

# Adherence to the DASH Diet and Risk of Breast Cancer

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## Research

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# Abstract

**Background:** The Dietary Approach to Stop Hypertension (DASH) eating pattern has been recommended as a healthy dietary plan by several international guidelines. However, data on the association between the DASH diet and breast cancer (BC) is limited. This study investigated the association between the DASH dietary pattern and risk of BC.

**Methods:** This is a hospital-based case-control study conducted between 2014 and 2016 in the Cancer Institute of Iran. Patients with histopathologically confirmed BC were recruited. Controls were healthy subjects who were frequency matched to cases by residential place and age ( $\pm 10$  years). A validated 168-item Food Frequency Questionnaire (FFQ) was applied to assess the dietary intake of participants. Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ). The DASH dietary pattern scores were calculated using the method introduced by Fung. Unconditional logistic regression, in which potential confounders were taken into account, was applied to determine the association between adherence to the DASH dietary pattern and odds of BC.

**Results:** The study participants comprised 477 patients with BC and 507 healthy controls. In the total population, patients with BC were slightly older (45.9 vs. 43.9 y,  $P=0.02$ ), had slightly higher BMI (21.9 vs. 20.2,  $P=0.01$ ) and were less physically active (20 vs. 27 MET h/wk,  $P<0.01$ ) than controls. In Model A, which was adjusted for age and energy intake, adherence to the DASH dietary pattern substantially reduced BC risk in the total population (OR for comparing extreme tertiles: 0.62; 95% CI 0.44-0.78;  $P_{\text{trend}}=0.004$ ). Even after controlling for more cofounders, greatest adherence to DASH diet was associated with a 34% reduction in risk of BC (OR 0.66; 95% CI 0.46, 0.94;  $P_{\text{trend}}=0.03$ ). In premenopausal women, adherence to the DASH dietary pattern was insignificantly associated with a 32% reduction in BC risk. This risk reduction was 38% in postmenopausal women, which was also not found to be significant.

**Conclusion:** Adherence to the DASH dietary pattern could be associated with an approximately 30% reduction in risk of BC. However, further studies, in particular studies with prospective design, are required to confirm this claim.

## Background

Breast cancer is the most common cancer among women worldwide. It was recognized as the fifth cause of cancer death both in low- and high-income countries. The GLOBOCAN report demonstrated that BC is increasing all over the world; around 1.38 million new cases of BC were diagnosed in 2008, increasing to 1.67 million in 2012[1-3]. Although its incidence rates are lower in most Asian countries than countries of the West, its incidence and mortality rate have risen substantially in most Asian areas [3-5].

Breast cancer is reported as the most prevalent cancer in Iran, with an ASR of 33.21 in 100,000 people [6]. Like most Asian countries, BC mortality happens in a younger age in Iran than high-income countries, with the mean age being 49.8 years in Iran [6-8]. This increases the social and economic cost of BC in these countries and emphasizes the importance of prevention and early detection of BC in this area[7]. It is clear that the first step of prevention is clarifying the associated risk factors.

Dietary factors have been mostly studied as a modifiable risk factor for BC alongside obesity (in post-menopausal women), physical inactivity, alcohol consumption and reproductive and hormonal factors [3,9]. Migration studies demonstrate that differences in dietary intake may play an important role in international variations in BC incidence [4]. However, the association between dietary habits and BC remained inconclusive in most aspects [9]. Most studies have investigated the association between individual nutrient or food intake and risk of BC with inclusive results [10]. Studies in this approach are valuable, however it is important to note that foods are eaten together and they have synergistic or antagonistic effects on each other. Therefore, dietary patterns are a more reliable approach in diet and

diseases studies [11,12]. Moreover, investigating the association between dietary patterns and risk of cancer could help in devising more comprehensible dietary guidelines.

The Dietary Approach to Stop Hypertension (DASH) diet is a dietary pattern initially recommended for management of hypertension[13] [Sacks, 1995 #14](13). It is high in fruits, vegetables, legumes and nuts which provide substantial amounts of plant proteins. It emphasizes whole grain, fruits and vegetables and minimizes the consumption of sodium, sweetened beverages and red and processed meats and recommends a medium amount of low-fat dairy [13]. Favorable effects of this diet on metabolic syndrome [14,15], diabetes [16] and cardiovascular diseases [17] have been suggested. This dietary pattern may have relevance to cancer prevention, particularly because it is highly similar to cancer prevention guidelines created by the American Cancer Society and World Cancer Research Fund [18,19]. Several studies have investigated the association between the DASH diet and different type of cancers [20-22]. However, these studies have been mostly focused on colorectal cancer [20-22]. Data on the association between this dietary pattern and risk of BC are insufficient, with inconclusive results[22]. Furthermore, these studies were mainly conducted in the USA and there are hardly any studies in low- or middle-income countries. Middle Eastern societies such as the Iranian population consume a diet high in grains and low in animal foods, which is different from both western and eastern countries [23-25]. Also, drinking alcohol and smoking, both of which are considered major risk factors of BC, are not commonplace in women of these countries [26,27]. Therefore, the effect of dietary patterns in this population could be dissimilar to other regions. Hence, this study investigated the association between the DASH diet and risk of BC in a hospital-based case-control study in Iranian women.

## Methods

**Participants:** This was a hospital-based case-control study conducted between 2014 and 2016 in the Cancer Institute of Iran, located at Imam Khomeini Hospital Complex in Tehran. Patients (n=486) with histopathologically confirmed BC were recruited. Patients were aged 19-80 years and had received a cancer diagnosis in the previous year, with no previous history of other cancers. Healthy subjects who come to visit their relatives in the same hospital and had no long-term dietary restrictions were recruited as controls. Controls (523) were frequency-matched to cases by residential place and age ( $\pm 10$ years).

**Assessment of Dietary Intake:** We used a validated 168-item Food Frequency Questionnaire (FFQ) to assess the dietary intake of participants. A detailed description of this FFQ, including its development and validity has been provided elsewhere [28]. Briefly, it was a willet FFQ including 168 questions related to intake of food items with standard portion sizes within the past 12 months. The participants were asked to recall their food intake in the preceding year through a face-to-face interview conducted by trained nutritionists. Patients with BC were asked to recall their food consumption prior to the appearance of cancer. Data was converted to daily intake, after which intake of energy and nutrients were computed using the USDA food composition table. Subjects who didn't answer to more than 70 items of the FFQ (n=25, 9 patients and 25 controls) were excluded. Further description of this study is reported elsewhere[29].

**Adherence to the DASH diet:** The DASH dietary pattern scores were calculated using the method introduced by Fung[30]. To investigate subjects' adherence to the DASH diet, we initially calculated energy-adjusted intake of food and nutrients using a residual method suggested by willet [31]. Participants were then categorized into quintiles of energy-adjusted foods and nutrients intake. The highest scores were allocated to individuals in the highest quintile of grains, vegetables, fruits, low-fat dairies, legumes and nuts. Clearly, the lowest quintiles of intake in these food groups received the lowest scores. Opposite scores were allocated to food groups or nutrients minimized in the DASH diet such as red and processed meats, sweetened beverages, sweets, and sodium intake. Finally, the total DASH score was

calculated by summing up the score of the eight components for each person. The DASH scores could therefore range from 8 to 40.

**Assessment of Breast Cancer:** Diagnosis of BC was made based on biopsy samples reviewed by an experienced pathologist. Patients with histopathologically confirmed BC (as defined by the second edition of the International Classification of Diseases for Oncology (ICDO-C50.0-C50.9). were enrolled. It should be mentioned that, only patients who had been diagnosed within one year prior to the date of the interview were recruited in the study.

**Assessment of Covariates:** Physical activity was assessed using the Global Physical Activity Questionnaire (GPAQ) which is a famous validated tool [32]. BMI was calculated using the weight and height of participants which were measured based on standard protocol. Demographic information and data on other risk factors of BC were obtained using a structured questionnaire through a face-to-face interview conducted by health bachelors.

**Statistical Analysis:** Characteristics of patients with BC and controls were compared using student's independent t test for continuous variables and chi-square test for categorical variables. Unconditional logistic regression models were used to determine the association between adherence to the DASH diet and odds of BC. In these analyses, we first controlled for age (continuous) and energy intake (continuous) in model A. In model B, additional adjustments were made for education (literate, illiterate), alcohol intake (yes or no), smoking status (yes, no), physical activity (MET h/week), family history of BC (yes, no), marital status (single, married), oral contraceptive use (yes, no), parity (number of children), fertility treatment (using drugs or other measures to increase pregnancy chances) (yes, no) and BMI (continuous). In all these analyses, the first tertile of the DASH diet score was considered as a reference and the odds ratios (ORs) and 95% CIs for BC were reported. The trend of odds ratios was examined by considering the DASH diet tertiles as a continuous variable. All statistical analyses were carried out using STATA (STATA, version 14, State Corp., College station, TX).

## Results

Study participants comprised 477 patients with BC and 507 healthy controls. Table 1 shows the distribution of patients and controls in pre-menopausal and post-menopausal subjects and overall, according to selected covariates. In the total population, patients with BC were slightly older (45.9 vs. 43.9 y,  $P=0.02$ ), had slightly higher BMI at 30 years of age (21.9 vs. 20.2,  $P=0.01$ ) and were less physically active (20 vs. 27 MET h/wk.  $P<0.01$ ) than controls. Patients were less likely to use post-menopausal hormones (2 vs. 10%,  $P=0.03$ ) or drink alcohol (6.3 vs. 2.5%,  $P<0.01$ ) than controls. A family history of BC was more common in patients overall (46 vs. 7%,  $P<0.001$ ).

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Table 1. Characteristics of the cases and controls recruited to study adherence to the DASH diet and risk of breast cancer by menopausal status <sup>1</sup>

Characteristics	Total			Pre-menopause			Post-menopause		
	Cases (n=477)	Controls (n=507)	p <sup>2</sup>	Cases (n=313)	Controls (n=308)	p <sup>2</sup>	Cases (n=156)	Controls (n=161)	p <sup>2</sup>
DASH score (mean)	23.6	24.3	0.02	24	25	0.05	24	24	0.13
Age (years)	45.9±10.3	43.9±11.2	<0.01	41.2±7.3	39.5±8.3	<0.01	55.4±8.7	53.9±9.3	0.15
BMI (kg/m <sup>2</sup> )	28.1±5.1	28.9±5.6	0.02	27.6±4.9	28.8±5.7	<0.01	29.1±5.3	30.0±5.3	0.11
BMI at age 30 (kg/m <sup>2</sup> )	21.9±8.8	20.2±11.4	0.01	21.9±8.9	20.6±11.5	0.12	21.8±8.4	20.4±10.8	0.24
Physical activity (MET h/wk.)	20.0±38.5	27.0±38.5	<0.01	20.3±25.9	28.2±37.8	<0.01	20.2±24.8	27.7±42.2	0.06
Education (literate, n, %)	416(87)	460(91)	0.08	293(94)	290(94)	0.78	116(74)	133(83)	0.07
Marital status (Married, n, %)	448(94)	479(94)	0.71	290(93)	294(96)	0.14	152(97)	159(99)	0.39
Smoking (yes, n, %)	18(3)	27(5)	0.24	10(3)	8(3)	0.66	8(5)	16(10)	0.11
Drinking Alcohol (yes, n (%))	(2.5)12	(6)31	0.01>	(3)9	(6)19	0.04	(2)3	(6)9	0.09
Family history of breast cancer (yes, n, %)	46(10)	7(1)	<0.001	30(10)	4(1)	<0.001	16(10)	3(2)	<0.01
Oral contraceptive use (yes, n, %)	227(48)	263(52)	0.18	154(49)	159(52)	0.57	69(44)	92(57)	0.02
Parity (number of children)	2.4±1.7	2.5±1.9	0.54	2.1±1.4	2.1±1.4	0.78	3.2±2.8	3.7±3.4	0.02
Hormone replacement therapy (yes, n, %)	2(0.4)	10(2)	0.03	0(0)	2(0.65)	0.15	2(1)	7(4)	0.1
Fertility treatment ((yes, n, %)	19(3.9)	30(6)	0.18	10(3)	19(6)		9(6)	9(6)	0.95

<sup>1</sup> reported figures are mean± SDs unless indicated

<sup>2</sup> obtained from independent' s t-test for continuous variables and chi-square test for categorical variables

In pre-menopausal subjects, patients with BC were slightly older (41.2 vs. 39.5 y, P<0.01) and were less physically active (20.3 vs. 28.2 MET h/wk. P<0.01) than controls. Pre-menopausal BC patients drank alcohol less frequently (9 vs. 19%, P<0.05) and were more likely to have had a history of BC in their relatives (30 vs. 4 %, P<0.001) compared to controls.

When examining the general characteristics of post-menopausal subjects, we found no difference in the prevalence of covariates except for family history of BC which was higher in patients (16 vs. 3 %, P<0.01) and oral contraceptive use

(44 vs. 57 %,  $P=0.02$ ) and number of children (3.2 vs. 3.7 n,  $P=0.02$ ) which were lower in patients compared to controls.

Intake of the DASH dietary pattern components in participants is shown in Table 2. Compared to controls, patients with BC had significantly lower intake of vegetables (309 vs. 346 g/d,  $P<0.01$ ) in the total sample. This was also observed in pre-menopausal subjects, with patients eating less vegetables than controls (305 vs. 352,  $P<0.01$ ). The energy intake of patients was slightly higher in this group (3127 vs. 2866 kcal/d,  $P=0.2$ ). Patients ate less grain than controls in post-menopausal subjects (428 vs. 470 g/d,  $P=0.03$ ).

Table 2. Dietary intake across participants in study of adherence to the DASH diet and risk of breast cancer overall and by menopausal status<sup>1</sup>

Food Group / Nutrient	Total			Pre-menopause			Post-menopause		
	Cases (n=477)	Controls (n=507)	p <sup>2</sup>	Cases (n=3013)	Controls (n=308)	p <sup>2</sup>	Cases (n=156)	Controls (n=161)	p <sup>2</sup>
Energy (kcal/d)	2965±1433	2965±1433	0.97	3127±1527	2866±1251	0.02	2633±92	2674±89	0.75
Grains (g/d)	450±207	448±207	0.05	463±214	436±223	0.12	428±170	470±173	0.03
Nuts and legumes (g/d)	56±49	60±67	0.13	54±43	62±78	0.13	59±59	57±48	0.75
Vegetables (g/d)	309±231	364±208	<0.01	305±217	352±221	<0.01	324±254	332±180	0.75
Fruits (g/d)	577±391	602±375	0.15	570±22	611±23	0.20	595±30	585±27	0.80
Low-fat dairy (g/d)	57±123	68±151	0.09	57±7	69±8	0.26	55±131	71±172	0.35
Red and processed meats (g/d)	20±23	20±22	0.36	20±21	20±25	0.83	20±28	20±14	0.78
Sweetened beverages (g/d)	100±170	90±6	0.85	100±176	90±115	0.47	103±156	87±156	0.36
Sodium (g/d)	1984±69	2115±84	0.11	1956±1313	2148±2273	0.20	1994±1731	2107±104	0.48

<sup>1</sup> reported figures are mean± SDs

<sup>2</sup> obtained from independent' s t-test

Multivariable adjusted ORs for BC across the tertiles of DASH diet score in these three groups are provided in **Table 3**. In the total study population, it was found that adherence to the DASH dietary pattern substantially reduced BC risk in model A which was adjusted for age and energy intake (OR for comparing extreme tertiles: 0.62; 95% CI 0.44-0.78;  $P_{\text{trend}}=0.004$ ). Even after additional controlling for education (literate, illiterate), smoking (yes, no), alcohol intake (yes, no), physical activity (MET h/wk.), family history of BC (yes, no), marital status (married/single), oral contraceptive use (yes, no), parity (number of children), fertility treatment (yes, no), hormone replace therapy (yes, no) and BMI ( $\text{kg}/\text{m}^2$ ), greatest adherence to the DASH diet was associated with a 34% reduction in risk of gastric cancer (OR 0.66; 95% CI 0.46, 0.94;  $P_{\text{trend}}=0.03$ ).

Table 3. Odd Ratios (ORs) and 95% Confidence Intervals (CIs) for breast cancer across tertiles of DASH score

	OR(95%CI)			P <sub>trend</sub> <sup>1</sup>
	Tertile 1	Tertile 2	Tertile 3	
Total				
No. of cases/ controls (477/507)	183/156	186/211	140/108	
Model A <sup>2</sup>	1	0.76(0.57-1.02)	0.62(0.44-0.87)	0.004
Model B <sup>3</sup>	1	0.78(0.58-1.07)	0.66(0.46-0.94)	0.03
Pre-menopause				
(No. of cases/ controls (313/308)	113/94	127/129	73/85	
Model A <sup>2</sup>	1	0.84(0.58-1.22)	0.68(0.46-1.22)	0.07
Model B <sup>3</sup>	1	0.92(0.62-1.37)	0.78(0.50-1.23)	0.29
Post-menopause				
(No. of cases/ controls (156/161)	64/51	61/69	31/41	
Model A <sup>2</sup>	1	0.69(0.42-1.2)	0.62(0.34-1.1)	0.09
Model B <sup>3</sup>	1	0.69(0.40-1.2)	0.66(0.35-1.2)	0.17

<sup>1</sup>Trend based on median value of each tertile

<sup>2</sup>Adjusted for age and energy intake

<sup>3</sup>Further adjusted for education (literate, illiterate), smoking (yes, no), alcohol intake (yes, no), physical activity (MET h/wk.), family history of breast cancer (yes, no), marital status (married/single), oral contraceptive use (yes, no), parity (number of children), fertility treatment (yes, no), hormone replace therapy (yes, no), BMI (kg/m<sup>2</sup>)

In pre-menopausal women, adherence to the DASH dietary pattern was associated with a 32% reduction in BC risk. This association was attenuated after adjusting for covariates and it was not found to be significant in either of the models. A similar trend was found in post-menopausal women. No significant association was shown in model A (OR 0.62; 95% CI 0.34, 1.1; P<sub>trend</sub>=0.09) and this did not change considerably after adjusting for different covariates.

Table 1. Characteristics of the cases and controls recruited to study adherence to the DASH diet and risk of breast cancer by menopausal status <sup>1</sup>

Characteristics  
 Total  
 Pre-menopause  
 Post-menopause  
 Cases  
 (n=477)  
 Controls  
 (n=507)  
 p<sup>2</sup>

Controls	Cases (n=313)
	(n=308) p <sup>2</sup>
Controls	Cases (n=156)
	(n=161) p <sup>2</sup>
DASH score (mean)	

	24.3	
	0.02	
	24	
	25	
	0.05	
	24	
	24	
	0.13	
Age (years)	45.9±10.3	
	43.9±11.2	
	<0.01	
	41.2±7.3	
	39.5±8.3	
	<0.01	
	55.4±8.7	
	53.9±9.3	
	0.15	
BMI (kg/m <sup>2</sup> )	28.1±5.1	
	28.9±5.6	
	0.02	
	27.6±4.9	
	28.8±5.7	
	<0.01	
	29.1±5.3	
	30.0±5.3	
	0.11	
BMI at age 30 (kg/m <sup>2</sup> )	21.9±8.8	
	20.2±11.4	
	0.01	
	21.9±8.9	
	20.6±11.5	
	0.12	
	21.8±8.4	
	20.4±10.8	
	0.24	
Physical activity (MET h/wk.)	20.0±38.5	
	27.0±38.5	
	<0.01	
	20.3±25.9	
	28.2±37.8	
	<0.01	
	20.2±24.8	
	27.7±42.2	
	0.06	
Education (literate, n, %)	416(87)	

	460(91)	
	0.08	
	293(94)	
	290(94)	
	0.78	
	116(74)	
	133(83)	
	0.07	
Marital status (Married, n,%)	448(94)	
	479(94)	
	0.71	
	290(93)	
	294(96)	
	0.14	
	152(97)	
	159(99)	
	0.39	
Smoking (yes, n, %)	18(3)	
	27(5)	
	0.24	
	10(3)	
	8(3)	
	0.66	
	8(5)	
	16(10)	
	0.11	
	(2.5)12	
	(6)31	
	0.01>	
	(3)9	
	(6)19	
	0.04	
	(2)3	
	(6)9	
	0.09	
Family history of breast cancer (yes, n, %)	46(10)	
	7(1)	
	<0.001	
	30(10)	
	4(1)	
	<0.001	
	16(10)	
	3(2)	
	<0.01	
Oral contraceptive use (yes, n, %)	227(48)	

(% ,Drinking Alcohol (yes, n

	263(52)
	0.18
	154(49)
	159(52)
	0.57
	69(44)
	92(57)
	0.02
Parity (number of children)	
	2.4±1.7
	2.5±1.9
	0.54
	2.1±1.4
	2.1±1.4
	0.78
	3.2±2.8
	3.7±3.4
	0.02
Hormone replacement therapy (yes, n, %)	
	2(0.4)
	10(2)
	0.03
	0(0)
	2(0.65)
	0.15
	2(1)
	7(4)
	0.1
Fertility treatment ((yes, n, %)	
	19(3.9)
	30(6)
	0.18
	10(3)
	19(6)
	9(6)
	9(6)
	0.95

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Red and processed meats (g/d)	20±23	20±22	0.36	20±21	20±25	0.83	20±28	20±14	0.78
Sweetened beverages(g/d)	100±170	90±6	0.85	100±176	90±115	0.47	103±156	87±156	0.36
Sodium (g/d)	1984±69	2115±84	0.11	1956±1313	2148±2273	0.20	1994±1731	2107±104	0.48

<sup>1</sup> reported figures are mean± SDs

<sup>2</sup> obtained from independent' s t-test

Multivariable adjusted ORs for BC across the tertiles of DASH diet score in these three groups are provided in **Table 3**. In the total study population, it was found that adherence to the DASH dietary pattern substantially reduced BC risk in model A which was adjusted for age and energy intake (OR for comparing extreme tertiles: 0.62; 95% CI 0.44-0.78;  $P_{\text{trend}}=0.004$ ). Even after additional controlling for education (literate, illiterate), smoking (yes, no), alcohol intake (yes, no), physical activity (MET h/wk.), family history of BC (yes, no), marital status (married/single), oral contraceptive use (yes, no), parity (number of children), fertility treatment (yes, no), hormone replace therapy (yes, no) and BMI ( $\text{kg}/\text{m}^2$ ), greatest adherence to the DASH diet was associated with a 34% reduction in risk of gastric cancer (OR 0.66; 95% CI 0.46, 0.94;  $P_{\text{trend}}=0.03$ ).

Table 3. Odd Ratios (ORs) and 95% Confidence Intervals (CIs) for breast cancer across tertiles of DASH score

	OR(95%CI)			P <sub>trend</sub> <sup>1</sup>
	Tertile 1	Tertile 2	Tertile 3	
Total				
No. of cases/ controls (477/507)	183/156	186/211	140/108	
Model A <sup>2</sup>	1	0.76(0.57-1.02)	0.62(0.44-0.87)	0.004
Model B <sup>3</sup>	1	0.78(0.58-1.07)	0.66(0.46-0.94)	0.03
Pre-menopause				
(No. of cases/ controls (313/308)	113/94	127/129	73/85	
Model A <sup>2</sup>	1	0.84(0.58-1.22)	0.68(0.46-1.22)	0.07
Model B <sup>3</sup>	1	0.92(0.62-1.37)	0.78(0.50-1.23)	0.29
Post-menopause				
(No. of cases/ controls (156/161)	64/51	61/69	31/41	
Model A <sup>2</sup>	1	0.69(0.42-1.2)	0.62(0.34-1.1)	0.09
Model B <sup>3</sup>	1	0.69(0.40-1.2)	0.66(0.35-1.2)	0.17

<sup>1</sup>Trend based on median value of each tertile

<sup>2</sup>Adjusted for age and energy intake

<sup>3</sup>Further adjusted for education (literate, illiterate), smoking (yes, no), alcohol intake (yes, no), physical activity (MET h/wk.), family history of breast cancer (yes, no), marital status (married/single), oral contraceptive use (yes, no), parity (number of children), fertility treatment (yes, no), hormone replacement therapy (yes, no), BMI (kg/m<sup>2</sup>)

In pre-menopausal women, adherence to the DASH dietary pattern was associated with a 32% reduction in BC risk. This association was attenuated after adjusting for covariates and it was not found to be significant in either of the models. A similar trend was found in post-menopausal women. No significant association was shown in model A (OR 0.62; 95% CI 0.34, 1.1;  $P_{\text{trend}}=0.09$ ) and this did not change considerably after adjusting for different covariates.

## Discussion

In this large hospital-based case-control study, we found a strong association between adherence to the DASH dietary pattern and odds of BC. This dietary pattern was associated with a 34% reduction in BC risk in the total study group. The risk reduction was 32% in premenopausal women, and 38% reduction in postmenopausal women, although the association was not found to be significant in these subgroups.

A few studies have investigated the association between this dietary pattern and risk of BC, with inconclusive results [33,34]. Studies mainly showed a protective effect of the DASH diet on risk of BC in post-menopausal women or receptor-negative BC[33]. However, several studies showed significant associations between the various components of the DASH dietary pattern and risk of BC. For instance, several studies indicated that high intake of red and processed meats could increase BC risk[35,36]. Fruits, vegetables and dairy are the most emphasized components of this dietary pattern and several studies have reported their protective effects on BC[37]. However, the comprehensive review on nutrition and BC prevention published by the World Cancer Research Fund revealed that the evidence on the association between foods or nutrients and risk of BC is not convincing [38,19]. This report asserted that there is limited evidence on the negative association between the risk of post- and pre-menopausal BC with intake of non-starchy vegetables and food containing carotenes and a high-calcium diet. Evidence on other dietary factors has been classified as inconclusive.

Several theories have been suggested as mechanisms of the association between the DASH dietary pattern and risk of cancers. The DASH dietary pattern emphasizes high intake of fruits, vegetables, dairy, whole grains, legumes and nuts. On the other hand, low consumption of sweetened beverages and red and processed meats might further explain the reduction of BC risk in individuals who follow this dietary pattern[38]. This diet is high in dietary fiber, calcium, folate, carotenes and phenolic compounds[39]. The association of these nutrients with BC risk has been suggested in several studies [40-43]. Furthermore, this dietary pattern is high in dietary antioxidants such as proanthocyanidines, flavonoids, stilbenes and alpha-tocopherols [44,39] which could reduce cancer risk[45-47]. Moreover, it is associated with lower circulating C-reactive protein which could explain the anti-inflammatory effect of this diet[48,49]. Decreased inflammation and enhanced antioxidant capacity of the body could suppress cell proliferation, spontaneous mutation and DNA methylation, all of which may lead to reduced cancer incidence.[47,50]

The DASH dietary pattern insists on higher intake of fiber and lower intake of simple carbohydrates, both of which are associated with lower glycemic index. It could therefore decrease the circulating level of insulin and insulin-like growth factor 1, which are associated with an elevated risk of oncogenesis [51,52]. Several studies have suggested a greater

risk of BC in hyperinsulinemia and diabetic patients [53,54]. Besides, higher intake of fiber may decrease circulating androstenedione and estrogen levels which indirectly diminish the risk of BC[55,56].

The DASH dietary pattern emphasizes consumption of low-fat dairy products which have been associated with lower risk of BC in several studies[57]. It has been proposed that calcium has anti-proliferation, pro-apoptotic and pro-differentiation effects on mammary gland cells [58,59]. Furthermore, conjugated linoleic acid (CLA) - a component in dairy products- has several anti-cancer capacities. It has been shown to inhibit cell proliferation, suppress production of inflammatory substances and empower immune responses[60,61].

Use of a valid and reproducible FFQ for dietary assessment, similarities in the socioeconomic status of patients and controls, controlling for several confounders and stratified analysis based on menopausal status could be mentioned as some of the strengths of this study. However, there are some limitations. First, a medium sample size limited us in finding significant associations in our subgroup analyses, since the sample sizes in quartiles of pre- and post-menopausal subjects were too small for us to find a significant association. Although we controlled for several confounders, the possibility of residual confounding and recall bias cannot be excluded in case-control studies[62]. Moreover, we should mention the possibility of misclassification of study participants based on their dietary intake which is a common problem in all epidemiological studies that use FFQ[62]. In order to reduce the possibility of misclassification, we applied energy-adjusted intake of food groups in order to compute adherence to the DASH dietary pattern[31]. One of the weak points in our approach in scoring individual adherence to the DASH dietary pattern is attributing equal weight to all food groups, while some food groups might have greater effects than others on BC development.

## Conclusion

On the basis of this case-control study, it appears that adherence to DASH dietary pattern was associated with around 30% reduction in risk of BC. This finding is in accordance with the current recommendations by World Cancer Research fund International (WCRC), American Cancer Society and International Agency for Research on Cancer (IARC) which emphasize consuming high amounts of plant-based foods in a person's daily diet. However, larger studies, in particular studies with a prospective design, are required to confirm the association between dietary patterns and risk of BC, particularly in post- or pre-menopausal women.

## Abbreviations

**DASH:** Dietary Approach to Stop Hypertension

**BC:** breast cancer

**BMI:** Body Mass Index

**MET:** Metabolic Equivalent

**FFQ:** Food Frequency Questionnaire

**GPAQ:** Global Physical Activity Questionnaire

**OR:** Odd Ratio

**CI:** Confidence Interval

## Declarations

**Ethical Approval and Consent to participate:** Face-to-face description of the study aims and protocol were provided to each participant before signing the written informed consent form. The study protocol was approved by the ethical committee of the Cancer Research Center, Tehran University of Medical Sciences (no. 93-03-51-27113).

### Consent for Publication

There is no personal information regarding any patients in our article.

### Availability of Supporting Data

Data would be available if requested.

### Competing Interest

None of the authors declared any conflicts of interest.

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### Authors' contributions

FT and KZ designed the study, BS supervised data collection and data cleaning. FT analyzed the data and drafted the manuscript. AE guided the drafting of the manuscript and revised the final edition. All authors approved the final version of the manuscript

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