Research Article

Healthy Eating Index-2010 and General/Central Obesity Among Adult Women Living in Tehran, Iran

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Abstract

Background: The prevalence of central and general obesity is increasing to epidemic levels and turning to a social health problem. A possible association may exist between nutritional adequacy and obesity.

Objectives: This study aimed to investigate the relationship of general and central obesity with diet quality in Iranian women by 2010 version of Healthy Eating Index (HEI-2010).

Methods: A total of 460 women aged 20 - 50 years old participated in this cross-sectional study. Dietary intake data was collected using a validated food frequency questionnaire. Anthropometric assessment was performed by standard methods and HEI-2010 was used to investigate diet quality. The association between HEI-2010 and general/central obesity was analyzed by logistic regression.

Results: The frequency of general and central obesity was 31 (15.1%) and 95 (21.5%), respectively. Of the participants, 330 (74.8%) had a low HEI-2010 total score. After adjusting for confounders, those with the high HEI-2010 total score had lower risk of central obesity (OR = 0.3; CI 95%: 0.14 - 0.70); however, the results were not significant for general obesity. Among the components of HEI-2010, the scores of dairy, total vegetables, empty calorie foods, refined grains and sodium were negatively associated with both general and central obesity ($P \leq 0.05$).

Conclusions: Lower risk of general and abdominal obesity is associated with a higher quality of dietary intake. Furthermore, the nutrition education programs for preventing obesity should be emphasized to promote higher intakes of dairy, fruits and vegetables and preventing high consumption of energy-dense foods and sodium.

Keywords: Nutritional Adequacy, HEI- 2010, Obesity, Women

1. Background

Overweight and obesity rates have dramatically increased through the past decades (1). A meta-analysis in 2017 reported the mean prevalence of obesity in > 18-year-old Iranian adults as 15.1% between 2000 and 2013 (1). Excessive body weight is associated with numerous chronic diseases including diabetes, metabolic syndrome, cardiovascular diseases, and cancer (2, 3) and higher mortality rates have been reported among obese people (4, 5). Body mass index (BMI) is generally used in determining general obesity, while waist circumference (WC) reflects the central obesity and is used for evaluating health risk (6).

Abdominal obesity, as one of the components of metabolic syndrome, is introduced as a major risk factor for cardiovascular diseases and the first cause of mortality, particularly in developing countries (6). Recent epidemiological studies of health outcomes including obesity and diet have changed the focus to overall diet quality and dietary pattern rather than individual nutrients due to the antagonist or synergistic effects of various nutrients on developing or preventing diseases (7, 8). Nutritional adequacy is a scale for assessing the overall quality of diet and adherence to dietary guidelines (9-11). Healthy dietary patterns can predict obesity (12) and previous research has reported relationships between HEI and risk biomarkers of diseases. Inverse relationships have been also reported between HEI and some inflammatory indices (13-15).

2. Objectives

Total HEI score provides an estimate of overall diet quality, while its component scores help study important components of diet (16). Hence, this study aimed to assess

the relationship between HEI and the component scores as well as central and general obesity among adult women living in Tehran, Iran.

3. Methods

3.1. Subjects

According to a study that assessed the relationship between diet quality and metabolic syndrome [9] in women presenting to the Endocrinology Center of Tehran University of Medical Sciences, the study population was calculated using below equation:

$$N\ each\ group = \frac{2\left(z_{1-\beta} + z_{1-\frac{\alpha}{2}}\right)^2 p\left(1-p\right)}{\left(P_1 - P_2\right)^2} \qquad (1)$$

Where $\beta = 0.1$; $\alpha = 0.05$; $P_1 = 0.575$; $P_2 = 0.43$.

The study population was increased to 460 women aged 20 - 50 years from 20 municipal regions in Tehran in order to increase the accuracy of this cross-sectional study. Participants were selected using the stratified random sampling.

Inclusion criteria were age ranging 20 - 50 years and residing in Tehran. Exclusion criteria were neuroendocrine and metabolic disorders, renal and liver diseases, pregnancy and lactation, or on any particular diet at sampling time due to cross-sectional nature of the study, or dissatisfaction with continuing participation in this study.

Written informed consent was obtained from all participants. The study protocol was approved by the Ethics Committee of the National Nutrition and Food Technology Research Institute, Tehran, Iran.

3.2. Dietary Intake Assessment

Trained dietitians assessed dietary intake with a valid and reliable semi-quantitative 168-item food frequency questionnaire (FFQ) through face-to-face interview [17, 18]. The consumption frequency of each food item was collected on daily, weekly, monthly and yearly basis and then converted to daily intake frequency [19]. The portion size of each consumed food item was converted to grams using the United States Department of Agriculture Food Composition Databases (USDA FCT) and the energy and nutrient content of foods were calculated. However, for traditional Iranian food items which were not listed in the USDA database (e.g. traditional breads), the Iranian FCT was used alternatively.

3.3. Diet Quality Scores

The data collected with FFQ was used to calculate HEI-2010. The scores and components are shown in Table 1. The components of HEI-2010 indicate adherence to the American Dietary Guidelines. The HEI-2010 consists of 12 components, 9 adequacy components (including whole fruit, total fruit, total greens and beans, vegetables, whole grains, dairy, total protein foods, seafood and plant proteins, and fatty acids (Mono Unsaturated Fatty Acid + Poly Unsaturated Fatty Acid /Saturated Fatty Acid) and 3 moderation components (refined grains, sodium, and empty calories) [16]. Legumes were considered as vegetables and green and bean group only after fulfilling the standard for the total protein foods [20]. Higher scores reflect higher intakes to adequacy components, and lower intake for the moderation components, since lower intakes are more desirable [20]. The total HEI-2010 score ranges from 0 to 100 with higher score indicating better adherence to dietary guidelines.

3.4. Anthropometric Measurements

Weight was measured using a digital scale (Seca, Germany) to the nearest 0.1 kg while participants wore light clothes and no shoes. Height was measured barefoot with a precision of 0.1 cm using tape meter fixed to wall. BMI was defined as weight (kg)/height (m)^2 and general obesity was considered as overweight and obesity (BMI $\geq$ 25) [21]. In addition, WC was measured at the level of the umbilicus and by a non-stretch flexible tape line muscle-bound without imposing any pressure to the body while standing at the end of a normal expiration [22].

3.5. Covariate Assessment

Socio-economic factors including age, marital status, number of children, duration of residence in Tehran, education status, employment status (yes/no), income (Rials) and current smoking status were also collected using an author-designed questionnaire. Physical activity level was measured using a validated self-report questionnaire [23] and expressed as metabolic equivalent task (MET) hours/day.

3.6. Statistical Analysis

Data was analyzed via the Statistical Package Software for Social Science, version 21 (SPSS Inc., Chicago, IL, USA). Analysis of variance (ANOVA) and chi-square tests were used for comparing general baseline characteristics according to HEI-2010 total score quartiles. Logistic regression models were used to assess the relationship between

Table 1. The Scores and Components of HEI-2010

Components	Maximum Score	Standard for Maximum Score	Standard for Minimum Score
Total fruit[a]	5	$\geq$ 0.8 cups equiv. per 1000 kcal	No fruits
Whole fruit[b]	5	$\geq$ 0.4 cups equiv. per 1000 kcal	No whole fruits
Total vegetables[c]	5	$\geq$ 1.1 cups equiv. per 1000 kcal	No vegetables
Greens and beansc	5	$\geq$ 0.2 cups equiv. per 1000 kcal	No dark green vegetables or Beans and Peas
Whole grains	10	$\geq$ 1.5 oz equiv. per 1000 kcal	No whole grains
Dairy[d]	10	$\geq$ 1.3 cups equiv. per 1000 kcal	No dairy
Total protein foods[e]	5	$\geq$ 2.5 oz equiv. per 1000 kcal	No protein foods
Seafood and plant proteins[e,f]	5	$\geq$ 0.8 oz equiv. per 1000 kcal	No seafood or plant proteins
Fatty acids[g]	10	(PUFA+MUFA)/SAFA $\geq$ 2.5	(PUFA+MUFA)/SAFA $\geq$ 1.2
Refined grains	10	$\leq$ 1.8 oz equiv. per 1000 kcal	$\geq$ 4.3 oz equiv. per 1000 kcal
Sodium	10	$\leq$ 1.1 grams per 1000 kcal	$\geq$ 2.0 grams per 1000 kcal
Empty calories[h]	20	$\leq$ 19% of energy	$\geq$ 50% of energy

[a]Includes fruit juice.
[b]Includes all forms except juice.
[c]Includes any beans and peas (called legume in HEI-2005) not counted as total protein foods (called Meat and beans in HEI-2005).
[d]Includes all milk products such as fluid milk, yogurt and cheese and fortified soy beverages.
[e]Includes beans and peas (and not vegetables) when the total protein food (called meat and beans in HEI-2005) standard is otherwise not met.
[f]Includes seafood, nuts, seeds, soy products (other than beverages) as well as beans and peas counted as total protein foods.
[g]Ratio of poly- and monounsaturated fatty acids to saturated fatty acids.
[h]Calories from solid fats, alcohol and added sugars; threshold for counting alcohol is > 13 g/1000 kcal

HEI-2010 total score and its components as well as central and general obesity (considering samples as overweight/obese and non-obese and with central obesity or normal) in different models. The relationships between WC and BMI variables with adherence to HEI-2010 components and its total score were assessed using linear regression and adjusted for confounding variables (total energy intake, marital status, age, education, smoking and income). P value $\leq$ 0.05 was considered as statistically significant.

4. Results

The mean $\pm$ SD of age, total energy intake, HEI-2010, WC and BMI were as follows: 33.59 $\pm$ 0.46 years, 2805.57 $\pm$ 44.4 kcal, 63.07 $\pm$ 0.42, 84.71 $\pm$ 0.4 cm and 20.53 $\pm$ 0.13 kg/m^2.

The frequency of general and central obesity was 15.1% and 21.5%, respectively. The majority of participants (approximately 74.8%) had low HEI-2010 total score.

Table 2 shows the major characteristics of study participants and HEI-2010 components according to quartiles of HEI-2010 total score. Age (36.0 $\pm$ 9 vs. 30.1 $\pm$ 9) was higher in the highest quartiles of HEI compared to the lowest quartile. There were no significant differences regarding tertiles neither for socio-economic variables nor for anthropometric indices. Furthermore, the scores of al-

most all of HEI-2010 components were higher in the highest quartile (and in the third quartile for green and beans), except for total protein and fatty acid scores which were not significant.

About the association between dietary components (total energy (kcal), total-sodium (g), total-MUFA, total-PUFA, total-saturated fat) and HEI-2010 quartiles, only women in the highest quartile of HEI-2010 total score had the lowest mean total sodium intake (P < 0.05).

The relationship between BMI, WC and HEI-2010 total score and the components are presented in Table 3. A significant negative relationship was found between HEI-2010 total score and BMI after adjusting for confounders of three models (marital status, age, education, smoking, income level, and total energy intake). Among the components, dairy had a negative association with BMI and WC and remained significant for BMI after adjusting for confounders; however, for WC the relationship was not significant after adjusting for energy and socio-economic factors in the third model. Furthermore, scores of refined-grains and empty-calorie were negatively related with general and central obesity after adjusting for confounders in the last 2 models (especially after adjusting for income) and the score of fatty acid was related to BMI which was not significant after adjusting for socioeconomic factors.

The risk of central obesity, according to quartiles of HEI-2010 are presented based on 3 various models in Ta-

Table 2. Descriptive Characteristics of the Study Participants According to HEI-2010 Quartiles[a]

Descriptive Value	HEI-2010				P Value[b]
	Q1	Q2	Q3	Q4	
WC, cm	85.03 ± 9	84.4 ± 9	85 ± 8.7	84.3 ± 7.4	0.87
BMI, kg/m^2	20.7 ± 3	20.6 ± 3	20.4 ± 3	20.2 ± 2.7	0.57
General obesity (overweight and obesity)[c]	9 (2)	8 (1.8)	9 (2)	5 (1.1)	0.58
Central obesity[c]	28 (6.3)	22 (5)	28 (6.3)	17 (3.8)	0.43
Age, y	30.1 ± 9	33 ± 10	34 ± 10	36 ± 9	0.00
Education, No. (%)					
Illiterate and elementary	20 (4.5)	19 (4.3)	26 (5.9)	21 (4.8)	
Secondary and high school	25 (5.7)	29 (6.6)	26 (5.9)	28 (6.3)	
Diploma	52 (11.8)	44 (10)	41 (9.3)	40 (9.1)	0.7
Graduated (Associate Degree, Bachelor, Master, PhD)	13 (2.9)	19 (4.3)	16 (3.6)	26 (6.2)	
Marital status[c]					
Single	21 (4.8)	23 (5.2)	17 (3.9)	13 (2.9)	
Married	86 (19.5)	86 (19.5)	89 (20.2)	95 (21.5)	0.23
Divorced and widowed	3 (0.7)	2 (0.5)	3 (0.7)	3 (0.7)	
Income, ×10000 Rials	399 ± 193	503 ± 308	528 ± 463	495 ± 4.68	0.83
Smoking[c]	108 (24.5)	107 (24.3)	106 (24)	108 (24.5)	0.88
Total fruit score	4.01 ± 1.7	4.11 ± 1.4	4.5 ± 0.93	4.74 ± 0.67	0.00
Whole-fruit score	4.2 ± 1.5	4.6 ± 1	4.9 ± 0.36	4.9 ± 0.76	0.00
Total-vegetables score	4.3 ± 1.4	4.7 ± 0.84	4.8 ± 0.63	4.9 ± 0.17	0.00
Greens and beans score	4.6 ± 1.09	4.8 ± 0.71	4.9 ± 0.15	4.8 ± 0.71	0.003
Total-protein score	2.86 ± 1.6	3.05 ± 1.5	3.28 ± 1.5	3.47 ± 1.3	0.20
Whole-grains score	2.5 ± 2.2	3.9 ± 2.3	4.6 ± 3.4	6.1 ± 3.2	0.00
Dairy-score	4.6 ± 3.06	5.4 ± 3.2	5.9 ± 3.2	6.5 ± 2.8	0.00
Sea food-plant-legume score	2.6 ± 1.7	3.08 ± 1.6	3.4 ± 1.5	3.8 ± 1.2	0.00
Fatty-acid-score	2.4 ± 3.6	2.6 ± 3.5	3.1 ± 3.6	2.8 ± 2.6	0.38
Sodium-score	2.3 ± 4.03	3.7 ± 4.3	4.3 ± 4.4	4.1 ± 4	0.00
Refined grain-score	2.3 ± 3.8	3.4 ± 4.1	4.9 ± 4.05	7.5 ± 2.5	0.00
Empty-calories score	14.2 ± 4.5	16.4 ± 4.2	17.1 ± 3.5	18.3 ± 2.6	0.00

Abbreviations: BMI, body mass index; WC, waist circumference.
[a] The amounts are measured by ANOVA test.
[b] P is considered significant if ≤ 0.05.
[c] The amounts are frequency (No.) and % of total measured by Pearson chi-square test.

ble 4 (95% CI). Those who were at the highest quartile of dairy score had 50% lower chance to be centrally obese in comparison to those being at the first quartile (OR = 0.5; 95% CI (0.2 - 0.9)). After adjusting for confounders in 2 additional models, women at the highest quartile of refined grain score and total HEI-2010 had 60% (OR = 0.4; 95% CI (0.2 - 0.9)) and 70% lower chance for central obesity (OR = 0.3; 95% CI (0.14 - 0.7)), (also women with higher score for sodium (OR = 3; 95% CI (0.9 - 9.6)) and medium score of

empty calorie items (OR = 3.7; 95% CI (0.9 - 14.1)) had a lower chance to be generally obese).

Total trend of central obesity was significantly decreasing across the quartiles of total HEI-2010, empty calorie and refined grain scores, and also after summating the scores of total and whole fruits and vegetables (probably due to the total vegetable score, which is not presented in Table 4).

Table 3. Modified Multivariable Linear Regression for HEI-2010 Total Score and Components According to WC and BMI Among Tehran Adult Women[a]

HEI-2010 Scores	Crude		Model 1[b]		Model 2[c]		Model3[d]	
	WC	BMI	WC	BMI	WC	BMI	WC	BMI
Total fruit	-0.09 (-0.7, 0.5)	-0.08 (-0.3, 0.12)	0.08 (-0.5, 0.7)	-0.06 (-0.3, 0.15)	-0.07 (-1.4, 0.4)	-0.027 (-0.26, 0.2)	0.2 (-0.4, 0.9)	-0.006 (-0.2, 0.2)
Whole fruit	0.04 (-0.8, 0.8)	0.14 (-0.27, 0.3)	0.2 (-0.3, 1.1)	0.04 (-0.2, 0.3)	0.17 (-0.7, 1)	0.03 (-0.27, 0.35)	0.4 (-0.5, 1.3)	0.07 (-0.2, 0.4)
Total vegetables	-0.08 (-0.9, 0.8)	-0.02 (-0.3, 0.27)	0.17 (-0.1.7)	0.01 (-0.3, 0.3)	0.26 (-0.6, 1.1)	0.02 (-0.23, 0.4)	0.5 (-0.4, 1.4)	0.12 (-0.2, 0.4)
Greens and beans	-0.7 (-1.8, 0.4)	-0.06 (-0.45, 0.3)	-0.5 (-1.6, 0.6)	-0.03 (-0.4, 0.3)	-0.04 (-1.2, 1.1)	0.06 (-0.3, 0.4)	0.15 (-1, 1.3)	0.09 (-0.3, 0.5)
Total protein	0.08 (-0.4, 0.6)	0.02 (-0.15, 0.2)	0.2 (-0.3, 0.7)	0.04 (-0.13, 0.2)	0.3 (-0.2, 0.8)	0.02 (-0.15, 0.2)	0.4 (-0.09, 1)	0.06 (-0.14, 0.2)
Whole grains	0.06 (-0.18, 0.3)	0 (-0.09, 0.07)	0.13 (-0.1, 0.38)	0 (-0.08, 0.09)	0.07 (-0.18, 0.3)	-0.01 (-0.1, 0)	0.15 (-0.11, 0.4)	0 (-0.1, 0.09)
Dairy	-0.3 (-0.6, -0.1)[e]	-0.1 (-0.2, -0.04)[e]	-0.3 (-0.5, 0.05)[e]	-0.12 (-0.2, 0.03)[e]	-0.27 (-0.5, -0.003)[e]	-0.13 (-0.2, 0.03)[e]	-0.22 (-0.5, 0.042)	-0.13 (-0.2, -0.03)[e]
Sea food plant legume	0.2 (-0.28, 0.7)	0.02 (-0.14, 0.19)	0.3 (-0.2, 0.8)	0.04 (-0.12, 0.2)	0.4 (-0.13, 0.9)	0.025 (-0.16, 0.2)	0.5 (-0.46, 1)	0.03 (-0.15, 0.2)
Fatty acid	0.15 (-0.07, 0.37)	0.07 (0.0, 015)[e]	0.15 (-0.7, 0.3)	0.07 (0.0, 0.15)[e]	-0.01 (-0.21, 0.2)	0.06 (-0.025, 0.14)	-0.015 (-0.2, 0.25)	0.6 (-0.02, 0.14)
Grain-refined	-0.01 (-1.6, 0.3)	-0.02 (-0.09, 0.04)	-0.1 (-0.3, 0.03)	-0.03 (-0.09, 0.03)	-0.2 (-0.4, 0)[e]	-0.06 (-0.14, 0)	-0.3 (-0.5, -0.09)[e]	-0.07 (-0.14, 0)
Sodium	0 (-0.13, 0.2)	0 (-0.06, 0.05)	-0.03 (-0.2, 0.16)	-0.01 (-0.08, 0.04)	-0.07 (-0.26, 0.1)	-0.03 (-0.09, 0.04)	-0.16 (-0.36, 0.03)	-0.04 (-0.11, 0.03)
Empty calorie	0.05 (-0.14, 0.2)	-0.05 (-0.1, 0.01)	0.03 (-0.16, 0.2)	-0.05 (-0.12, 0.01)	-0.04 (-0.2, 0.1)	-0.09 (-0.16, 0.01)[e]	-0.06 (-0.28, 0.14)	-0.09 (-0.17, -0.01)[e]
HEI-2010	-0.15 (-0.15, 0.07)	-0.02 (-0.05, 0.0)	0 (-0.1, 0.07)	-0.02 (-0.05, 0)	-0.08 (-0.18, 0.01)	-0.05 (-0.08, -0.01)	0.08 (-0.17, 0.02)	-0.04 (-0.08, -0.01)[e]

[a] The amounts are standardized coefficients (Beta) (CI: 95%).
[b] Model 1: adjusting energy for crude model.
[c] Model 2: adjusting the marital status, age, education, smoking and income factors.
[d] Model 3: adjusting energy for model 2.
[e] P value is considered significant if ≤ 0.0.

Table 4. Modified Multivariable Logistic Regression for HEI-2010 Total Score and Its Components According to Central Obesity[a]

Components	Crude, Central Obesity				Model 1[b], Central Obesity				Model 2[c], Central Obesity			
	Q2	Q3	Q4	P Trend	Q2	Q3	Q4	P Trend	Q2	Q3	Q4	P Trend
Total fruit[d]	1.2 (0.4 - 3.4)	0.5 (0.15 - 2.2)	1(0.5 - 2)	0.9	1.3 (0.4 - 4)	0.8 (0.2 - 4)	1.3 (0.6 - 2.5)	0.5	1(0.3 - 3.2)	0.6 (0.14 - 3)	0.9 (0.4 - 2)	0.8
Whole-fruit	1.8 (0.3 - 12.3)	1.8 (0.36 - 10.3)	1.8 (0.62 - 5.4)	0.3	1.7 (0.2 - 12.5)	2 (0.3 - 1.4)	2.1 (0.6 - 6.4)	0.2	1.2 (0.1 - 10.4)	1.3 (0.1 - 10.7)	1.3 (0.2 - 6.6)	0.7
Total-vegetables	1.9 (0.6 - 5.6)	0.8 (0.07 - 8.4)	0.8 (0 - 8.3)	0.1	2.7 (0.9 - 8.4)	1.1 (0.1 - 13.5)	1.1 (0.1 - 12.3)	0.04	2.5 (0.6 - 10.1)	1 (0.08 - 14)	1(0.09 - 12.3)	0.1
Green and Beans	2.3 (0.15 - 34.8)	2.1 (0.2 - 21.7)	1.9 (0.4 - 8.7)	0.4	3.3 (0.15 - 73)	4.8 (0.2 - 107)	6 (0.7 - 50)	0.06	3 (0.16 - 65)	4.3 (0.19 - 100)	4.8 (0.5 - 46)	0.1
Total-protein	0.7 (0.4 - 1.1)	0.9 (0.4 - 1.6)	0.7 (0.3 - 1.3)	0.4	0.8 (0.4 - 1.8)	0.9 (0.5 - 1.8)	0.9 (0.5 - 2)	0.8	0.6 (0.2 - 1.3)	0.6 (0.3 - 1.4)	0.9 (0.3 - 1.5)	0.5
Whole-grains	1.1 (0.5 - 2.2)	1.6 (0.7 - 3.5)	1.4 (0.7 - 2.7)	0.2	1.1 (0.5 - 2.2)	1.3 (0.6 - 2.7)	1.4 (0.7 - 2.7)	0.2	0.9 (0.5 - 2)	1.1 (0.5 - 2.4)	1.1 (0.5 - 2.4)	0.47
Dairy-score	0.7 (0.4 - 1.4)	0.8 (0.44 - 1.5)[e]	0.5 (0.2 - 0.9)[e]	0.07	0.7 (0.4 - 1.5)	0.9 (0.4 - 1.8)	0.6 (0.3 - 1.2)	0.3	0.5 (0.2 - 1)	0.6 (0.3 - 1.3)	0.4 (0.16 - 0.8)[e]	0.8
Sea-food-plant-legume	1.2 (0.6 - 2.4)	0.9 (0.4 - 2)	0.8 (0.5 - 1.5)	0.6	1.5 (0.7 - 3.2)	1.2 (0.5 - 2.8)	0.9 (0.5 - 1.7)	0.8	1.4 (0.6 - 3)	1 (0.4 - 2.5)	0.8 (0.4 - 1.5)	0.5
Fatty-acid	1.2 (0.6 - 2.3)	0.9 (0.5 - 1.9)	1.6 (0.8 - 3)	0.2	1.2 (0.6 - 2.5)	0.7 (0.3 - 1.6)	1.1 (0.5 - 2.4)	0.9	1.2 (0.6 - 2.5)	0.8 (0.3 - 1.7)	1.2 (0.5 - 2.6)	0.8
Refined grain	0.6 (0.2 - 1.5)	0.7 (0.4 - 1.3)	0.6 (0.3 - 1.1)	0.1	0.5 (0.2 - 1.5)	0.6 (0.4 - 1.2)	0.4 (0.2 - 0.8)[e]	0.01	0.5 (0.2 - 1.5)	0.6 (0.3 - 1.2)	0.4 (0.2 - 0.9)[e]	0.03
Sodium	1 (0.5 - 2)	1.5 (0.7 - 3)	0.7 (0.4 - 1.4)	0.6	0.9 (0.5 - 2)	1.2 (0.5 - 3)	0.6 (0.3 - 1.2)	0.4	0.9 (0.5 - 2)	1.2 (0.5 - 2.7)	0.7 (0.4 - 1.6)	0.6
Empty-calorie	1.5 (0.16 - 13.7)	0.8 (0 - 8.4)	0.9 (0.1 - 8.2)	0.09	1.5 (0.1 - 18.4)	0.8 (0 - 10.7)	0.7 (0 - 9)	0.02	1.5 (0.1 - 18.4)	0.8 (0 - 10.7)	0.8 (0 - 10)	0.05
HEI-2010	0.7 (0.4 - 1.3)	1(0.5 - 1.8)	0.5 (0.2 - 1)	0.1	0.6 (0.3 - 1.3)	0.8 (0.4 - 1.7)	0.4 (0.2 - 0.8)[e]	0.02	0.6 (0.3 - 1.2)	0.8 (0.4 - 1.6)	0.3 (0.14 - 0.7)[e]	0.6

[a] The amounts are OR with 95% CI.
[b] Model 1: adjusting the marital status, age, education, smoking and income factors.
[c] Model 2: Model 1 is also adjusted for total energy intake.
[d] First quartile is considered as reference.
[e] P value is considered significant.

5. Discussion

The study findings showed a negative relationship between HEI-2010 diet quality index, and the chance of general and abdominal obesity.

To our knowledge, this is the first study assessing the relationship of the 2010 version of HEI with general and central obesity in a population-based sample of Iranian women.

Overall, higher HEI-2010 total score and lower chance of obesity were consistent with previous studies including Multi-Ethnic Study of Atherosclerosis on 6814 men and women aged 45 - 84 years from 6 US sites (24), the NHANES III (7), and Baltimore Longitudinal Study of Aging on Amer-

icans ([25](#)).

However, the Iranian cohort of Tehran Lipid and Glucose Study ([17](#)), another article from Isfahan province of Iran on 410 young female students aged 18 - 28 years ([11](#)) and also the Framingham Offspring/Spouse study3 (FOS3) ([26](#)) did not find any significant relationship between diet quality indices and obesity, which may be due to sample size and different scoring patterns.

Since all components of HEI-2010 do not similarly predict the relationship between general and central obesity, each component was separately investigated.

Socio-economic indices were not significantly related to the HEI-2010, but it appears that aging may significantly influence better choices of healthy foods. This finding also agrees with that in the Iranian cohort of Tehran Lipid and Glucose Study (TLGS) 2010 ([17](#)).

Investigating the components in detail showed that increased sodium score was negatively related to general obesity. According to available evidence, high sodium consumption is associated with a higher risk for overweight/obesity ([27](#)) and an inverse relationship exists between sodium intake and HEI-2010 ([21](#)). This association can be attributed to the fact that high levels of sodium are associated with increased adipocyte mass and insulin sensitivity (in rats) and increased insulin resistance and prevalence of metabolic syndrome in humans ([28](#)).

Among the adequacy components, dairy score was negatively related to WC and BMI; as a valuable predictor of central and general obesity. The reverse relationship between dairy consumption and obesity may be due to the calcium content and particular fats and bioactive peptides which was proven before ([29](#)).

In addition, the score of fatty acid (mono and poly saturated ratio to saturated fats) was negatively related to BMI at the crude model, but not significantly when adjusted for other confounders in this study. One-point increase in saturated fat score (HEI-2005) may be related to 3.1% decrease in abdominal obesity risk ([7](#)). This can be explained as a higher HEI component score for this nutrient shows meeting or close to meeting recommendations of 10% or less of energy from saturated fatty acids ([7](#)), which has been proven to be associated with obesity ([30](#)).

Another finding among the HEI moderation subgroups was negative relationship of refined grains and empty calorie scores with WC and BMI anthropometric indices, when the socio-economic factors and total energy intake were adjusted. As mentioned before, energy intake can seriously affect this scoring system and should be considered.

Discretionary fat and added sugar (existing in empty calorie foods) play an important role in general and central obesity morbidity due to high calorie content ([21](#)).

Furthermore, weight gain has been shown to be inversely associated with the intake of high-fiber meals including fruits and vegetables and whole-grain foods ([26](#)), but positively related with the intake of refined-grain foods as they are calorie-dense and usually considered unhealthy dietary patterns ([26](#)).

The trend of central obesity according to the score of total fruit, whole fruit and total vegetables in combination was decreasing especially with regard to total vegetables score (similarly due to fiber and antioxidant content) ([25](#)). These findings are consistent with NHANES III study on American males and females ([25](#)).

The results of the present observational study should be interpreted cautiously for its self-reporting nature and possible under- and over-estimation of particular food items. Furthermore, according to the HEI scoring system, even those who consumed more than the recommended amount of food groups received full score, which may be considered a limitation because they were not approved according to the cut-offs ([21](#)). In addition, the existing criteria for abdominal obesity diagnosis for the Asian adult population is $\geq$ 88 cm for women, which was not considered in this study. Alternatively, the current study provides novel information regarding the relationship of a diet quality index and its components with obesity. Other strengths of the current study are a high participation rate (89%), population-based sampling and adjusting various confounders especially socio-economic status, which influenced the results.

5.1. Conclusions

This study reports new findings about HEI-2010 diet quality index and obesity in an Iranian population. Overall, the results showed a lower risk of general and abdominal obesity with higher quality of diet. In addition, higher intakes of dairy, fruits and vegetables and preventing high consumption of empty calorie foods, sodium, saturated fatty acids and refined grains are recommended to reduce obesity. Therefore, probably the components of a diet quality index can be independently beneficial for weight management. Considering our cross-sectional method, future research is recommended to examine the relationship of adiposity with HEI-2010 and its component scores in larger sample sizes.

Acknowledgments

References

1. Fallahzadeh H, Saadati H, Keyghobadi N. [Estimating the prevalence and trends of obesity in Iran populations from 2000 to 2011: A meta-analysis study]. *J Shahid Sadoughi Univ Med Sci*. 2017;**25**(9):681–9. Persian.

2. Dougkas A, Reynolds CK, Givens ID, Elwood PC, Minihane AM. Associations between dairy consumption and body weight: A review of the evidence and underlying mechanisms. *Nutr Res Rev*. 2011;**24**(1):72–95. doi: 10.1017/S095442241000034X. [PubMed: 21320381].

3. Ramsay JE, Ferrell WR, Crawford L, Wallace AM, Greer IA, Sattar N. Maternal obesity is associated with dysregulation of metabolic, vascular, and inflammatory pathways. *J Clin Endocrinol Metab*. 2002;**87**(9):4231–7. doi: 10.1210/jc.2002-020311. [PubMed: 12213876].

4. Patterson RE, Frank LL, Kristal AR, White E. A comprehensive examination of health conditions associated with obesity in older adults. *Am J Prev Med*. 2004;**27**(5):385–90. doi: 10.1016/j.amepre.2004.08.001. [PubMed: 15556738].

5. Flegal KM, Graubard BI, Williamson DF, Gail MH. Excess deaths associated with underweight, overweight, and obesity. *JAMA*. 2005;**293**(15):1861–7. doi: 10.1001/jama.293.15.1861. [PubMed: 15840860].

6. Ntandou G, Delisle H, Agueh V, Fayomi B. Abdominal obesity explains the positive rural-urban gradient in the prevalence of the metabolic syndrome in Benin, West Africa. *Nutr Res*. 2009;**29**(3):180–9. doi: 10.1016/j.nutres.2009.02.001. [PubMed: 19358932].

7. Tande DL, Magel R, Strand BN. Healthy Eating Index and abdominal obesity. *Public Health Nutr*. 2010;**13**(2):208–14. doi: 10.1017/S1368980009990723. [PubMed: 19650960].

8. Guo X, Warden BA, Paeratakul S, Bray GA. Healthy Eating Index and obesity. *Eur J Clin Nutr*. 2004;**58**(12):1580–6. doi: 10.1038/sj.ejcn.1601989. [PubMed: 15162130].

9. Yosaee S, Esteghamati A, Nazari Nasab M, Khosravi A, Alinavaz M, Hosseini B, et al. Diet quality in obese/overweight individuals with/without metabolic syndrome compared to normal weight controls. *Med J Islam Repub Iran*. 2016;**30**:376. [PubMed: 27493920]. [PubMed Central: PMC4972048].

10. Azadbakht L, Mirmiran P, Azizi F. Dietary diversity score is favorably associated with the metabolic syndrome in Tehranian adults. *Int J Obes (Lond)*. 2005;**29**(11):1361–7. doi: 10.1038/sj.ijo.0803029. [PubMed: 16116493].

11. Haghighatdoost F, Karimi G, Esmaillzadeh A, Azadbakht L. Sleep deprivation is associated with lower diet quality indices and higher rate of general and central obesity among young female students in Iran. *Nutrition*. 2012;**28**(11-12):1146–50. doi: 10.1016/j.nut.2012.04.015. [PubMed: 22951155].

12. Rezazadeh A, Rashidkhani B, Omidvar N. Association of major dietary patterns with socioeconomic and lifestyle factors of adult women living in Tehran, Iran. *Nutrition*. 2010;**26**(3):337–41. doi: 10.1016/j.nut.2009.06.019. [PubMed: 19819112].

13. Kant AK, Graubard BI. A comparison of three dietary pattern indexes for predicting biomarkers of diet and disease. *J Am Coll Nutr*. 2005;**24**(4):294–303. doi: 10.1080/07315724.2005.10719477. [PubMed: 16093407].

14. McCabe-Sellers BJ, Bowman S, Stuff JE, Champagne CM, Simpson PM, Bogle ML. Assessment of the diet quality of US adults in the Lower Mississippi Delta. *Am J Clin Nutr*. 2007;**86**(3):697–706. doi: 10.1093/ajcn/86.3.697. [PubMed: 17823435].

15. Weinstein SJ, Vogt TM, Gerrior SA. Healthy Eating Index scores are associated with blood nutrient concentrations in the third National Health And Nutrition Examination Survey. *J Am Diet Assoc*. 2004;**104**(4):576–84. doi: 10.1016/j.jada.2004.01.005. [PubMed: 15054343].

16. Guenther PM, Casavale KO, Reedy J, Kirkpatrick SI, Hiza HA, Kuczynski KJ, et al. Update of the healthy eating index: HEI-2010. *J Acad Nutr Diet*. 2013;**113**(4):569–80. doi: 10.1016/j.jand.2012.12.016. [PubMed: 23415502]. [PubMed Central: PMC3810369].

17. Mirmiran P, Esfahani FH, Mehrabi Y, Hedayati M, Azizi F. Reliability and relative validity of an FFQ for nutrients in the Tehran lipid and glucose study. *Public Health Nutr*. 2010;**13**(5):654–62. doi: 10.1017/S1368980009991698. [PubMed: 19807937].

18. Asghari G, Rezazadeh A, Hosseini-Esfahani F, Mehrabi Y, Mirmiran P, Azizi F. Reliability, comparative validity and stability of dietary patterns derived from an FFQ in the Tehran Lipid and Glucose Study. *Br J Nutr*. 2012;**108**(6):1109–17. doi: 10.1017/S0007114511006313. [PubMed: 22251608].

19. Ghafarpour H, HoushiarRad M, Kianfar H. *Guidance of Household Scales Conversion factors and edible food percentages*. 1st ed. Tehran: Agricultural Sciences; 1992. Persian.

20. Guenther PM, Kirkpatrick SI, Reedy J, Krebs-Smith SM, Buckman DW, Dodd KW, et al. The Healthy Eating Index-2010 is a valid and reliable measure of diet quality according to the 2010 Dietary Guidelines for Americans. *J Nutr*. 2014;**144**(3):399–407. doi: 10.3945/jn.113.183079. [PubMed: 24453128]. [PubMed Central: PMC3927552].

21. Asghari G, Mirmiran P, Rashidkhani B, Asghari-Jafarabadi M, Mehran M, Azizi F. The association between diet quality indices and obesity: Tehran Lipid and Glucose Study. *Arch Iran Med*. 2012;**15**(10):599–605. [PubMed: 23020534].

22. Lohman TG. Anthropometric standardization reference manual. In: Lohman TJ, Roache AF, Martorell R, editors. *Advances in body composition assessment*. Champaign: IL: Human Kinetics; 1992. doi: 10.1249/00005768-199208000-00020.

23. Aadahl M, Jorgensen T. Validation of a new self-report instrument for measuring physical activity. *Med Sci Sports Exerc*. 2003;**35**(7):1196–202. doi: 10.1249/01.MSS.0000074446.02192.14. [PubMed: 12840642].

24. Gao SK, Beresford SA, Frank LL, Schreiner PJ, Burke GL, Fitzpatrick AL. Modifications to the healthy eating index and its ability to predict obesity: The multi-ethnic study of atherosclerosis. *Am J Clin Nutr*. 2008;**88**(1):64–9. doi: 10.1093/ajcn/88.1.64. [PubMed: 18614725].

25. Bailey RL, Mitchell DC, Miller CK, Still CD, Jensen GL, Tucker KL, et al. A dietary screening questionnaire identifies dietary patterns in older adults. *J Nutr*. 2007;**137**(2):421–6. doi: 10.1093/jn/137.2.421. [PubMed: 17237321].

26. Quatromoni PA, Copenhafer DL, D'Agostino RB, Millen BE. Dietary patterns predict the development of overweight in women: The Framingham Nutrition Studies. *J Am Diet Assoc*. 2002;**102**(9):1239–46. doi: 10.1016/S0002-8223(02)90275-0. [PubMed: 12792620].

27. Newby PK, Muller D, Hallfrisch J, Andres R, Tucker KL. Food patterns measured by factor analysis and anthropometric changes in adults. *Am J Clin Nutr*. 2004;**80**(2):504–13. doi: 10.1093/ajcn/80.2.504. [PubMed: 15277177].

28. Yi SS, Kansagra SM. Associations of sodium intake with obesity, body mass index, waist circumference, and weight. *Am J Prev Med*. 2014;**46**(6):e53–5. doi: 10.1016/j.amepre.2014.02.005. [PubMed: 24842744].

29. Alegria-Lertxundi I, Rocandio Pablo A, Arroyo-Izaga M. Cheese consumption and prevalence of overweight and obesity in a Basque adult population: A cross-sectional study. *Int J Food Sci Nutr*. 2014;**65**(1):21–7. doi: 10.3109/09637486.2013.836741. [PubMed: 24138541].

30. Hosseinpour-Niazi S, Mirmiran P, Naderi Z, Sadeghi M, Azizi F. [Association between intake of polyunsaturated fatty acids and the metabolic syndrome and its components among adults: Tehran lipid and glucose study]. *J School Med*. 2012;**35**(4):225–36. Persian.