Adherence to Healthy Eating Index-2015 and Obesity Among Iranian Adults: Yazd Health Study-TAMYZ and Shahedieh Cohort Study

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Abstract

Objectives: Data demonstrated a relationship between obesity and increasing the risk of mortality and morbidity of chronic diseases. Inconsistent data regarding the association between adherence of Healthy Eating Index-2015 (HEI-2015) and obesity is identified. Thus, this study intends to address this relationship among a large sample of both urban and suburb areas of Iranian adults.

Methods: This cross-sectional study was performed by 10693 participants of Shahedieh cohort study (n=3943) and TAghzieh Mardom-e-Yazd (TAMYZ) which was conducted on Yazd Health Study participants, (n=6750) living in urban and suburb areas. Dietary intake was assessed by using a validated Food Frequency Questionnaire (FFQ). In all participants, anthropometric indices including body mass index were measured. Multivariate logistic regression analysis was utilized to assess the relationship of HEI-2015 with obesity.

Results: No significant association was found between adherence to the HEI-2015 diet and odds of general and central obesity.

Conclusions: Our findings showed adherence to HEI-2015 might have no protective effect on odds of general obesity. Also, in suburb region and whole population of both urban and suburb regions greater compliance of men to HEI-2015 diet might have a positive effect on odds of central obesity. Moreover, in suburb area participants in the highest quintile significantly were smoker and had higher level of SES. Finally, the casual effect of HEI-2015 on obesity needs to be investigated further in prospective studies and among different populations.

1. Introduction

Obesity is a health hazard [1] that decreases life expectancy and increases mortality from chronic diseases including atherosclerotic cardiovascular diseases, type 2 diabetes, certain types of cancer [2–4], and infectious diseases [5] such as covid-19 [6]. During recent decades the global prevalence of obesity is increasing more than six-fold [7] and reported to be 39% in adults [8]. Right now the number of obese people exceeds 650 million in the world [8]. Based on the literature, incidence of the obesity can be related to single dietary components, like nutrients [9–13], foods [14–17] or food groups [18–22]. Epidemiologic studies over the association between diet and health outcomes including obesity, have focused on overall dietary quality and dietary pattern instead of a single nutrient such as fat [23–25]. Individuals consume foods together instead of a single food alone, therefore; focusing on the dietary pattern provides a better conspectus of the interaction of different nutrients and the relationship between diet and obesity [26]. Assessing the quality of the diet in comparison with the quantity of single food or nutrients provides a more comprehensive view of the diet-diseases relationships, which shows the balance and interaction of foods and beverages [27]. The Healthy Eating Pattern Index (HEI) is a dietary quality index developed by the US Department of Agriculture (USDA) to monitor compliance with my pyramid diet guidelines [28]. The HEI score provides the overall quality of the diet, and also the score of HEI components is used to

examine the relationship between intake of important dietary components and obesity [29]. HEI include nutrients and foods that reduce risk of chronic diseases [30]. Although HEI is primarily used to measure the overall quality of the diet, it can also be used as a predictor of obesity [31]. Because, firstly it considers the calorie intake in scoring that is associated with obesity [32]. Secondly, this diet is a density energy marker that is independent of calorie intake; the energy-dense diet is positively associated with obesity [33]. Some studies have suggested inverse relationships between diet quality and risks for overall obesity in general adult populations [31, 34]. Previous studies conducted on the association between compliance to HEI-2015 diet and obesity had yielded conflicting results. For examples, some studies did not observe a significant relationship [27, 35, 36] otherwise, the others have shown a significant association between higher adherence to HEI-2015 and lower odds of obesity [29, 31, 37–40]. Moreover, there is a relative shortage of knowledge on whether overall diet quality evaluated by HEI-2015 impacts obesity among Iranians adults living in Yazd. This study targeted at evaluating the relationship between HEI diet and obesity among a large sample of Iranian adults living in both urban and suburb areas of Yazd, central of Iran.

2. Material And Methods

2.1 Study design and population

The present cross-sectional study was carried out on the data collected from two cohort studies (Shahedieh and Yazd Health Study -YaHS). Dietary foods and supplements have been investigated in the YaHS sub-study, called Yazd Nutrition Survey (YNS), locally known as TAMYZ in Persian. Detailed information about the protocol of the YaHS study conducted in urban area is published previously [41]. In Shahedieh study the investigated individuals included a total of 8966 from the suburb region within the age range of 35–70 years. The YaHS study recruited 10038 people from the urban and rural areas within the age range of 20–70 years. Participants were being on a weight loss or specific diet and having a total daily energy intake of less than 800 or higher than 6500 kcal or history of diseases such as diabetes, cardiovascular diseases, stroke, fatty liver, hypertension, cancer, and thyroid, were excluded from the study because such diseases may change the participants' diet.

2.2 Dietary assessment

The validated semi-quantitative FFQ with 178 items and 551 questions was used as an interview by trained interviewers to evaluate the dietary foods and supplements [42]. In this regard, participants were supposed to report their usual consumption frequency of food items (number of times per month, week, or day) in the past 12 months. Moreover, food photo book were provided to find out exact explanations about the portion sizes of food by the interviewer. We combined single food items into 40 groups based on their similarity and converted all food items to gram per day using household portion size of food intakes [43] finally, the nutrient intakes were calculated.

2.5 Calculation of HEI diet score

The latest version of HEI-2015 were designed in 2015, in accordance to the 2015–2020 dietary guidelines provided for Americans [44]. In this method, the HEI-2015 diet score was calculated based on 13 food groups with a total maximum score of 100. Nine components (adequate intake) including total fruits, whole fruits, total vegeTables, greens and beans, whole grains, dairy, total protein foods, seafood and plant protein and fatty acids ((Polyunsaturated fatty acid + Monounsaturated fatty acids)/ Saturated fatty acid). Four components (moderate intake) contain refined grains, sodium, added sugars and saturated fats. In this method similar to HEI-2005 and HEI-2010, we scored each of these components on a density basis out of 1,000 calories with the exception of fatty acids, which is a ratio of unsaturated to saturated fatty acids. Adequacy components were assigned 0 to 5 points in order of minimum and maximum consumption. However, the maximum scores that can be assigned to dairy, whole grains and fatty acids, is 10. For the moderation components, the minimum and maximum consumption can range from 0 to 10, respectively. Scores of HEI-2015 was calculated for each participant regarding the 13 food items were summed. Later, the participants were categorized based on the dietary pattern scores' quintiles (quintile 1: low consumption, quintile 5: high consumption of a given food pattern). Next, the contributors' characteristics were measured across quintiles of each dietary pattern and the data were calculated by mean ± standard deviation for continuous variables and percentage for categorical variables.

2.3 Anthropometric assessment

Trained investigator measured Height and body weight. All anthropometric indicators gauged with three repetitions; before the interview, after completing one-third of the questionnaire, and after completing two-thirds of the questions. We gauged Height by using a wall-fixed tape measure without bumps with a precision of 0.1 cm with barefoot while contributors' heads, shoulder blades, buttocks, and heels were rested against the wall. Moreover, participants' weights were measured using a porTable, digital scale (Omron BF511 Inc. Nagoya, Japan) with a precision of 0.1 kg, while they were in light clothing and without shoes. We computed the body mass index (BMI) according the following formula: weight (kg) by height (meters) squared. Waist circumference recorded to the nearest 0.5 cm using non-stretch tape placed midway between iliac crest and lowest rib while participants were in the standing position [45].

2.4 Assessment of covariates

Additional variables of participants including age, gender, marital status, smoking status (non-smoker, ex-smoker, current smoker), socioeconomic status (SES) (weak, moderate, high) and diseases were obtained using the demographic and medical history questionnaires. Interviewers assessed the SES score according to predefined questionnaire about the infrastructure facilities (source of drinking water and sanitation facility), housing condition (e.g., the number of rooms, type of home ownership), durable assets' ownership (e.g., dishwasher, car, television), and education level [46]. Then, the total SES score, ranging from 0 to 3, was measured by adding up the assigned scores; a score of 3 showed high SES. Moreover, the Iranian version of International Physical Activity Questionnaire (IPAQ) was applied to calculated the contributors' physical activity (never, < 1 h/week, > 1 h/week), and participants with more than 1 h of activity per week were supposed as physically active [47].

2.6 Statistical analysis

The scores of the HEI-2015 diet were classified into quintiles. The first quintiles considered as the reference and the quintile categories were also considered as ordinal variables in the analyses to compute the overall trend of odds ratios (OR) across increasing quintiles of dietary pattern scores. Analysis of variance was performed for describing the mean differences of the continuous variables and we applied chi-squared test to assess the difference between categorical variables. Multivariable logistic regression analysis was also fitted in different models to determine the association of quintiles of HEI-2015 score and obesity. In first model, we adjusted age, energy intake (kcal/d), gender. Besides, in the second model we adjusted additional confounder including smoking status, SES, marital status (married, single, widowed, divorced), physical activity level, and diseases. The IBM SPSS version 20.0 was run to analyze the data and the significant P value was set at < 0.05.

Finally, the relationship between HEI-2015 dietary pattern with odds of obesity as well as central obesity in the general population of both studies (Shahedieh + YaHS), was examined with meta-analysis (fix method) by comprehensive meta-analysis software.

3. Result

3.1 Study population characteristic in urban area

In YaHS and TAMYZ studies, of 6750 participants who remained and included in final analysis 74.8% aged between 20–49 years and 25.1% were above 50 years old. Besides, prevalence of obesity was identified 21.2% (men, 8.6%; women, 12.6%). Also, **Supplementary Table 1** presents the general characteristics of the participants in the HEI-2015s' quintiles in YaHS and TAMYZ studies. With regards, those with a high score of the HEI-2015 were more likely to be men (P = 0.008), smoker (P = 0.02) and had a higher height (P = 0.04).

3.2 Study population characteristic in suburb area

In Shahedieh cohort study, 3943 participants entered in final analysis 73.3% of the participants aged between 35–49 years and 26.6% were above 50 years old. Besides, prevalence of obesity was 26.7% (men, 10.1%; women, 16.6%). Also, **Supplementary Table 2** presents participants' characteristics based on the HEI-2015s' quintiles in Shahedieh study. In this regard, participants in the highest quintile had a significant increase in weight (P = 0.001), height (P = 0.002), smoking (P = 0.02) and SES (P = 0.01).

3.3 HEI-2015 dietary pattern and general obesity

Multivariable-adjusted OR and 95% CI for general obesity across quintiles of HEI-2015 diets' score were provided for YaHS and TAMYZ studies (Table 1), shahedieh study (Table 2), and whole population of both studies (Shahedieh and YaHS - TAMYZ) (Table 3). Neither in YaHS and TAMYZ studies (OR: 1.08; 95% CI: 0.90, 1.31) nor in Shahedieh study (OR: 1.24; 95% CI: 0.99, 1.55) and whole population of both

studies (OR: 1.14; 95% CI: 0.99, 1.32) no significant association was found between more adherence to the HEI-2015 diet and odds of general obesity.

Table 1
Odds ratio (95 % CI) for **general obesity** according to quintiles (Q) of HEI-2015 dietary pattern in a sample of Iranian adults (n = 3943); and also stratified by gender (n = 6750) in YaHS cohort study (urban area)[1]

"HEI-2015" dietary pattern				
	Q1	**Q3**	**Q5**	**P trend**
Whole population				
Model I[a]	1	1.03 (0.86–1.23)	1.16 (0.97–1.38)	**0.07**
Model II[b]	1	0.99 (0.82–1.19)	1.08 (0.90–1.31)	**0.25**
Men				
Model I	1	0.95 (0.75–1.21)	1.11 (0.88–1.40)	**0.26**
Model II	1	0.88 (0.58–1.13)	1.03 (0.80–1.32)	**0.61**
Women				
Model I	1	1.11 (0.84–1.46)	1.19 (0.90–1.59)	**0.18**
Model II	1	1.06 (0.78–1.44)	1.14 (0.84–1.55)	**0.22**

[1] Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for gender; smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

Table 2
Odds ratio (95 % CI) for **general obesity** according to quintiles (Q) of HEI-2015 dietary pattern in a sample of Iranian adults in suburb area (Shahedieh cohort study: n = 3943)[1]

"HEI-2015" dietary pattern				
	Q1	**Q3**	**Q5**	**P trend**
Whole population				
Model I[a]	1	1.20 (0.96–1.48)	1.17 (0.94–1.46)	**0.34**
Model II[b]	1	1.22 (0.98–1.53)	1.24 (0.99–1.55)	**0.11**
Men				
Model I	1	1.28 (0.93–1.77)	1.33 (0.98–1.81)	**0.06**
Model II	1	1.22 (0.87–1.70)	1.32 (0.96–1.81)	**0.04**
Women				
Model I	1	1.16 (0.86–1.57)	1.01 (0.73–1.41)	**0.60**
Model II	1	1.28 (0.94–1.74)	1.16 (0.82–1.63)	**0.77**

[1] Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

Table 3
Odds ratio (95 % CI) of for **general obesity** according to quintiles (Q) of HEI-2015 dietary pattern les in the whole population of both urban and suburb studies (Shahedieh + YaHS; n = 10693)[1]

"HEI-2015" dietary pattern					
	Q1	**Q3**	**P-value**	**Q5**	**P-value**
Whole population					
Model I[a]	1	1.09 (0.94–1.25)	**0.19**	1.16 (1.01–1.33)	**0.03**
Model II[b]	1	1.07 (0.93–1.24)	**0.29**	1.14 (0.99–1.32)	**0.06**
Men					
Model I	1	1.05 (0.87–1.28)	**0.57**	1.18 (0.98–1.42)	**0.08**
Model II	1	0.99 (0.79–1.23)	**0.99**	1.13 (0.93–1.37)	**0.21**
Women					
Model I	1	1.13 (0.92–1.38)	**0.23**	1.10 (0.89–1.27)	**0.24**
Model II	1	1.16 (0.93–1.44)	**0.17**	1.14 (0.93–1.40)	**0.18**

[1] The relationship between HEI-2015 dietary pattern with odds of general obesity in the whole population of both studies (Shahedieh + YaHS), with meta-analysis in fix method by comprehensive meta-analysis software was examined. Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for gender; smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

3.4 HEI-2015 dietary pattern and central obesity

Multivariable-adjusted OR and 95% CI for central obesity across quintiles of HEI-2015 diets' score were provided for YaHS and TAMYZ studies (Table 4), shahedieh study (Table 5), and whole population of both studies (Shahedieh and YaHS - TAMYZ) (Table 6). In YaHS and TAMYZ studies no significant

relationship was observed between individuals' adherence to this diet and the odds of central obesity. However, after adjusting for confounding factors including age, sex and total energy, the findings indicated that greater compliance of men to HEI-2015 diet was directly associated with increasing odds of central obesity in shahedieh study (OR: 1.52; 95% CI: 1.02, 2.26) and whole population of both study (OR: 1.32; 95% CI: 1.06, 1.65) which did not remain significant after adjusting for other confounding variables including physical activity, education, marital status, smoking, SES and history of other diseases.

Table 4
Odds ratio (95 % CI) for **central obesity** according to quintiles (Q) of HEI-2015 dietary pattern in a sample of Iranian adults (n = 6750); and also stratified by gender in YaHS cohort study (urban area)[1]

"HEI-2015" dietary pattern				
	Q1	**Q3**	**Q5**	**P trend**
Men*				
Model I	1	1.14 (0.87–1.49)	1.25 (0.96–1.62)	**0.22**
Model II	1	1.09 (0.82–1.45)	1.12 (0.84–1.48)	**0.79**
Women*				
Model I	1	1.04 (0.81–1.24)	0.99 (0.77–1.28)	**0.17**
Model II	1	1.07 (0.81–1.39)	1.01 (0.77–1.32)	**0.76**

[1] Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for gender; smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

*Central obesity with waist circumference was defined as ≤ 102 cm in men and ≤ 88 cm in women.

Table 5

Odds ratio (95 % CI) for **central obesity** according to quintiles (Q) of HEI-2015 dietary pattern in a sample of Iranian adults (n = 3943); and also stratified by gender in Shahedieh cohort study (suburb area)[1]

"HEI-2015" dietary pattern				
	Q1	**Q3**	**Q5**	**P trend**
Men*				
Model I	1	1.25 (0.82–1.93)	1.52 (1.02–2.26)	**0.06**
Model II	1	1.17 (0.76–1.81)	1.45 (0.97–2.17)	**0.05**
Women*				
Model I	1	1.09 (0.78–1.52)	0.83 (0.58–1.18)	**0.10**
Model II	1	1.21 (0.86–1.70)	0.93 (0.64–1.35)	**0.36**

[1] Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for gender; smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

*Central obesity with waist circumference was defined as ≤ 102 cm in men and ≤ 88 cm in women.

Table 6
Odds ratio (95 % CI) of for **central obesity** according to quintiles (Q) of HEI-2015 dietary pattern in the whole population of both urban and suburb studies (Shahedieh + YaHS; n = 10693)[1]

"HEI-2015" dietary pattern					
	Q1	**Q3**	**P-value**	**Q5**	**P-value**
Men*					
Model I	1	1.17 (0.93–1.46)	**0.17**	1.32 (1.06–1.65)	**0.36**
Model II	1	1.14 (0.87–1.41)	**0.27**	1.22 (0.96–1.53)	**0.09**
Women*					
Model I	1	1.05 (0.86–1.29)	**0.58**	0.93 (0.75–1.14)	**0.50**
Model II	1	1.12 (0.90–1.38)	**0.28**	0.98 (0.78–1.22)	**0.86**

[1]The relationship between HEI-2015 dietary pattern with odds of central obesity in the whole population of both studies (Shahedieh + YaHS), with meta-analysis in fix method by comprehensive meta-analysis software was examined. Data are OR (95 % CI).

[a] Model I: adjusted for age; and total energy intake.

[b] Model II: in addition to age and total energy intake additionally adjusted for gender; smoking status; Socioeconomic Status; marital status; physical activity level; diseases.

*Central obesity with waist circumference was defined as ≤ 102 cm in men and ≤ 88 cm in women.

4. Discussion

The association between adherences to the HEI-2015 investigated in the present large-scale cross-sectional study. The findings of our study indicated that higher adherence to HEI-2015 was not significantly related with general obesity. To the best of our knowledge, this was the first study assessed the relation between adherence to HEI-2015 and obesity in the Middle East countries like Iran that performed by a large sample of both urban and suburb regions. Our results are consistent with some studies among 124 old & middle-aged Croatian women [35], 101 Canadian pregnant women [36], American adults (n = 240) and adolescents (n = 133) [27], which did not observe a significant relationship between higher adherence to HEI-2015 and obesity. However, other studies conducted in the United States [29, 31, 37–39] and China [40] have shown a significant association between greater adherence to the HEI-2015 diet and lower odds of obesity.

The HEI-2015 is a good index assessing diet quality [44] because of higher intake of fruits, vegeTables, legumes and whole grains as low energy density foods whereas lower intake of refined grains, sweets and red and processed meats. Grater compliance to this dietary pattern is related with lower odds of some chronic disease [48] such as obesity. Belonging of the original indexes to non-Asian population, different eating patterns of food components between the Middle East countries like Iran and other countries like America, and diversities of HEI-2015 with HEI-2010 and aHEI may be the reason for these inconsistencies [44]. Also, Our findings indicated that after adjusting for confounders higher compliance to HEI-2015 were positively associated with central obesity odds in men of suburb area (1.52 times) and whole population of both urban and suburb areas (1.32 times). However, this results did not remain significant after adjusting for further confounders. Recent study indicated that population of Shahedieh as a suburb region have different diet quality and lifestyle compared to residents of the urban region [49]. For example, in suburb area preparation of dairy products like milk, cheese, and yogurt as a major component of HEI-2015 are through local cows which have more fat than pasteurized and commercial packed ones commonly consumed in urban area. Also, results of present study in suburb area showed participants with greater adherence to the HEI-2015 were smoker and had higher level of SES. Additionally, data revealed that the lack of medical and primary prevention services and reduced welfare facilities such as recreations centers, supermarkets in these areas are further causes [50–52].

The major limitation of current study is the use of cross-sectional study design, which can evaluate associations but cannot establish evidence of a causal relationship between HEI-2015 and obesity. However, the association of poor diet and progression of several chronic diseases is accepted generally. In addition, this study conducted on adults living in Yazd, so we could not generalize our results because of the variations of food intakes in Yazd with other cities in Iran. Additionally, Under-reporting and possible dietary change is common in nutritional studies by some contributors especially those who are obese. Although exact methods was administered measurement error for some study variables may have incorporated errors may exist.

Despite the limitations, this study enjoys some strength. The study presented large-scale evidence regarding the association of adherence to HEI-2015 and obesity among Iranian adults living in urban and suburb areas of Yazd. Second, we tried to adjusted maximum potential confounders as far as possible. Third, the present investigation utilizes comprehensive and validated FFQ for assessing the dietary intake.

Conclusion

Mainly our findings showed, although there are no significant association between adherence to HEI-2015 and odds of general obesity but in suburb region and whole population of both urban and suburb regions greater compliance of men to HEI-2015 diet was accompanied by increasing odds of central obesity which did not remain significant after adjusting for further confounding variables. Also we conclude that, in suburb area participants in the highest quintile were smoker and had a significantly higher level of SES.

However, the casual effect of HEI-2015 on obesity needs to be investigated further in prospective studies and among different populations.

Abbreviations

FFQ, Food Frequency Questionnaire; IPAQ, International Physical Activity Questionnaire; HEI, Healthy Eating Index; SES, socioeconomic status; TAMEZ, TAghzieh Mardom-e-Yazd; YaHS, Yazd Health Study; YNS, Yazd Nutrition Survey necrosis.

Declarations

Ethics approval and consent to participate

The study's protocols and procedures were ethically reviewed and approved by a recognized ethical body (Ethics Committee of Shahid Sadoughi University of Medical Science with ethics code of (IR.SSU.SPH.REC.1397.123)). This study does not involve any human or animal testing. Also, this study conforms to the Declaration of Helsinki, US, and/or European Medicines Agency Guidelines for human subjects. Consent to participate is not applicable.

Consent for publication

This manuscript is not being simultaneously submitted elsewhere and no portion of the data has been published elsewhere.

Availability of data and material

Data described in the manuscript and analytic code will be made available upon request pending application and approval.

Competing interests

The authors declare that they have no conflict of interest.

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Author Contributions

SS-KH and MH made substantial contributions to the conception and design of the manuscript, preparation manuscript, as well as performing statistical analysis and data interpretation. They also approved the final manuscript for submission and critical revision. HM-KH, MM, and AN contributed to

data interpretation and also critically revised the manuscript for important intellectual content and approved the final manuscript for submission.

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Conflict of Interest

The authors declare no conflict of interest to report regarding this study.

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