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Abstract

Background: We investigated the association between plant-based diets indices: an overall plant-based diet index (PDI); a healthful plant-based diet index (hPDI); and an unhealthful plant-based diet index (uPDI), with metabolic syndrome (MetS) among Iranian older adults.

Methods: This cross-sectional study included 178 older adults who were referred to health centers in Tehran, Iran. Blood and urine samples were collected to measure serum total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglycerides (TG). We created an overall PDI, hPDI and uPDI from semi quantitative food-frequency questionnaire (FFQ) data.

Results: Our crude results showed that TG, sBP, dBP, FBS, HDL-C and WC did not significantly differ between tertiles of PDI, hPDI and uPDI. After adjusting for confounders, the results of TG, sBP, dBP, FBS, HDL-C and WC remained non-significant. There was also no significant association of PDI (OR: 0.92; 95% CI: 0.43–1.96), hPDI (OR: 1.07; 95% CI: 0.51–2.21) and uPDI (OR: 1.03; 95% CI: 0.48–2.17) with MetS, even after adjustment for confounders.

Conclusions: Our findings showed that plant-based diets are not significantly associated with risk of MetS in Iranian older adults.

Keywords: plant-based diet index, healthful plant-based diet, metabolic syndrome, older adults

Introduction

Metabolic syndrome (MetS), classified as a group of metabolic abnormalities, is a clinical condition used to characterize individuals at risk of cardiovascular-related mortality [1-4]. MetS is specified by a cluster of metabolic abnormalities, including hyperglycemia, hypertension, abdominal obesity, and dyslipidemia [5]. However, many factors contribute to the pathogenesis of MetS, where insulin resistance and obesity are the most prominent factors. MetS is a rapidly growing, worldwide, pandemic with an average prevalence of 31% [6]. Also, MetS represents a complex interaction between genetic, environmental, and metabolic factors, in which diet is a strong and modifiable environmental factor. Certain diets and nutrients have been manifest to play a protective role against the increase of MetS risk [7,8].

Diet plays an important role in the progression overweight, obesity, and obesity-related diseases, and there has been growing attention on plant-based diets, which have been associated with a lower risk of type 2 diabetes (T2D), coronary heart disease (CHD), and other cardiometabolic diseases [9,10]. Plant-based diets have been related to lowering the risk of different diseases [11-13], including CHD [10,14], the leading global cause of death [15]. However, these studies suffer from key limitations. With the exception of a recent study [12], most previous studies [10,14] have determined plant-based diets as 'vegetarian' diets, which constitute a group of dietary patterns that exclude some or all animal foods. As suggestions based on increasing dietary changes are easier to adopt, it is important to recognize how gradual decreases in animal food intake with concomitant increases in consumption of plant foods affect cardiovascular health, abdominal obesity, hyperglycemia, hypertension, and dyslipidemia. To overcome these limitations, new indices have been suggested which are based on plant diets: an overall plant-based diet index (PDI), which accents consumption of all plant food while diminishing animal food intakes, healthful plant-based diet index (hPDI), which accents intake of healthy plant foods related with making better health consequences such as fruits, whole grains, and vegetables; and an unhealthful plant-based diet index (uPDI), which accents consumption of less healthy plant foods known to be related with a higher risk of several diseases [16]. In three US cohorts, it was documented that the PDI was inversely related with T2D risk, with a potent inverse association for hPDI, and a positive relationship for uPDI [16]. To the author's knowledge, no study has investigated plant-based diet indices in an Iranian population. Therefore, the aim of this study was to investigate the association of plant-based diet indices with MetS in older adults.

Subjects and methods

Study population

This cross-sectional study was conducted on 178 older adults (51 men and 127 women), with a mean age of 67.04 (60-83), who were referred to health centers in Tehran, Iran. Participants were selected using a two-stage cluster sampling of 25 Health centers in Tehran. Health centers in Tehran were divided into five regions: North, South, East, West, and Central, and participants were equitably recruited from each of the five regions, using random selection We established self-reported diagnosis of disease, including diabetes, hypertension, and cardiovascular disease. Physical activity, smoking, income, and medication use history were collected by a valid questionnaire. Systolic and diastolic blood pressure (SBP and DBP, respectively) was measured by a trained physician, in the right arm, with a standard mercury sphygmomanometer, after the participant had been sitting quietly for 15 min. This measurement was followed by a second measurement 1-2 min later, and the mean of the two was calculated.

Anthropometric measurements

Patient's height was measured, unshod, using a wall-mounted stadiometer with a sensitivity of 0.1 cm (Seca, Germany), and weight was measured using digital scales (Seca 808, Germany) with an accuracy of 0.1 kg with light clothes and unshod. BMI was calculated by dividing weight in kilograms by the square of height in meters. Waist circumference was measured with a tape measure between the iliac crest and the lowest rib, in line with standardized procedures.

Laboratory investigation

We obtained 10 ml of blood and 3 ml urine samples between the hours of 7-10 am from all participants, in a fasted state. Following this, blood samples were gathered in acid-washed test tubes without anticoagulant. Then, after being stored 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. Fasting blood sugar (FBS) was assayed by the enzymatic (glucose oxidase) colorimetric method using a commercial kit (Pars Azmun, Tehran, Iran). Serum total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C) were measured using a cholesterol oxidase phenol aminoantipyrine method, and triglyceride (TG) was measured using a glycerol-3 phosphate oxidase phenol aminoantipyrine enzymatic method. Serum low-density lipoprotein cholesterol (LDL-C) was calculated using the Fried Ewald formula.

Definition of metabolic syndrome

MetS was defined according to the NCEP- ATP III classification, as three or more of; waist circumference >102 cm, fasting plasms glucose ≥5/6mmol/l, or a known diagnosis of diabetes, fasting serum triglyceride ≥1.7mmol/l, fasting high-density lipoprotein (HDL) cholesterol <1.03mmol/l, or blood pressure ≥ 130/85mmHg [17].

Dietary assessment and calculation of the Plant-based Diet Index

Dietary intakes of subjects was evaluated by means of a valid and reliable semi-quantitative food frequency questionnaire (FFQ), with 168 food items [18]. Trained researchers via face-to-face interviews, asked subjects to report their frequency of intake of each food item, during the past year on a daily, weekly, or monthly basis. These reports were converted to daily intakes, then we used this dietary data to generate three versions of a plant-based diet: an overall PDI, hPDI, and uPDI [16]. Table 1 details examples of food group constituents. We created 18 food groups based on nutrient and culinary similarities within the larger categories of healthy plant foods (whole grains, fruits, vegetables, nuts, legumes, vegetable oils, tea/coffee), less healthy plant foods (fruit juices, refined grains, potatoes, sugar-sweetened beverages, sweets/desserts), and animal foods (animal fat, dairy, eggs, fish/seafood, meat, miscellaneous animal-based foods). We ranked food groups into tertiles, which were subsequently given positive or inverse scores. With positive scores, participants above the highest tertile of a food group received a score of 3 and those below the lowest tertile received a score of 1. With inverse scores, this pattern of scoring was inversed. For PDI, plant food groups were given positive scores, while animal food groups were given inverse scores. For hPDI, positive scores were allocated to healthy plant food groups, and inverse scores to less healthy plant food groups and animal food groups. Finally, for uPDI, positive scores were allocated to less healthy plant food groups, and inverse scores to healthy plant food groups and animal food groups. The 18 food group scores were summed to establish the indices.

Statistical analysis

People were grouped based on the tertiles of PDI, hPDI, and uPDI. To compare general characteristics among tertiles, we used one-way analysis of variance (ANOVA) for quantitative variables, and Chi-square tests for qualitative variables. Logistic multiple-regression was performed to evaluate the relationship between tertiles of PDI, uPDI, and hPDI with other variables, including FBS, insulin, HDL, TG, and systolic and diastolic blood pressure. Analyses were adjusted for age, sex, smoking, physical activity, marital status, income level, BMI, total energy, diabetes, hypertension, and dyslipidemia. All statistical analyses were performed using

SPSS (Statistical Package for Social Sciences) for Windows 25.0 software package (SPSS, Chicago, IL). The level of statistical significance was set, *a priori*, at $p < 0.05$.

Results

General characteristics of study participants across categories of PDI, hPDI, and uPDI are presented in (Table 2). There was no significant differences in age, weight, BMI, WHR, WC, % body fat, sex, physical activity, and smoking across between tertiles of PDI, hPDI, and uPDI, respectively. Also, our crude model results showed that TG, SBP, DBP, FBS, HDL-C, and WC did not significantly differ between tertiles of PDI, hPDI, and uPDI. After adjusting for confounders, including age, sex, smoking, physical activity, marital status, income level, BMI, total energy, diabetes, hypertension, and dyslipidemia, the results remained non-significant (Table 3).

Multivariable-adjusted odds ratio (OR) and 95% confidence intervals (CIs) for MetS, according to tertiles of PDI, hPDI, and uPDI, are presented in (Table 4). In the crude model, our results indicated no significant relationship of PDI (OR: 0.92; 95% CI: 0.43–1.96), hPDI (OR: 1.07; 95% CI: 0.51–2.21) and uPDI (OR: 1.03; 95% CI: 0.48–2.17) scores with risk of MetS. After adjustment for confounders, the mentioned association remained unchanged PDI (OR: 0.72; 95% CI: 0.30–1.72), hPDI (OR: 1.09; 95% CI: 0.48–2.48), and uPDI (OR: 0.98; 95% CI: 0.43–2.26).

Discussion

In the present cross-sectional study, we found no significant association between PDI, hPDI, and uPDI with the probability of MetS and its components, in both crude and adjusted models.

Recently published studies have evaluated the relationship of PDI and the risk of chronic diseases ,such as T2D [19] and CHD [20]. However, there is a distinct dearth of studies that have examined the association of PDI and MetS. In contrast to the findings of previous studies [21,22], this study did not support the association between plant-based diets with odds of having MetS. In Satija et al.[16], the relationship of an overall PDI, hPDI, and uPDI with T2DM occurrence in three prospective cohort studies in the US was examined, and the authors suggested that PDI, especially when it is rich in high-quality plant foods, is related to a potential decreased risk of T2D incidence. Further, following Sabaté and Wien [23], it was reported that vegetarian diets are related to reduced BMI and a decreased prevalence of obesity in adults and children. Putatively, it may because plant-based diets have a low overall energy density, but tare rich in complex carbohydrates, fiber, and water, which could, conceivably, help to improve satiety and resting energy expenditure [23]. Moreover, a systematic review and meta-analysis by Chun Shing K et al. [24] demonstrated that, among included observational studies (8 studies with 183,321 subjects), there was a modest cardiovascular benefit, but no obvious decrease in overall mortality, associated with a vegetarian diet. Findings of another meta-analysis showed that total vegetable consumption was associated to a lower risk of the MetS, while green vegetable consumption was not related to the MetS in subgroup analysis [25]. Thus, it seems that the type of vegetable intake is of great importance. Moreover, in accordance with the literature review carried out by Dietary Guidelines Advisory Committee in 2015, vegetarianism was linked to lower systolic and diastolic blood pressure, possibly because of the high amount of potassium and magnesium [26]. In a cross-sectional study of 773 subjects (30–94 years), a vegetarian dietary pattern was associated with a 56% lower risk of having the MetS, compared with a non-vegetarian dietary pattern [27]. Moreover, adherence to a lacto-vegetarian pattern in healthy Chinese people (age 21–76 years) resulted in a lower BMI, BP ,and serum levels of TAG, total cholesterol, LDL, FBG and the total cholesterol:HDL ratio [28]. A study conducted in Iran also reported that a vegetarian diet was inversely associated with a 2.3 times higher chance of elevated FBG [29]. Further, results of another study showed that the soybean and its products are good sources of plant protein, which may be helpful in decreasing low-density lipoprotein (LDL) serum concentration [30], and therein, acting as a protective agent against MetS occurrence.

In contrast to our findings, accumulating evidence shows that a more plant-based, less animal-based, diet may be associated with lower risk of CVD risk factors. However, there is not sufficient evidence to suggest that a total elimination of meat or animal products is associated better health status. Notwithstanding, it appears that recommendations based on increasing fruits and vegetables intake would improve the plant-based dietary index units and decrease CVD risk factors. Reports from Iran showed that intake of fruit and vegetables in older adults was lower than the recommended minimum of five daily servings, and varied greatly with age, marital status, educational attainment, and income level [31]. The association of a Mediterranean-style diet, rich in fruits and vegetables, and lower risk of MetS and its components in older populations has been shown in previous studies [32,33]. However, higher adherence to a Mediterranean diet in Iranian people did not predict MetS components and incidence, respectively, after a 3-year follow up investigation [34]. Discrepancies between results may be related to the differences in the availability of foods, variety in food processing, and preparation, which may change the nutrient composition of the same food [35].

Fruits and vegetables are the two main components of vegetarian diets. Fruits include an abundance of antioxidants and phytochemicals. Indeed, a sufficient intake of antioxidants can modify oxidative stress by decreasing levels of reactive oxygen species (ROS_s), as evidenced in both human and animal studies [36,37]. The higher consumption of fruits can have a beneficial effect on reducing an inflammatory marker C-reactive protein (CRP), which is related to overall inflammation and oxidative stress [38,39]. In addition, animal studies and human epidemiological studies have demonstrated polyphenols, an antioxidant, may exert favorable influences on glucose metabolism, possibly by decreasing oxidative stress and enhancing endothelial function [40].

The useful effects of high dietary soluble fiber on improving postprandial glucose, in addition to glucose metabolism, have been reported in randomized clinical trials [41]. A plant-based diet usually includes a large amount of fiber, essential amino acids, unsaturated fatty acids, chlorogenic acids, and antioxidants. For instance, the rich sources of fiber and antioxidants are vegetables and fruits. Furthermore, nuts are rich in poly-unsaturated fatty acids; soy and beans are sources of high-quality plant protein; whole grains are a good source in fiber and plant protein, and coffee and tea possess sufficient amounts of phenol chlorogenic acid [42]. It is well established that fiber has a pronounced role in lessening gastric emptying, and thus, glycemic responsiveness [43], so it could be useful in preventing more inflammation [44], and indeed obesity [45]. Moreover, magnesium, which is rich in a plant-based diet, has a critical role in glucose metabolism [46]; thus, better glycemic control, insulin sensitivity, and less inflammation are accessible through adherence to a healthful plant-based diet.

Evidence from randomized controlled trials has shown that plant-based diets may confer protective effects against increases in body weight, lipid profile, glycemic control, and blood pressure, respectively [47-49]. Intake of protein, magnesium, dietary fiber, and consumption of unsaturated fat may be linked to changes in blood pressure [50]. It has been postulated that a plant-based diet, rich in potassium, may yield increases in vasodilation and glomerular filtration rate, while reducing renin level, reabsorption of renal sodium, reactive oxygen species production, and platelet accumulation that results in decreased blood pressure [27]. A plant-based diet is associated with reduced risk of each component of MetS, with the exception of HDL cholesterol [51], a lower waist circumference [51], lower levels of triglycerides, LDL cholesterol, blood glucose, and blood pressure [27,51,52].

Strengths and Limitations

To the authors knowledge, this is the first study to have examined the association between the plant-based diet index and MetS. In this paper, the food frequency questionnaire method was used to assess the dietary intake of patients, which can accurately reflect long-term intake in adults. Furthermore, the enrollment of trained dieticians for the interviews to gather the food frequency data would be expected to decrease any possible misclassification error, as compared with self-administration. In addition, we sought to adjust all possible potential confounders. However, despite the strengths of our novel investigation, some limitations are inevitable. Because of the cross-sectional design, the possibility of residual confounding could not be ignored. Another limitation was the small sample size that could affect the ability of the study to identify a weak relationship. Unfortunately, due to time and budgetary restraints, the recruitment of more subjects was infeasible. Finally, because the present study was cross-sectional is design, causal inferences cannot be made.

Conclusions

The findings of out study showed that there was no significant relationship between PDI and MetS in older adults. Moreover, our study highlights that more research is needed into the relationship between PDI and MetS in large cohort studies and well-designed clinical trials.

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