Souni *et al. Journal of Health, Population and Nutrition* (2025) 44:127
https://doi.org/10.1186/s41043-025-00879-2

Journal of Health, Population and Nutrition

RESEARCH **Open Access**

The association between plant-based diet indices and the risk of breast cancer: a case-control study

Fateme Souni[1], Fatemeh Mansouri[1], Fatemeh Jafari[2], Reza Sharifi[3], Sepideh PourvatanDoust[4], Zainab Shateri[5], Mehran Nouri[6*] and Bahram Rashidkhani[7*]

Abstract

Background Previous studies examining the relationship between plant-based diets and breast cancer (BrC) have provided conflicting evidence. To address these inconsistencies, we aimed to evaluate the association between the plant-based diet index (PDI), healthful PDI (hPDI), and unhealthy PDI (uPDI) with the odds of BrC in Iranian women.

Methods The current case-control research was performed on 133 Iranian women with BrC and 265 controls. The study subjects were selected from hospitals in Tehran. PDI, hPDI, and uPDI were categorized into eighteen food groups based on nutrient composition similarity. The relationship between PDIs and BrC was assessed using logistic regression.

Results After adjusting for confounding factors, the chance of developing BrC was lower in the highest tertile of hPDI compared to the lowest tertile (odds ratio (OR) = 0.495; 95% confidence interval (CI): 0.274–0.891; P = 0.019). In addition, postmenopausal women in the second and last tertiles of hPDI had lower odds of BrC than those in the first tertile (T) (T_2: OR = 0.342; 95% CI: 0.141–0.828; P = 0.017– T_3: OR = 0.262; 95% CI: 0.107–0.639; P = 0.003) in the adjusted model. Furthermore, in premenopausal women in the highest tertile of uPDI, the odds of BrC were increased compared to the lowest tertile (OR = 2.546; 95% CI: 1.051–6.167; P = 0.038) in the adjusted model.

Conclusions Adherence to a healthy plant-based dietary pattern, including vegetables, fruits, whole grains, nuts, and legumes, seems to be beneficial for BrC prevention, particularly in postmenopausal women. Future prospective cohort studies that consider menopausal status and the type of BrC are needed to support these findings.

Keywords Plant-based diet, Dietary patterns, Breast cancer, Breast cancer prevention, Risk factors, Tehran

*Correspondence:
Mehran Nouri
mehran_nouri71@yahoo.com
Bahram Rashidkhani
rashidkhani@yahoo.com
[1]Department of Clinical Nutrition, School of Nutrition and Food Sciences, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Department of Nutritional Sciences, The Pennsylvania State University, University Park, PA, USA
[3]Department of Prosthodontics, Faculty of Dentistry, Tabriz University of Medical Sciences, Tabriz, Iran
[4]Department of Food Science and Technology, Science and Research Branch, Islamic Azad University, Tehran, Iran
[5]Department of Nutrition and Biochemistry, School of Medicine, Ilam University of Medical Sciences, Ilam, Iran
[6]Infertility and Reproductive Health Research Center, Health Research Institute, Babol University of Medical sciences, Babol, Iran
[7]Department of Community Nutrition, Faculty of Nutrition and Food Technology, National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Introduction

Breast cancer (BrC) is the most common cancer in women all over the world [1]. While certain risk factors for BrC, including genetics, age, and reproductive history, are considered non-modifiable, several factors, such as alcohol consumption, smoking, body mass index (BMI), and dietary habits, are known to be potentially modifiable targets for BrC prevention [2]. The prevalence of this cancer in Iranian women is estimated to be 23.6% [3].

Lifestyle modifications, particularly dietary modifications, are estimated to decrease morbidity and mortality related to BrC by one-third [4]. However, results from epidemiological studies investigating the association between individual nutrients, foods, and the risk of BrC are inconsistent [5, 6]. These inconsistencies may be explained by the complex interactions between various food components [7, 8]. Therefore, to address this issue, rather than focusing on the effects of individual nutrients or food items, dietary patterns are defined and applied to capture the interactions and combined effects of dietary components [9].

Research has shown that several dietary patterns, such as the Mediterranean [10] and Dietary Approaches to Stop Hypertension (DASH) [11] diets, are protective against BrC, while the Western dietary pattern [12] increases its risk. Additionally, the lower prevalence of BrC among the Asian population, who have a higher intake of plant-based foods compared to women from Western countries, suggests the potential role of a vegetarian diet in BrC prevention [13].

Previous methods used to investigate the impact of plant-based diets on BrC did not consider the different nutritional values and quality of plant foods [14]. To assess the quality of plant-based diets, Satija et al. suggested using a general plant-based diet index (PDI), healthful PDI (hPDI), and unhealthy PDI (uPDI) scoring approach [15]. Plant-based diets are characterized by the occasional consumption of animal-based foods and the consumption of mostly plant-based foods [16]. The Middle Eastern diet, specifically in Iran, is mostly plant-based. However, a significant portion of an individual's daily energy comes from refined grains such as bread and white rice [17]. Therefore, this population presents a valuable opportunity to differentiate the effects of unhealthy and healthy plant-based diets on the risk of BrC. Previous studies examining the relationship between the effects of plant-based diets and BrC have provided conflicting evidence in Iranian women [18–20]. To address these inconsistencies, the present study aimed to investigate the relationship between PDI, hPDI, and uPDI with the odds of BrC in Iranian women.

Methods

Study design

The current case-control study was conducted on Iranian women with BrC. The participants, aged between 30 and 65 years, were selected from two general hospitals in Tehran (Imam Hossein and Shohadaye Tajrish hospitals). The case group consisted of women who had been diagnosed with BrC within the past six months histologically. The control group comprised women with non-neoplastic diseases who were also from the same hospitals. Two controls were randomly selected for each case from a single medical center. The sample size of the study was determined based on previous research (odds ratio (OR) = 0.47, confidence interval (CI) = 0.24–0.94, power $\beta = 0.20$, and $\alpha = 0.05$) [21].

The current study's participation rate was 92%. Participants who did not complete more than

50 items of the food frequency questionnaire (FFQ) and those with an energy intake lower or higher than the mean ± three standard deviations (SD) were excluded [22]. As a result, 265 controls and 133 cases were included in the final analysis. All individuals provided written informed consent. The present study was approved by Shahid Beheshti University of Medical Sciences (Research Institute of Nutrition and Food Sciences).

Dietary assessment and measurements

A reliable and valid 168-item FFQ was applied to evaluate participants' dietary intake [23]. Their consumption was converted to daily frequency, and using the household measures handbook, these intake frequencies were then translated into grams per day [24]. The United States Department of Agriculture (USDA) food composition table was utilized to calculate the foods' nutrients and energy.

Three models of plant-based diets, including uPDI, hPDI, and PDI, were categorized into eighteen food groups based on similarities in nutrient composition [25–27]. All foods were divided into three main classes: animal foods (various animal-based foods, meat, fish/seafood, dairy, eggs, and animal fat), unhealthy plant foods (sugar-sweetened beverages, sweets/desserts, fruit juices, refined grains, and potatoes), and healthy plant foods (fruits, nuts, tea/coffee, vegetables, legumes, vegetable oils, and whole grains). In hPDI and PDI, the maximum intake of healthy plant foods and total plant foods received a score of 10, while the minimum intake received a score of 1. In uPDI, the lowest and highest intakes of unhealthy plant foods scored 1 and 10, respectively. The total score of each index was between 18 and 180 [26–29]. A higher score in each index indicated greater adherence to the dietary pattern. The details of food items and index scores are shown in Supplementary Table 1.

Socio-demographic and anthropometric assessments

Trained dietitians conducted all measurements and questionnaires during a single interview. A validated questionnaire was utilized to assess physical activity, with results reported in terms of metabolic equivalent of task (MET)-hours per day (MET-h/d) [30]. A non-stretchable tape measure fixed to a wall was used to measure participants' height with an accuracy of 0.5 cm. Participants' weight was measured using a digital scale with an accuracy of 0.1 kg while they were dressed in minimal clothing and without shoes. BMI was calculated by dividing weight (kg) by the square of height (m^2). We also used a checklist to collect participants' clinical information, lifestyle details, and socio-demographic-economic factors. This included family history of cancer (yes/no), nighttime bra wearing (yes/no), duration of breastfeeding (in months), age at marriage (in years), age (in years), age at first pregnancy (in years), smoking history (yes/no), menopausal status (pre-menopause or post-menopause), and whether they take supplements or medications (yes/no).

Table 1 The baseline characteristics of the study participants

Variables	Cases (133)	Controls (265)	*P*-value
Age (years) ^	49.5 ± 10.7	47.1 ± 10.1	**0.030**
Marriage age (years) &	19.0 (6.00)	18.0 (5.0)	0.413
Age at first pregnancy (years) &	20.0 (8.0)	20.0 (5.0)	0.053
Breastfeeding time (months) &	36.0 (48.0)	48.0 (48.0)	0.109
Physical activity (MET-h/day) &	32.0 (6.2)	31.7 (6.0)	0.700
BMI (kg/m^2) &	29.6 (7.6)	28.9 (6.2)	0.129
Energy (kcal/day) &	2396.2 (873.9)	2541.5 (1053.4)	0.072
Fiber (g/day) &	33.5 (17.8)	35.3 (22.6)	0.175
PDI score &	97.0 (21.0)	98.0 (20.5)	0.167
hPDI score &	94.0 (20.5)	98.0 (19.0)	**0.012**
uPDI score &	101.0 (21.5)	98.0 (18.0)	0.056
Smoking, % *	3.0	3.4	0.999
Yes	97.0	96.6	
No			
Education, % *	10.1	8.7	0.252
Illiterate	41.8	50.8	
Less than diploma	48.1	40.5	
Diploma and higher			
Menopausal status, % *	45.9	57.0	0.085
Pre-menopause	54.1	43.0	
Post-menopause			
Family history of cancer, yes, % *	30.1	20.8	**0.047**
Wearing bra at night, yes, % *	78.9	71.2	0.116
Vitamin D supplements, yes, % *	15.0	24.2	**0.037**
Multivitamin/mineral supplements, yes, % *	6.0	6.8	0.833
Zinc supplements, yes, % *	0.8	1.9	0.668
Iron supplements, yes, % *	14.3	16.7	0.565
Calcium supplements, yes, % *	26.3	27.4	0.905
Omega-3 supplements, yes, % *	6.0	11.7	0.076
Herbal drugs, yes, % *	18.8	26.9	0.083

MET: metabolic equivalent of task, BMI: body mass index, PDI: plant-based diet index, hPDI: healthy plant-based diet index, uPDI: unhealthy plant-based diet index

^ Using independent samples T-test for normal continuous variables

& Using Mann-Whitney U test for abnormal continuous variables

* Using chi-square test for categorical variables.

-Values are mean ± SD or median (IQR) for continuous and percentage for categorical variables.

Statistical analysis

For statistical analysis, SPSS (version 26.0) was utilized. To determine the normal distribution of variables, the Kolmogorov-Smirnov test was applied. The level of significance was a p-value of less than 0.05. In the present study, the independent samples T-test and chi-square test were used for parametric continuous and categorical variables, respectively. The Mann-Whitney U test was used for non-parametrically distributed continuous variables. The relationship between PDIs and BrC, as well as the relationship between PDIs and BrC by menopausal status and BMI, was evaluated using logistic regression in two crude and adjusted models (adjusted for age (years), BMI (kg/m^2), family history of cancer (yes/no), energy intake (kcal/day), fiber intake (g/day), menopausal status (pre-/postmenopausal), vitamin D supplement (yes/no), physical activity (MET-h/day), and smoking (yes/no)). Covariates were selected based on previous studies on BrC that identified contributing factors to the condition [31–33].

Results

The baseline characteristics of the current study illustrated that the mean age of cases was higher than that of the controls ($P = 0.030$). However, the hPDI score of the control group was higher than that of the cases ($P = 0.012$). There was a significant difference between the control and case groups in terms of family history of cancer ($P = 0.047$) and taking vitamin D supplements ($P = 0.037$) (Table 1).

The relationship between PDIs and BrC is presented in Table 2. In model 1 of the hPDI, the odds of developing BrC in the second and last tertiles were lower than those in the first tertile (T) (T_2: OR = 0.591; 95% CI: 0.360–0.970; $P = 0.037$– T_3: OR = 0.523; 95% CI: 0.310–0.884; $P = 0.015$). After adjusting for age (years), BMI (kg/m^2), family history of cancer (yes/no), energy intake (kcal/day), fiber intake (g/day), menopausal status (pre-/postmenopausal), vitamin D supplement (yes/no), physical activity (MET-h/day), and smoking (yes/no), this relationship remained significant in the last tertile (OR = 0.495; 95% CI: 0.274–0.891; $P = 0.019$).

Table 3 shows the relationship between PDIs and BrC based on menopausal status. In postmenopausal women, lower odds of BrC were observed in the second

Table 2 Association between plant-based diet indices and breast cancer

Tertiles of Indices	Case / Control	Model 1			Model 2		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
PDI							
T_1 (≤ 91)	51/86	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	44/87	0.853	0.517–1.408	0.534	1.008	0.534–1.902	0.981
T_3 (≥ 106)	38/92	0.697	0.417–1.163	0.167	1.048	0.578–1.899	0.878
hPDI							
T_1 (≤ 91)	58/80	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	42/98	**0.591**	**0.360–0.970**	**0.037**	0.640	0.373–1.099	0.106
T_3 (≥ 106)	33/87	**0.523**	**0.310–0.884**	**0.015**	**0.495**	**0.274–0.891**	**0.019**
uPDI							
T_1 (≤ 94)	42/98	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (95–105)	36/88	0.955	0.562–1.622	0.863	0.890	0.501–1.580	0.691
T_3 (≥ 106)	55/79	1.624	0.986–2.676	0.057	1.432	0.794–2.583	0.232

PDI: plant-based diet index, hPDI: healthy plant-based diet index, uPDI: unhealthy plant-based diet index, T: tertile, OR: odds ratio, CI: confidence interval, Ref: reference

Model 1: crude model. Model 2: adjusted for age (years), BMI (kg/m^2), family history of cancer (yes/no), energy intake (kcal/day), fiber intake (g/day), menopausal status (pre-/postmenopausal), vitamin D supplement (yes/no), physical activity (MET-h/day), and smoking (yes/no)

Table 3 Association between plant-based diet indices and breast cancer by menopausal status

Tertiles of Indices	Case / Control	Model 1			Model 2		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
Premenopausal							
PDI							
T_1 (≤ 91)	26/48	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	21/55	0.705	0.352–1.410	0.323	0.787	0.367–1.686	0.537
T_3 (≥ 106)	14/49	0.527	0.246–1.130	0.100	0.843	0.327–2.171	0.723
hPDI							
T_1 (≤ 91)	24/49	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	25/61	0.837	0.426–1.643	0.605	0.858	0.411–1.790	0.858
T_3 (≥ 106)	12/42	0.583	0.260–1.306	0.190	0.660	0.272–1.607	0.660
uPDI							
T_1 (≤ 94)	16/56	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (95–105)	20/57	1.228	0.578–2.610	0.593	1.092	0.479–2.491	0.834
T_3 (≥ 106)	25/39	**2.244**	**1.061–4.744**	**0.034**	**2.546**	**1.051–6.167**	**0.038**
Postmenopausal							
PDI							
T_1 (≤ 91)	25/38	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	23/32	1.092	0.523–2.281	0.814	1.492	0.640–3.477	0.354
T_3 (≥ 106)	24/43	0.848	0.417–1.726	0.650	1.132	0.452–2.840	0.791
hPDI							
T_1 (≤ 91)	34/31	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	17/37	**0.419**	**0.197–0.889**	**0.023**	**0.342**	**0.141–0.828**	**0.017**
T_3 (≥ 106)	21/45	**0.425**	**0.209–0.866**	**0.018**	**0.262**	**0.107–0.639**	**0.003**
uPDI							
T_1 (≤ 94)	26/42	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (95–105)	16/31	0.834	0.383–1.813	0.646	0.778	0.328–1.847	0.569
T_3 (≥ 106)	30/40	1.212	0.613–2.393	0.581	0.870	0.364–2.081	0.755

PDI: plant-based diet index, hPDI: healthy plant-based diet index, uPDI: unhealthy plant-based diet index, T: tertile, OR: odds ratio, CI: confidence interval, Ref: reference.

Model 1: crude model. Model 2: adjusted for age (years), BMI (kg/m^2), family history of cancer (yes/no), energy intake (kcal/day), fiber intake (g/day), vitamin D supplement (yes/no), physical activity (MET-h/day), and smoking (yes/no)

Table 4 Association between plant-based diet indices and breast cancer by BMI category

Tertiles of Indices	Case / Control	Model 1			Model 2		
		OR	95% CI	*P*-value	OR	95% CI	*P*-value
BMI less than 25 kg/m^2							
PDI							
T_1 (≤ 91)	8/13	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	11/28	0.638	0.208–1.963	0.434	0.461	0.130–1.641	0.232
T_3 (≥ 106)	4/21	0.310	0.077–1.237	0.097	0.179	0.025–1.269	0.085
hPDI							
T_1 (≤ 91)	13/19	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	8/23	0.508	0.174–1.482	0.215	0.504	0.149–1.706	0.271
T_3 (≥ 106)	2/20	**0.146**	**0.029–0.735**	**0.020**	**0.113**	**0.017–0.760**	**0.025**
uPDI							
T_1 (≤ 94)	4/24	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (95–105)	12/24	3.000	0.847–10.631	0.089	3.960	0.888–17.665	0.071
T_3 (≥ 106)	7/14	3.000	0.744–12.094	0.122	4.762	0.873–25.965	0.071
BMI more than 25 kg/m^2							
PDI							
T_1 (≤ 91)	43/73	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	33/58	0.966	0.546–1.708	0.905	1.181	0.636–2.195	0.598
T_3 (≥ 106)	34/70	0.825	0.473–1.439	0.497	1.216	0.618–2.395	0.571
hPDI							
T_1 (≤ 91)	45/61	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (92–105)	34/75	0.615	0.351–1.075	0.088	0.719	0.394–1.313	0.283
T_3 (≥ 106)	31/65	0.646	0.364–1.150	0.138	0.571	0.304–1.074	0.082
uPDI							
T_1 (≤ 94)	38/74	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_2 (95–105)	24/64	0.730	0.396–1.345	0.313	0.953	0.341–1.250	0.198
T_3 (≥ 106)	48/63	1.484	0.863–2.552	0.154	1.240	0.657–2.340	0.507

PDI: plant-based diet index, hPDI: healthy plant-based diet index, uPDI: unhealthy plant-based diet index, T: tertile, OR: odds ratio, CI: confidence interval, Ref: reference,, BMI: body mass index.

Model 1: crude model. Model 2: adjusted for age (years), family history of cancer (yes/no), energy intake (kcal/day), fiber intake (g/day), menopausal status (pre-/postmenopausal), vitamin D supplement (yes/no), physical activity (MET-h/day), and smoking (yes/no)

and last tertiles of hPDI in comparison to the first tertile in the crude model (T_2: OR = 0.419; 95% CI: 0.197–0.889; P = 0.023– T_3: OR = 0.425; 95% CI: 0.209–0.866; P = 0.018). After adjusting for the role of some potential confounders, the association remained significant between hPDI and BrC risk in postmenopausal women (T_2: OR = 0.342; 95% CI: 0.141–0.828; P = 0.017– T_3: OR = 0.262; 95% CI: 0.107–0.639; P = 0.003). Furthermore, in premenopausal women in the highest tertile of uPDI, the odds of BrC were increased compared to the lowest tertile (OR = 2.244; 95% CI: 1.061–4.744; P = 0.034) in the crude model. This association remained significant after adjusting for potential confounders (OR = 2.546; 95% CI: 1.051–6.167; P = 0.038). No significant relationship was observed in other indices in post- and premenopausal women in the adjusted models.

Table 4 shows the relationship between PDIs and BrC based on BMI category. In individuals with a BMI ofless than 25 kg/m^2, lower odds of BrC were found in the highest tertile of hPDI in comparison to the lowest tertile in both crude and adjusted models (crude model: OR = 0.146; 95% CI: 0.029–0.736; P = 0.020– adjusted model: OR = 0.113; 95% CI: 0.017–0.760; P = 0.025). No significant relationship was observed in other indices in both groups.

Discussion

In the present case-control research, we found a significant inverse relationship between hPDI and the risk of BrC. However, no significant association was observed between PDI and uPDI with the risk of BrC. Furthermore, the analysis based on menopause status revealed an inverse relationship between hPDI and BrC risk in postmenopausal women, while a direct relationship was observed between uPDI and BrC risk in premenopausal women.

The hypotheses concerning the main environmental factors that promote carcinogenesis emphasize lifestyle choices, especially diet. Individuals in developed countries usually consume diets that are energy-dense and high in fat and animal products, while their intake of vegetables, fruits, and fiber is lower. In contrast, people living in countries with low BrC incidence and mortality, such as those in Asia and Africa, tend to have different dietary patterns [34].

In the current study, a higher hPDI, which is a measure of following a high-quality plant-based diet, was related to lower odds of BrC. Similar results were also reported in Sasanfar et al.'s study [20]. In addition, Rigi et al.'s study showed a negative relationship between hPDI and the risk of BrC in a case-control design [19]. Moreover, the results of other studies showed an inverse relationship between hPDI and BrC risk [35, 36]. In contrast to our findings, a hospital-based case-control study conducted by Payandeh et al. did not show a significant relationship between hPDI and BrC [18]. The hPDI emphasizes the consumption of nutritious plant foods, such as vegetables, fruits, and whole grains, which are linked to better health outcomes [15]. The findings of a systematic review on dietary patterns and the risk of BrC revealed that dietary patterns emphasizing higher intake of legumes, whole grains, vegetables, and fruits were inversely related to the risk of BrC [37]. Observational studies have shown that a prudent diet, which includes high poultry, low-fat dairy, fruits, fish, whole grains, and vegetables, is related to an 18% reduction in BrC risk [12]. These diets are rich in fiber, phytochemicals, antioxidants, and vitamins E and C while being low in total and saturated fat and cholesterol [38]. These nutrients may have antioxidant, anti-inflammatory, and deoxyribonucleic acid (DNA) protective effects, improving cell signaling, cycle regulation, and angiogenesis related to cancer initiation [39]. Additionally, the high fiber content of these diets may reduce gastrointestinal transit time and the contact of carcinogens with the colonic mucosa while increasing short-chain fatty acid production [40].

The findings of the current study did not reveal a significant association between PDI and uPDI with BrC in Iranian women. Previous studies examining this relationship have reported inconsistent findings [18–20]. Consistent with our results, a case-control study by Payandeh et al. involving Iranian women found no significant association between PDI and uPDI with the risk of BrC [18]. Similarly, another case-control study among Iranian women did not show a significant relationship between PDI and uPDI with BrC odds [20]. The results obtained from the prospective NutriNet-santé cohort showed no significant link between a pro-plant-based dietary score and the risk of BrC [40]. Moreover, results obtained from a large prospective study (more than 90% of the study population were premenopausal women) did not show a significant linear association between greater adherence to pro-vegetarian diets (PVG), including diets emphasizing plants and some animal products, and BrC incidence [41]. Conversely, a population-based case-control study by Rigi et al. identified a significant inverse relationship between PDI and uPDI with the risk of BrC [19]. The lack of a relationship between uPDI and the risk of BrC can be attributed to the fact that the consumption of refined grains such as bread, white rice, potatoes, and sweets, which are considered as unhealthy plant-based foods, is the primary source of energy in the Iranian population. This might reduce the chance of detecting an existing inverse relationship between uPDI and BrC [17, 42]. Plant-based diets can enhance glycemic control and insulin resistance, which are linked to estrogen receptor (ER)-negative BrC [15]. However, in recent years, despite the increase in ER-positive BrC, the incidence of ER-negative BrC has decreased [37]. This might explain why studies often fail to detect the relationship between plant-based diets and BrC without considering tumor type. Therefore, due to the important role of estrogen in BrC, the type of tumors (ER-negative or -positive), consumption of estrogen-containing contraceptives, and hormone therapy need to be considered in future studies. As hormonal factors greatly affect BrC, the detection of the effects of dietary factors might be challenging.

In the present study, we observed a protective effect of hPDI on BrC in postmenopausal women. Additionally, a direct relationship between uPDI and BC risk was found in premenopausal women. The results of a prospective cohort study showed that there is an inverse relationship between hPDI and the risk of BrC in postmenopausal women [35]. Also, a case-control study conducted by Rigi et al. showed an inverse relationship between hPDI and BrC risk only in Iranian postmenopausal women. However, their study did not show a significant relationship between uPDI and BrC risk in premenopausal women [19]. Moreover, the findings of the study by Sasanfar et al. indicated the inverse relationship between hPDI and the odds of BrC in postmenopausal women and the lack of relationship between uPDI and the risk of BrC in premenopausal women [20]. Shah et al. discovered that participants in the highest quintile of the hPDI had a 15% lower risk of developing ER-positive BrC compared to those in the lowest quintile. Similarly, greater adherence to the uPDI was associated with a 20% increased odds of ER-positive BrC [36]. Therefore, hormone receptor status is a crucial prognostic and diagnostic characteristic of breast tumors and should be carefully considered.

The findings of this study revealed an inverse relationship between hPDI and the risk of BrC in individuals with a BMI of less than 25. However, based on BMI classification, no relationship between other indicators and BrC risk was observed for individuals with a BMI of less than 25 or greater than 25. Limited studies have examined the relationship between these indices, based on BMI, and the risk of BrC. In the study conducted by Payandeh et al., no relationship was observed between any of the PDIs and the risk of BrC in individuals with a BMI of less than or greater than 25 [18]. Adhering to a plant-based diet, particularly one that is abundant in nutritious plant foods, is associated with reduced body fat, improved weight management, and a lower risk of obesity [43]. BMI is one of the modifiable risk factors associated with BrC risk [44]. The potential inverse relationship between hPDI and BMI in women with BrC may be partly due to a higher intake of beneficial components found in plant-based foods. This suggests that a healthful plant-based diet offers improved diet quality compared to an unhealthy plant-based diet [45]. The primary sources of vegetable proteins include nuts, legumes, soybeans, vegetables, and fruits, all of which provide antioxidants and fiber. Additionally, nuts are a significant source of polyunsaturated fatty acids. Furthermore, tea and coffee are excellent sources of antioxidants [46, 47]. As a result, healthy plant-based diets can contribute to reducing the risk of BrC by lowering BMI and providing beneficial substances with cancer-preventive properties.

This study has several strengths and limitations. Subgroup analysis based on the menopausal status of women and BMI is one of the strengths of this research. Considering the quality of plant-based diets and including diets with limited consumption of animal foods rather than vegetarian diets in which animal foods are completely eliminated is more practical to differentiate between plant-based foods and those who preferentially consume more plant-based foods and fewer animal-based foods but are not vegetarian. Due to self-reporting in completing the FFQ, the study is prone to recall bias. However, to minimize this limitation, a valid questionnaire with high validity and repeatability was used in the Iranian population. Also, the hospital-based design was one of the main limitations of the current study. Moreover, this study did not consider the hormone receptor status of patients' tumors. In addition, the small sample size can be mentioned as another limitation of the current research. Finally, even though we considered various confounding factors, due to the observational nature of the study, the effects of residual confounding factors could not be entirely excluded.

Conclusions

Overall, we did not find any significant relationship between PDIs and the risk of BrC, except for hPDI. However, adhering to a healthy plant-based dietary pattern, which includes vegetables, fruits, whole grains, nuts, and legumes, seems to be beneficial for preventing BrC in postmenopausal women. Additionally, we found a significant association between uPDI and BrC odds in premenopausal women. It is recommended that future prospective cohort studies take into account the type of BrC and menopausal status to further support these findings.

Abbreviations

BrC	Breast cancer
PDI	Plant-based diet index
hPDI	Healthful plant-based diet index
uPDI	Unhealthy plant-based diet index
OR	Odds ratio
CI	Confidence interval
T	Tertile
BMI	Body mass index
DASH	Dietary approaches to stop hypertension
FFQ	Food frequency questionnaire
SD	Standard deviation
USDA	United States department of agriculture
MET	Metabolic equivalent of task
PVG	Pro-vegetarian diets
ER	Estrogen receptor
DNA	Deoxyribonucleic acid

Acknowledgements

We sincerely thank all field investigators, staff, and participants of the present study.

Author contributions

F.S, F.M, F.J, R.S and S.P; Contributed to writing the first draft. M.N, Z.S and B.R; Contributed to all data and statistical analysis and interpretation of data. M.N and B.R.; Contributed to the research concept, supervised the work, and revised the manuscript. All authors read and approved the final manuscript.

Funding

Not applicable.

Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the ethical standards of the Declaration of Helsinki and was approved by the Research Institute of Nutrition and Food Sciences of Shahid Beheshti University of Medical Sciences. All participants read and signed the informed consent form.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 18 April 2024 / Accepted: 11 April 2025
Published online: 19 April 2025

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, Bray F. Global Cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2021;71(3):209–49.
2. Diet nutrition. physical activity and breast cancer- revised 2018 [https://www.wcrf.org/wp-content/uploads/2021/02/Breast-cancer-report.pdf]
3. Kazeminia M, Salari N, Hosseinian-Far A, Akbari H, Bazrafshan M-R, Mohammadi M. The prevalence of breast cancer in Iranian women: a systematic review and meta-analysis. Indian J Gynecologic Oncol. 2022;20(1):14.
4. Clinton SK, Giovannucci EL, Hursting SD. The world Cancer research fund/american Institute for Cancer research third expert report on diet, nutrition, physical activity, and cancer: impact and future directions. J Nutr. 2020;150(4):663–71.
5. Fraser GE, Jaceldo-Siegl K, Orlich M, Mashchak A, Sirirat R, Knutsen S. Dairy, soy, and risk of breast cancer: those confounded milks. Int J Epidemiol. 2020;49(5):1526–37.

6. Seiler A, Chen MA, Brown RL, Fagundes CP. Obesity, dietary factors, nutrition, and breast cancer risk. Curr Breast cancer Rep. 2018;10:14–27.
7. Wiseman M. The second world cancer research fund/american Institute for cancer research expert report. Food, nutrition, physical activity, and the prevention of cancer: a global perspective: nutrition society and BAPEN medical symposium on 'nutrition support in cancer therapy'. Proc Nutr Soc. 2008;67(3):253–6.
8. Willett W. Diet and breast cancer. J Intern Med. 2001;249(5):395–411.
9. Sicahni PH, Makhtoomi M, Leilami K, Shateri Z, Mohammadi F, Nouri M, Omidbeigi N, Mehrabani S, Rashidkhani B. Dietary and lifestyle indices for hyperinsulinemia and colorectal cancer risk: a case-control study. BMC Gastroenterol. 2023;23(1):434.
10. van den Brandt PA, Schulpen M. Mediterranean diet adherence and risk of postmenopausal breast cancer: results of a cohort study and meta-analysis. Int J Cancer. 2017;140(10):2220–31.
11. Soltani S, Benisi-Kohansal S, Azadbakht L, Esmaillzadeh A. Association between adherence to dietary approaches to stop hypertension eating plan and breast Cancer. Nutr Cancer. 2021;73(3):433–41.
12. Xiao Y, Xia J, Li L, Ke Y, Cheng J, Xie Y, Chu W, Cheung P, Kim JH, Colditz GA, et al. Associations between dietary patterns and the risk of breast cancer: a systematic review and meta-analysis of observational studies. Breast Cancer Res. 2019;21(1):16.
13. Travis RC, Allen NE, Appleby PN, Spencer EA, Roddam AW, Key TJ. A prospective study of vegetarianism and isoflavone intake in relation to breast cancer risk in British women. Int J Cancer. 2008;122(3):705–10.
14. Martínez-González MA, Sánchez-Tainta A, Corella D, Salas-Salvadó J, Ros E, Arós F, Gómez-Gracia E, Fiol M, Lamuela-Raventós RM, Schröder H, et al. A provegetarian food pattern and reduction in total mortality in the prevención Con Dieta mediterránea (PREDIMED) study. Am J Clin Nutr. 2014;100(Suppl 1):s320–8.
15. Satija A, Bhupathiraju SN, Spiegelman D, Chiuve SE, Manson JE, Willett W, Rexrode KM, Rimm EB, Hu FB. Healthful and unhealthful Plant-Based diets and the risk of coronary heart disease in U.S. Adults. J Am Coll Cardiol. 2017;70(4):411–22.
16. Pieters M, Swanepoel AC. The effect of plant-based diets on thrombotic risk factors. Pol Arch Intern Med. 2021;131:16123.
17. Sasanfar B, Toorang F, Maleki F, Esmaillzadeh A, Zendehdel K. Association between dietary total antioxidant capacity and breast cancer: a case-control study in a middle Eastern country. Public Health Nutr. 2021;24(5):965–72.
18. Payandeh N, Shahinfar H, Amini MR, Jafari A, Safabakhsh M, Imani H, Shab-Bidar S. The lack of association between plant-based dietary pattern and breast cancer: A hospital-based case-control study. Clin Nutr Res. 2021;10(2):115.
19. Rigi S, Mousavi SM, Benisi-Kohansal S, Azadbakht L, Esmaillzadeh A. The association between plant-based dietary patterns and risk of breast cancer: A case–control study. Sci Rep. 2021;11(1):3391.
20. Sasanfar B, Toorang F, Booyani Z, Vassalami F, Mohebbi E, Azadbakht L, Zendehdel K. Adherence to plant-based dietary pattern and risk of breast cancer among Iranian women. Eur J Clin Nutr. 2021;75(11):1578–87.
21. Ching S, Ingram D, Hahnel R, Beilby J, Rossi E. Serum levels of micronutrients, antioxidants and total antioxidant status predict risk of breast cancer in a case control study. J Nutr. 2002;132(2):303–6.
22. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake:basal metabolic rate. A practical guide to its calculation, use and limitations. Int J Obes Relat Metab Disord. 2000;24(9):1119–30.
23. Asghari G, Rezazadeh A, Hosseini-Esfahani F, Mehrabi Y, Mirmiran P, Azizi F. Reliability, comparative validity and stability of dietary patterns derived from an FFQ in the Tehran lipid and glucose study. Br J Nutr. 2012;108(6):1109–17.
24. Ghaffarpour M, Houshiar-Rad A, Kianfar H. The manual for household measures, cooking yields factors and edible portion of foods. Tehran: Nashre Olume Keshavarzy. 1999;7(213):42–58.
25. Satija A, Bhupathiraju SN, Rimm EB, Spiegelman D, Chiuve SE, Borgi L, Willett WC, Manson JE, Sun Q, Hu FB. Plant-based dietary patterns and incidence of type 2 diabetes in US men and women: results from three prospective cohort studies. PLoS Med. 2016;13(6):e1002039.
26. Jafari F, Amini Kahrizsangi M, Najam W, Fattahi MR, Nouri M, Ghalandari H, Askarpour M, Hamidian Shirazi M, Akbarzadeh M. Association of plant-based dietary patterns with metabolic syndrome: baseline results from the Persian Kavar cohort study (PKCS). Int J Food Sci Nutr 2023:1–11.
27. Lotfi M, Nouri M, Turki Jalil A, Rezaianzadeh A, Babajafari S, Ghoddusi Johari M, Faghih S. Plant-based diets could ameliorate the risk factors of cardiovascular diseases in adults with chronic diseases. Food Sci Nutr. 2023;11(3):1297–308.
28. Zamani B, Daneshzad E, Siassi F, Guilani B, Bellissimo N, Azadbakht L. Association of plant-based dietary patterns with psychological profile and obesity in Iranian women. Clin Nutr. 2020;39(6):1799–808.
29. Borazjani M, Nouri M, Venkatakrishnane K, Najafi M, Faghih S. Association of plant-based diets with lipid profile and anthropometric indices: a cross-sectional study. Nutr Food Sci. 2022;52(5):830–42.
30. Aadahl M, Jørgensen T. Validation of a new self-report instrument for measuring physical activity. Med Sci Sports Exerc. 2003;35(7):1196–202.
31. Gronwald J, Byrski T, Huzarski T, Cybulski C, Sun P, Tulman A, Narod SA, Lubinski J. Influence of selected lifestyle factors on breast and ovarian cancer risk in BRCA1 mutation carriers from Poland. Breast Cancer Res Treat. 2006;95:105–9.
32. Easton DF, Ford D, Bishop DT. Breast and ovarian cancer incidence in BRCA1-mutation carriers. Breast Cancer linkage consortium. Am J Hum Genet. 1995;56(1):265.
33. Kotsopoulos J, Lubinski J, Lynch HT, Neuhausen SL, Ghadirian P, Isaacs C, Weber B, Kim-Sing C, Foulkes WD, Gershoni-Baruch R. Age at menarche and the risk of breast cancer in BRCA1 and BRCA2 mutation carriers. Cancer Causes Control. 2005;16:667–74.
34. Pierce JP, Faerber S, Wright FA, Rock CL, Newman V, Flatt SW, Kealey S, Jones VE, Caan BJ, Gold EB. A randomized trial of the effect of a plant-based dietary pattern on additional breast cancer events and survival:: the women's healthy eating and living (WHEL) study. Control Clin Trials. 2002;23(6):728–56.
35. Romanos-Nanclares A, Willett WC, Rosner BA, Collins LC, Hu FB, Toledo E, Eliassen AH. Healthful and unhealthful plant-based diets and risk of breast cancer in US women: results from the nurses' health studies. Cancer Epidemiol Biomarkers Prev. 2021;30(10):1921–31.
36. Shah S, Mahamat-Saleh Y, Ait-Hadad W, Koemel NA, Varraso R, Boutron-Ruault M-C, Laouali N. Long-term adherence to healthful and unhealthful plant-based diets and breast cancer risk overall and by hormone receptor and histologic subtypes among postmenopausal females. Am J Clin Nutr. 2023;117(3):467–76.
37. Dandamudi A, Tommie J, Nommsen-Rivers L, Couch S. Dietary patterns and breast Cancer risk: A systematic review. Anticancer Res. 2018;38(6):3209–22.
38. McEvoy CT, Temple N, Woodside JV. Vegetarian diets, low-meat diets and health: a review. Public Health Nutr. 2012;15(12):2287–94.
39. Fantini M, Benvenuto M, Masuelli L, Frajese GV, Tresoldi I, Modesti A, Bei R. In vitro and in vivo antitumoral effects of combinations of polyphenols, or polyphenols and anticancer drugs: perspectives on cancer treatment. Int J Mol Sci. 2015;16(5):9236–82.
40. Grosso G, Buscemi S, Galvano F, Mistretta A, Marventano S, La Vela V, Drago F, Gangi S, Basile F, Biondi A. Mediterranean diet and cancer: epidemiological evidence and mechanism of selected aspects. BMC Surg. 2013;13(Suppl 2):S14.
41. Romanos-Nanclares A, Toledo E, Sánchez-Bayona R, Sánchez-Quesada C, Martínez-González M, Gea A. Healthful and unhealthful provegetarian food patterns and the incidence of breast cancer: results from a mediterranean cohort. Nutrition. 2020;79–80:110884.
42. Esmaillzadeh A, Azadbakht L. Food intake patterns May explain the high prevalence of cardiovascular risk factors among Iranian women. J Nutr. 2008;138(8):1469–75.
43. Jarvis SE, Nguyen M, Malik VS. Association between adherence to plant-based dietary patterns and obesity risk: a systematic review of prospective cohort studies. Appl Physiol Nutr Metab. 2022;47(12):1115–33.
44. Iyengar NM, Arthur R, Manson JE, Chlebowski RT, Kroenke CH, Peterson L, Cheng T-YD, Feliciano EC, Lane D, Luo J. Association of body fat and risk of breast cancer in postmenopausal women with normal body mass index: a secondary analysis of a randomized clinical trial and observational study. JAMA Oncol. 2019;5(2):155–63.
45. D'Angelo A, Vitale S, Palumbo E, Augustin LS. Healthy and unhealthy Plant-Based diets and body weight in breast Cancer survivors: A narrative review. Epidemiol Biostatistics Public Health 2023, 18(2).
46. Thompson AS, Tresserra-Rimbau A, Karavasiloglou N, Jennings A, Cantwell M, Hill C, Perez-Cornago A, Bondonno NP, Murphy N, Rohrmann S. Association of healthful plant-based diet adherence with risk of mortality and major chronic diseases among adults in the UK. JAMA Netw Open. 2023;6(3):e234714–234714.

47. Chen Z, Schoufour JD, Rivadeneira F, Lamballais S, Ikram MA, Franco OH, Voortman T. Plant-based diet and adiposity over time in a middle-aged and elderly population: the Rotterdam study. Epidemiology. 2019;30(2):303–10.

Publisher's note