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Association of major dietary patterns with the risk of obesity among the population from the South-West of Iran: findings from Hoveyzeh cohort study

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Abstract

Introduction Obesity is a multi-factorial metabolic disorder, the development and progression caused by genetic, physiological, metabolic, socio-economic, and lifestyle factors (especially physical activity and diet). Therefore, considering the high prevalence of obesity and its complications, and considering that dietary patterns are different in different populations and geographical locations, the present study aims to identify and investigate the relationship between dietary patterns and obesity diseases in the adult population of the Hovizeh city.

Method 5821 participants (2076 obese group and 3745 not obese group) from Hoveyzeh cohort study for this case-control study were chosen. Data related to dietary, demographic, anthropometric, and physical activity information were obtained through a questionnaire. Dietary patterns were identified using factor analysis. The logistic regression method with adjustment for demographic factors, energy intake, physical activity, and blood pressure and diabetic medication was used to determine the relationship between significant food patterns and obesity.

Results In this study, four major food patterns were identified: 1) Healthy dietary pattern characterized by a high intake of vegetables and high-protein foods,2) Traditional Defined by high consumption of green vegetables, onions, garlic, fruits, refined grains, white meat, liquid oils, and tomatoes, 3) Sweets and snacks, 4) Good oils. Although there was a significant association between sweets and snacks pattern and obesity risk in the crude model ($P < 0.05$), this association was no longer significant after adjusting for confounding factors. Good oils pattern showed a significant relationship with obesity in the crud and first adjusted model ($P < 0.05$), but this association was also not significant after adjusting for blood pressure and diabetes medication use. None of these dietary patterns were significantly associated with obesity or other anthropometric indicators after full adjustments for confounders.

Conclusion Identifying dietary patterns that influence obesity within a population helps inform strategies for obesity prevention and management. However, in this study, no significant association was found between the identified dietary patterns and obesity.

Clinical trial number Not applicable.

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Keywords Obesity, Food pattern, Factor analysis

Introduction

Obesity is a multi-factorial metabolic disorder caused by by a range of factors, including genetic, physiological, metabolic, socio-economic and, lifestyle factors (especially physical activity and diet) [1]. According to studies, overweight and obesity are two of the main health problems across all stages of life. The World Health Organization has shown that the prevalence of overweight and obesity has increased dramatically in recent years [2]. Globally, obesity is spreading at an epidemic rate, with projections estimating that by 2030, 1.12 billion people will be obese, and 2.16 billion will be overweight [3, 4]. Research has shown that the prevalence of obesity and overweight are also increasing in Iran [5].

The increasing prevalence of obesity underscores the substantial role that lifestyle factors, including diet, play in the etiology of obesity [6]. Most studies to date have evaluated the association between intake of nutrients or food items and obesity, separately. However, this method overlooks the interactions between nutrients when consumed together [7]. Therefore, the results of these studies do not fully show a complete picture of the relationship between food and chronic diseases within populations. So, it is recommended to study dietary patterns, as this approach allows for a more comprehensive evaluation of diet's impact [8, 9].

Due to the lack of exploration in all nutrients of food and the interaction between nutrients, the use of dietary patterns can alleviate concerns about confounding factors and food interactions [9, 10]. Also, since the dietary pattern reflects eating behaviors, it can give more details about the etiology of obesity, and examining the dietary patterns of people can provide more practical solutions to prevent overweight, obesity, and related diseases [10, 11].

Dietary patterns have been examined in various studies, for example, in a large cohort study in China, the relationship between three major dietary patterns and metabolically healthy or unhealthy obesity phenotypes showed that a higher intake of diverse foods, compared to agricultural and animal husbandry lifestyles, was positively associated with metabolically healthy overweight/obesity [12]. Another study in low-income urban areas of Pakistan suggested the impacts of lifestyle and sociodemographic factors on the relationship between dietary patterns and obesity [13]. Additionally, other important lifestyle factors, such as meal timing in relation to dietary patterns, have been investigated. A cross-sectional study in Tehran found no relationship between major dietary patterns at dinner and obesity [14].

Since dietary patterns provide a clearer picture of food behavior, this approach is useful in identifying healthy food behaviors to prevent and control obesity. Therefore, this study investigated the relationship between different major dietary patterns and obesity in a cohort study in southwest of Iran.

Methods

Study participants

This case-control study is based on information obtained from the Hoveyzeh cohort study. Hoveyzeh cohort is part of the epidemiological study of the Persian cohort in which 180,000 Iranians participated [15].

All participants completed four questionnaires: two clinical questionnaires, one general questionnaire, and one food frequency questionnaire. This study utilized phase one cohort data, including anthropometric indices, blood indices, and dietary intake information.

Participants were recruited using stratified random sampling to ensure representation across different demographic groups. After considering the inclusion and non-inclusion criteria, 5821 people aged 35–70 remained. Two thousand seventy-six people were in the case group and, 3745 in the control group. The case group had BMI above 30 and, the control group had BMI below 30. Inclusion criteria does not have weight loss or weight gain diets in the past year, no pregnancy and lactation, no history of diabetes, pre-diabetes, cardiovascular disease, heart attacks and strokes and, types of cancers in the past year, Non-use of drugs that reduce or increase appetite and exclusion criteria were energy intake less than 800 and more than 4200 kcal. To address any potential biases during participant selection, careful consideration was given to the application of these criteria.

The study aimed to reduce selection bias by ensuring that the inclusion and exclusion criteria were uniformly applied across all participants. Furthermore, any discrepancies or uncertainties during the selection process were reviewed and resolved by the research team to maintain the integrity of the cohort.

Informed consent was obtained from all subjects. The study was approved by ethics committee of Ahvaz Jundishapur University of Medical Sciences. The ethical number is *IR.AJUMS.REC.1399.725.*

Measurement of anthropometrics and other variables

The participants' personal information such as age, gender, ethnicity, marital status, educational level, occupational status, smoking, socio-economic status (home and car ownership status, number of people living in the home, home ownership status, number of domestic and foreign trips, etc.), job history, income source, place of residence (materials used in assessing the place of residence, type of fuel used for heating and cooking, source of water used), sleep status (number of hours of sleep and use of sleeping pills) were obtained from the general questionnaire.

Also, part of the general questionnaire was dedicated to daily physical activity. An indicator called MET which shows the intensity of physical activity to calculate physical activity. A MET is the energy expended for sitting still and is equivalent to one kilocalorie consumed per kilogram of body weight per hour. Each activity is assigned a score based on the MET. Depending on the type and duration of physical activity, one physical activity score was calculated for each person. The measured indices were weight, height, body mass index, waist circumference and, hip circumference. Blood pressure was also measured [16]. Weight was measured using a Seca 755 stand scale with light clothing and without shoes. Height was measured using a 206 Seca walled without shoes, hats, or clamps with the shoulders in a normal position, the legs together, the heels stuked to the wall from behind, and the knees without bending. BMI was computed by dividing weight in kilograms by the square of height in meters. Waist circumference was measured with a tape measure without elasticity from the midpoint between the lowest rib and the iliac crest while standing and without pressure on the body. The hip circumference was measured with the same conditions in the maximum hip position with an accuracy of 0.1 cm (as in the waist circumference). Blood pressure was measured twice from the left and right arm after five minutes of rest with a time interval of ten minutes and, their mean was considered as blood pressure. Blood samples were taken from all participants between 7 and 9 a.m. after 8 to 12 h of fasting and were used to measure serum cholesterol, LDL.c, HDL.c, triglyceride and, fasting blood sugar. All experiments were performed in accordance with relevant guidelines and regulations [17].

Dietary assessment

Participants' food intake was assessed through a 130-item food frequency questionnaire which, was valid and reliable for Iranian foods [15]. The interview was well conducted by an expert nutritionist.

To reduce under-reporting or over-reporting, the nutritionist explained the serving sizes of food items to the participants and, if necessary, showed them pictures of the actual sizes of these items. Their consumption was then marked as times per day, week, month or, year in the past year, and consumption values were converted to grams using the home scale guide.

The energy and nutrients of the food items in the food frequency questionnaire were then determined using data from the USDA Food Ingredients Table in the Nutritionist 4 software database. In cases where food items were not in this software (such as Lavash bread and Barbari bread), the table of Iranian food ingredients was used.

The factor analysis method was used to identify the dietary patterns. In this method, food items were first categorized into 19 groups (their similarity in nutritional composition and previous studies) and based on the relationship between these food groups, food patterns were determined using SPSS software by principal component analysis. With the help of these obtained patterns, the relationship between dietary patterns and obesity was determined.

Statistical analysis

Food items were first divided into 19 groups based on their similarity in nutritional composition to determine the dominant dietary patterns. The results of the KMO and Bartlett tests were checked for sample adequacy. Then, the principal component analysis method with orthogonal rotation (varimax) was used to extract food patterns. In the current study, the number of factors (dietary patterns) was determined considering the criteria of eigenvalue > 1.3 and the analysis of the scree plot. In each pattern, food groups with a factor loading above 0.3 were retained in the pattern. Study participants were then categorized based on the dietary food quartile. The first quartile indicated low intake and, the last quartile showed high adherence to the dietary pattern.

The association between quartile of 4 dietary patterns and, the risk of obesity was calculated by odds ratio (OR) and the 95% confidence intervals (CIs) using multivariable logistic regression. In this regard, three models of logistic regression were assessed; model 1 was crude, model 2 was adjusted for age, gender, education, economic status, job, energy intake and, physical activity, and model 3 was further adjusted for blood pressure medication and diabetes medication.

Covariates were chosen based on their known or suspected associations with both dietary patterns and obesity, as identified in previous literature. Adjustments for these covariates were made to minimize bias and improve the accuracy of the estimated associations between dietary patterns and obesity outcomes. One-way analysis of variance and Univariate analysis were used to examine the relationship between dietary pattern quarters and anthropometric indices and, Binary logistic was used to evaluate hyper triglyceridemic waist Phenotype.

To compare between case and control groups, an independent t-test was used for quantitative data and, a chi-square test was used for qualitative data.

Table 1 Characteristics of the study participants across obese and control groups

Quantities variables	Obese (*n* = 2076)		Control (*n* = 3745)		*p*
	mean	SD	mean	SD	
Age(year)	46.3	7.7	48.3	9.4	< 0.001
Weight (kg)	89.2	11.5	68.9	11.5	< 0.001
Height (cm)	162.3	8.3	165.2	9.2	< 0.001
BMI (kg/m^2)	33.8	3.1	25.1	3.1	< 0.001
Waist circumference(cm)	108.8	8.3	91.8	8.7	< 0.001
WHR	0.96	0.06	0.93	0.06	< 0.001
VAI	490.0	270.0	284.8	323.8	< 0.001
SBP (mmHg)	113.2	16.8	110.3	17.2	< 0.001
DBP (mmHg)	71.9	11.0	69.9	10.9	< 0.001
TG(mg/dl)	167.0	85.4	144.1	95.6	< 0.001
FBS(mg/dl)	95.9	10.8	92.8	10.3	< 0.001
Cholesterol(mg/dl)	190.7	36.7	186.9	37.9	< 0.001
Energy (kcal)	2801.5	695.0	2825.5	704.0	0.20

Data are presented as means and SD; Using independent sample t test

BMI: body mass index; WHR: waist to hip ratio; VAI: visceral adiposity index; SBP: systolic blood pressure; DBP: diastolic blood pressure; TG: triglyceride

Table 2 Comparision qualitative variables of obesity and control groups

Variables	Obese (*n* = 2076)		Control (*n* = 3745)		*p*
	n	%	*N*	%	
Sex					< 0.001
Male	515	24.8%	1681	44.9%	
Female	1561	75.2%	2064	55.1%	
Marital status					0.009
Single	72	3.5%	193	5.2%	
Married	1843	88.8%	3232	86.3%	
Widow	117	5.6%	248	6.6%	
Divorced	44	2.1%	72	1.9%	
Level of education					0.002
Illiterate	1278	61.6%	2309	61.7%	
Primary school	371	17.9%	563	15.0%	
Secondary school	150	7.2%	253	6.8%	
High school diploma	142	6.8%	302	8.1%	
University	135	6.5%	318	8.5%	
Economic level					< 0.001
Poorest	346	16.7%	865	23.1%	
Poor	401	19.3%	875	23.4%	
Moderate	477	23.0%	724	19.3%	
Rich	447	21.5%	676	18.1%	
Richest	405	19.5%	605	16.2%	
HWPhenotype					< 0.001
No	1181	56.9%	3108	83.0%	
Yes	895	43.1%	637	17.0%	

Data are presented as numbers or %; Using Chi-square. BMI body mass index; HWPhenotype; hypertriglyceridemic waist Phenotype

Quantitative data were reported as mean and standard deviation and, qualitative data were reported as number and percentage.

Results

In Table 1, comparision the quantitative variablesbetween obesity and the control groups. There was a significant difference ($P < 0.001$) between age, weight, height, BMI, waist circumference, waist-to-hip ratio, blood pressure, visceral adiposity index, triglyceride, fasting blood sugar and, cholesterol. There was no significant difference in energy intake variables between the case and control groups.

In Table 2, the qualitative variables of obesity and control groups were compared. There was a statistically significant difference between the variables of gender, economic status and hypertriglyceridemic waist phenotype ($P < 0.001$), education ($P = 0.002$) and, maternal status ($P = 0.009$).

The food groups used in the analysis and their constituent food items are shown in Table 3. Foods were placed in groups based on similarity. Then, using factor analysis, and considering the results of sample size adequacy tests (KMO = 0.761 and Bartlett's test of sphericity = 9366.258), and scree plot diagrams, four major food patterns with eigen value greater than 1.3 were detected. These patterns accounted for 38.361% of the variance of the whole population.

A) Vegetables and high proteins food pattern: In this pattern, consumption of legumes, green vegetables and other vegetables, tomatoes, fruits, dairy, red meat and, whole grains were high and this pattern included 10.501% of the total variance.
B) Traditional pattern: In this pattern, consumption of green vegetables, onion and garlic, fruits, refined grains, white meat, liquid oil and, tomatoes were high and included 10.043% of the total variance.
C) Sweets and snacks pattern: In this pattern, consumption of red meat and processed meat, white meat, sugars, cakes and biscuits, nuts, pickles, salt, chips and, puffs were high and this pattern accounted for 9.723% of the total variance.
D) Good oils pattern: In this pattern, the consumption of liquid oil and olive oil was high and the consumption of refined grains and solid oils was low, and this pattern included 8.094% of the variance of the population.

Table 4. shows the factor loading of food groups in the major patterns for correlation with obesity. In this table, only food groups with a factor load more significant 0.3 are reported.

Table 3 Food items were placed in food groups based on similarity

	Foods or food groups	Food items
1	Whole grains	Baked barley, diet bread, wheat crumbs and corn
2	Refined grains	Lavash bread, Sangak bread, Barbary bread, baguette bread, rice, pasta, rice flour bread, local bread and potatoes
3	Meat	Red meat, tongue, heart, liver, kidney, brain and sheep's head and trotters, hamburgers and pizza, Sausages, kebabs,
4	White meat	Chicken, eggs, fish and tuna
5	Green vegetables	Lettuce, cucumber, vegetables, cooked vegetables, celery, artichoke, bell peppers, green peas, green beans, squash, green peppers, dried vegetables, okra and malvaceae
6	Tomato	Tomato and tomato paste
7	Garlic and onion	garlic and onion
8	Other vegetables	Cabbage, eggplant, beets, carrots and mushrooms
9	Fruits	Cantaloupe, warmth, melon, watermelon, apricot, cherry, sour cherry, peach, nectarine, green tomato, berry, strawberry, plum, fig, grape, apple, kiwi, citrus, pomegranate, banana, persimmon, date, raisin, Dried fruit and natural juice
10	Nuts	Walnuts, Peanuts,, Seed Nuts and Other Nuts
11	Solid oil	Butter, margarine, solid oil, cream and top milk
12	Liquid oil	Liquid oil, ground sesame and mayonnaise
13	Olive oil	olive oil and olives
14	Dairy	Milk, yogurt, cheese, yogurt drink (doogh), curd, flavored milk and Ice cream
15	Sweets	Sugar, candy, honey, jam, sugar, date juice, chocolate, halva, beer, soft drinks, industrial juices and compote
16	Beans	Bean, pea, Lentils, mung bean, soy, broad bean, split beans
17	Dessert	Cookies, cream cookies, biscuits
18	Chips and and cheetos puff	Chips and and cheetos puff
19	Condiments	Pickles, other pastes

Table 4 Factor loading for major dietary patterns

Food groups	Dietary patterns			
	Vegetables and high proteins food	Traditional	Sweets and snacks	Good oils
Beans	0.62			
Other vegetables	0.59			
Green vegetables	0.53	0.48		
Dairy	0.51			
Meat	0.44		0.33	
Whole grains	0.44			
Tomato	0.30	0.68		
Garlic and onion		0.58		
Fruits		0.53		
Refined grains		0.49		
White meat		0.38		
Sweets			0.59	
Dessert			0.55	
Nuts			0.55	
Condiments			0.54	
Chips and and cheetos puff			0.53	
Solid oil				-0.77
Liquid oil		0.30		0.70
Olive oil				0.44

Table 5. shows the odds ratio of obesity in the quarters of dietary patterns. The odds ratio was first calculated in the unadjusted model (crude model). The second model was adjusted for the confounding variables of age, sex, education, economic status, employment status, energy intake and, physical activity. The third model, in addition to the previous confounding variables, was adjusted for the use of hypertension and diabetes drugs. In the vegetables and high protein foods pattern, the risk of obesity in the crude model in the second, third and fourth quartiles was not significant compared to the reference (first) quartile. Moreover, in the second and third models, the result of the analysis did not change. In the traditional model, the risk of obesity in the crude model was not significant in the second and third quartiles compared to the reference (first) quartile, however, in the fourth quartile compared to the reference quartile, the risk of obesity increased by 29%. In the second model, the results for the second quartile relative to the reference quartile were not significant. In contrast, the risk of obesity rose by 35% and 64% in the third and fourth quartiles, respectively, when compared to the reference quartile. In the third model, the second and fourth quartiles were not significant compared to the reference quartile, however, the third quartile reduced the risk of obesity by 92% compared to the reference quartile. In the sweets and snacks pattern, the risk of obesity in the crude model in the second, third and fourth quartiles was not significant compared to the reference (first) quartile. In the second and third models, the result of the analysis did not change. In the good oils pattern, the risk of obesity in the crude model increased by 25%, 43%, and 51%, respectively, in the second, third, and, fourth quartiles compared to the reference quartile. In the second model, the risk of obesity increased by 31%, 32%, and 26% in the second, third,

Table 5 Odds ratio and 95% confidence intervals for the association between dietary patterns and obesity

Food patterns	Q1	Q2	Q3	Q4	*P*-trend
Vegetables and high protein foods					
Model 1	1	0.97(0.81–1.17)	0.95(0.79–1.15)	1.04(0.87–1.25)	0.80
Model 2	1	0.95(0.78–1.14)	0.92(0.76–1.11)	1.01(0.83–1.23)	0.74
Model 3	1	1.44(0.25–8.28)	0.20(0.02–1.65)	0.61(0.10–3.54)	0.36
Traditional					
Model 1	1	1.08(0.90–1.31)	1.17(0.97–1.41)	1.29(1.08–1.55)	0.03
Model 2	1	1.21(0.99–1.46)	1.35(1.11–1.63)	1.64(1.35–1.99)	< 0.001
Model 3	1	0.60(0.09–3.84)	0.08(0.01–0.72)	0.34(0.04–2.52)	0.16
Sweets and snacks					
Model 1	1	0.86(0.72–1.04)	1.05(0.87–1.26)	1.13(0.94–1.35)	0.03
Model 2	1	0.84(0.69–1.02)	0.99(0.82–1.20)	1.05(0.86–1.26)	0.12
Model 3	1	0.88(0.15–5.10)	0.31(0.03–2.71)	0.25(0.02–2.99)	0.59
Good oils					
Model 1	1	1.25(1.04–1.51)	1.43(1.19–1.73)	1.51(1.25–1.81)	< 0.001
Model 2	1	1.26(1.04–1.53)	1.32(1.09–1.61)	1.26(1.03–1.54)	0.02
Model 3	1	0.06(0.00-0.87)	0.13(0.01–1.37)	0.25(0.02–2.82)	0.17

Model 1: crude

Model 2: adjusted for age, gender, education, economic status, job, energy intake and physical activity

Model 3: additionally adjusted for blood pressure medication and diabetes medication

and fourth quartiles compared to the reference quartile. However, in the third model, the second quartile showed a 94% increase in obesity risk compared to the reference quartile, while the third and fourth quartiles did not demonstrate significant results in comparison. The variables were entered into logistic regression analysis uncategorized to calculate P-trend. The P-trend was not significant in the vegetables and high protein food pattern. In the traditional pattern, it was significant in the crude and second models, but not in the third model. In the sweets and snacks pattern, it was significant in the crude model, but not significant in the second and third models. The good oils pattern was significant in the first and second models, but not in the third model.

Table 6. shows the relationship between dietary quartiles and body mass index, waist circumference, waist-to-hip circumference, visceral fat index, and hypertriglyceridemic waist phenotype in obese patients. One-way analysis of ANOVA was used to investigate the relationship between dietary quartiles and body mass index, waist circumference, waist circumference to hip circumference and visceral fat index in obese patients. A Univariate test was used to adjust with confounding factors. Binary logistic analysis was used to evaluate the relationship between dietary quartiles and hypertriglyceridemic waist phenotype in obese patients.

The results showed that more adherence to sweets and snacks pattern reduced waist circumference and WHR, but no significant results were seen after adjusting for confounding factors. Also, more adherence to the traditional pattern and good oils pattern increased the amount of hypertriglyceridemic waist circumference phenotype, but no significant results were seen after adjusting for confounding factors.

Discussion

Previous studies on the relationship between various dietary patterns and obesity show inconsistence findings. In this case-control study, the association between dietary patterns and obesity was examined. Due to the integration of lifestyle and food culture, as well as the accessibility of various food ingredients in different parts of Iran in recent years, no significant differences are found in food culture among the people of Iran today. Therefore, although the present study was conducted using data from a large cohort study in southwest Iran, the outcomes are likely representative of other parts of the country.

Four major dietary patterns were identified: vegetables and high protein foods, traditional, sweets and snacks, and good oils. The "vegetables and high-protein foods" pattern, characterized by high consumption of legumes, green vegetables, other vegetables, dairy products, meat, tomatoes, and whole grains, showed no significant relationship with obesity risk or anthropometric indicators. Gurbannejad et al. found a protein-rich food pattern including legumes, offal, fish, eggs, red meat, high-fat dairy products, simple grains, and vegetables to be directly related to weight loss. Prior studies suggest that high-protein diets increase satiety by enhancing the thermogenic effect, potentially explaining the relationship between high-protein food patterns and leanness [18].

In the study of Sharaf Kazemzadeh et al., the traditional food pattern, characterized by refined carbohydrates, whole grains, vegetables, red and processed meats, and

Table 6 General characteristics of obese participants according to quartiles (Q) of dietary pattern scores

Characteristics	Q1	Q2	Q3	Q4	*p*-value*	*p*.value+
Vegetables and high protein						
BMI (kg/m^2)	33.7 ± 3.1	33.8 ± 3.3	33.5 ± 3	33.8 ± 3.1	0.56	0.56
Waist circumference(cm)	108.8 ± 8.5	109.0 ± 8.9	107.9 ± 8.6	108.5 ± 7.4	0.30	0.24
WHR	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	0.64	0.38
VAI	487.2 ± 275	472.7 ± 265.5	479.2 ± 261.3	507.9 ± 280.4	0.31	0.63
HWP	158(42.4%)	140(39%)	150(42.4%)	176(46.7%)	0.21	0.42
Traditional						
BMI (kg/m^2)	34 ± 3.5	33.7 ± 3.2	33.6 ± 3.0	33.5 ± 2.8	0.23	0.27
Waist circumference(cm)	108.3 ± 8.6	108.6 ± 9.0	108.6 ± 8.5	108.7 ± 7.5	0.92	0.55
WHR	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	0.58	0.16
VAI	454 ± 274.1	499 ± 271.8	491.5 ± 269.4	499.9 ± 267.7	0.08	0.07
HWP	125(37.3%)	160(45.3%)	156(41.7%)	183(45.6%)	0.08	0.84
Sweets and snacks						
BMI (kg/m^2)	33.8 ± 3.1	33.8 ± 3.1	33.5 ± 3.1	33.7 ± 3.2	0.65	0.59
Waist circumference(cm)	109.7 ± 8.4	108.7 ± 8.4	108.4 ± 8.3	107.5 ± 8.3	0.006	0.56
WHR	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	0.9 ± 0.06	< 0.001	0.81
VAI	480.6 ± 274.8	489.1 ± 251	480.2 ± 282.7	497.9 ± 272.5	0.77	0.91
HWP	160(43.8%)	134(40.6%)	164(43.5%)	166(42.5%)	0.82	0.33
Good oils						
BMI (kg/m^2)	33.3 ± 2.8	33.7 ± 3.1	33.8 ± 3.3	33.9 ± 3.1	0.06	0.72
Waist circumference(cm)	108.2 ± 8.6	109 ± 8.6	108.6 ± 8.7	108.5 ± 7.6	0.68	0.49
WHR	0.9 ± 0.06	0.9 ± 0.05	0.9 ± 0.06	0.9 ± 0.06	0.006	0.40
VAI	492.5 ± 292.5	499.5 ± 267.3	464.4 ± 267.5	493.7 ± 259.9	0.27	0.27
HWP	138(44.8%)	145(41%)	156(40%)	185(45%)	0.38	0.07

p.value+: adjusted for age, gender, education, economic status, job, energy intake, physical activity and take blood pressure and diabetes medication

Data are presented as means ± SD; Using Analysis of Variance (ANOVA), HW Phenotype is presented as n (%) Analyzed by Binary logistic

BMI: body mass index; WHR: waist to hip ratio; VAI: visceral adiposity index; HWP: hyper triglyceride waist circumference phenotype

sources of saturated and trans fats, was positively associated with higher fat, cholesterol, and calcium intake, as well as with obesity indices [19].

Shaneshin and Nazari identified a "healthy" dietary pattern, emphasizing whole grains, lean proteins, various vegetables, and fruits, which showed a reduced likelihood of general obesity but no significant correlation with waist circumference or abdominal obesity, though a significant relationship with body mass index (BMI) was found [20]. Esmailzadeh and Azadbakht's study of women teachers in Tehran also showed that those in the highest quintile of the healthy eating pattern had lower risks of general and abdominal obesity compared to those in the lowest quintile [18]. The negative relationship between the healthy eating pattern observed in the recent study with body mass index and abdominal obesity can be explained by the effect of low glycemic index, low energy density and, high fiber of food groups such as legumes, vegetables and, fruits and, intake of low fats.

Increasing the intake of soluble and insoluble fiber in a healthy diet increases the feeling of satiety after eating and reduces hunger again with the same energy intake. So diets with high fiber reduce energy intake and weight. In general, it seems that a healthy eating pattern can be the cause of weight loss and lower body mass index. Variation in food pattern in terms of having processed meat and viscera and not being loaded with liquid oil and fruits may may account for these findings.

In the study of Esmailzadeh et al., a healthy food pattern includes fruits, other vegetables, tomatoes, poultry and chickens, legumes, cabbage-shaped vegetables, green leafy vegetables, tea, juice, whole grains, potatoes, low-fat dairy products, and fish, yellow vegetables and low butter consumption, high-fat dairy products and, solid oil. This study showed an inverse relationship between healthy eating patterns and, body mass index and, waist circumference [21]. In the study of Rezazadeh et al., the healthy food pattern includes other vegetables, fruits, yellow vegetables, cabbage vegetables, tomatoes, low-fat dairy butter, poultry and chicken, olives, natural juice, potatoes, milk and, coffee. The results showed that following a healthy eating pattern in the study mentioned earlier has an inverse relationship with waist circumference and body mass index [22]. The negative relationship of the healthy eating pattern observed in the mentioned study with body mass index, waist size, general obesity and, abdominal obesity can be attributed to the effect of low glycemic index [23], low energy density [24] and, high fiber of food groups such as legumes, vegetables, fruits and intake of low fats [25] should be justified on intake of food and appetite.

Traditional food pattern was associated with a high consumption of green vegetables, tomatoes, syrups, refined grains, white meat and, fruits. Following this pattern had no significant relationship with the risk of obesity and anthropometric indicators. In the study of Nasreddine et al., the traditional Lebanese food pattern in terms of having grains, fruits and, vegetables is similar to the traditional pattern of the present study. The results of this study conducted among preschool children, showed that the Lebanese traditional model reduced the risk of overweight in preschool children. The traditional Lebanese food pattern contains less high-calorie foods such as sweets and fast foods, which is associated with less energy intake, fat and, sugar, thus helping to reduce the risk of obesity [26]. Also, consuming more fruits, vegetables and dairy products in the traditional Lebanese pattern increases the intake of several nutrients and phytochemicals, including fiber and calcium [27]. Dietary fiber plays a role in regulating appetite and weight [28].

The "sweets and snacks" pattern, associated with high intakes of sweets, cakes, biscuits, nuts, pickles, and salty snacks, was not significantly related to obesity risk or anthropometric indicators. However, Rezazadeh et al. found that an "unhealthy" food pattern—including processed meat, mayonnaise, soft drinks, sweets, refined grains, chips and puffs, cakes and biscuits, industrial juices, red meat, nuts, and fried potatoes, hydrogenated oils, eggs, butter, high-fat dairy products, sugar and, visceral meatwas positively correlated with BMI and waist circumference [22]. Foods with a high glycemic index, such as those rich in refined sugars, can induce hunger and overeating, thus contributing to increased fat storage and weight gain [29, 30]. The possible mechanism proposed for the positive relationship between unhealthy food patterns and abdominal obesity is that this food pattern leads to weight gain and abdominal obesity due to their high calories and because they are less thermogenic. In addition, an increase in salt intake leads to a decrease in the satiety signal, causing disturbances in the digestive system and increasing the activity of the renin-angiotensin system, which in, this way causes weight gain [31]. One study showed that reducing the consumption of Western food items including high-fat dairy products, fruits and fresh juices, buns and bread, instant foods, eggs, sweets and snacks, coarse grain, Western-style fast foods, nuts and seeds, and sugar-sweetened beverages combined with low intakes of rice, animal oil, preserved vegetables, and leafy green vegetables is related to abdominal obesity [32]. The non-significant relationship between unhealthy food patterns and obesity in this study may be attributed to factors such as the level of satiety, meal timing, and basal metabolic rate, which can affect the anthropometric results [33, 34].

The "good oils" pattern did not correlate with obesity in this study, unlike findings from studies on Mediterranean diets rich in olive oil, which have shown beneficial effects on body weight and waist circumference [35–42]. Differences in the type of oils consumed and food preparation methods may explain this variation. Also, since in the questionnaire used in the present study, the participants were not asked about the type of liquid oil.

Regardless of positive points in the current study, there are some limitations in the study. A validated and reliable Food Frequency Questionnaire (FFQ) was used, and the application of factor analysis provided a clearer understanding of dietary patterns in the population than methods used in other studies. However, measurement error such as overestimation or underestimation in FFQ questionnaire is indispensable. While most studies use the FFQ questionnaire to assess dietary patterns, evaluating other aspects of lifestyle factors that may be as interplay factors in obesity and dietary patterns, such as meal timing and the number of main and snack meals, could help to explain the outcome studies. To further clarify the relationship between dietary patterns and obesity, other underlying factors such as participants satiety levels, meal timing, and basal metabolic rate should have been examined.

Conclusion

In this study, there was no significant relationship between dietary patterns and obesity and anthropometric indicators. The healthy food pattern, including vegetables and high-protein foods in this study, was different compared to previous studies. Further epidemiological studies considering underlying socio-behavioral and genetic factors in other parts of Iran with different ethnicities are needed to determine various dietary patterns.

Abbreviations

FBS	Fasting blood sugar
HDL.c	High density lipoprotein cholestrolcholesterol
LDL.c	Low density lipoprotein cholesterol
NCD	Non communicable diseases
FFQ	Food frequency questionnaire
MET	Metabolic equivalent of task
BMI	Body mass index
WC	Waist circumference
HC	Hip circumference
WHR	Waist to hip ratio
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
TG	Triglyceride
HWP	Hypertriglyceridemic waist phenotype
VAI	Visceral adiposity index

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Author contributions

A.M. designed the original intervention. S.A.H., A.M., B.Z. collected and interpreted the data and were the major contributors to writing the manuscript. B. Ch analyzed the data. Review and Editing were accomplished by M.F. All authors reviewed and confirmed the final manuscript. The authors read and approved the final manuscript.

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Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All subjects filled out a written informed consent before the study initiation. All procedures performed in studies involving human participants adhered to the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The protocol of the study was approved by ethics committee of Ahvaz Jundishapur University of Medical Sciences. The ethical number is IR.AJUMS.REC.1399.725.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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