The association of plant-based dietary patterns with visceral adiposity, lipid accumulation product, and triglyceride-glucose index in Iranian adults

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Abstract

Abstract Background: We sought to investigate whether adherence to a more plant-based, and less animal-based, diet is associated with visceral adiposity, lipid accumulation product (LAP), and triglyceride-glucose index (TyG) in Iranian adults. Methods: This cross-sectional study was conducted on 270 adults aged between 18-75 years old. We created three plant-based diets. including an overall plant-based diet index (PDI), hPDI, and uPDI based on tertiles regarding the intake of animal- or plant-based food items obtained from a semi-quantitative food-frequency questionnaire. Results: Higher hPDI was significantly associated with lower body mass index (BMI) (P-value = 0.01), lower waist circumference (P-value<0.001), and lower waist-hip ratio (P-value<0.001). A significant increase was found for high-density lipoproteins (HDL) (P-trend <0.001) with a significant decrease for LAP (P-value = 0.03) in those with higher adherence to hPDI. Moreover, greater adherence to PDI was associated with a significant increase in diastolic blood pressure (DBP) (p-value=0.01) and fat free mass (FFM) (p-value=0.01). There were no significant associations between PDIs and TyG and VFA. Conclusion: We found that a higher hPDI score was significantly associated with better anthropometric measurements. A significant increase was found for HDL and a significant decrease was found for LAP on hPDI. However, a higher PDI score was significantly associated with higher DBP and higher FFM.

Introduction

Obesity, a progressive chronic disease, is a significant general medical issue, both in developed and developing countries, over the most recent 3 decades (1). Further, body fat distribution plays a significant role in metabolic syndrome incident involving obesity, insulin resistance, hyperinsulinemia, dyslipidemia, glucose intolerance, and hypertension. In general, visceral adiposity appears to play a central role in chronic disease as opposed to regional or generalized obesity (2). Several empirical studies have reported that diets focused on plant-based nutrients can elicit reductions in body weight and result in an improvement of chronic diseases, including cardiovascular diseases. Some biological pathways may also be considered as possible reasons behind this association, including changes in satiety, inflammation, and the composition of the gut microbiome (3). Plant-based diets have been related to a decreased risk of different disease sicknesses, along with (CHD), the leading worldwide contributor to loss of life (4). Most previous research investigating plant-based diets, compared those people who are vegetarian or vegan versus non vegetarians; whilst a limited number of research further labeled plant-based diets as semi-vegetarian, lactovegetarian, and vegan diets, Nonetheless, the currently available evidence has failed to cope with variation in plant-based diets (5, 6), largely because most general groups of people do not follow a strict vegan or vegetarian diets. The extent to which adherence to an overall more plant-based and less animal-based diet influences adiposity

(7), and is associated with chronic disease, is of great interest. In general, three plant-based indices have evolved typically consists of a plant-based diet index (PDI), a healthy plant-based diet index (hPDI), and an unhealthy plant-based diet index (uPDI). The hPDI offers a high-quality plant-based diet rich in whole grains, fruits, vegetables, and nuts and poor in fruit juices, refined grains, and sweets, while uPDI is the opposite (7). Presently, however, the association between plant-based diets and adiposity-related biomarkers remains unknown (4, 8). Therefore, we sought to investigate whether adherence to a more plant-based and less animal-based diet is associated with visceral adiposity, lipid accumulation product, and triglyceride-glucose index in Iranian adults.

Subjects and Methods

Study design

A total of 270 adults (118 males and 152 females) aged between 18-75 years old were enrolled in this cross-sectional study. After a full description of the study objectives, all participants provided written informed consent. Participants were recruited based on inclusion criteria, including an age range of 18-75 years and willingness to participate in our study, and exclusion criteria, including diagnosed chronic diseases such as kidney, liver and pulmonary disease, diabetics, hormonal and cardiovascular diseases, pregnant and lactating women, receiving any special medication or supplements (slimming medicine, hormone, sedative, supplements containing thermogenic substances such as caffeine and green tea, linoleic acid conjugate etc.), and people affected with active infectious or inflammatory diseases. According to inclusion and exclusion criteria, subjects were chosen and interviewed to collect data on demographics, smoking status, physical activity, diet, and supplement use; following which, an anthropometric assessment was conducted.

Diet assessment

Regular dietary intake was evaluated using a valid and reliable 168-item semiquantitative food frequency questionnaire (sq-FFQ). Respondents were asked to select, on a daily, weekly, or monthly basis, the usual frequency of food intakes with a standard serving size during the past year. Previously, the validity and reliability of this FFQ were confirmed (9). Based on household measures, portion sizes of food eaten were calculated in grams per day (10). To evaluate dietary nutrient intakes, dietary intakes were analyzed using Nutritionist IV software.

Covariates

Physical activity, age, sex, education, smoking, marital status were included as covariates in the present study. Participants completed a questionnaire designed to assess the participants' demographic (age, education, sex and marital status), lifestyle, such as smoking and physical activity. Educational status was categorized into illiterate, under diploma, diploma, and educated. Marital status categorized into married or single. Smoking was classified as non-smoker, former, or current smoker. Physical activity was grouped into low, moderate and high

Calculation of plant-based-diet

We developed a general plant-based diet index (PDI), a healthful plant-based diet index (hPDI), and an unhealthful plant-based diet index (uPDI) (**Table 1**) following a procedure similar to that of MartínezGonzález et al (11). For PDI, respondents obtained a rating of 5 for each set of plant foods for which they were above the largest quintile of intake, a result of 4 for each set of plant food for which they were above the second largest quintile but below the lowest quintile and so on, with a score of 1 for consumption below the lowest quintile (positive scores). On the other hand, for each animal food group, participants received a score of 1 in instances they were above the highest quintile of consumption, a score of 2 for each animal food group for which they were between the highest and second highest quintile, and so on, with a score of 5 for consumption below the lowest quintile (reverse scores).

For hPDI, healthy plant food groups were provided positive ratings, and less healthy plant food groups and animal food groups were reversed results. Finally, for uPDI, positive ratings were given to less safe groups of plant foods and inverse scores were given to healthy groups of plant foods and animal groups(8). Finally, in order to generate their general rating on the plant-based dietary index, these quintile-scores categories were implemented for each person.

Anthropometric measures and body composition

Height was measured, with participants unshod, by a stadiometer (Seca, Germany), and other parameters such as weight, body mass index (BMI), waist-hip ratio and waist circumference and body composition including, fat mass, fat-free mass, body fat percentage, total body fat, visceral fat mass, abdominal fat mass were measured using the InBody analyzer (InBody 720, Biospace, Tokyo, Japan).

Physical activity

Physical activity was assessed using a validated short form of the International Physical Activity Questionnaire (IPAQ) (12). Subjects were grouped into three categories, including very low (<600 MET-minute/week), low (600-3000 MET-minute/week), moderate and high (>3000 MET-minute/week), calculated based on Metabolic Equivalents (METs) (13).

Blood pressure

Blood pressure was measured twice, with participants in a seated position, after a 10-15-minute rest, using a digital sphygmomanometer (Beurer, BC 08, Germany), and the mean of the two measurements was considered as the participant's systolic and diastolic blood pressure.

Laboratory investigations

A 20 ml blood sample was obtained between the hours of 07:30-09:00 (am) from all participants, following an overnight fast. Then, the blood samples were collected in acid-washed test tubes without anticoagulant. After storing at room temperature for 30 minutes and clot formation, blood samples were centrifuged at 1500 g for 20 minutes. Serums were stored in - 80° C until future testing. Glucose was evaluated using a commercial kit (Pars Azmun, Tehran, Iran), by the enzymatic (glucose oxidase) colorimetric method. Serum TC and HDL-C were measured using a cholesterol oxidase phenol aminoantipyrine method, and TG was measured using a glycerol-3 phosphate oxidase phenol aminoantipyrine enzymatic method. Serum LDL-C was calculated using the Friedewald formula.

Definitions

The triglyceride (TG)-glucose (TyG) index was calculated as the ln (Fasting TG[mg/dL] $\times$Glucose [mg/dL]/2)(14). LAP was calculated as (WC-65) $\times$TG in men, and (WC-58) $\times$TG in women(15). We categorized general obesity by using body mass index (BMI) where values >30kg/m^2 defined as obesity (16). According to the NCEP- ATP III classification, central obesity was defined as waist circumference >102 cm for men and WC>88cm for females, fasting plasma glucose [?]5/6mmol/l, or a known diagnosis diabetes, fasting serum triglyceride [?]1.7mmol/l, fasting high-density lipoprotein (HDL) cholesterol <40mg/dl for men and HDL<50mg/dl for females, or blood pressure [?] 130/85mmHg(17). Moreover, we categorized participants into two groups based on median of values for TyG index, LAP, visceral adiposity. LAP and TyG were converted to binary variables based on their median values (Median TyG=8.49; median LAP=32.28).

Statistical analysis

Differences, by type of plant based-dietary index (PDI, hPDI, uPDI), were evaluated using Analysis of Variance (ANOVA) and by χ2 tests for categorical data. Analysis of Covariance (ANCOVA) was used in comparing traditional CVD risk factors (HDL, TG, TC, LDL, glucose, and blood pressure) and body composition by types of plant-based dietary indices. Logistic regression analysis was used to compute multivariable-adjusted odds ratios (ORs) and 95% CIs for the association of plant-based dietary indexes with CVD risk factors. Adjustments were made for age, sex, diabetes, cardiovascular disease (CVD), menopause status, education status smoking, physical activity, and dietary energy intake in the ANCOVA and logistic regression analysis. All statistical analyses were performed using The Statistical Package for the Social Sciences (SPSS version 25; SPSS Inc). We considered $p < 0.05$ to represent statistical significance.

Results

Characteristics of participants according to tertile of PDI, hPDI, and uPDI are presented in **Table 2.** A total of 270 participants (118 men and 152 women) were included in this study, with a mean age of 36.52 years old and mean BMI of 25.44. Participants with higher scores on PDI or hPDI were more active and less likely to smoke than lower scoring counterparts. Moreover, participants in the highest tertile of hPDI were well educated. Adherence to hPDI was significantly associated with lower BMI (p= 0.01), lower waist circumference (p<0.001), and lower waist-hip ratio (p<0.001); whilst a decrease was found for FFM across tertiles of hPDI (p= 0.06). Participants in the lowest tertile of PDI had a lower weight (p= 0.01) and FFM (p= 0.02). **(Table 2).Table 3** details mean and standard deviation of food groups across tertiles of PDI, hPDI, and uPDI scores. Adherence to PDI was significantly associated with greater intake of fruits (p<0.001), vegetables (p=0.001), nuts (p<0.001), legumes (p<0.001), tea and coffee (p=0.02), refined grains (p<0.001), sugar sweetened (p<0.01), and sweets and dessert (p<0.001). Adherence to hPDI was also significantly associated with greater intake of fruits (p<0.01), nuts(p=0.02), vegetables oils (p<0.001) and lower intake of fruit juices(p<0.01), refined grains(p<0.001), potatoes (p<0.001), sugar sweetened (p<0.001), sweets and dessert (p<0.001), other (p<0.001), dairy and egg (p<0.01). Participants in the highest tertile of uPDI consumed higher levels of refined grains (p=0.04), sugar sweetened (p<0.001), sweets and dessert (p=0.01) and had lower intake of fruits, vegetables, nuts, legumes, vegetables oils, animal fat, dairy, meat (p<0.001), whole grains (p=0.02), tea and coffee (p<0.01), and egg and fish or seafood (p=0.01) **(Table 3).** Dietary intake of study participants across tertiles of PDI, hPDI, and uPDI scores are indicated in **Table 4** . Intake of riboflavin, niacin, pyridoxine, folate, vitamin B12, vitamin E, vitamin C, vitamin K, potassium, calcium, magnesium, iron, zinc (p value<0.001 for all comparisons) and thiamin was lower (p-value=0.02) in the highest tertile of uPDI, and greater in the highest tertile PDI groups. Those in the highest tertile of hPDI had a lower intake of calcium, selenium, vitamin E, and thiamin, and higher vitamin A. Mean and standard deviation of body composition and traditional CVD risk factors across tertiles of PDI, hPDI, and uPDI scores are indicated in **Table 5** . A significant increase was found for DBP (p-value=0.01), and FFM (p-value=0.01) across tertiles of PDI. Adherence to hPDI showed a significant increase for HDL (P -trend < 0.01) and a significant decrease for LAP (P -value = 0.03). In contrast, we did not observe any significant associations between adherence to uPDI and central obesity biomarkers **(Table 5).**Multivariable-adjusted odds ratio (OR) and 95% confidence intervals (CIs) for CVD risk factors across tertiles of PDI, hPDI, and uPDI are indicated in **Table 6** . Participants in the highest tertile of PDI had a lower chance of general obesity (p-value=0.1), hypertension (p-value=0.9), hyperglycemia (p-value=0.1), TyG (p-value=0.9), and LAP (p-value=0.9), but results were not statistically significant. There was also no statistically significant association across tertiles of hPDI with general obesity (p-value=0.2), central obesity (p-value=0.6), TyG(p-value=0.7), and visceral adiposity (p-value=0.3). Moreover, there was no association for chance of visceral adiposity (p-value=0.05), general obesity (p-value=0.3), central obesity (p-value=0.5), hypertension (p-value=0.2), hypertriglyceridemia (p-value=0.5), higher LAP (p-value=0.5), and higher TyG (p-value=0.5) across tertiles of uPDI. Our results showed that there was no significant difference in the odds of CVD risk factors, or higher levels of LAP and TyG index, across tertiles of PDI, hPDI and uPDI, even after controlling for potential confounders **(Table 6).**

Discussion

This cross-sectional study revealed that adherence to the hPDI was significantly associated with lower BMI, body weight, FFM, WC, and waist-hip ratio. Furthermore, a significant decrease in LAP was associated with adherence to hPDI. However, we did not observe any significant association between adherence to uPDI and central obesity. We found no statistically significant increased odds for visceral adiposity, general obesity, central obesity, hypertension, hypertriglyceridemia, higher LAP, and higher TyG across the tertiles of PDI, hPDI, and uPDI.

According to our results, a greater intake of fruits, nuts, vegetable oils, and a lower intake of fruit juices, refined grains, potatoes, sugar-sweetened, sweets and dessert, and dairy and egg was related to greater adherence to hPDI. In Panagiotakos et al (18), subjects with high adherence to hPDI were significantly protected against CVD; whilst a 25% reduction in CVD events for men and an approximately 10% reduction for women were also reported. In the European Prospective Investigation into Cancer and Nutrition study (19), a 32% lower risk of progressing CHD was observed for vegetarians compared with non-vegetarians. A low-fat, vegetarian diet is the only dietary pattern to have shown protective influences against atherosclerotic plaque formation in clinical trials (20, 21), particularly when combined with exercise and stress management. Vegetarian diets are often more healthful because they contain lower amounts of total fat, saturated fat, cholesterol, and total energy, while rich in polyunsaturated fatty acids, fiber, vitamins C and E, folate, iron, magnesium, and copper (22). Fiber contributes to 'bulk out' the diet without any calories, consequently, this triggers satiety and weight loss. Moreover, soluble fiber binds with bile acids in the small intestines, increasing fecal bile salt excretion and thus reducing cholesterol (23), and moderating post-prandial insulinemic and glycemic responses (24). Therefore, a high fiber consumption, accomplished with greater adherence to a plant-based diet, has been associated with decreased body weight, lower blood pressure and blood lipids, reduced plaque development and cardiovascular risk, and lower risk of type 2 diabetes (25-27). Another factor is vegetable proteins which can act to decrease the levels of blood lipids, and reduce the risk of obesity and cardiovascular disease and is attributed to the maximization of hepatic fatty acid oxidation (28-31). High intake of antioxidants and micronutrients from whole plant foods represents another potential cardio-metabolic beneficial mechanism (32). Indeed, the antioxidant capacity of polyphenol compounds, due to the scavenging of free radicals and protecting against oxidative stress is reported in in-vitro studies (33). This antioxidant capacity, potentially concomitant with their ability to modify nitric oxide (NO) production, potentiate the polyphenol compounds to maintain vascular homeostasis (34). Our findings showed that subjects in the highest tertile of uPDI consumed higher levels of refined grains, sugar-sweetened, sweets, and dessert, and had a lower intake of fruits, vegetable, nuts, legumes, vegetable oils, animal fat, dairy, meat, whole grains, tea and coffee, egg and fish or seafood. The results of Kim et al (35), who highlighted that higher consumption of animal foods and a higher risk of cardiovascular disease, cardiovascular disease mortality, and all-cause mortality are associated, are concordant with numerous observational studies that reported higher intakes of animal foods, particularly red and processed meat, are linked to an increased risk of these outcomes (36-39). Lower intake of animal protein and saturated fatty acids have been suggested to be beneficial for the prevention of obesity (40, 41). Moreover, animal protein is also rich in heme iron and other nutrients from red meat processing, such as sodium and nitrites, and have been suggested to increase the risk of cardio-metabolic diseases (42, 43). To the authors knowledge, the present study represents the first investigation into the association between the plant-based diet index with visceral adiposity, lipid accumulation product, and triglyceride-glucose index, which should be considered a major strength. In this paper, the food frequency questionnaire method was used to examine the dietary intake of patients, which is a validated, reliable, and robust tool that can reflect long-term dietary intake in adults. Furthermore, the recruitment of trained dieticians for the interviews to collect the food frequency data would be expected to decrease any possible misclassification error compared with self-administration. Moreover, we considered that the potential beneficial impacts of a more plant-based diet were independent of less healthy plant foods, for instance, sweets, sugary beverages, and refined grains, thereby the quality of plant-based foods ingested is important. In addition, we endeavored to adjust for all possible potential confounders. However, some limitations are unavoidable and must be considered. Due of the cross-sectional design, the likelihood of residual confounding cannot be ignored; moreover, the cross-sectional design prevents any causal inference being made.

Conclusion

In conclusion, the present study demonstrates that adherence to hPDI is associated with a significant decrease in LAP, lower BMI, body weight, FFM, WC, and waist-hip ratio. However, there was no significant relationship between the plant-based diet index (PDI) and the risk of obesity, hypertension, hypertriglyceridemia, higher LAP, and higher TyG among subjects. Our study highlights that more investigations into the relationship between PDI and MetS in large cohort studies and well-designed clinical trials are necessitated.

Moreover, the importance of plant-based diet quality is critical and needs to be further explored.

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Table 1. Examples of Food Items Constituting the 18 Food Groups

	Plant Food Groups	PDI	hPDI	uPDI
Healthy				
Whole grains	Cooked oatmeal, dark bread, other grains	Positive scores	Positive scores	Reverse scores

	Plant Food Groups	PDI	hPDI	uPDI
Fruits	Watermelon, fresh apples or pears, oranges, grapefruit, lemon, fig, nectarine, kiwi, persimmon, tangerine, peaches, cantaloupe, melon, pomegranate, date, strawberries, apricots or plums, cherry, Raisins or grapes, bananas, pineapple	Positive scores	Positive scores	Reverse scores
Vegetables	Tomatoes, broccoli, cabbage, cauliflower, carrots, mixed vegetables, yellow or winter squash, eggplant or zucchini, spinach cooked, spinach raw, leaf lettuce, celery, mushrooms, beets, garlic, onion	Positive scores	Positive scores	Reverse scores
Nuts	Nuts, peanut butter	Positive scores	Positive scores	Reverse scores
Legumes	String beans, soybeans, beans or lentils, peas or beans	Positive scores	Positive scores	Reverse scores
Vegetable oils	Olive, olive oil	Positive scores	Positive scores	Reverse scores
Tea and coffee	Tea, coffee	Positive scores	Positive scores	Reverse scores
Less healthy				
Fruit juices	Apple juice, orange juice, grapefruit juice, other fruit Juice	Positive scores	Reverse scores	Positive scores
Refined grains	Refined grains, white bread, biscuits, white rice, crackers, cake, macaroni, vermicelli	Positive scores	Reverse scores	Positive scores

	Plant Food Groups	PDI	hPDI	uPDI
Potatoes	French fries, baked or mashed potatoes, potato or chips	Positive scores	Reverse scores	Positive scores
Sugar sweetened beverages	Colas	Positive scores	Reverse scores	Positive scores
Sweets and desserts	Chocolates, candy bars, candy without chocolate, cookies (home-baked and ready-made), cake (home-baked and ready-made), jams or jellies or preserves or syrup or honey	Positive scores	Reverse scores	Positive scores
	Animal Food Groups			
Animal fat	Butter added to food, butter or lard used for cooking	Reverse scores	Reverse scores	Reverse scores
Dairy	Skim low fat milk, whole milk, cream, sour cream, ice cream, yogurt, dried whey cream cheese, other cheese	Reverse scores	Reverse scores	Reverse scores
Egg	Eggs	Reverse scores	Reverse scores	Reverse scores
Fish or seafood	Canned tuna, other fish	Reverse scores	Reverse scores	Reverse scores
Meat	Chicken with skin, chicken without skin, processed meats, liver, hamburger, hot dog, beef or lamb mixed dish, kielbasa	Reverse scores	Reverse scores	Reverse scores
Other	Pizza, mayonnaise or other creamy salad dressing, puff, salt	Reverse scores	Reverse scores	Reverse scores

FFQ = food frequency questionnaire; hPDI = healthful plant-based diet index; PDI = overall plant-based diet index; uPDI = unhealthful plant-based diet index

Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores

	PDI score	**PDI score**	**PDI score**		**hPDI score**	**hPDI score**	**hPDI score**		**uPDI score**	**uPDI score**	**uPDI score**	
Characteristics	T1 (37-51)	T2 (52-56))	T3 (57-69)	p	T1 (36-51)	T2 (52-57)	T3 (58-69)	p	T1 (29-51)	T2 (52-57)	T3 (58-73)	p
N	81	91	83		81	91	93		81	91	83	
Age (year)	37.5±13.9	34.4±12.2	37.7±12.9	0.18	39.7±13.0	34.0±12.1	36.1±13.5	0.01	37.3±14.0	36.3±12.5	36.0±12.8	0
Weight (kg)	69.0±14.1	75.4±17.9	71.8±13.9	0.01	76.7±15.6	69.8±16.9	69.7±13.3	<0.001	73.1±17.5	71.5±13.9	71.5±15.5	0
FFM (kg)	46.7±11.2	51.8±13.9	50.8±11.5	0.02	52.3±12.6	48.6±12.7	48.2±11.7	0.06	50.3±12.5	49.4±12.7	49.4±12.0	0
FM (kg)	22.2±8.40	23.1±10.9	21.0±8.22	0.36	23.8±9.7	21.1±9.41	21.6±8.51	0.13	22.7±11.1	21.7±6.65	22.1±9.81	0
BMI kg/m2)	25.1±4.4	26.1±5.3	25.0±3.9	0.22	26.6±4.7	24.6±4.9	25.0±4.0	0.01	25.8±5.6	25.2±3.5	25.2±4.6	0
WC (cm)	87.4±11.4	91.0±13.9	88.9±11.2	0.14	92.9±12.6	86.8±12.6	87.6±10.	<0.001	89.7±13.8	88.9±10.4	88.5±12.6	0
WHR	0.89±0.06	0.90±0.06	0.90±0.06	0.30	0.92±0.06	0.88±0.06	0.89±0.06	<0.001	0.90±0.06	0.90±0.05	0.89±0.06	0
Sex, n(%)				<0.001				0.03				0
Male	25(9.8%)	41(16.1%)	43(16.9%)		45(17.6%)	32(12.5%)	32(12.5%)		59.3	53.8	59.0	
Female	67(26.3%)	45(17.6%)	34(13.3%)		38(14.5%)	52(20.4%)	56(22.0%)					
Education, n(%)				0.60				<0.001				0
Under diploma	8(3.1%)	5(2.0%)	7(2.7%)		10(3.9%)	6(2.4%)	4(1.6%)		5(2.0%)	4(1.6%)	11(4.3%)	
Diploma	13(5.1%)	19(7.5%)	16(6.3%)		25(9.8%)	15(5.9%)	8(3.1%)		15(5.9%)	19(7.5%)	14(5.5%)	
Educated	71(27.8%)	62(24.3%)	54(21.2%)		48(18.8%)	63(24.7%)	76(29.8%)		61(23.9%)	68(26.7%)	58(22.7%)	

Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	T 2 G e c a t t c p t p a t t t c F h a u s
Smoking, n(%)				0.86				0.81				0
Not smoking	82(32.2%)	76(29.8%)	64(25.1%)		73(28.6%)	70(27.5%)	79(31.0%)		68(26.7%)	79(31.0%)	75(29.4%)	
Quit smoking	9(3.6%)	8(3.2%)	11(4.2%)		9(3.6%)	11(4.4%)	8(3.2%)		12(4.8%)	10(4.0%)	6(2.4%)	
Moderate and high smoking	1(0.4%)	2(0.8%)	2(0.8%)		1(0.4%)	3(1.2%)	1(0.4%)		1(0.4%)	2(0.8%)	2(0.8%)	
Activity level, n(%)				0.50				0.50				0
Low	32(12.5%)	39(15.3%)	28(11.0%)		32(12.5%)	29(11.4%)	28(14.9%)		25(9.8%)	41(16.1%)	33(12.9%)	
Moderate	43(16.9%)	31(12.2%)	31(12.2%)		35(13.7%)	40(15.7%)	30(11.8%)		35(13.7%)	34(13.3%)	36(14.1%)	
High	17(6.7%)	16(6.3%)	18(7.1%)		16(6.3%)	15(5.9%)	20(7.8%)		21(8.2%)	16(6.3%)	14(5.5%)	
Diabetes, n(%)				0.94				0.43				0
Yes	3(1.2%)	3(1.2%)	2(0.8%)		3(1.2%)	1(0.4%)	4(1.6%)		4(1.6%)	2(0.8%)	2(0.8%)	
No	89(34.9%)	83(32.5%)	75(29.4%)		80(31.4%)	83(32.5%)	84(32.9%)		77(30.2%)	89(34.9%)	81(31.8%)	
CVD, n(%)				0.56				0.56				0
Yes	1(0.4%)	3(1.2%)	2(0.8%)		3(1.2%)	2(0.8%)	1(0.4%)		3(1.2%)	2(0.8%)	1(0.4%)	
No	91(35.8%)	83(32.7%)	74(29.1%)		80(31.5%)	81(31.9%)	87(34.3%)		78(30.7%)	89(35.0%)	81(31.9%)	
Menopause, n (%)												0
Yes	13(9.0%)	11(7.6%)	10(6.9%)		11(7.6%)	8(5.5%)	15(10.3%)		13(9.0%)	7(4.8%)	14(9.7%)	
No	53(36.6%)	34(23.5%)	24(16.6%)		27(18.6)	44(30.3%)	40(27.6%)		34(23.4%)	42(29.0%)	35(24.1%)	

Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	Table 2. General characteristics of participants across the tertiles of PDI, hPDI, and uPDI scores	[illegible]
P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	P value less than 0.05 was considered significant. Values are based on average ± standard deviation or reported percentage. One-way ANOVA for quantita-	[illegible]

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Table 3. Mean and standard deviation of food groups across tertiles of PDI, hPDI, and uPDI scores

Food groups
n
Whole grains (g/day)
Fruits (g/day)
Vegetables (g/day)
Nuts (g/day)
Legumes(g/day)
Vegetables Oils (g/day)
Tea and Coffee (g/day)
Fruit juices (g/day)
Refined grains (g/day)
Potatoes (g/day)
Sugar sweetened beverages(g/day)
Sweets and dessert (g/day)
Animal fat(g/day)
Dairy (g/day)
Egg (g/day)
Fish or seafood (g/day)
Meat (g/day)
Other (g/day)

ANOVA was used for statistical comparisons between quantitative variables, and chi-square test was used for statistical com

Table 4. Dietary intakes across tertiles of PDI, hPDI, and uPDI scores

Biomarkers
Thiamin, mg/d
Ριβοφλαιν, μγ/δ
Niacin, mg/d
Pyridoxine, mg/d
Folate, mg/d
ῗταμιν B12, μγ/δ
Vitamin E, mg/d
Vitamin D, IU/d
ῗταμιν A, μγ/δ
Vitamin C, mg/d
ῗταμιν K, μγ/δ
K, mg/d
Na, mg/d
Ca, mg/d
Mg, mg/d
Fe, mg/d
Se, mg/d
Zn, mg/d

P value less than 0.05 was considered significant. Values are based on mean ± standard deviation PDI: plant based diet ind

Table5.mean and standard deviation of body composition and traditio

Table 6. Multivariate adjusted odds ratios and 95% confidence intervals for CVD risk factors across tertiles of PDI, hPDI a

General Obesity
Central obesity

Table 6. Multivariate adjusted odds ratios and 95% confidence intervals for CVD risk factors across tertiles of PDI, hPDI a

Hypertension
Visceral adiposity
Hypertriglyceridemia
Hyperglycemia
LAP
TyG

General Obesity
Central obesity
Hypertension
Visceral adiposity
Hypertriglyceridemia
Hyperglycemia
LAP
TyG

General Obesity(cm)
Central obesity(cm)
Hypertension(mmHg)
Visceral adiposity
Hypertriglyceridemia (mg/dL)
Hyperglycemia(mg/dL)
LAP
TyG
P value Adjusted for age, sex, education, physical activity, smoking, , CVD, diabetes, menopause status and energy intake.

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