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Original Research

An Unhealthy Plant-Based Diet Increases Risk of Hypertension but not Framingham Risk Score in Adults

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A B S T R A C T

Backgrounds: We investigated the relation of plant-based diets (PDs) with hypertension (HTN) and Framingham risk score (FRS) in Iranian adults.

Objectives: We hypothesized that healthy PDs might have positive effects on blood pressure (BP) and FRS, whereas less-healthy plant-based foods might have negative effects.

Methods: The current cross-sectional study was performed on 527 middle-aged adults (45.7% women), who were selected through a multistage cluster random-sampling method. The assessment of dietary intakes was performed by using a validated food-frequency questionnaire. Twelve-hour fasting blood samples were collected to evaluate total cholesterol and high-density lipoprotein concentrations. BP was measured through the standard method and HTN was defined as BP $\geq$130/80 mmHg. FRS was used to predict the 10-y risk for development of cardiovascular disease (CVD).

Results: The prevalence of HTN and high FRS among study participants were, respectively, 62% and 15.6%. After adjustment for potential confounders, plant-based diet index (PDI) and healthy plant-based diet index (hPDI) were not significantly associated with HTN [odds ratio (OR): 0.99; 95% confidence interval (CI): 0.55, 1.79 and OR: 0.83; 95% CI: 0.45, 1.53, respectively)]. However, those in the highest tertile of unhealthy plant-based diet index (uPDI) in comparison with those in the bottom tertile had a 100% increased odds of HTN (OR: 2.00; 95% CI: 1.04, 3.88). Greater adherence to PDI, hPDI, and uPDI was not related to high FRS chance, in fully adjusted model (OR: 0.50; 95% CI: 0.15, 1.65; OR: 1.03; 95% CI: 0.26, 4.04; and OR: 2.05; 95% CI: 0.56, 7.52, respectively).

Conclusions: This study demonstrated that less-healthy PDs would enhance the chance of HTN in Iranian adults, although PDIs were not significantly related to the 10-y risk of developing CVD.

Keywords: plant-based diets, hypertension, Framingham risk score, cross-sectional, adults

Introduction

Hypertension (HTN), known as a major risk factor of cardiovascular disease (CVD), has been recently defined as systolic blood pressure (SBP) $\geq$130 mmHg or/and diastolic blood pressure (DBP) $\geq$80 mmHg [1]. HTN is also associated with debilitating conditions such as stroke, heart attack, and kidney failure, which impose an economic burden on societies [2]. Moreover, HTN can increase risk of dementia in elders [3,4]. The number of HTN sufferers has been increased from 1990 till 2019. Most of this increase has occurred in low- and middle-income societies [5]. Even if the prevalence rate does not increase, it is

Abbreviations: AACCI, American Association of Cereal Chemists International; BP, blood pressure; CI, confidence interval; CVD, cardiovascular disease; DASH, dietary approaches to stop hypertension; DBP, diastolic blood pressure; FFQ, food-frequency questionnaire; FRS, Framingham risk score; hPDI, healthy plant-based diet index; HTN, hypertension; MET, metabolic equivalent; OR, odds ratio; PD, plant-based diet; PDI, plant-based diet index; RCT, randomized controlled trial; SBP, systolic blood pressure; SPSS, statistical package for the social science; TC, total cholesterol; uPDI, unhealthy plant-based diet index.

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predicted that the total prevalence can grow to 60% by 2025 [6]. The prevalence of HTN in Iran was reported to be 25% by the year of 2017 [7].

Several factors such as age, genetics, sex, and lifestyle factors such as unhealthy eating habits, great sodium and light potassium intake, overweight or obesity, and physical inactivity can increase BP levels were assumed as nonmodifiable and modifiable agents [8]. Different dietary components and groups of foods are known to have an association with HTN risk [9–11]. Moreover, several dietary patterns have been developed to prevent and/or treat high BP; the most effective one is dietary approaches to stop hypertension (DASH) diet [12]. In addition, some previous studies demonstrated that vegetarian diets compared with omnivorous diets were inversely related to BP [12,13]. In contrast, the intake of red meat and processed meat products seems to be related to higher risk of developing HTN [10,14].

Findings of several prior studies have demonstrated different effects of food groups or diets on Framingham risk score (FRS) and BP. In a cross-sectional investigation on middle-aged women and men, a J-shape relation between dietary calcium consumption and FRS was observed; such that the FRS score was the lowest value at ~300–1200 mg/d of calcium intake and after which (>1200 mg/d), a sharp increase in the score was observed [15]. A 6-y follow-up cohort study demonstrated that a posteriori-derived healthy dietary pattern was related to a lower FRS in Iranians, but the relation between the Western dietary pattern or traditional dietary pattern and FRS was not significant in this population [16]. Moreover, an 8-wk intervention on healthy adults revealed that a whole-food plant-based diet (PD) could significantly decrease SBP and DBP [17]. Another 4-wk intervention demonstrated that a PD along with excluding all animal-based foods could reduce SBP, DBP and the need for antihypertensive drugs [18]. In addition, in the SU.VI.MAX cohort, high-fruit and vegetable intakes seemed to be related to a significantly lower 5-y increase in SBP and DBP with aging [19]. However, in a cross-sectional investigation performed on adults with predominantly PDs, no connection was seen between calcium dietary intake and BP or HTN risk [20]. Most of these studies had been conducted in European and American countries and the findings were contradictory. Moreover, few studies in this regard have been conducted in Middle Eastern populations and the relation between PD and with HTN and FRS has not been evaluated yet. Therefore, the current study investigated the relationship between PDs with HTN and FRS in Iranian adults. We hypothesized that healthy PDs might impose positive effects on BP and FRS, whereas less-healthy plant-based foods might have negative effects.

Methods

Study design and participants

The current cross-sectional designed study was carried out in 2021 on a sample that represented adults in Isfahan, one of central cities in Iran. The calculation of the sample size was performed according to a prevalence of 42.7% HTN among Iranian adults according to a previous investigation [21], confidence interval (CI) of 95%, power of 80%, and precision (d) of 4.5%. A minimum of 464 subjects were required. Data were not collected during COVID-19 waves or quarantine time. However, given the possibility of a low response rate due to the prevalence of COVID-19 pandemic during data collection, 600 middle-age individuals from both sexes were asked for the participation in our study. These individuals were adults working in 20 schools selected through the use of a multistage cluster random-sampling method; all teachers, employees, school managers, crews, and assistants of selected schools were included to create a proper sample that represents a general adult population with various socioeconomic statuses.

Subjects with the following criteria were not invited to this study: *1*) being pregnant or breastfeeding; *2*) having a history of type 1 diabetes, cardiovascular disease, stroke, or cancer; and *3*) adhering to a weight-loss or weight-gain diet. Among individuals who were invited, 543 of them agreed to participate in the research (90.5% of response rate). Then, we excluded individuals with the following criteria: *1*) did not have data of their BP measurement ($n = 8$); *2*) had left more than 70 items blank on the food-frequency questionnaire (FFQ) ($n = 4$); *3*) reported a total energy intake outside the range of 800–4200 kcal/d (as under-reporters and over-reporters of energy intake) ($n = 3$); and *4*) did not accept blood drawn ($n = 1$). Eventually, 527 adults were considered in the analysis. The study procedure was conducted on the basis of the declaration of Helsinki. A STROBE-Checklist of items that should be included in reports of cross-sectional studies was provided. A written consent to inform was provided by all participants. The protocol of the study was ethically approved by the local Ethics Committee of Isfahan University of Medical Sciences (no. IR.MUI.RESEARCH.REC.1399.615).

Patient and public involvement

Patients and the public were not involved in any way in the design, conduct, reporting, or dissemination plans of the research.

Assessment of dietary intake

The assessment of dietary intakes of individuals was performed by a validated semiquantitative 168-item FFQ formatted based on the Willett method [22]. Reasonable correlations of food intakes obtained by this questionnaire and those assessed by multiple 24-h dietary recalls were revealed through a previous validation investigation conducted on 132 middle-age adults [22]; the correlation coefficients in men were 0.55 for total intake of energy, 0.39 for carbohydrate, 0.65 for proteins, 0.65 for magnesium, and 0.67 for fiber. These correlation coefficients in women were respectively 0.56, 0.50, 0.47, 0.39, and 0.60. The reproducibility of the FFQ was additionally determined by comparing nutrient intakes derived from the applied FFQ on 2 different occasions, 1 y apart [22]. Participants were instructed by an expert dietitian how to complete the FFQ and report the frequency and amount of each food item consumed during the preceding year. Then, through household measures, the consumed foods portion sizes were changed to g/d [23]. Finally, all food items were entered into Nutritionist IV software, for obtaining daily intake of energy and all nutrients.

Assessment of plant-based diet indices

According to a previously proposed procedure by Satija et al. [24–26], 3 different plant-based diet indices (PDIs) were defined by the use of dietary intakes data: *1*) an overall PDI, *2*) a healthy plant-based diet index (hPDI(, and *3*) an unhealthy plant-based diet index (uPDI). Eighteen various groups of foods were determined according to the similarities in nutrient content and culinary ways within larger categories of healthy plant foods, less-healthy plant foods, and animal foods.

Assessment of overall PDI

Groups of healthy plant foods were whole grains, fruits, vegetables, legumes, vegetable oils, nuts, and tea/coffee, whereas less-healthy plant food groups were consisted of refined grains, potatoes, fruit juices, sweets or desserts, and sugar-sweetened beverages. Moreover, animal food groups included different types of meat, fish or seafood, animal fats, dairy, eggs, and miscellaneous animal-based foods. Margarine was not considered in these indices; instead, we made adjustment for it, as a covariate. In addition, because of the impossibility of determining trans-fatty acids intact amount in foods, this item was not included in the indices; hydrogenated vegetable oil intake was considered as another covariate in the analysis. Then, each of the 18 abovementioned food groups was divided into consumption quintiles and each quintile got a positive or negative point. With positive points, individuals in the highest quintile of consumption of the food group were given a score of 5, whereas participants in the lowest quintile got a score of 1. In case of reverse scores, subjects with highest consumption of the food group (quintile 5) received a score of 1, and individuals with the lowest intake (quintile 1) received a score of 5. For PDI, positive scores were considered for all plant food groups, whereas reverse scores were considered for animal food groups. Then, points of these 18 different food groups were summed up for obtaining the score of each index for each individual, with a theoretical range of 18 (lowest possible score) to 90 (highest possible score).

Assessment of hPDI

To define hPDI, positive points were considered for healthy plant foods and negative points were considered for less-healthy plant food groups and animal food groups.

Assessment of uPDI

For defining uPDI, positive scores were considered for less-healthy plant food groups, whereas negative scores were considered for healthy plant food groups and animal food groups.

Assessment of BP

BP measurement was performed for each individual after a 5-min of resting time with an empty bladder and no previous physical activity. A measurement was conducted using a digital sphygmomanometer (OMRON, M3, HEM-7154-E), with an accuracy of 0.5 mmHg, from the right arm while the participant was sitting. After a 5- to 10-min interval, the measurement was repeated and the mean value of 2 measurements was considered as SBP and DBP for each participant. HTN was defined according to the latest cut-off points as SBP ≥130 mmHg and/or DBP ≥80 mmHg or use of antihypertension medications [1].

Assessment of FRS

The 10-y risk of developing CVD was calculated for each participant through FRS based on the method described by Agostino et al. [27]. The following 8 risk factors were used to predict this score: age, gender, total cholesterol (TC), HDL-c, SBP, use of antihypertension drugs, smoking, and having diabetes. After calculation, individuals were grouped into those with a high risk of CVD (FRS ≥10%) and those with a low risk of CVD (FRS <10%) [28,29]. Blood samples were collected after 12 h of fasting; then, samples were allowed to clot, and finally centrifuging for separation of serum was the last stage. TC and HDL-c measurements were performed by cholesterol oxidase/-peroxidase method using the BioSystems analyzer.

Assessment of other variables

Weight and height of subjects were measured without shoes and while wearing minimal clothes. Standing height measurement was performed to the nearest 0.1 cm by a tape measure. The weight measurement was performed through the use of the body composition analyzer (Tanita MC-780MA). Calculating of BMI was performed as weight (kg) divided by height squared (m^2). Data about additional confounders including age, gender, education status, marital status, homeownership, smoking habits, number of family members, medical history of medication use, and diseases were collected by a self-reported questionnaire. Physical activity was measured through the use of the validated International Physical Activity Questionnaires questionnaire [30]. Three categories of activity (walking, moderate-intensity activities, and vigorous-intensity activities) were evaluated by this questionnaire. For all types of activities, data of both the frequency (d/wk) and duration (min/d) were collected. The metabolic equivalents (METs) of 3.3, 4.0, and 8.0 were, respectively, considered for walking, moderate-intensity, and vigorous-intensity activities. Then, MET-min/wk score calculation for each type of activity was performed through the following formula: MET of activity × minutes × days of week. The scores for all types of activity were summed to obtain a total activity score. Finally, participants were classified as inactive (<600 MET-min/wk), minimally active (≥600 to <3000 MET-min/wk), or active (≥3000 MET-min/wk).

Statistical analysis

For examination of the quantitative variables normality, the Kolmogorov–Smirnov test was performed. The quantitative and qualitative variables were reported as mean ± SD/SE and percentage, respectively. First, all individuals were distributed in tertiles of PDI, hPDI, and uPDI according to the scores calculated for each of the 3 patterns. Then, the comparison of the continuous and categorical variables across these tertiles was performed through the use of one-way analysis of variance and chi-square test, respectively. Age, gender, and energy-adjusted dietary intakes of individuals across tertiles of PDI, hPDI, and uPDI were compared by the use of analysis of covariance. For the identification of the relation of PDI, hPDI, uPDI, and HTN with high FRS (>10%), multivariable logistic regression was performed. The odds ratio (OR) and 95% CI for HTN and high FRS were calculated in both crude and adjusted models. Covariates were determined based on prior literature examining the association between dietary intake and HTN [29,31,32] or FRS [16,33,34]. In the first model, for both HTN and high FRS, adjustments were performed for age, gender, and energy intake. In addition, smoking, education status, physical activity, marital status, family size, homeownership, and margarine and trans-fatty acids intakes were adjusted in the second model for high FRS. History of diabetes was added to other mentioned confounders in the second model for HTN. BMI was added to adjustments for both HTN and high FRS in the last model. The first tertile of PDI, hPDI, and uPDI was assumed as the reference category in all models. SPSS software version 26.0 was used for all statistical analyses. *P* values <0.05 were used for consideration of statistically significance.

Result

This population-based cross-sectional study was conducted on a number of 527 adults having a mean age of 42.65 (±11.19) (SD) years and an average weight of 75.77 (±14.59) kg; 54.3% of subjects were men. Among study participants, 62% of them (n = 327) had HTN (defined as BP ≥130/80 mmHg or using antihypertensive drugs) and 15.6% of them (n = 82) were at high risk of developing cardiovascular diseases (defined as FRS ≥10%).

General characteristics and cardio-metabolic factors of study subjects across tertiles of PDI, hPDI, and uPDI are presented in Table 1. No statistically significant diversity was observed in demographic or cardio-metabolic features of participant across tertiles of PDI. However, those in the highest tertile of hPDI were older, had higher socioeconomic status, and were more likely to suffer from type 2 diabetes. Moreover, compared with the bottom tertile, those in the highest tertile of uPDI were more likely to be men, younger, and have a lower socioeconomic status.

Energy, macro-, and micronutrients of study participants across tertiles of PDI, hPDI, and uPDI are provided in Table 2. Subjects in the highest tertile of PDI reported a higher intake of energy, carbohydrate, total fiber, whole grains, fruits, and sweets/desserts, and a lower intake of protein, fat, animal fat, dairy, fish, and meats as compared with those in the lowest tertile. Among tertiles of hPDI, those in the highest tertile consumed more carbohydrate, sodium, total fiber, whole grains, vegetables and fruits and less energy, protein, fat, sweets or desserts, and different types of animal foods, compared with those in the first tertile of intake. In comparison with the bottom tertile, adults in the highest tertile of uPDI had lower intake of energy, protein, fat, total fiber, whole grains, vegetables, and fruits as well as higher intake of carbohydrate, refined grains, sweets or desserts, and fruit juice.

Crude and multivariate adjusted OR and 95% CI for HTN across tertiles of PDI, hPDI, and uPDI are reported in Table 3. PDI was not significantly associated with HTN in crude ($OR_{T3\ vs.\ T1}$: 1.15; 95% CI: 0.75, 1.77) or fully adjusted model ($OR_{T3\ vs.\ T1}$: 0.99; 95% CI: 0.55, 1.79). No significant relation was also found between hPDI categories and odds of HTN, in crude model ($OR_{T3\ vs.\ T1}$: 1.29; 95% CI: 0.84, 1.99). After making adjustments for all cofounders, no significant relation between hPDI and HTN was found ($OR_{T3\ vs.\ T1}$: 0.83; 95% CI: 0.45, 1.53). To the contrary, highest category of adherence to uPDI was related to a higher odds of HTN; such that, in fully adjusted model, those in the highest tertile of uPDI comparing with those in the lowest tertile had a 100% increased odds of HTN ($OR_{T3\ vs.\ T1}$: 2.00; 95% CI: 1.04, 3.88).

Crude and multivariate adjusted OR and 95% CI for HTN across tertiles of PDI, hPDI, and uPDI, stratified by sex are provided in Table 4. In women, after adjustment for all potential confounders, no significant relation was seen between greater adherence to PDI or hPDI and odds of HTN; however, subjects in the highest category of uPDI, in comparison with the bottom category, were 2.19 times more likely to have HTN, after adjustment for age and energy intake ($OR_{T3\ vs.\ T1}$: 2.19; 95% CI: 1.01, 4.73). More adjustment for demographic confounders strengthened the association ($OR_{T3\ vs.\ T1}$: 2.80; 95% CI: 1.01, 7.77); but in the fully adjusted model the significant association disappeared ($OR_{T3\ vs.\ T1}$: 2.54; 95% CI: 0.90, 7.17). In men, after all potential confounders were adjusted, no significant correlation was observed between PDI, hPDI, or uPDI and HTN.

Crude and multivariate adjusted OR and 95% CI for high FRS across tertiles of PDI, hPDI, and uPDI are reported in Table 5. PDI was not significantly related to high FRS in the crude ($OR_{T3\ vs.\ T1}$: 1.10; 95% CI: 0.62, 1.94) or fully adjusted model ($OR_{T3\ vs.\ T1}$: 0.50; 95% CI: 0.15, 1.65). The same finding was obtained for hPDI, after adjustment for all potential confounders ($OR_{T3\ vs.\ T1}$: 1.03; 95% CI: 0.26, 4.04). Also, no significant relationship was found between uPDI and high FRS in crude ($OR_{T3\ vs.\ T1}$: 0.83; 95% CI: 0.45, 1.52) and fully adjusted model ($OR_{T3\ vs.\ T1}$: 2.05; 95% CI: 0.56, 7.52).

Discussion

This cross-sectional study revealed no significant relationship among PDI or hPDI and HTN in Iranian adults; but greater adherence to uPDI was correlated with increased odds of HTN in this adult population. On the basis of the latest cut-off points for defining HTN, the number of participants suffering from HTN was more than expected among Iranians. No significant relation was found between PDI, hPDI, and uPDI and the 10-y risk of developing CVD. To the best of our knowledge, this study was the first investigation that evaluated the association between PDs with HTN and FRS among Iranian adults.

HTN, as a major chronic condition, is associated with premature CVDs and mortality [35]. We found that 62% of Iranian adults had high BP. So, finding strategies to manage BP could be useful in this population. As a modifiable risk factor, dietary intake could be associated with risk of HTN [9–11]. Our findings suggested that decreasing intakes of less-healthy plant-based foods could be helpful for adults to reduce risk of HTN and its related chronic conditions.

Several prior studies have examined the associations between intake of different types of foods or dietary patterns and HTN. In an 8-wk whole-food plant-based lifestyle modification program, weight loss, reductions in SBP and DBP, and total and LDL cholesterol were observed in response to consuming different types of fruits, vegetables, and whole grains, and excluding all types of animal-based foods from the diet [17]. A systematic review and meta-analysis conducted on 30 randomized controlled trials (RCTs) have documented that compared with a control diet, the DASH diet could reduce BP, independent of having HTN, baseline BP, and using antihypertensive medication. Moreover, the mentioned review found that DASH diet had a stronger effect on BP in younger participants, and this diet could reduce BP independent of the concomitant energy restriction [36], whereas in an RCT on newly diagnosed patients with HTN, a DASH-based diet in comparison with usual care advice showed no significant differences between-groups [37].

TABLE 1
General characteristics and cardio-metabolic factors across tertiles of PDI, hPDI, and uPDI, cross-sectional analysis on all study participants ($n = 527$)[1]

	Tertiles of PDI				Tertiles of hPDI				Tertiles of uPDI			
	T1 ($n = 184$)	T2 ($n = 167$)	T3 ($n = 176$)	P value[2]	T1 ($n = 167$)	T2 ($n = 176$)	T3 ($n = 184$)	P value[2]	T1 ($n = 168$)	T2 ($n = 184$)	T3 ($n = 175$)	P value[2]
Range	<52	52–56	>56	—	<51	51–57	>57	—	<51	51–57	>57	—
Sex (male) (%)	55.4	53.3	54.0	0.92	60.5	54.5	48.4	0.08	47.6	52.7	62.3	0.02
Age (y)	41.9 ± 11.58	42.5 ± 10.44	43.6 ± 11.45	0.35	36.8 ± 9.90	44.1 ± 10.42	46.6 ± 10.84	<0.001	43.1 ± 10.52	44.3 ± 11.38	40.5 ± 11.32	0.01
Weight (kg)	75.9 ± 14.64	75.6 ± 13.75	75.8 ± 15.36	0.98	77.5 ± 14.85	75.2 ± 14.25	74.8 ± 14.60	0.18	76.3 ± 16.01	75.5 ± 13.31	75.6 ± 14.52	0.88
Height (cm)	168.1 ± 8.71	167.4 ± 8.47	167.4 ± 8.48	0.69	170.1 ± 8.89	166.8 ± 8.40	166.2 ± 7.89	<0.001	167.6 ± 80.50	166.7 ± 8.28	168.6 ± 8.80	0.11
BMI (kg/m^2)	26.8 ± 4.48	26.9 ± 4.11	27.0 ± 4.69	0.94	26.7 ± 4.33	27.0 ± 4.34	27.1 ± 4.63	0.75	27.0 ± 4.86	27.1 ± 4.05	26.6 ± 4.40	0.44
Waist circumference (cm)	92.5 ± 12.02	92.1 ± 10.64	93.4 ± 11.73	0.58	92.6 ± 11.89	92.7 ± 11.16	92.7 ± 11.50	0.99	93.0 ± 12.65	92.9 ± 10.43	92.2 ± 11.43	0.77
Cholesterol (mg/dL)	186.1 ± 33.36	182.9 ± 29.05	182.3 ± 34.06	0.48	181.1 ± 31.37	188.2 ± 31.48	182.1 ± 32.67	0.08	182.2 ± 32.59	189.1 ± 34.60	179.7 ± 28.71	0.02
HDL cholesterol (mg/dL)	56.0 ± 10.30	54.3 ± 9.50	55.8 ± 10.06	0.21	54.3 ± 10.38	56.2 ± 9.31	55.6 ± 10.21	0.21	55.6 ± 10.5	55.7 ± 10.33	54.9 ± 9.58	0.73
Systolic blood pressure (mmHg)	121.9 ± 14.67	121.2 ± 16.55	121.8 ± 16.67	0.92	120.3 ± 14.99	121.4 ± 15.78	123.1 ± 16.86	0.26	122.0 ± 15.63	122.4 ± 16.12	120.5 ± 16.06	0.49
Physically activity (inactive) (%)	39.3	26.5	32.0	0.02	36.1	35.8	26.9	0.29	24.4	34.8	38.9	0.03
Education (university graduated) (%)	88.5	89.2	89.0	0.98	88.6	87.4	90.7	0.61	94.0	86.8	86.3	0.04
Marital status (married) (%)	82.4	84.3	80.5	0.82	77.6	89.1	80.2	0.03	83.2	84.0	79.9	0.42
Smoking status (smokers) (%)	5.2	0.7	3.3	0.17	2.7	4.4	2.5	0.36	3.9	0.6	5.2	0.14
Family size (>4 members) (%)	14.3	13.3	16.1	0.75	15.0	12.8	15.8	0.71	14.5	16.5	12.6	0.59
House ownership (yes) (%)	73.9	79.1	72.4	0.41	67.5	72.7	84.3	0.01	84.4	72.2	69.0	0.01
History of type 2 diabetes (yes) (%)	4.9	5.4	5.7	0.95	2.4	4.0	9.3	0.01	7.1	5.5	3.4	0.31

Abbreviations: hPDI, healthy plant-based diet; PDI, plant-based diet; uPDI, unhealthy plant-based diet.
[1] For continuous variables, values are mean ± SD. For categorical variables, values are percentage.
[2] *P* value obtained from 1-way analysis of variance and χ^2 test for quantitative and categorical variables, respectively.

TABLE 2

Dietary intakes (energy and macro/micronutrients) of study participants across tertiles of PDI, hPDI, and uPDI, cross-sectional analysis on all study participants (n = 527)[1]

	Tertiles of PDI				Tertiles of hPDI				Tertiles of uPDI			
	T1 (n = 184)	T2 (n = 167)	T3 (n = 176)	P value[2]	T1 (n = 167)	T2 (n = 176)	T3 (n = 184)	P value[2]	T1 (n = 168)	T2 (n = 184)	T3 (n = 175)	P value[2]
Range	<52	52-56	>56	—	<51	51–57	>57	—	<51	51–57	>57	—
Energy (kcal)	1900.8 ± 44.41	2293.7 ± 46.57	2654.4 ± 45.41	<0.001	2425.5 ± 54.94	2253.0 ± 50.72	2165.1 ± 51.02	0.01	2699.3 ± 46.21	2253.3 ± 44.2	1896.5 ± 45.69	<0.001
Protein (% of E)	15.6 ± 0.19	14.2 ± 0.20	12.9 ± 0.20	<0.001	14.6 ± 0.23	14.4 ± 0.22	13.8 ± 0.22	0.04	15.2 ± 0.21	14.2 ± 0.20	13.4 ± 0.21	<0.001
Carbohydrate (% of E)	58.1 ± 0.58	61.0 ± 0.60	63.7 ± 0.59	<0.001	58.5 ± 0.65	60.4 ± 0.60	63.5 ± 0.60	<0.001	57.9 ± 0.61	61.1 ± 0.58	63.6 ± 0.60	<0.001
Fat (% of E)	27.8 ± 0.49	26.8 ± 0.51	25.7 ± 0.50	0.01	28.5 ± 0.54	27.0 ± 0.50	25.1 ± 0.50	<0.001	29.2 ± 0.50	26.8 ± 0.48	24.5 ± 0.49	<0.001
Cholesterol (mg)	332.0 ± 8.50	282.1 ± 8.36	211.5 ± 8.67	<0.001	308.8 ± 9.42	279.7 ± 8.63	242.5 ± 8.72	<0.001	343.5 ± 9.05	264.9 ± 8.04	222.7 ± 8.84	<0.001
SFA (g)	25.9 ± 0.57	22.0 ± 0.56	18.8 ± 0.59	<0.001	24.9 ± 0.62	21.9 ± 0.57	20.3 ± 0.58	<0.001	24.3 ± 0.64	22.1 ± 0.57	20.6 ± 0.62	<0.001
MUFA (g)	23.9 ± 0.52	21.8 ± 0.51	19.5 ± 0.53	<0.001	23.6 ± 0.55	21.7 ± 0.50	20.1 ± 0.51	<0.001	23.6 ± 0.56	21.4 ± 0.49	20.5 ± 0.54	0.01
PUFA (g)	15.1 ± 0.57	16.5 ± 0.56	16.6 ± 0.58	0.12	15.4 ± 0.60	16.5 ± 0.55	16.2 ± 0.56	0.42	17.3 ± 0.60	15.9 ± 0.54	15.0 ± 0.59	0.04
Sodium (mg)	3646.2 ± 199.34	3796.7 ± 196.02	3890.1 ± 203.4	0.72	3859.0 ± 209.00	3765.5 ± 191.65	3708.8 ± 193.64	0.88	3984.2 ± 210.19	3976.9 ± 186.67	3362.9 ± 205.38	0.06
Potassium (mg)	3633.8 ± 82.21	3849.7 ± 80.83	3823.9 ± 83.88	0.15	3316.6 ± 82.11	3743.1 ± 75.29	4194.8 ± 76.08	<0.001	4331.1 ± 80.58	3806.2 ± 71.57	3180.3 ± 78.74	<0.001
Total fiber (g)	19.1 ± 0.49	21.5 ± 0.48	23.1 ± 0.50	<0.001	17.6 ± 0.48	20.8 ± 0.44	24.7 ± 0.44	<0.001	23.6 ± 0.51	21.4 ± 0.46	18.6 ± 0.50	<0.001
Food groups												
Whole grains (g/d)	35.1 ± 3.77	38.1 ± 3.71	48.8 ± 3.85	0.04	21.4 ± 3.81	40.0 ± 3.49	58.7 ± 3.53	<0.001	55.3 ± 3.93	40.5 ± 3.49	26.7 ± 3.84	<0.001
Vegetables (g/d)	347.3 ± 18.14	376.5 ± 17.83	371.4 ± 18.50	0.50	300.8 ± 18.58	354.3 ± 17.04	434.2 ± 17.22	<0.001	465.3 ± 18.40	358.9 ± 16.34	273.8 ± 17.98	<0.001
Fruits (g/d)	454.4 ± 24.07	529.6 ± 23.67	568.8 ± 24.56	0.01	372.1 ± 23.68	491.7 ± 21.72	671.2 ± 21.94	<0.001	584.7 ± 25.35	532.9 ± 22.51	433.7 ± 24.77	<0.001
Nuts (g/d)	9.6 ± 0.98	13.3 ± 0.97	12.8 ± 1.00	0.02	9.4 ± 1.03	11.8 ± 0.94	14.1 ± 0.95	0.01	15.7 ± 1.03	11.1 ± 0.92	8.8 ± 1.01	<0.001
Legumes (g/d)	32.7 ± 2.85	37.2 ± 2.80	48.0 ± 2.90	0.01	28.0 ± 2.96	41.8 ± 2.71	47.0 ± 2.74	<0.001	46.0 ± 2.99	44.2 ± 2.66	27.6 ± 2.92	<0.001
Vegetable oils (g/d)	9.9 ± 0.75	11.6 ± 0.74	12.3 ± 0.77	0.09	8.7 ± 0.78	12.1 ± 0.71	12.6 ± 0.72	0.01	14.1 ± 0.78	10.5 ± 0.70	9.2 ± 0.77	<0.001
Tea/coffee (g/d)	510.3 ± 58.46	735.0 ± 57.49	856.7 ± 59.65	<0.001	515.4 ± 61.48	769.9 ± 56.38	792.7 ± 56.97	0.01	804.4 ± 62.63	660.3 ± 55.63	633.1 ± 61.20	0.13
Fruit juice (g/d)	31.2 ± 4.69	32.3 ± 4.61	40.2 ± 4.78	0.38	46.6 ± 4.88	32.2 ± 4.48	25.9 ± 4.52	0.01	20.8 ± 4.92	36.7 ± 4.37	45.5 ± 4.81	0.01
Refined grains (g/d)	330.7 ± 13.31	329.9 ± 13.09	355.5 ± 13.58	0.34	376.0 ± 13.67	355.6 ± 12.54	288.8 ± 12.67	<0.001	234.1 ± 12.59	327.7 ± 11.19	450.8 ± 12.31	<0.001
Potatoes (g/d)	25.5 ± 2.67	26.5 ± 2.63	40.6 ± 2.72	<0.001	41.1 ± 2.78	31.6 ± 2.55	20.8 ± 2.57	<0.001	20.2 ± 2.82	36.0 ± 2.51	35.7 ± 2.76	<0.001
Sugar-sweetened beverages (g/d)	33.4 ± 6.75	30.6 ± 6.64	49.0 ± 6.89	0.14	52.1 ± 7.06	34.3 ± 6.48	28.0 ± 6.54	0.05	33.2 ± 7.15	31.3 ± 6.35	48.8 ± 6.99	0.16
Sweets/desserts (g/d)	53.0 ± 3.95	68.1 ± 3.89	75.7 ± 4.03	0.01	76.9 ± 4.15	65.0 ± 3.81	55.2 ± 3.84	0.01	47.4 ± 4.14	69.7 ± 3.68	78.0 ± 4.05	<0.001
Animal fat (g/d)	7.0 ± 0.67	5.24 ± 0.66	3.49 ± 0.68	0.01	7.4 ± 0.70	4.8 ± 0.64	3.8 ± 0.65	0.01	5.3 ± 0.72	5.4 ± 0.64	5.2 ± 0.70	0.97
Dairy (g/d)	401.8 ± 20.23	319.6 ± 19.89	225.0 ± 20.64	<0.001	327.3 ± 21.86	312.0 ± 20.05	311.6 ± 20.26	0.85	402.6 ± 21.56	315.1 ± 19.15	235.9 ± 21.07	<0.001
Eggs (g/d)	30.6 ± 1.69	28.4 ± 1.66	21.5 ± 1.72	0.01	28.8 ± 1.79	27.9 ± 1.64	24.2 ± 1.66	0.14	37.4 ± 1.72	25.4 ± 1.53	18.4 ± 1.68	<0.001
Fish (g/d)	10.6 ± 0.71	7.0 ± 0.69	4.9 ± 0.72	<0.001	10.6 ± 0.74	7.1 ± 0.68	5.3 ± 0.69	<0.001	10.2 ± 0.75	7.2 ± 0.67	5.4 ± 0.74	<0.001
Meat (g/d)	122.3 ± 4.32	102.1 ± 4.25	71.2 ± 4.40	<0.001	111.7 ± 4.70	102.4 ± 4.31	83.8 ± 4.36	<0.001	115.1 ± 4.77	93.4 ± 4.23	88.9 ± 4.66	<0.001
Miscellaneous (g/d)	16.3 ± 1.13	11.0 ± 1.11	7.9 ± 1.15	<0.001	17.4 ± 1.17	11.4 ± 1.07	7.2 ± 1.08	<0.001	15.3 ± 1.21	10.5 ± 1.07	10.0 ± 1.18	0.01

Abbreviations: E, energy intake; hPDI, healthy plant-based diet; PDI, plant-based diet; uPDI, unhealthy plant-based diet.

[1] Values are mean ± SE. Energy intake was adjusted for age and sex; all other values were adjusted for age, sex, and energy intake.

[2] P value obtained from analysis of covariance test for adjustment of energy intake.

TABLE 3
Multivariate adjusted odds ratio (OR) and 95% confidence interval (CI) for hypertension across tertiles of PDI, hPDI, and uPDI, cross-sectional analysis on all study participants ($n = 527$)[1]

	Tertiles of PDI				Tertiles of hPDI				Tertiles of uPDI			
	T1 ($n = 184$)	T2 ($n = 167$)	T3 ($n = 176$)	*P*-trend[2]	T1 ($n = 167$)	T2 ($n = 176$)	T3 ($n = 184$)	*P*-trend[2]	T1 ($n = 168$)	T2 ($n = 184$)	T3 ($n = 175$)	*P*-trend[2]
Cases (*n*)	112	102	113		99	108	120		101	114	112	
Crude	1 (Ref.)	1.01 (0.66, 1.55)	1.15 (0.75, 1.77)	0.52	1 (Ref.)	1.09 (0.71, 1.68)	1.29 (0.84, 1.99)	0.25	1 (Ref.)	1.08 (0.70, 1.66)	1.18 (0.76, 1.83)	0.46
Model 1	1 (Ref.)	0.95 (0.59, 1.51)	1.01 (0.61, 1.69)	0.96	1 (Ref.)	0.74 (0.46, 1.21)	0.82 (0.50, 1.36)	0.47	1 (Ref.)	1.10 (0.68, 1.77)	1.53 (0.89, 2.62)	0.12
Model 2	1 (Ref.)	0.71 (0.41, 1.23)	0.98 (0.54, 1.75)	0.90	1 (Ref.)	0.70 (0.40, 1.23)	0.80 (0.44, 1.46)	0.48	1 (Ref.)	1.08 (0.62, 1.88)	2.08 (1.09, 3.97)	0.03
Model 3	1 (Ref.)	0.72 (0.41, 1.26)	0.99 (0.55, 1.79)	0.95	1 (Ref.)	0.71 (0.40, 1.24)	0.83 (0.45, 1.53)	0.56	1 (Ref.)	1.03 (0.58, 1.81)	2.00 (1.04, 3.88)	0.04

Abbreviations: hPDI, healthy plant-based diet; PDI, plant-based diet; uPDI, unhealthy plant-based diet.
[1] All values are odds ratios and 95% confidence intervals. Model 1: adjusted for age, sex, and energy intake. Model 2: additionally, adjusted for physical activity, marital status, education, family size, smoking, diabetes, homeownership, margarine, and trans-fatty acids. Model 3: additionally, adjusted for BMI.
[2] Obtained by the use of tertiles of PDI, hPDI, or uPDI as an ordinal variable in the model.

Another meta-analysis on the effect of plant-based dietary patterns on BP revealed that a diet consisting of increased plant-based foods with limitation or elimination in animal products (including the Mediterranean, DASH, Vegan, Lacto-ovo vegetarian, high-fiber, Nordic, and high-fruit and vegetable diets) could lower both SBP and DBP in both male and female population [38].

The association between dietary patterns or food groups and FRS has also been considered. Ebrahimof et al. [16] in a cross-sectional analysis found that a posteriori-derived healthy dietary pattern consisted of plant-based foods could be used in the prevention program of cardiovascular diseases among Iranians. In another study on 267 men, the consumption of nut and legume was related to higher HDL-c and lower LDL-c concentrations, but no significant association was found with the 10-y FRS or other CVD risk factors [39]. Shahavandi et al. [29] also found that none of major dietary patterns including healthy, unhealthy, and traditional dietary pattern was significantly associated with the predicted risk for the development of CVD (measured by FRS) or its components. To the contrary, in a 4-wk prospective randomized trial, a plant-based with no-added-fat diet in comparison with the American Heart Association diet could significantly decrease CVD risk factors in both adults and pediatrics [40]. Contradiction in findings of previous investigations might have happened because of the differences in the design of the study, population of study, methods used for collecting data, or the outcome of interests among these investigations.

A previous investigation on 3 prospective cohort studies revealed that each 10% increment in the adherence of hPDI over 4 y of follow up was associated with a 9% decline in the type 2 diabetes risk. [41]. However, in the current study, the frequency of participants with type 2 diabetes in the highest category of hPDI was higher than the lowest category (9.3 compared with 2.4%; $P = 0.01$). This finding might be obtained due to the influences of other confounders. Therefore, we made adjustment for history of diabetes when we assessed the relation between hPDI and HTN to obtain an independent relationship from this covariate.

We found no significant relations between hPDI, PDI, and HTN, whereas a direct association with uPDI was found. These findings might be due to a relatively low consumption of whole grains—as a component of hPDI and PDI—in our study population (with a mean intake of ~40.6 g/d, as shown in Table 2), and a notably higher consumption of refined grains—as a component of uPDI (with a mean intake of ~338.74 g/d, as shown in Table 2). According to the definition outlined by the American Association of Cereal Chemists International (AACCI), grains are categorized as whole grains if 8 g out of 30 g of their total weight is originated from whole grains; otherwise, they are classified as refined grains [42]. More than 55% of energy intake in the Iranian population is derived from carbohydrates, but based on the AACCI definition, refined grains, sweets, and desserts constitute the largest part of carbohydrate intake in Iranian adults [43]. In addition, in the current study, the difference between the highest compared with the lowest tertile of whole grain consumption in hPDI categories was narrow (58.7 compared with 21.4 g/d), whereas the difference among the highest compared with the lowest tertile of refined grain consumption in uPDI categories was wide (450.8 compared with 234.1 g/d); this wide difference might have made it easier to find this probable relation.

TABLE 4

Multivariate adjusted odds ratio (OR) and 95% confidence interval (CI) for hypertension across tertiles of PDI, hPDI, and uPDI, cross-sectional analysis on male ($n = 286$) and female ($n = 241$) participsnts[1]

	Tertiles of PDI				Tertiles of hPDI				Tertiles of uPDI			
	T1	T2	T3	*P*-trend[2]	T1	T2	T3	*P*-trend[2]	T1	T2	T3	*P*-trend[2]
Women (participants/ cases)	82/42	78/45	81/39		66/35	80/40	95/51		88/43	87/42	66/41	
Crude	1 (Ref.)	1.30 (0.70, 2.42)	0.88 (0.48, 1.64)	0.70	1 (Ref.)	0.89 (0.46, 1.70)	1.03 (0.55, 1.93)	0.89	1 (Ref.)	0.98 (0.54, 1.77)	1.72 (0.90, 3.29)	0.12
Model 1	1 (Ref.)	1.31 (0.68, 2.53)	0.91 (0.45, 1.85)	0.79	1 (Ref.)	0.65 (0.32, 1.32)	0.73 (0.37, 1.45)	0.44	1 (Ref.)	1.04 (0.54, 2.01)	2.19 (1.01, 4.73)	0.05
Model 2	1 (Ref.)	1.17 (0.52, 2.64)	0.86 (0.37, 2.02)	0.75	1 (Ref.)	0.66 (0.28, 1.56)	0.76 (0.31, 1.85)	0.60	1 (Ref.)	0.88 (0.38, 2.06)	2.80 (1.01, 7.77)	0.05
Model 3	1 (Ref.)	1.13 (0.50, 2.56)	0.79 (0.34, 1.88)	0.61	1 (Ref.)	0.64 (0.27, 1.52)	0.77 (0.31, 1.90)	0.65	1 (Ref.)	0.83 (0.35, 1.97)	2.54 (0.90, 7.17)	0.08
Men (participants/ cases)	102/70	89/57	95/74		101/64	96/68	89/69		80/58	97/72	109/71	
Crude	1 (Ref.)	0.81 (0.45, 1.49)	1.61 (0.85, 3.06)	0.17	1 (Ref.)	1.40 (0.77, 2.55)	2.00 (1.05, 3.79)	0.03	1 (Ref.)	1.09 (0.56, 2.13)	0.71 (0.38, 1.33)	0.24
Model 1	1 (Ref.)	0.65 (0.33, 1.27)	1.11 (0.52, 2.37)	0.85	1 (Ref.)	0.81 (0.42, 1.59)	0.90 (0.42, 1.90)	0.75	1 (Ref.)	1.15 (0.56, 2.37)	1.13 (0.53, 2.43)	0.77
Model 2	1 (Ref.)	0.49 (0.22, 1.10)	1.11 (0.46, 2.73)	0.92	1 (Ref.)	0.63 (0.28, 1.41)	0.68 (0.27, 1.72)	0.40	1 (Ref.)	1.43 (0.62, 3.26)	1.90 (0.75, 4.79)	0.17
Model 3	1 (Ref.)	0.51 (0.23, 1.15)	1.24 (0.50, 3.09)	0.75	1 (Ref.)	0.67 (0.29, 1.52)	0.69 (0.27, 1.78)	0.43	1 (Ref.)	1.49 (0.64, 3.48)	2.09 (0.81, 5.38)	0.13

Abbreviations: hPDI, healthy plant-based diet; PDI, plant-based diet; uPDI, unhealthy plant-based diet.

[1] All values are odds ratios and 95% confidence intervals. Model 1: adjusted for age and energy intake. Model 2: additionally, adjusted for physical activity, marital status, education, family size, smoking, diabetes, homeownership, margarine, and trans-fatty acids. Model 3: additionally, adjusted for BMI.

[2] Obtained by the use of tertiles of PDI, hPDI, or uPDI as an ordinal variable in the model.

TABLE 5

Multivariate adjusted odds ratio (OR) and 95% confidence interval (CI) for high Framingham risk score (>10%) across tertiles of PDI, hPDI, and uPDI, cross-sectional analysis on all study participants ($n = 527$)[1]

	Tertiles of PDI				Tertiles of hPDI				Tertiles of uPDI			
	T1 ($n = 184$)	T2 ($n = 167$)	T3 ($n = 176$)	*P*-trend[2]	T1 ($n = 167$)	T2 ($n = 176$)	T3 ($n = 184$)	*P*-trend[2]	T1 ($n = 168$)	T2 ($n = 184$)	T3 ($n = 175$)	*P*-trend[2]
Cases (*n*)	28	25	29		11	29	42		26	33	23	
Crude	1 (Ref.)	0.98 (0.55, 1.76)	1.10 (0.62, 1.94)	0.74	1 (Ref.)	2.80 (1.35, 5.80)	4.20 (2.08, 8.46)	<0.001	1 (Ref.)	1.18 (0.68, 2.10)	0.83 (0.45, 1.52)	0.54
Model 1	1 (Ref.)	0.87 (0.32, 2.41)	0.54 (0.19, 1.54)	0.24	1 (Ref.)	1.16 (0.39, 3.46)	1.15 (0.39, 3.41)	0.84	1 (Ref.)	0.85 (0.34, 2.13)	1.20 (0.41, 3.46)	0.78
Model 2	1 (Ref.)	0.73 (0.22, 2.44)	0.49 (0.15, 1.63)	0.24	1 (Ref.)	1.27 (0.37, 4.41)	1.23 (0.33, 4.53)	0.80	1 (Ref.)	1.01 (0.36, 2.85)	1.59 (0.46, 5.53)	0.50
Model 3	1 (Ref.)	0.70 (0.21, 2.38)	0.50 (0.15, 1.65)	0.25	1 (Ref.)	1.27 (0.35, 4.64)	1.03 (0.26, 4.04)	0.96	1 (Ref.)	1.18 (0.40, 3.47)	2.05 (0.56, 7.52)	0.30

Abbreviations: hPDI, healthy plant-based diet; PDI, plant-based diet; uPDI, unhealthy plant-based diet.

[1] All values are odds ratios and 95% confidence intervals. Model 1: adjusted for age, sex, and energy intake. Model 2: additionally, adjusted for physical activity, marital status, education, family size, smoking, homeownership, margarine, and trans-fatty acids. Model 3: additionally, adjusted for BMI.

[2] Obtained by the use of tertiles of PDI, hPDI, or uPDI as an ordinal variable in the model.

PDs might be linked to BP and FRS through several probable mechanisms. First, healthy PDs would improve endothelial function as compared with animal-based diets through 2 possible mechanisms [44]. Animal fat causes an inflammatory response because of transportation of bacterial endotoxins into the bloodstream [45]. This inflammation can cause endothelial function damage within some hours after consumption of animal fat; the dilation ability of blood vessels would get worsened in such a condition [46]. Moreover, the improvement of the endothelial function could be contributed to fruits rich in flavonoid and vegetables rich in nitrate, which would make an increment in plasma concentrations of nitric oxide, and finally decrease BP within hours of consumption [47]. In addition, individuals who eat more plant foods have usually lower BMI values and obesity risk in comparison with others, because of the low energy density that whole plant foods provide for them [48]. Also, most plant foods are rich sources of potassium. A meta-analysis of RCTs revealed that an increment in potassium intake would decrease BP and risk of stroke [49]. Greater potassium intake might reduce BP in various ways, including vasodilation, increasing glomerular filtration rate and decreasing renin secretion, renal sodium re-absorption, platelet aggregation, and reactive oxygen species production [50]. In addition, PDs have lower sodium content than those in the Western diets. It has been estimated that processed foods are responsible for three-quarters of an individual's sodium intake [51], so switching calorie intake sources of an individual to whole plant foods may decrease sodium intake. Furthermore, dietary fiber of plant foods has several useful effects on cardiovascular health due to decreasing serum cholesterol levels through an increment in the bile acids excretion [52]. Moreover, dietary fiber inhibits synthesis of fatty acid in liver through the production of short-chain fatty acids by fermenting soluble fiber in the colon [53]. In addition, high consumption of dietary fiber in participants was associated with a decreased chance of type 2 diabetes through increasing sensitivity to insulin [54]. As hypercholesterolemia, HTN and type 2 diabetes are all major risk factors for CVD [27]; greater dietary fiber intake through PDs might slow down the progression of cardiovascular diseases and decrease risk of deaths from these conditions.

Some strengths and limitations must be taken into account in the present study. First of all, this was the first study that evaluated relation of 3 PDIs with HTN and FRS among Iranian adults. In addition, the effect of a wide range of potential confounders was considered in the analysis. Moreover, the selection of the study sample was by using a multistage cluster random-sampling method; so, a representative Iranian adult sample was obtained and findings could be extrapolated to the general adult population. However, some weaknesses should be noted while interpreting our results. The causality cannot be inferred, due to the cross-sectional design of the study; more prospective studies should be performed to discover a causal relationship. Moreover, despite the fact that our data collection was not conducted during COVID-19 waves or quarantine periods, this pandemic might alter the population's dietary consumption and physical activity, which might have effects on FRS and HTN [55] and therefore might change our findings. Although the assessment of dietary intakes was performed through a validated FFQ, recall bias and many other errors depending on memory, fixed list of foods, and portion sizes might result in misclassification of study participants.

To conclude, the current population-based cross-sectional study revealed that less-healthy PDs would increase the chance of HTN in Iranian adults, although PDs were not significantly related to the 10-y risk of developing cardiovascular disease. More prospective investigations are required to confirm these findings.

Author contributions

The authors' responsibilities were as follows—EM, PR, FS, SM, ZH, PS: contributed to conception, design, data collection, data interpretation, manuscript drafting, approval of the final version of the manuscript, and agreed for all aspects of the work.

Conflict of interest

The authors report no conflicts of interest.

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Ethical approval and consent to participate

All participants provided an informed written consent. The study protocol was ethically approved by the local Ethics Committee of Isfahan University of Medical Sciences (no. IR.MUI.RESEARCH.REC. 1399.615).

Consent for publication

All authors approved the final version of the manuscript, and agreed for all aspects of the work to be published.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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