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RESEARCH NOTE



# The association between dietary patterns and cardiovascular disease risk factors in Iranian adults: a cross-sectional study

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## Abstract

**Background** Dietary patterns are important factors associated with cardiovascular diseases (CVDs). We examined the association between dietary patterns derived from factor analysis and CVD risk factors.

**Methods** In the present cross-sectional study, a total of 3,687 adults (aged 40 to 70 years) with one or more types of CVDs were enrolled as participants. A validated semi-quantitative food-frequency questionnaire was utilized to assess food intakes, and then dietary patterns were extracted by factor analysis. Fasting blood sugar (FBS), lipid profile, anthropometric indices, and blood pressure (BP) were measured. Multivariable-adjusted logistic regression analysis was employed to ascertain the odds ratio (OR) of CVD risk factors associated with posteriori dietary patterns. In this study, healthy and unhealthy dietary patterns were identified.

**Results** Adherence to a healthy dietary pattern was associated with a decrease in systolic BP (SBP) (OR = 0.78; 95% confidence interval (CI): 0.62–0.99) and high-density lipoprotein cholesterol (HDL-C) levels (OR = 1.32; 95% CI: 1.06–1.64). Additionally, greater adherence to the unhealthy dietary pattern was positively associated with SBP (OR = 1.43; 95% CI: 1.13–1.80) and diastolic BP (DBP) (OR = 1.33; 95% CI: 1.01–1.76).

**Conclusions** We concluded that greater adherence to an unhealthy dietary pattern was associated with an increase in SBP and DBP. On the other hand, greater adherence to a healthy dietary pattern could be effective in reducing SBP. Further investigation is recommended to validate these findings.

**Keywords** Dietary patterns, Healthy pattern, Unhealthy pattern, Cardiovascular diseases

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## Introduction

Chronic diseases represent a significant contributor to worldwide mortality [1], with cardiovascular diseases (CVDs) ranking as the most prevalent among them [2]. Several studies have demonstrated that effectively managing and controlling risk factors associated with CVDs, including obesity, hyperlipidemia, hypertension, and elevated blood sugar levels, can lead to improvements in patient outcomes [3]. Although genetic susceptibility could trigger the development and progression of CVDs, lifestyles such as nutrition, smoking, and physical activity are the most important modifiable factors [4].

Numerous studies have shown that the consumption of different food groups and different types of patterns can be positively or negatively associated with risk factors for CVDs [5–7]. While some research has explored dietary patterns, the majority of previous studies have concentrated on investigating the relationships between specific micronutrients or food groups and chronic diseases [8]. Because micronutrients or foods are consumed together and interact with each other, dietary pattern studies are likely to be more useful and generalizable [9].

The majority of research findings suggest that dietary patterns featuring a higher consumption of healthy and natural foods, such as vegetables, fruits, whole grains, and fish, are associated with a reduced risk of chronic diseases. Conversely, diets rich in unhealthy foods, such as processed foods, high sodium (Na) content, saturated fatty acids (SFAs), trans fatty acids, and sugars, have been linked to an elevated risk of chronic diseases [10–13].

There are several studies that have investigated the relationship between healthy and unhealthy food patterns in patients with type 2 diabetes, metabolic syndrome, and mortality [14–16]. However, limited studies have been conducted to thoroughly investigate the potential correlation between adherence to various dietary patterns and a decreased risk of developing CVDs [17–20].

While different studies have delineated prevalent dietary patterns across various populations, there are few Iranian studies exploring the link between predominant dietary patterns and multiple risk factors for CVDs in patients. Consequently, our study sought to identify prevalent dietary patterns and assess their correlation with blood lipids, blood pressure (BP), fasting blood sugar (FBS), and anthropometric indices in individuals with CVDs.

## Methods

### Study population

This cross-sectional study utilized baseline data from the Kharameh cohort study. The Kharameh cohort study, a part of the Prospective Epidemiological Research Studies in Iran (PERSIAN) [21], enrolled 10,663 individuals aged 40 to 70 years between 2014 and 2017 [22]. The main goals of this cohort study were to examine the occurrence and determinants of non-communicable diseases. The study design and objectives have been previously published [21]. Patients diagnosed with one or more types of CVDs (heart failure, angina, and myocardial infarction), or hypertension were eligible for inclusion in the study. Participants with untreated illnesses in the acute phase and mental disorders were excluded from the study. Additionally, participants for whom dietary data, physical examinations, or biochemical assessments were not available, as well as participants who's their energy intake was under-reported (<800 kcal/day) or over-reported (>4200 kcal/day), were excluded (Fig. 1). This study was approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1399.1115).

### Measurements

The participants' demographic information, medical history, physical activity, and smoking status were collected during the interviews. Demographic characteristics included age, sex, and education. The participants' smoking status was assessed based on their responses to a yes-or-no question. Physical activity was evaluated through a questionnaire that captured the duration of various activities throughout the day, including exercise, work, sleep, and meals. Then, the metabolic equivalent of task (MET) for each activity was calculated. Finally, the total amount of MET (hours/day) was calculated for each participant [23]. A trained team measured the participants' BP following a 10-minute rest in a seated position, utilizing a standard calibrated sphygmomanometer (Reister model, Germany). The measurement was conducted twice, and the mean values of systolic BP (SBP) and diastolic BP (DBP) were reported.

### Anthropometric and biochemical assessments

Weight, height, waist circumference (WC), and hip circumference (HC) were measured by trained personnel while participants wore light clothing and were not wearing shoes. Height, WC, and HC measurements were recorded to the nearest 0.1 cm, and weight measurements were recorded to the nearest 0.1 kg. The body mass index (BMI) was calculated by dividing weight by the square of height.

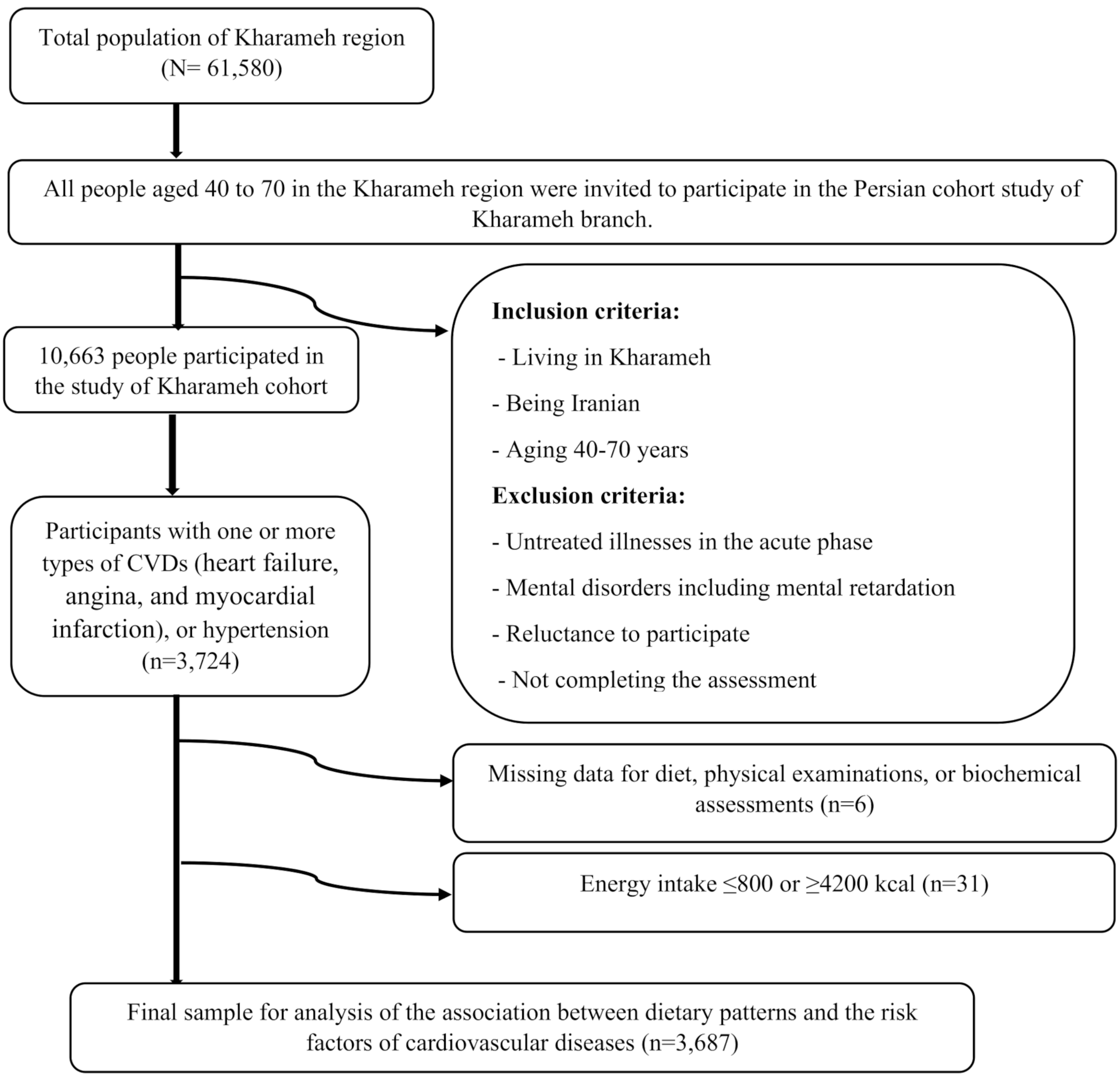


**Fig. 1** Flow diagram of the study

After fasting for 10–14 h, blood samples of 20 mL were collected from each participant and stored at -80 °C until further analysis. Total cholesterol (TC), triglycerides (TG), and FBS levels were determined using enzymatic methods with the Mindray device (manufactured in Japan) and Pars Azmoon kits. High-density lipoprotein cholesterol (HDL-C) levels were assessed following the instructions provided in the lab kit. Additionally, low-density lipoprotein cholesterol (LDL-C) was calculated using the Friedewald formula [24].

### Cardiovascular risk factors

The abnormal values were defined as follows: BMI ≥ 30 kg/m², SBP ≥ 135 mmHg, DBP ≥ 85 mmHg, FBS ≥ 126 mg/dL, TG ≥ 150 mg/dL, TC ≥ 200 mg/dL, LDL-C ≥ 130 mg/dL, and HDL-C < 40 mg/dL for men and < 50 mg/dL for women [25, 26].

### Dietary assessment

The participants' typical dietary intake was assessed using a 130-item semi-quantitative food frequency questionnaire (FFQ) [27]. Food items listed in the FFQ were converted into grams using household scales. Additionally, the adapted version of Nutritionist IV software for Iranians (version 7; N-Squared Computing, Salem, OR, United States) was employed to calculate nutrient and energy intake.

Food items were categorized into food groups based on their similarities (the list of food items included in each group is shown in the Supplementary Table 1). The principal component factor analysis method was applied to identify dietary patterns. To ascertain the dominant dietary patterns, the varimax rotation method was utilized to generate a distinct matrix. Additionally, eigenvalues and scree plots were examined to determine the number of dominant dietary patterns. Subsequently, factor scores for each dietary pattern were computed by summing the food groups weighted by their factor score matrix. The extracted dietary patterns were named based on our interpretation of previous research and data (scree plot was added in Supplementary File).

### Statistical analysis

IBM SPSS Statistics version 20.0 was used for data analysis, with a significance level set at $p$-value < 0.05. The participants' dietary intakes were adjusted for total energy intake using the residual method. Bartlett's test of sphericity (BTS) and the Kaiser-Meyer-Olkin (KMO) test were used to assess the relationship between variables and the adequacy of the sample size, respectively. In this study, the KMO value was 0.724, indicating acceptable sample adequacy. Two dietary patterns were identified based on the scree plot diagram and eigenvalues (> 1.5). Finally, participants were stratified into quartiles based on their dietary pattern scores.

Covariates, including sex, age, energy intake, physical activity, and smoking status, were considered potential confounders. The normal distribution of the data was assessed using the Kolmogorov-Smirnov test. Baseline continuous data were presented as mean ± standard deviation (SD), while categorical variables were expressed as frequency and percentage (%). The one-way analysis of variance (ANOVA) test was employed to compare nutrients and food items across the quartiles of dietary patterns. Two separate multivariable logistic regression analyses were conducted to evaluate the association between dominant dietary patterns and the likelihood of CVD risk factors.

**Table 1** Baseline characteristics of the participants

| Variables | Mean | SD | Number (percent) |
|---|---|---|---|
| Age (years) | 55.72 | 7.93 | |
| Sex (men) *N*, % | | | 1,174 (31.8) |
| Smoking (no) *N*, % | | | 3,013 (81.7) |
| Education level *N*, % | | | |
| Illiterate | | | 1551 (42.1) |
| Primary school | | | 1501 (40.7) |
| Secondary School | | | 318 (8.6) |
| Diploma and higher | | | 317 (8.6) |
| Physical activity (MET/day) | 37.15 | 5.12 | |
| Weight (kg) | 70.10 | 12.29 | |
| Height (cm) | 160.89 | 8.80 | |
| WC (cm) | 98.98 | 11.41 | |
| HC (cm) | 101.78 | 8.49 | |
| WHR | 0.97 | 0.07 | |

WC: waist circumference, HC: hip circumference, WHR: waist-to-hip ratio, MET: metabolic equivalent of task

-Values are mean ± standard deviation (SD) or number (percent)

## Results

Our study comprised 3,687 participants diagnosed with one or more types of CVDs. Baseline features of the study population are reported in Table 1. The mean age of the study participants was 55.72, and 31.8% of the sample size were men.

Based on the principal component analysis (PCA), the sample in our study was adequate according to BTS and KMO tests (BTS < 0.001 and KMO = 0.724). Regarding PCA, two dietary patterns were identified: a healthy dietary pattern and an unhealthy dietary pattern. These patterns collectively explained 22.14% of the variance in dietary intake. The healthy dietary pattern showed a positive association with fruits, vegetables, nuts, citrus, pickles, high-fat dairy, fish, olives and olive oil, dried fruits, low-fat dairy, beans, whole grains, red meat, poultry, juices, vegetable oils, and soy consumption. The unhealthy dietary pattern was composed of sweetened drinks, sweet desserts, sugar, tea, potatoes, solid fats, chocolate, refined grains, snacks, processed meats, and eggs (Table 2).

According to Table 3, individuals in the upper quartiles of the healthy dietary pattern exhibited higher consumption of energy, protein, fat, fiber, cholesterol, trans-fat, monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs), beta-carotene, vitamin E, vitamin C, potassium (K), calcium (Ca), and magnesium (Mg), and lower intake of carbohydrates, selenium (Se) ($P < 0.001$ for all, except trans-fat and Ca). Also, the higher intakes of energy, fat, cholesterol, trans-fat, SFAs, MUFAs, and lower consumption of protein, fiber, PUFAs, beta-carotene, vitamin E, vitamin C, vitamin $B_9$, K, Mg, Ca, and Se were found in the higher unhealthy dietary pattern quartile ($P < 0.001$ for all, except vitamins C and K).

As shown in Table 4, adherence to a healthy dietary pattern was significantly associated with a higher consumption of whole grains, beans, soy, red meat, fish, poultry, vegetables, vegetable oils, olive oil, fruits, citrus, juices, dried fruits, nuts, pickles, low-fat dairy, high-fat dairy, and a lower intake of refined grains, potatoes, solid oils, sugar, sweetened drinks, sweet

**Table 2** Factor loading of food groups for two dietary patterns among the participants

| Variable | Healthy pattern | Unhealthy pattern |
|---|---|---|
| Fruits | 0.669 | -0.172 |
| Citrus | 0.494 | -0.171 |
| Dried Fruits | 0.363 | -0.260 |
| Vegetables | 0.549 | -0.171 |
| Potato | 0.237 | 0.342 |
| Olives & Olive Oil | 0.351 | -0.338 |
| Vegetable Oils | 0.206 | -0.278 |
| Solid Fats | -0.020 | 0.419 |
| Pickles | 0.519 | -0.099 |
| Nuts | 0.503 | -0.145 |
| Beans | 0.452 | 0.039 |
| Soy | 0.248 | -0.014 |
| Low-Fat Dairy | 0.415 | -0.079 |
| High-Fat Dairy | 0.458 | -0.139 |
| Whole Grains | 0.285 | -0.226 |
| Refined Grain | 0.130 | 0.322 |
| Red Meat | 0.381 | 0.050 |
| Poultry | 0.369 | 0.050 |
| Fish | 0.450 | -0.108 |
| Processed Meats | 0.159 | 0.297 |
| Egg | 0.298 | 0.234 |
| Juices | 0.267 | -0.132 |
| Sweetened Drinks | 0.374 | 0.618 |
| Sweet Desserts | 0.293 | 0.637 |
| Sugar | 0.074 | 0.617 |
| Chocolate | 0.242 | 0.292 |
| Snacks | 0.217 | 0.281 |
| Tea | 0.122 | 0.450 |

desserts, and tea ($P<0.001$ for all, except potatoes, sweetened drinks, and sweet desserts). Also, participants in the highest quartiles of the unhealthy dietary pattern had a higher consumption of processed meats, eggs, potatoes, solid oils, sugar, sweetened drinks, sweet desserts, snacks, tea, and chocolate, compared to those in the lowest quartile ($P<0.001$ for all). Furthermore, consumption of refined grains, whole grains, vegetable oils, olive oil, fruits, dried fruits ($P<0.001$ for all), fish ($P=0.011$), citrus ($P=0.004$), juices ($P=0.001$), nuts ($P=0.001$), pickles ($P=0.048$), low-fat dairy ($P=0.01$), and high-fat dairy ($P=0.001$) tends to decrease across quartiles of the unhealthy dietary pattern.

Also, as shown in Table 5, participants in the last quartile of the healthy dietary pattern were more likely to have lower SBP (odds ratio (OR) = 0.75; 95% confidence interval (CI): 0.59–0.94), TC (OR = 0.77; 95% CI: 0.63–0.94), LDL-C (OR = 0.77; 95% CI: 0.62–0.95), and HDL-C (OR = 1.65; 95% CI: 1.34–2.03) compared to the first quartile in the crude model. However, after adjusting for age, sex, smoking, energy intake, and physical activity, only SBP and HDL-C remained significant (OR = 0.78, 95% CI: 0.62–0.99, and OR = 1.32; 95% CI: 1.06–1.64, respectively).

Additionally, individuals in the last quartile of an unhealthy dietary pattern had a greater chance of higher SBP and DBP (OR = 1.31; 95% CI: 1.05–1.64, and OR = 1.34; 95% CI: 1.02–1.77, respectively) compared to the first quartile in the crude model. Moreover, after adjusting for potential confounders, these relationships remained significant (OR = 1.43; 95% CI: 1.13–1.80, and OR = 1.33; 95% CI: 1.01–1.76, respectively). No significant relationship was observed in other variables.

## Discussion

In this cross-sectional study, we found that adhering to an unhealthy dietary pattern was significantly associated with a 1.43-fold increase in SBP and a 1.33-fold increase in DBP. These results highlight the potential impact of a poor diet on CVD risk factors. Conversely, following a healthy dietary pattern was associated with a significant reduction in SBP and HDL-C levels (a decrease of 22% and 1.32-fold, respectively). Nevertheless, no significant correlations were found between healthy and unhealthy dietary patterns and other variables.

We observed that an unhealthy dietary pattern could elevate both SBP and DBP. A cross-sectional study on 1,070 Chinese older adults with one or more cardiovascular risk factors or a history of CVDs showed that a Western dietary pattern (including fresh milk, peanuts, light-colored vegetables, potatoes, red meat, and flour grains) could increase SBP and DBP [28]. In a cross-sectional study on people with metabolic syndrome, He et al. indicated that a Western dietary pattern is associated with increased SBP and DBP [29]. Also, Berg et al. found a positive association between BP and a fast energy pattern (more consumption of white bread, fast foods, soft drinks, and snacks) [30]. This relationship was also observed in Shiraz adolescents who followed a Western dietary pattern (abundant in sweets and desserts, soft drinks, mayonnaise, and processed meats) [31]. Livingstone et al. reported that diets low in fiber and high in SFAs: PUFAs and Na: K could be related to hypertension [32]. In contrast, in their study, McNaughton et al. could not find any significant relationship between a high-fat and sugar pattern with BP in adolescents [33].

In an unhealthy dietary pattern, processed meats, butter, and high-fat milk have been shown to elevate BP because high Na intake negatively affects intravascular volume and increases BP [34]. Besides, more refined carbohydrates and high fructose intake in an unhealthy dietary pattern could manipulate the renin-angiotensin system and increase hypertension [35, 36].

**Table 3** Participants' dietary intakes across the quartiles of healthy and unhealthy dietary pattern scores

| Nutrients | Healthy pattern | | | | | Unhealthy pattern | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | *P* value | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | *P* value |
| Energy (kcal/d) | 1985.16 ± 21.51 | 2056.81 ± 18.56 | 2265.63 ± 18.43 | 2598.98 ± 22.75 | **< 0.001** | 2034.74 ± 21.71 | 2024.61 ± 16.69 | 2282.43 ± 18.17 | 2582.82 ± 25.02 | **< 0.001** |
| Carbohydrate (gr/d) | 371.69 ± 0.89 | 368.79 ± 0.92 | 364.73 ± 0.91 | 359.84 ± 1.18 | **< 0.001** | 367.09 ± 0.85 | 367.65 ± 0.83 | 365.17 ± 0.91 | 366.36 ± 1.27 | 0.289 |
| Protein (gr/d) | 67.77 ± 0.30 | 69.95 ± 0.28 | 72.24 ± 0.31 | 74.48 ± 0.38 | **< 0.001** | 71.73 ± 0.30 | 72.14 ± 0.28 | 70.90 ± 0.31 | 68.39 ± 0.42 | **< 0.001** |
| Fat (gr/d) | 53.62 ± 0.36 | 54.10 ± 0.33 | 55.81 ± 0.35 | 58.45 ± 0.45 | **< 0.001** | 55.09 ± 0.33 | 54.27 ± 0.32 | 55.77 ± 0.37 | 56.51 ± 0.50 | **< 0.001** |
| Fiber (gr/d) | 22.70 ± 0.19 | 23.51 ± 0.14 | 25.65 ± 0.15 | 29.16 ± 0.23 | **< 0.001** | 26.05 ± 0.19 | 25.81 ± 0.18 | 24.57 ± 0.18 | 23.42 ± 0.23 | **< 0.001** |
| Cholesterol (mg/d) | 188.36 ± 2.48 | 200.62 ± 2.56 | 214.06 ± 2.94 | 217.22 ± 3.40 | **< 0.001** | 195.47 ± 2.45 | 195.71 ± 2.50 | 213.32 ± 2.94 | 215.89 ± 3.59 | **< 0.001** |
| Trans Fat (mg/d) | 0.20 ± 0.006 | 0.21 ± 0.006 | 0.23 ± 0.007 | 0.23 ± 0.007 | **0.002** | 0.21 ± 0.005 | 0.19 ± 0.004 | 0.21 ± 0.006 | 0.26 ± 0.009 | **< 0.001** |
| SFAs (gr/d) | 19.11 ± 0.18 | 19.15 ± 0.18 | 19.45 ± 0.19 | 19.65 ± 0.22 | 0.168 | 18.36 ± 0.16 | 18.86 ± 0.17 | 19.86 ± 0.19 | 20.18 ± 0.24 | **< 0.001** |
| MUFAs (gr/d) | 14.71 ± 0.15 | 14.97 ± 0.13 | 15.87 ± 0.14 | 17.33 ± 0.19 | **< 0.001** | 15.66 ± 0.14 | 14.94 ± 0.13 | 15.70 ± 0.15 | 16.40 ± 0.21 | **< 0.001** |
| PUFAs (gr/d) | 8.03 ± 0.10 | 8.32 ± 0.08 | 9.31 ± 0.09 | 10.96 ± 0.13 | **< 0.001** | 9.52 ± 0.10 | 8.80 ± 0.09 | 8.77 ± 0.10 | 9.13 ± 0.14 | **< 0.001** |
| Beta-Carotene (IU/d) | 3950.23 ± 75.37 | 4210.89 ± 60.65 | 5064.19 ± 72.26 | 6169.49 ± 127.83 | **< 0.001** | 5047.17 ± 95.34 | 4928.85 ± 82.47 | 4638.42 ± 79.77 | 4425.38 ± 93.18 | **< 0.001** |
| Vit E (mg/d) | 6.37 ± 0.07 | 6.77 ± 0.05 | 7.50 ± 0.05 | 8.59 ± 0.09 | **< 0.001** | 7.54 ± 0.06 | 7.16 ± 0.06 | 7.03 ± 0.06 | 7.17 ± 0.09 | **< 0.001** |
| Vit C (mg/d) | 99.48 ± 1.76 | 105.24 ± 1.15 | 123.86 ± 1.36 | 151.19 ± 2.20 | **< 0.001** | 121.73 ± 1.60 | 120.26 ± 1.70 | 117.41 ± 1.83 | 113.04 ± 1.98 | **0.004** |
| Vit $B_9$ (mcg/d) | 567.07 ± 2.90 | 566.09 ± 2.82 | 561.05 ± 3.19 | 569.09 ± 4.03 | 0.351 | 570.55 ± 3.02 | 583.34 ± 2.98 | 562.95 ± 2.92 | 541.61 ± 3.9 | **< 0.001** |
| K (mcg/d) | 2975.84 ± 26.04 | 3133.69 ± 18.21 | 3457.43 ± 20.47 | 3892.05 ± 29.98 | **< 0.001** | 3403.38 ± 24.05 | 3358.19 ± 25.78 | 3291.08 ± 25.99 | 3282.32 ± 30.84 | **0.002** |
| Ca (mg/d) | 1021.89 ± 6.46 | 1035.91 ± 6.11 | 1034.80 ± 6.88 | 1050.59 ± 8.06 | **0.035** | 1058.24 ± 6.38 | 1077.03 ± 6.37 | 1026.79 ± 6.14 | 962.66 ± 8.18 | **< 0.001** |
| Mg (mg/d) | 303.50 ± 1.57 | 310.93 ± 1.13 | 326.76 ± 1.28 | 356.81 ± 2.04 | **< 0.001** | 328.89 ± 1.66 | 326.08 ± 1.46 | 319.43 ± 1.48 | 315.32 ± 1.98 | **< 0.001** |
| Se (mcg/d) | 101.30 ± 0.65 | 100.55 ± 0.62 | 97.86 ± 0.66 | 96.50 ± 0.84 | **< 0.001** | 100.11 ± 0.61 | 101.86 ± 0.61 | 99.51 ± 0.66 | 94.37 ± 0.89 | **< 0.001** |

-Vit: vitamin; SFAs: saturated fatty acids; MUFAs: monounsaturated fatty acids; PUFAs: polyunsaturated fatty acids; K: potassium; Ca: calcium; Mg: magnesium; Se: selenium

-Values are mean ± standard error

-*P*-value less than 0.05 was considered significant

-One-way ANOVA has been used

Other findings of the current study were a negative association between a healthy dietary pattern and HDL-C and its lack of relationship with other lipid profiles. Similarly, Wang et al. found that greater adherence to a traditional diet (rich in dark- and light-colored vegetables, fruits, rice, animal meat, poultry, and oils) was associated with a high risk of low HDL-C [37]. Additionally, Najafi et al. found a positive relationship between a healthy dietary pattern and levels of HDL-C [6]. Furthermore, another cross-sectional study observed that a cosmopolitan dietary pattern (with a greater intake of vegetables and white meat) was related to an increased level of HDL-C [38]. However, in a clinical trial study involving 116 patients diagnosed with metabolic syndrome, it has been demonstrated that the Dietary Approach to Stop Hypertension (DASH) diet (including increased consumption of whole grains, low-fat dairy, vegetables, and lower consumption of cholesterol, total fat, and saturated fat) is significantly linked to an increase in HDL levels [39]. Meanwhile, there are also investigations that could not find any significant relationship between a healthy dietary pattern and blood lipids [40]. One justification for our findings could be that a healthy dietary pattern is high in carbohydrates and low in fats. Accordingly, Yang et al. reported that receiving more than 60% of energy intake from carbohydrates can have negative effects, such as lowering HDL-C [41]. Similarly, Park et al. observed that in Korean women, intake of over 70% of energy from carbohydrate sources was related to low HDL-C levels [42].

Also, we observed that greater adherence to the healthy dietary pattern was related to a lower SBP level. In the study conducted by Azadbakht et al., it was demonstrated that a DASH diet could effectively reduce SBP in patients with metabolic syndrome [39]. Similarly, a population-based study on 7,185 adolescents found a reverse association between a healthy dietary pattern and BP levels, even in non-obese participants [43]. Also, Xu et al. concluded that increased intake of whole grains, fresh fruits, vegetables, and dairy reduced the risk of high BP levels [44]. However, in a cross-sectional study of 2,518 participants in the Chinese population, no association between a healthy dietary pattern (greater consumption of fruits, pickled vegetables, whole grains, fish, eggs, and milk) and BP was observed [45]. In the present study, participants with a healthy dietary pattern had higher intakes of Mg, Ca, K, and fiber. These components in a healthy dietary pattern, by influencing endothelial function and preventing an increase in carotid intima-media thickness (CIMT), can effectively reduce BP [46]. Previous studies suggest that the DASH diet with a high intake of fruits and vegetables, similar to our study's healthy dietary pattern, could decrease BP by increasing the bioavailability of nitric oxide (NO) [47].

In the current study, we could not find any significant relationship between any of the healthy and unhealthy dietary patterns and BMI and FBS levels. Meanwhile, in previous studies, following a healthy dietary pattern could decrease abdominal obesity and fasting glucose [48]. On the contrary, Lutsey et al. could not find any association between a prudent dietary pattern and the risk of obesity or diabetes but observed that a Western dietary pattern could increase abdominal obesity, BP, and fasting glucose [49]. The different results of the studies can be attributed to the influence of different ethnicities and the different eating habits of each ethnicity. It has already been shown that dietary patterns in different ethnicities can have different effects on the risk factors for CVDs [50]. Other studies have not proven their relationship with obesity or FBS [51, 52].

### Limitations

In this study, we employed validated questionnaires and accounted for various confounding factors to enhance the reliability of our findings. Also, a large sample size was another strength of the present study. Nonetheless, several limitations should be acknowledged. Firstly, the likelihood of recall bias in self-reported dietary intake may have influenced the results. Secondly, the cross-sectional design of the study precludes establishing a causal relationship. Additionally, there may be other unmeasured or unadjusted confounders, such as family history of related diseases, which could have impacted our results.

## Conclusions

In conclusion, greater adherence to an unhealthy dietary pattern, which includes a higher intake of fats and refined carbohydrates, was associated with an increase in SBP and DBP. On the other hand, greater adherence to a healthy dietary pattern, which includes a higher consumption of whole grains, beans, soy, fish, vegetables, fruits, citrus, dried fruits, nuts, and low-fat dairy, could be effective in reducing SBP.

**Table 4** The mean and standard error of food items across the quartiles of healthy and unhealthy dietary patterns

| Food items | Healthy Pattern | | | | | Unhealthy Pattern | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | *P* value | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | *P* value |
| Refined Grains (g/d) | 454.79 ± 4.43 | 454.33 ± 3.81 | 413.06 ± 4.22 | 339.08 ± 5.24 | **< 0.001** | 403.02 ± 4.21 | 439.46 ± 4.28 | 432.59 ± 4.60 | 399.15 ± 5.63 | **< 0.001** |
| Whole Grains (g/d) | 28.45 ± 1.47 | 25.86 ± 1.31 | 31.71 ± 1.67 | 54.10 ± 3.22 | **< 0.001** | 45.13 ± 2.23 | 33.51 ± 1.55 | 27.01 ± 1.49 | 28.78 ± 2.45 | **< 0.001** |
| Beans (g/d) | 23.44 ± 0.56 | 25.62 ± 0.54 | 26.93 ± 0.59 | 31.37 ± 0.94 | **< 0.001** | 26.41 ± 0.56 | 27.14 ± 0.66 | 26.65 ± 0.64 | 26.26 ± 0.84 | 0.811 |
| Soy (g/d) | 1.52 ± 0.08 | 1.67 ± 0.08 | 1.91 ± 0.10 | 2.67 ± 0.17 | **< 0.001** | 2.01 ± 0.10 | 1.88 ± 0.11 | 1.79 ± 0.10 | 1.96 ± 0.13 | 0.523 |
| Red Meat (g/d) | 14.78 ± 0.54 | 17.05 ± 0.58 | 20.01 ± 0.66 | 22.84 ± 0.90 | **< 0.001** | 18.86 ± 0.56 | 18.24 ± 0.59 | 18.73 ± 0.69 | 17.78 ± 0.88 | 0.677 |
| Processed Meat (g/d) | 1.48 ± 0.13 | 1.38 ± 0.11 | 1.38 ± 0.13 | 1.11 ± 0.16 | 0.275 | 1.42 ± 0.13 | 0.84 ± 0.07 | 1.09 ± 0.10 | 2.16 ± 0.20 | **< 0.001** |
| Fish (g/d) | 2.44 ± 0.15 | 2.15 ± 0.10 | 3.11 ± 0.15 | 4.84 ± 0.27 | **< 0.001** | 3.51 ± 0.17 | 3.01 ± 0.15 | 2.82 ± 0.17 | 2.81 ± 0.22 | **0.011** |
| Poultry (g/d) | 24.79 ± 0.62 | 27.16 ± 0.67 | 32.18 ± 0.82 | 32.36 ± 0.99 | **< 0.001** | 28.47 ± 0.66 | 28.21 ± 0.72 | 29.42 ± 0.76 | 29.75 ± 1.01 | 0.461 |
| Eggs (g/d) | 18.51 ± 0.50 | 19.46 ± 0.50 | 20.56 ± 0.62 | 19.84 ± 0.67 | 0.074 | 17.70 ± 0.46 | 18.03 ± 0.46 | 21.19 ± 0.62 | 22.02 ± 0.75 | **< 0.001** |
| Vegetables (g/d) | 411.60 ± 6.39 | 457.02 ± 5.79 | 516.48 ± 6.62 | 577.79 ± 9.72 | **< 0.001** | 495.89 ± 6.66 | 493.79 ± 7.97 | 475.87 ± 7.01 | 475.27 ± 8.07 | 0.077 |
| Potatoes (g/d) | 23.53 ± 0.68 | 26.73 ± 0.75 | 24.85 ± 0.78 | 23.10 ± 0.92 | **0.005** | 19.97 ± 0.63 | 21.99 ± 0.62 | 27.87 ± 0.77 | 30.13 ± 1.08 | **< 0.001** |
| Vegetable Oil (g/d) | 4.60 ± 0.15 | 5.72 ± 0.16 | 6.71 ± 0.18 | 7.74 ± 0.20 | **< 0.001** | 7.01 ± 0.16 | 6.32 ± 0.017 | 5.36 ± 0.17 | 5.46 ± 0.21 | **< 0.001** |
| Solid Oils (g/d) | 13.52 ± 0.39 | 11.13 ± 0.38 | 8.72 ± 0.36 | 6.60 ± 0.39 | **< 0.001** | 7.43 ± 0.30 | 9.11 ± 0.34 | 12.21 ± 0.42 | 12.89 ± 0.50 | **< 0.001** |
| Olive Oil (g/d) | 0.78 ± 0.07 | 0.60 ± 0.04 | 1.03 ± 0.07 | 2.56 ± 0.15 | **< 0.001** | 1.83 ± 0.11 | 1.14 ± 0.08 | 0.81 ± 0.07 | 0.81 ± 0.08 | **< 0.001** |
| Sugar (g/d) | 39.27 ± 1.37 | 33.20 ± 1.05 | 25.13 ± 0.93 | 15.98 ± 0.99 | **< 0.001** | 26.41 ± 1.15 | 21.12 ± 0.66 | 28.84 ± 0.86 | 42.39 ± 1.76 | **< 0.001** |
| Sweetened Drink (mL/d) | 70.96 ± 3.18 | 60.70 ± 2.16 | 63.75 ± 2.70 | 60.23 ± 3.10 | **0.022** | 60.05 ± 2.72 | 38.69 ± 1.29 | 59.12 ± 1.94 | 106.22 ± 4.49 | **< 0.001** |
| Sweet Desserts (g/d) | 50.41 ± 2.80 | 43.88 ± 1.83 | 43.68 ± 1.99 | 37.61 ± 2.17 | **0.001** | 41.76 ± 2.21 | 25.43 ± 0.83 | 38.42 ± 1.34 | 76.94 ± 3.80 | **< 0.001** |
| Salt (g/d) | 3.40 ± 0.05 | 3.46 ± 0.05 | 3.35 ± 0.06 | 3.39 ± 0.07 | 0.666 | 3.32 ± 0.05 | 3.38 ± 0.05 | 3.37 ± 0.05 | 3.55 ± 0.07 | 0.063 |
| Snacks (g/d) | 1.65 ± 0.12 | 1.96 ± 0.14 | 1.92 ± 0.15 | 1.59 ± 0.17 | 0.202 | 1.62 ± 0.13 | 1.15 ± 0.07 | 1.74 ± 0.13 | 2.82 ± 0.24 | **< 0.001** |
| Fruits (g/d) | 221.51 ± 4.88 | 238.47 ± 3.91 | 295.24 ± 4.95 | 360.34 ± 6.81 | **< 0.001** | 288.43 ± 5 | 284.13 ± 5.02 | 273.96 ± 5.70 | 246.37 ± 6.01 | **< 0.001** |
| Citrus (g/d) | 32.78 ± 1.25 | 33.35 ± 0.91 | 41.93 ± 1.18 | 55.64 ± 2.01 | **< 0.001** | 43.31 ± 1.31 | 40.72 ± 1.22 | 39.71 ± 1.44 | 36.16 ± 1.58 | **0.004** |
| Juices (mL/d) | 1.91 ± 0.29 | 0.95 ± 0.10 | 1.47 ± 0.17 | 4.20 ± 0.48 | **< 0.001** | 2.27 ± 0.29 | 2.66 ± 0.32 | 2.10 ± 0.28 | 1.02 ± 0.25 | **0.001** |
| Dried Fruits (g/d) | 4.31 ± 0.26 | 3.58 ± 0.17 | 5.61 ± 0.25 | 8.79 ± 0.44 | **< 0.001** | 6.90 ± 0.31 | 5.75 ± 0.27 | 4.41 ± 0.23 | 4.26 ± 0.33 | **< 0.001** |
| Nuts (g/d) | 5.45 ± 0.24 | 5.13 ± 0.20 | 6.35 ± 0.22 | 9.86 ± 0.40 | **< 0.001** | 7.42 ± 0.26 | 6.46 ± 0.21 | 6.12 ± 0.26 | 6.04 ± 0.36 | **0.001** |
| Pickles (g/d) | 30.02 ± 0.96 | 31.80 ± 0.80 | 41.76 ± 1.14 | 49.75 ± 1.52 | **< 0.001** | 39.95 ± 1.04 | 38.02 ± 1.12 | 36.59 ± 1.08 | 35.83 ± 1.31 | **0.048** |
| Tea (g/d) | 815.26 ± 19.16 | 763.68 ± 17.25 | 682.93 ± 18.67 | 625.10 ± 19.46 | **< 0.001** | 677.14 ± 17.62 | 641.88 ± 12.73 | 723.65 ± 16.26 | 901.66 ± 27.53 | **< 0.001** |
| Chocolate (g/d) | 1.23 ± 0.06 | 1.21 ± 0.05 | 1.27 ± 0.07 | 1.24 ± 0.09 | 0.943 | 1.05 ± 0.06 | 1.00 ± 0.04 | 1.27 ± 0.05 | 1.72 ± 0.12 | **< 0.001** |
| Low-fat Dairy (g/d) | 72.08 ± 2.06 | 80.11 ± 2.16 | 95.91 ± 2.66 | 104.92 ± 3.33 | **< 0.001** | 89.56 ± 2.30 | 92.19 ± 2.45 | 85.99 ± 2.66 | 80.05 ± 2.95 | **0.010** |
| High-fat Dairy (g/d) | 107.46 ± 2.76 | 123.81 ± 2.52 | 143.86 ± 3.08 | 170.41 ± 4.18 | **< 0.001** | 142.97 ± 3.10 | 137.22 ± 3.14 | 130.10 ± 3.02 | 125.29 ± 3.59 | **0.001** |

-Values are mean ± standard error

-*P*-value less than 0.05 was considered significant

-One-way ANOVA has been used

**Table 5** Crude and adjusted odds ratios and 95% CIs for lipid profile, blood pressure, fasting blood sugar, and BMI across quartiles of healthy and unhealthy dietary pattern scores

| Variables | Healthy pattern | | | | Unhealthy pattern | | | |
|---|---|---|---|---|---|---|---|---|
| | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ |
| BMI (kg/m$^2$) Abnormality | | | | | | | | |
| Crude | 1.00 | 1.16 (0.95, 1.40) | 1.13 (0.94, 1.38) | 1.09 (0.89, 1.3) | 1.00 | 0.99 (0.82, 1.20) | 1.01 (0.83, 1.22) | 0.91 (0.75, 1.11) |
| Adjusted | 1.00 | 1.13 (0.93, 1.38) | 1.13 (0.93, 1.38) | 1.19 (0.97, 1.47) | 1.00 | 0.94 (0.77, 1.14) | 1.02 (0.84, 1.24) | 1.01 (0.82, 1.24) |
| SBP (mmHg) Abnormality | | | | | | | | |
| Crude | 1.00 | 0.79 (0.64, 0.98) | 0.86 (0.69, 1.06) | **0.75 (0.59, 0.94)** | 1.00 | 1.13 (0.91, 1.41) | 1.13 (0.91, 1.41) | **1.31 (1.05, 1.64)** |
| Adjusted | 1.00 | 0.80 (0.65, 1.00) | 0.90 (0.72, 1.12) | **0.78 (0.62, 0.99)** | 1.00 | 1.17 (0.94, 1.46) | 1.22 (0.97, 1.52) | **1.43 (1.13, 1.80)** |
| DBP (mmHg) Abnormality | | | | | | | | |
| Crude | 1.00 | 0.89 (0.67, 1.17) | 1.09 (0.83, 1.42) | 1.15 (0.88, 1.52) | 1.00 | 1.04 (0.79, 1.38) | 1.17 (0.89, 1.53) | **1.34 (1.02, 1.77)** |
| Adjusted | 1.00 | 0.88 (0.66, 1.16) | 1.06 (0.81, 1.39) | 1.11 (0.84, 1.47) | 1.00 | 1.04 (0.79, 1.37) | 1.17 (0.89, 1.53) | **1.33 (1.01, 1.76)** |
| FBS (mg/dL) Abnormality | | | | | | | | |
| Crude | 1.00 | 0.92 (0.74, 1.15) | 1.16 (0.93, 1.43) | 1.06 (0.85, 1.33) | 1.00 | 1.19 (0.97, 1.47) | 0.80 (0.64, 1.00) | 1.20 (0.96, 1.49) |
| Adjusted | 1.00 | 0.93 (0.74, 1.15) | 1.17 (0.95, 1.46) | 1.12 (0.89, 1.41) | 1.00 | 1.19 (0.96, 1.47) | 0.83 (0.66, 1.04) | 1.31 (1.05, 1.64) |
| Triglycerides (mg/dL) Abnormality | | | | | | | | |
| Crude | 1.00 | 0.91 (0.75, 1.11) | 1.14 (0.95, 1.38) | 1.07 (0.88, 1.30) | 1.00 | 0.95 (0.79, 1.15) | 0.95 (0.79, 1.15) | 0.96 (0.79, 1.17) |
| Adjusted | 1.00 | 0.91 (0.75, 1.11) | 1.13 (0.94, 1.37) | 1.07 (0.88, 1.31) | 1.00 | 0.94 (0.78, 1.13) | 0.95 (0.78, 1.14) | 0.96 (0.79, 1.18) |
| Total Cholesterol (mg/dL) Abnormality | | | | | | | | |
| Crude | 1.00 | 1.04 (0.87, 1.26) | 0.92 (0.76, 1.11) | **0.77 (0.63, 0.94)** | 1.00 | 1.18 (0.98, 1.43) | **1.28 (1.06, 1.55)** | 1.09 (0.89, 1.33) |
| Adjusted | 1.00 | 1.04 (0.86, 1.26) | 0.97 (0.80, 1.17) | 0.85 (0.69, 1.04) | 1.00 | 1.18 (0.98, 1.43) | **1.34 (1.11, 1.62)** | 1.18 (0.96, 1.45) |
| LDL-C (mg/dL) Abnormality | | | | | | | | |
| Crude | 1.00 | 0.99 (0.81, 1.21) | 0.85 (0.69, 1.05) | **0.77 (0.62, 0.95)** | 1.00 | 1.15 (0.93, 1.41) | 1.21 (0.99, 1.48) | 1.11 (0.90, 1.38) |
| Adjusted | 1.00 | 0.99 (0.81, 1.21) | 0.89 (0.72, 1.09) | 0.82 (0.66, 1.03) | 1.00 | 1.15 (0.94, 1.41) | **1.25 (1.02, 1.53)** | 1.18 (0.95, 1.47) |
| HDL-C (mg/dL) Abnormality | | | | | | | | |
| Crude | 1.00 | 1.00 (0.81, 1.24) | **1.28 (1.04, 1.57)** | **1.65 (1.34, 2.03)** | 1.00 | 1.03 (0.84, 1.27) | 1.08 (0.88, 1.32) | 1.15 (0.94, 1.42) |
| Adjusted | 1.00 | 1.01 (0.81, 1.26) | 1.14 (0.92, 1.41) | **1.32 (1.06, 1.64)** | 1.00 | 1.04 (0.84, 1.28) | 0.97 (0.79, 1.20) | 0.93 (0.75, 1.16) |

SBP: systolic blood pressure, DBP: diastolic blood pressure, FBS: fasting blood sugar, LDL-C: low-density lipoprotein cholesterol, HDL-C: high-density lipoprotein cholesterol, BMI, body mass index

-Values are odds ratios and 95% CI (Adjusted for age, sex, energy intake, physical activity, and smoking).

-Obtained by logistic regression

-Significant values are shown in bold.

**Abbreviations**

BMI Body mass index
BP Blood pressure
BTS Bartlett's test of sphericity
CAD Coronary artery disease
CI Confidence interval
CIMT Carotid intima-media thickness
CVDs Cardiovascular diseases
DBP Diastolic blood pressure
FFQ Food frequency questionnaire
FBS Fasting blood sugar
HC Hip circumference
HDL-C High-density lipoprotein cholesterol
KMO Kaiser-Meyer-Olkin
LDL-C Low-density lipoprotein cholesterol
MET Metabolic equivalent of task
Mg Magnesium
MUFAs Monounsaturated fatty acids
NO Nitric oxide
OR Odds ratio
PCA Principal component analysis
PUFAs Polyunsaturated fatty acids
SBP Systolic blood pressure
Se Selenium
SFAs Saturated fatty acids
TG Triglycerides
WC Waist circumference
WHR Waist-to-hip circumference
Ca Calcium

## Supplementary Information

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Supplementary Material 1

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**Author contributions**
M.L., S.M.J., K.L., M.A., and M.N.; Contributed to writing the first draft. M.N., Z.S., and M.G.J.; Contributed to all data and statistical analysis and interpretation of data. A.R. and S.F.; Contributed to the research concept, supervised the work, and revised the manuscript. All authors read and approved the final manuscript.

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**Data availability**
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Declarations

### Ethics approval and consent to participate
This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Ethics Committee of Shiraz University of Medical Sciences (IR.SUMS.REC.1399.1115). All participants read and signed the informed consent form.

### Conflict of interest
No.

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