price C et al. (2000) Guide to measuring household food security: Revised.

29 Hosmer D, Lemeshow S (2000) Applied Logistic Regression., 2nd ed. (Wiley: New York.). NY, USA.

30 Gowda C, Hadley C, Aiello AE (2012) the association between food insecurity and inflammation in the US adult population. Am J Public Health 102, 1579-1586.

31 Farrell P, Thow AM, Abimbola S et al. (2017) How food insecurity could lead to obesity in LMICs When not enough is too much: a realist review of how food insecurity could lead to obesity in low-and middle-income countries. Health Promot Int 33, 812-826.

32 Carter KN, Lanumata T, Kruse K et al. (2010) What are the determinants of food insecurity in New Zealand and does this differ for males and females? Aust N Z J Public Health 34, 602-608.

33 N Gearhardt A, Davis C, Kuschner R et al. (2011) The addiction potential of hyperpalatable foods. Current drug abuse reviews 4, 140-145.

34 Gholizadeh F, Moludi J, Yagin NL et al. (2018) The relation of Dietary diversity score and food insecurity to metabolic syndrome features and glucose level among pre-diabetes subjects. Prim Care Diabetes.

35 Mortazavi Z, Dorosty AR, Eshraghian MR et al. (2017) Household Food Insecurity in Southeastern Iran: Severity and Related Factors. Int. J. Food Sci.

36 Hojaji E, Zavoshy R, Noroozi M et al. (2015) Assessment of household food security and its relationship with some pregnancy complications. J Mazandaran Univ Med Sci 25, 87-98.

37 Narmaki E, Shirasb F, Qorbani M et al. (2017) Association between food security and anthropometric measurements, body composition, blood pressure in women attending municipality sports clubs in west of tehran. Iranian Journal of Diabetes and Metabolism 16, 103-110.

38 To QG, Frongillo EA, Gallegos D et al. (2014) Household Food Insecurity Is Associated with Less Physical Activity among Children and Adults in the US Population, J Nutr 144, 1797-1802.

39 Theodoridis X, Grammatikopoulou M, Gkiouras K et al. (2018) Food insecurity and Mediterranean diet adherence among Greek university students. Nutr Metab Cardiovasc Dis 28, 477-485.

40 Pei CS, Appannah G, Sulaiman N (2018) Household food insecurity, diet quality, and weight status among indigenous women (Mah Meri) in Peninsular Malaysia. Nutr Res Pract 12, 135-142.

41 Leung CW, Epel ES, Ritchie LD et al. (2014) Food insecurity is inversely associated with diet quality of lower-income adults. J Acad Nutr Diet 114, 1943-1953. e1942.

42 Huet C, Rosol R, Egeland GM (2012) The Prevalence of Food Insecurity Is High and the Diet Quality Poor in Inuit Communities–3. J Nutr 142, 541-547.

43 Bocquier A, Vieux F, Lioret S et al. (2015) Socio-economic characteristics, living conditions and diet quality are associated with food insecurity in France. Public Health Nutr 18, 2952-2961.

44 Kim HJ, Oh K (2015) Household food insecurity and dietary intake in Korea: results from the 2012 Korea National Health and Nutrition Examination Survey. Public Health Nutr 18, 3317-3325.

45 Ghattas H, Barbour JM, Nord M et al. (2013) Household Food Security Is Associated with Agricultural Livelihoods and Diet Quality in a Marginalized Community of Rural Bedouins in Lebanon. J Nutr 143, 1666-1671.

46 Gamba R, Leung CW, Guendelman S et al. (2016) Household food insecurity is not associated with overall diet quality among pregnant women in NHANES 1999–2008. Matern Child Health J. 20, 2348-2356.

47 Sharpe PA, Whitaker K, Alia KA et al. (2016) Dietary intake, behaviors and psychosocial factors among women from food-secure and food-insecure households in the United States. Ethn Dis 26, 139.