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Original Article

The Association Between Dietary Patterns and Cardiovascular Disease Risk Factors in Fasa Adult Rural Population, Southern Iran: A Cohort of Prospective Epidemiological Research Studies in Iran (PERSIAN)

Atefeh Kohansal[1], Maryamsadat Riasatian[1], Kimia Leilami[2], Alireza Rafieipoor[3], Reza Homayounfar[4,5,*]

1. Department of Community Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
2. Department of Clinical Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
3. School of Nursing, Hormozgan University of Medical Sciences, Hormozgan, Bandar Abbas, Iran
4. National Nutrition and Food Technology Research Institute, Faculty of Nutrition Sciences and Food Technology, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
5. Noncommunicable Diseases Research Center, Fasa University of Medical Sciences, Fasa, Iran

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**Corresponding author:*
Reza Homayounfar, PhD;
National Nutrition and Food Technology Research Institute,
Faculty of Nutrition Sciences and Food Technology,
Shahid Beheshti University of Medical Sciences,
Tehran, Iran.
Email: r_homayounfar@yahoo.com
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ABSTRACT

Background: Over the past few decades, the association between dietary patterns and chronic diseases, such as cardiovascular diseases and their risk factors, has garnered significant attention. Therefore, this study examined the relationship between dietary patterns, lipid profile, and anthropometric indices among adults aged 30 to 75 in the rural population of Iran.

Methods: This descriptive-analytical cross-sectional study included 5,220 participamts (3,467 females and 1,753 males) in Fasa adult rural population, Southern Iran as a cohort of Prospective Epidemiological Research Studies in Iran (PERSIAN). Lipid profile and anthropometric indices were measured using standard methods. Nutritional data were collected through a semi-quantitative, 125-item food frequency questionnaire (FFQ). Dietary patterns were identified through factor analysis.

Results: After adjusting for potential confounders, the mean percentages of fat, fat mass, and lean body mass were significantly higher in the highest tertile of the healthy dietary pattern when compared to the first tertile ($p<0.001$ for all, except for lean body mass). However, in the adjusted model, the highest tertile of the unhealthy food pattern was associated with a higher mean high-density lipoprotein cholesterol (HDL-C) level ($p<0.001$) and a lower mean percentage of fat ($p=0.025$) in comparison to the first tertile.

Conclusion: This study suggests that a healthy diet may not always offer protection against cardiovascular disease risk factors. However, further prospective studies in different geographical regions are required to draw more definitive conclusions.

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Introduction

Cardiovascular diseases (CVDs) are still the most leading cause of death worldwide (1) and impose a substantial socioeconomic burden on governments (2, 3). Similarly, in Iran, CVD have been identified as the primary cause of mortality and disability (4). The risk factors of CVD can be categorized into two groups of (i) non-modifiable factors, such as age, gender, race, ethnicity, family history, socioeconomic status; and (ii) modifiable factors, such as dietary habits, weight gain, low physical activity, stress, smoking, alcohol consumption, and health conditions like diabetes, hypertension and hyperlipidemia (5). It was shown that about 80% of CVD-related death can be prevented through lifestyle modifications, with diet being the most impactful factor (6). As a modifiable risk factor, diet has recently gained significant attention, with increasing efforts directed toward nutritional interventions (7, 8).

Most previous studies examining the relationship between diet and CVD risk factors have focused on individual nutrients or single foods rather than assessing overall dietary patterns (DPs). However, nutrients are not consumed in isolation; meals comprise a variety of foods, resulting in complex combination of macronutrients and micronutrients (9, 10). Previous studies investigating the association between DPs and various CVD risk factors using reduced rank regression (RRR) have predominantly been conducted in North America and Europe. These studies primarily focused on pathways involving disease-related inflammatory biomarkers (11), serum lipids (12), and nutrient intakes (13). Eating habits vary significantly between the Middle East and the West (14), yet only a limited number of studies focus on Middle Eastern populations. Therefore, we conducted this study to investigate the association between major DPs and CVD risk factors among adults in the rural population of Fasa.

Materials and Methods

This cross-sectional study builds upon findings from a cohort study conducted in Fasa, Fars province, Southern Iran as a cohort of the Prospective Epidemiological Research Studies in Iran (PERSIAN), which investigates non-communicable diseases (NCDs) over time. Initially, healthcare workers (Behvarz) at each health house in villages and small towns explained the study's objectives to potential participants and invited them to participate according to the study protocol. The study included 11,097 individuals aged between 35 and 70 who resided in the rural area of Sheshdeh, Fasa, Southern Iran as well as residents from 24 surrounding villages in the city This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Medical Research and Ethics Committee of Shiraz University of Medical Science (IR.SUMS.REC.1399.392). All participants read and signed the informed consent form.

The inclusion criteria for the study were willingness to participate, being aged between 30 and 75 years, and residing in the Sheshdeh region of Fasa city, Southern Iran. Participants who declined to cooperate, failed to complete the questionnaire (n=4697), did not undergo physical and biochemical assessments (n=871), or reported daily energy intake outside the range of 800 to 4200 kcal (n=309) were excluded from the study. Ultimately, 5,220 men and women were included in the final analysis. The general information checklist was completed through interviews and included personal details such as age (in years), gender (male or female), physical activity (MET/day), educational level (in years), dietary habits, and anthropometric data. In addition, the study utilized checklists to gather information on participants health issues related to NCDs, as well as their alcohol consumption or smoking habits. Physical activity was also recorded. Participants were instructed to bring their medications to ensure accurate documentation of their medication history during the interview.

Initially, the participant's weight was measured using a SECA scale, with minimal clothing and without shoes, to the nearest 0.1 kg. Height was recorded without shoes using a tape measure with an accuracy of 0.1 cm. Body mass index (BMI) was then calculated by division of weight (kg) by height square (m^2). Waist circumference (WC) was determined in the narrowest point of the waist, and hip circumference (HC) around the broadest part, using a non-stretchable tape to the nearest 0.1 cm. Also, body fat mass percentage, non-fat mass, and fat mass distribution in the trunk, hands, and leg were evaluated using the BIA device (Tanita BC-418, Tanita, Tokyo, Japan). A 25 mL of blood samples were collected after 12 hours of fasting. Fasting blood glucose (FBS) and serum lipid concentration, including triglyceride (TG), total cholesterol (TC), low- and high-density lipoprotein cholesterol (LDL-C and HDL-C), were measured using an autoanalyzer device with the colorimetric method and Pars azmoone kits.

A 125-item Food Frequency Questionnaire (FFQ) with Willet format, adapted for Iranian dietary habits, was used to assess dietary intake (15). Participants reported the frequency of consumption for each food item, based on its standard size, over the last year, categorized as daily, weekly, monthly or annually. Finally, an updated version of Nutritionist

IV software was used to estimate the mean intake of energy and nutrients. Principal component analysis (PCA) was performed to identify DPs. To reduce complexity, the 125 food items were grouped into 27 categories: refined and whole grains, nuts, legumes and soy, poultry, fish, red meat, processed food, miscellaneous animal-based foods, dairy products, cheese, egg, saturated fats, liquid oil, olive, green vegetables, yellow vegetables, other vegetables, tomato, fruits, fruit juice, dried fruits, pickles, salt, snacks, drinks, sweets and desserts, tea and coffee, and sauces and condiments.

Factor loadings were used to calculate the contribution of each food group to the DPs, and the correlation between food groups and DPs was assessed. Kaiser–Meyer–Olkin (KMO) and Bartlett's tests were performed for data reduction. Based on previous studies, a factor loading of 0.2 or higher was considered significant. The KMO value was 0.761, and Bartlett's test of sphericity was also significant ($p<0.001$) (Table 1). Finally, individuals were classified into tertiles based on their DPs. Two patterns were identified in our analysis: healthy and unhealthy DPs. According to the factor loading table, the healthy pattern included legumes and soy, nuts, red meat, poultry, fish, miscellaneous animal-based foods, dairy products, cheese, fruits, fruit juices, green vegetables, yellow vegetables, other vegetables, tomatoes, pickles, salt, dried fruits, and sauces and condiments. The unhealthy pattern included refined grains, whole grains, processed foods, eggs, saturated fats, olives, snacks, beverages, sweets and desserts, and tea and coffee.

In this study, all statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) software (version 22, Chicago, IL, USA). The normality of variables was first assessed using the Kolmogorov-Smirnov test. Baseline characteristics were presented as mean±standard deviation (SD) for continuous variables and percentage for categorical variables. To compare quantitative variables, such as macronutrients and micronutrient intake, nutrients were energy-adjusted using the residual method. The one-way ANOVA test was then applied. To determine the exact observed relationship between groups, post hoc analysis was performed utilizing Bonferroni test. Additionally, the ANCOVA test was employed to examine the mean distribution of lipid profile and anthropometric indices across DPs in both crude and

Table 1: Factor loading and scattering matrices expressed for dietary patterns determined by the factor loading method.

Food groups	Healthy pattern	Unhealthy pattern
Refined grains	0.26	0.48
Whole grains	-	-0.35
Legumes and soy	0.42	-
Red Meat	0.37	-
Processed food	0.29	0.38
Poultry	0.39	-
Fish	0.39	-
Egg	0.27	0.39
Miscellaneous animal-based foods	0.41	-
Dairy products	0.44	-0.18
Cheese	0.30	-
Saturated fats	0.20	0.42
Liquid oil	-	-
Olive	0.24	0.32
Nuts	0.44	-
Fruits	0.64	-0.21
Fruit juice	0.43	-0.25
Green vegetables	0.28	-
Yellow vegetables	0.40	-0.23
Other vegetables	0.55	-
Tomato	0.41	-
Pickles	0.40	-
Salt	0.23	0.32
Snacks, drinks, sweets, desserts	0.42	0.46
Tea and coffee	-	0.36
Dried fruits	0.37	-0.32
Sauces and condiments	0.32	-
Percentage of variance justified	13.56	7.1

A factor load more significant than 0.20 was considered. The factor analysis method has been used to extract food patterns.

adjusted models, with adjustment for gender (male/female), age (years), BMI (kg/m^2), energy (kcal/day), fiber intake (g/day), and education (years). The chi-square or Fisher's exact test was also used to compare categorical variables. A *p* value of less than 0.05 was considered statistically significant.

Table 2: Baseline characteristics of the study participants.

Quantitative ariables	Mean±standard deviation
Age (year)	49.88±9.78
Weight (kg)	65.67±13.08
Height (cm(	159.88±9.11
BMI (kg/m^2)	25.8±4.97
Waist circumference (cm)	93.61±12.04
Hip circumference (cm)	99.63±9.21
Wrist circumference (cm)	16.54±1.31
Education (year)	4.43±3.94
Categorical variables	Number (percent)
Gender (number (%))	
Man	3467 (66.40)
Female	1753 (33.60)
Marital status (number (%))	
Single	216 (4.10)
Married	4492 (86.10)
Dead wife (widow)	457 (8.70)
Divorced	55 (1.10)

kg: Kilogram; cm: Centimeter; BMI: Body mass index. Values were reported as mean SD for continuous and percentage for categorical variables.

Table 3: Baseline characteristics of the study participants based on the healthy and unhealthy food pattern tertiles.

Variable	Healthy dietary pattern			*P* value	Unhealthy dietary pattern			*P* value
	Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)		Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)	
Age (year) *	50.30± 9.90[a]	49.91± 9.77[a]	49.41± 9.65[b]	0.027	52.58± 9.83[a]	49.59± 9.56[b]	47.46± 9.26[c]	≤0.001
Weight (kg) *	62.97± 12.59[a]	65.32± 13.01[b]	68.73± 12.99[c]	≤0.001	65.05± 12.51[a]	65.87± 13.33[a]	66.09± 13.36[a]	0.048
Height (cm)*	159.16± 8.64[a]	159.09± 9.15[a]	160.59± 9.46[b]	≤0.001	157.13± 7.49[a]	159.1± 9.07[b]	162.59± 9.77[c]	≤0.001
BMI (kg/m^2) *	24.9± 4.84[a]	25.82± 4.92[b]	26.67± 4.92[c]	≤0.001	26.35± 4.77[a]	26.01± 5.01[a]	25.04± 5.03[b]	≤0.001
Waist circumference (cm)*	91.53± 12.05[a]	93.59± 12.03[b]	95.71± 11.67[c]	≤0.001	95.43± 11.70[a]	93.97± 11.95[b]	91.44± 12.09[c]	≤0.001
Hip circumference (cm)*	98.01± 8.98[a]	99.42± 9.25[b]	101.46± 9.07[c]	≤0.001	100.02± 9.01[a]	100.04± 9.50[a]	98.82± 9.07[b]	≤0.001
Wrist circumference (cm)*	16.33± 1.28[a]	16.49± 1.25[b]	16.8± 1.34[c]	≤0.001	16.37± 1.30[a]	16.53± 1.29[b]	16.71± 1.31[c]	≤0.001
Education (year)*	3.99± 3.78[a]	4.38± 3.88[b]	4.93± 4.09[c]	≤0.001	3.60± 3.81[a]	4.44± 3.79[b]	5.26± 4.03[c]	≤0.001
Gender (number (%))&				0.023				≤0.001
Man	34.5%	31.9%	34.3%		18.5%	30.2%	52%	
Female	65.5%	68.1%	65.70%		81.5%	69.8%	48%	
Marital status (number (%)) &				0.005				0.001
Single	5.1%	3.6%	3.7%		4.7%	4%	3.7%	
Married	83.8%	86%	88.3%		80.6%	86.3%	91.3%	
Dead wife (widow)	9.6%	9.4%	7.3%		13.5%	8.6%	4.2%	
Divorced	1.4%	1%	0.7%		1.2%	1.1%	0.8%	

kg: Kilogram; cm: Cntimeter; BMI: Body mass index. Values were presented as mean±SD for continuous variables or as percentage for categorical variables. * Using One-way ANOVA test for continuous variables. & Using chi-square test for categorical variables. One-way ANOVA test followed by Bonferony test was used for post Hoc analysis. Means with same superscript letters (aa, bb or cc) were not significantly different (p>0.05). Significant values were shown in bold.

Results

Data from 5220 participants, including 1753 males and 3467 females, were included into the final analysis. The baseline characteristics of the participants were shown in Table 2. According to Table 3, in the healthy food pattern, the mean age in the last tertile was significantly lower than in the first tertile (p=0.027). However, the mean weight, height, BMI, WC, HC, and educational level in the last tertile were significantly higher than in the first tertile (p<0.001 for all). In the unhealthy food pattern, the mean age, BMI, WC, and HC in the last tertile were significantly lower than in the first (p<0.001). However, the mean weight, height, WC, and education in the third tertile of this pattern were significantly higher in the first tertile (p<0.001 for all, except for weight).

In the healthy food patterns, the average intake of energy, protein, total fat, fiber, monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) were significantly higher in the last tertile. On the other hand, the mean intake of carbohydrates, trans and saturated fatty acids (SFAs) and cholesterol in the last tertile were significantly lower than in the first one (p<0.001 for all). In the unhealthy food pattern, the average intake of energy, total fat, trans fatty acids, SFAs, cholesterol, MUFAs, and PUFAs in the third tertile were significantly more than in the first tertile (p<0.001 for all, except for trans fatty acids and cholesterol). Conversely, the average intake of carbohydrates, protein, and fiber in the last tertile were significantly lower than in the first tertile (p<0.001) (Table 4).

As shown in Table 5, in the healthy food patterns, the mean level of triglycerides, cholesterol, percentage of fat, fat mass, and lean body mass in the last tertile were significantly higher than in the first tertile in the crude model (p<0.001 for all, except for cholesterol). However, after adjusting for potential confounders, in the last tertile of the healthy pattern, the mean percentage of fat, fat mass, and lean body mass remained significantly higher when compared to the first tertile (p<0.001 for all, except for lean body mass). Moreover, in the crude model, the mean level of cholesterol (p=0.026), percentage of fat (p<0.001), and fat mass (p<0.001) were significantly lower, whereas LDL-C (p=0.034) and lean body mass (p<0.001) were significantly higher in the last tertile of unhealthy food pattern in comparison to the first tertile. However, in the adjusted model, compared to the first tertile of the unhealthy food pattern, a higher mean level of HDL-C (p<0.001) and a lower mean percentage of fat (p=0.025) were seen in the last tertile.

Table 4: The amount of energy, macronutrients and micronutrients intake of study participants based on the healthy and unhealthy food pattern tertiles.

Variable	Healthy dietary pattern			*P* value	Unhealthy dietary pattern			*P* value
	Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)		Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)	
Energy (Kcal/day)	2173.07± 677.91[a]	2538.20± 617.34[b]	3074.22± 826.76[c]	≤0.001	2207.64± 656.23[a]	2464.00± 631.55[b]	3113.22± 817.94[c]	≤0.001
Carbohydrate (g/day)	442.03± 40.09[a]	435.53± 42.52[b]	435.49± 49.94[c]	≤0.001	450.22± 30.47[a]	439.16± 36.50[b]	423.22± 57.43[c]	≤0.001
Protein (g/day)	73.44± 11.56[a]	77.53± 10.72[b]	81.52± 14.56[c]	≤0.001	79.02± 8.83[a]	76.81± 10.80[b]	76.73± 17.24[c]	≤0.001
Fat (g/day)	63.06± 16.92[a]	65.23± 18.68[b]	65.92± 20.43[c]	≤0.001	59.02± 20.03[a]	64.35± 22.65[b]	70.79± 32.65[c]	≤0.001
Fiber (g/day)	21.61± 5.31[a]	25.70± 5.63[b]	32.78± 9.95[c]	≤0.001	28.45± 8.16[a]	27.33± 8.15[b]	24.39± 9.01[c]	≤0.001
Trans fatty acids (g/day)	0.21± 0.16[a]	0.21± 0.18[b]	0.20± 0.21[c]	≤0.001	0.17± 0.12[a]	0.19± 0.15[b]	0.26± 0.26[c]	0.039
SFAs (g/day)	25.96± 10.58[a]	25.87± 11.56[b]	24.27± 11.40[c]	≤0.001	21.27± 7.54[a]	25.29± 9.81[b]	29.49± 13.79[c]	≤0.001
MUFAs (g/day)	18.46± 5.99[a]	19.43± 6.86[b]	20.01± 8.27[c]	≤0.001	17.55± 5.88[a]	19.24± 5.93[b]	21.29± 8.73[c]	≤0.001
PUFAs (g/day)	8.17± 2.86[a]	9.25± 3.38[b]	10.63± 4.59[c]	≤0.001	9.03± 3.38[a]	9.29± 3.23[b]	9.75± 4.65[c]	≤0.001
Cholesterol (mg/day)	245.40± 109.99[a]	245.84± 108.03[b]	236.39± 118.82[c]	≤0.001	192.26± 72.19[a]	232.88± 82.60[b]	301.82± 140.40[c]	0.002

kcal: Kilocalorie; g: Gram; mg: Milligram; SFAs: Saturated fatty acids; MUFA: Mono-unsaturated fatty acids, PUFAs: Poly-unsaturated fatty acids. Values were presented as mean±SD. Using One-way ANOVA test for continuous variables. One-way ANOVA test followed by Bonferony test was used for post Hoc analysis. Means with same superscript letters (aa, bb or cc) were not significantly different (p>0.05). Significant values were shown in bold.

Table 5: The mean of lipid profiles and anthropometric indices in study participants based on the healthy and unhealthy food pattern tertiles.

Variable	Healthy dietary pattern			*P* value	Unhealthy dietary pattern			*P* value
	Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)		Low adherence (n=1739)	Medium adherence (n=1741)	High adherence (n=1740)	
Lipid Profile								
Triglyceride (mg/dL)								
Crude model	123.46±74.12[a]	129.52±79.85[a]	135.24±83.65[b]	≤0.001	131.39±75.38[a]	129.66±84.36[a]	127.17±78.29[a]	0.290
Adjusted model[1]	123.55±74.25[a]	129.53±79.90[a]	135.30±83.72[a]	0.783	131.67±75.64[a]	129.66±84.36[a]	127.12±78.26[a]	0.346
Cholesterol (mg/dL)								
Crude model	185.16±39.04[a]	186.84±38.68[a]	189.54±41.31[b]	0.005	188.95±40.36[a]	187.28±40.08[a]	185.32±38.66[b]	0.026
Adjusted model[1]	185.19±39.09[a]	186.83±38.71[a]	189.57±41.22[a]	0.570	189.00±40.39[a]	187.28±40.08[a]	185.35±38.62[a]	0.542
LDL-C (mg/dL)								
Crude model	109.03±37.72[a]	109.08±32.75[a]	109.89±34.40[a]	0.693	110.61±35.02[a]	109.65±32.89[a]	107.73±31.87[b]	0.034
Adjusted model[1]	109.17±32.69[a]	109.06±32.79[a]	109.94±34.30[a]	0.441	110.76±34.98[a]	109.65±32.89[a]	107.79±31.82[a]	0.835
HDL-C (mg/dL)								
Crude model	51.44±14.84[a]	51.80±15.84[a]	52.60±17.55[a]	0.092	51.99±14.86[a]	51.69±15.78[a]	52.16±17.60[a]	0.690
Adjusted model[1]	51.31±14.76[a]	51.79±15.85[a]	52.57±17.53[a]	0.399	51.85±14.74[a]	51.69±15.78[a]	52.14±17.61[b]	≤0.001
Anthropometric indices								
Fat percentage (%)								
Crude model	27.84±9.98[a]	29.56±9.64[b]	30.55±9.69[b]	≤0.001	32.09±8.61[a]	29.59±9.57[b]	25.57±10.30[c]	≤0.001
Adjusted model[2]	27.85±9.98[a]	29.56±9.64[b]	30.55±9.69[c]	≤0.001	32.12± 8.58	29.59± 9.57	25.57±10.30	0.025
Fat mass (kg)								
Crude model	18.30±8.90[a]	20.02±8.77[b]	21.75± 9.27[c]	≤0.001	21.63±8.57[a]	20.17±9.02[b]	17.62±9.22[c]	≤0.001
Adjusted model[2]	18.31±8.90[a]	20.02±8.77[b]	21.75± 9.27[c]	≤0.001	21.65±8.57[a]	20.17±9.02[a]	17.62±9.22[a]	0.151
Lean Body Mass (kg)								
Crude model	45.06±7.46[a]	45.52±7.33[a]	47.51± 8.11[b]	≤0.001	43.86±6.78[a]	45.71± 7.63[b]	48.49±8.16[c]	≤0.001
Adjusted model[2]	45.07±7.63[a]	45.52±7.33[a]	47.51± 8.11[b]	0.001	43.84±6.78[a]	45.71± 7.63[a]	48.51±8.15[a]	0.781

mg: Milligram; dL: Decilitre; kg: Kilogram; LDL-C: Low density lipoprotein cholesterol; HDL-C: High density lipoprotein cholesterol. Values were presented as mean±SD. Using ANCOVA test for continuous variables. [1]Adjusted for gender (male/female), age (years), BMI (kg/m^2), energy (kcal/day) and fiber intake (g/day), education (years). [2]Adjusted for gender (male/female), age (years), energy (kcal/day) and fiber intake (g/day), education (years). One-way ANOVA test followed by Bonferony test was used for post Hoc analysis in crude model. ANCOVA test followed by Bonferony test was used for post Hoc analysis in adjusted model. Means with same superscript letters (aa, bb or cc) were not significantly different (p>0.05). Significant values were shown in bold.

Discussion

In this cross-sectional study, the results showed a direct relationship between greater adherence to a healthy DP and the mean of percentage of body fat, fat mass and lean body mass. Also, a direct relationship was seen between greater adherence to an unhealthy DP and mean HDL-C, while a reverse relationship was seen between unhealthy DP and percentage of fat. These results differ from those of some other studies. Sandra *et al.*'s study found that the waist-to-hip ratio (WHR) was significantly related to fiber and carbohydrate consumption (16). A study by Latorre-Millán *et al.*, involving 674 children aged 5 to 16 years, reported that healthy

DPs were associated with lower abdominal fat and reduced CVD risk in both overweight and normal-weight children (17). Additionally, a cross-sectional study on 125 postmenopausal women in New Zealand showed that consuming fatty fish, sports drinks, and seafood had a significant inverse relationship with WC, BMI, and body fat percentage (18). Our study is in line with the the results of this study (18) that those following healthy DPs with higher fish consumption had a smaller WC.

Further evaluations show that, although consumption of healthy food groups such as legumes, nuts, seafood, and olive oil, along with nutrients like fiber, unsaturated fats, vitamins, and various minerals increased with greater adherence to healthy DPs, the intake of energy, total carbohydrate from fruit and juices, and subsequently sucrose and fructose also increased. Contrary to expectations and the results of previuos studies, this may explain the lack of a significant relationship between adherence to a healthy eating pattern and the body composition in this study (19). Evidence from randomized controlled trials (RCTs) and observational studies suggests that total carbohydrates intake is neither harmful nor beneficial for cardiovascular health (20). One study has suggested that the quality of carbohydrates may be more important for CVD outcomes than carbohydrate quantity. Public health organizations recommended limiting free sugars or added sugars to 5-10% of total daily energy intake. Meta-analyses of RCTs in adults showed that reducing free sugar intake in an ad libitum diet reduced the total energy intake, which was associated with body weight loss (21).

Finding from the Health Professionals Follow-up Research findings suggest that a Western DP with high consumption of red meat, processed meat, high-fat dairy products, and refined grains is associated with coronary heart disease (CHD) mortality but not with blood lipid concentrations (10, 22). The results of the recent study showed that with the increased adherence to a healthy food pattern (i.e., the last tertile), the average level of triglycerides, cholesterol, and HDL were significantly higher than in the first tertile. However, this difference was no longer significant after adjusting for confounders. Also, no significant relationship was observed in mean LDL before and after adjustment for confounders, suggesting that adherence to a healthy food pattern does not have a significant impact on mean LDL levels.

Most studies have reported results opposite to those of our study. For example, a recent study by Najafi *et al.* on the Iranian urban population observed that greater adherence to a healthy eating pattern could have a protective effect and increase the HDL-C levels (23). Similarly, Ibrahimov *et al.* showed that following a healthy DP, which includes consuming more fruits and juices, vegetables, liquid oils, and nuts while reducing refined grains, can be a key factor in preventing heart disease (24). In Haddad *et al.*'s study, after adjusting for confounding factors, only TG level had a direct relationship with an unhealthy diet (25). The discrepancy between the results of the present study and previous studies is likly due to the nature of our study design, as cross-sectional studies cannot establish cause-and-effect relationship.

Followers of a healthy diet pattern in the third tertile had significantly higher body weight than those in other tertiles. Examination of their diets revealed that the high consumption of fruits and vegetables in healthy diets increased the intake of B vitamins, which can stimulate appetite. As a result, long-term consumption of these foods may lead to increased energy intake and the weight gain. Additionally, these individuals consumed significantly more dairy products. It has been suggested that the beneficial effects of dairy products, as a primary source of calcium, on weight and lipid profiles are most evident when low-fat-dairy products are consumed (26-28). In contrast, the consumption of high-fat dairy products can contribute to weight gain. It has been reported that most of the dairy products consumed in Iran are high-fat, containing more than 2.5% fat, which aligns with the greater availability of high-fat dairy products among the study participants (29).

Moreover, our finding showed that in healthy DP, average intake of energy, protein, total fat, fiber, MUFA and PUFA, and all evaluated micronutrients were significantly higher in last tertile. On the other hand, the mean intake of carbohydrates, trans and SFA, and cholesterol in the last tertile was significantly lower than the first tertile. Strong and consistanent evidences indicate that greater adherence to DPs rich in fruits, vegetables, whole grains, nuts, legumes, unsaturated oils, dairy products, poultry, and fish, but low in red and processed meats, as well as sugar- and fat-rich dairy products, is associated with a reduced risk of CVD, including CHD and stroke, in healthy adults (30).

Western DPs are characterized by high consumption of sweets, tea, eggs, snacks, fast food, potatoes, fizzy drinks, pickled foods, organ meats, and butter. At baseline, both DPs were significantly correlated with CVD risk factors such as BMI, WC, HC, WHR, FBG, TC, TG, and HDL-C. It is noteworthy that the results indicated adherence to a balanced DPs was not significantly associated with CVD events over the 6-year follow-up. However, adherence to a Western DP was strongly linked to an increased risk of CVD events and associated dangers

(31). In line with these finding, Sun *et al.* reported that adherence to Western DP is associated with higher BMI, WC, and TG levels when compared to healthy and balanced DP (32). Moreover, Oikonomou *et al.* highlighted a relationship between the severity of coronary artery disease (CAD) in individuals with stable CAD and adherence to a Western DP that, further classifies it as an unhealthy DP (33).

Finally, the dietary prevention of CVD should be prioritized throughout life from the cradle to the grave, regardless of the presence or absence of disease, and at both individual to a population levels. To make healthy choices more accessible, dietary recommendations and policies need to be clearly communicated and effectively targeted. While there are no "magic foods", maintaining a diverse and fresh diet is essential (33). Higher consumption of certain food groups, such as vegetables, fruits, and whole grains, commonly identified as part of a prudent or healthy diet, has been consistently associated with a lower risk of CVD in previous studies (24, 34, 35). These dietary groups may reduce the risk of CVD through multiple metabolic pathways. For example, the antioxidants and polyphenols abundant in plant-based meals strengthen the body's antioxidant defence, prevent lipid oxidation, and improve endothelial function (36, 37). Additionally, the high fibre content in these foods supports improved lipid metabolism, better blood sugar regulation, and reduced inflammation (38, 39). A healthy, environmentally sustainable, and cost-effective diet can be achieved through collaboration among patients, health professionals, the food industry, and policymakers. Such efforts can lead to a significant reduction in cardiovascular events. Early education and access to healthy foods are crucial for establishing lifelong healthy eating habits, which can be passed on to future generations (40).

Several points should be considered when interpreting these findings. First, the cross-sectional design of the study limits the ability to establish causality. Second, there may be confounding factors that were not accounted for in the analysis. Third, while the FFQ is a practical tool for collecting dietary information in epidemiological studies, it does not provide a precise measurement of participants' actual intake. Despite these limitations, the study possesses notable strengths. It utilized data from the Fasa cohort, which includes a large and diverse sample size. Additionally, the collection of comprehensive demographic and social information enables a robust examination of potential confounders, allowing for the adjustment of several key confounding factors in all analyses.

Conclusion

The findings of this study suggest that consuming a healthy diet may not always be effectively protect against the risk factors of cardiovascular diseases. More definitive conclusions could be drawn through further prospective studies with larger sample sizes and conducted across diverse geographical areas.

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Authors' Contribution

A.K., M.R., K.L. and A.R.: Contributed to writing the first draft. R.H.: Contributed to all data and statistical analysis and interpretation of data. R.H.: Contributed to the research concept, supervised the work, and revised the manuscript. All authors read and approved the final manuscript.

Conflict of Interest

Not applicable.

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