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The association between dietary phytochemical index and bacterial vaginosis risk: secondary analysis of case-control study

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Abstract

Introduction By studying the dietary habits of patients with bacterial vaginosis (BV) and the controls, we aim to find out whether the dietary intakes of phytochemicals could reduce the odds of BV. To the best of our knowledge, no study has ever examined the matter before. Therefore, we decided to conduct this secondary analysis of case-control study to examine the association between dietary phytochemicals and BV.

Method This case-control study was conducted at the gynecological clinic of Imam Hossein Hospital using a convenience sampling method from November 2020 to June 2021. To diagnose BV, all participants underwent examination by a gynecologist, assessing the presence of 3 or 4 criteria from the Amsel criteria. A validated semi-quantitative food frequency questionnaire was used. The phytochemical index was determined using McCarty's method. To assess the association between dietary phytochemical intake and the odds of BV, binary logistic regression was utilized.

Results After adjusting for potential confounders, the association between phytochemical index and BV remained significant (odds ratio (OR) = 0.349, 95% confidence interval (CI): 0.176–0.695, *p*-value = 0.003). Furthermore, each unit increase in fat intake was associated with higher odds of BV (OR = 1.008, 95% CI: 1.002–1.014, *p*-value = 0.006), and a positive family history of BV continued to show significantly increased odds of BV (OR = 3.442, 95% CI: 2.068–5.728, *p*-value < 0.001).

Conclusion In summary, the findings of this study indicate that increased consumption of dietary phytochemicals is associated with a reduced risk of BV among Iranian women of reproductive age. Additional research, especially longitudinal dietary studies, is required to explore the potential impact of dietary modifications on BV.

Keywords Phytochemicals, Dietary phytochemicals, Phytonutrients, Bacterial vaginosis, Bacterial vaginitis

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Introduction

The vagina hosts a wide variety of bacteria which are dynamic and ever-changing. However, under normal circumstances, lactobacilli make up the majority of them. This optimum proportion is believed to fight off infections by producing lactic acid and maintaining an acidic environment. Disruption of the said proportion, perhaps through the increase in the amount of various anaerobic bacteria, is called bacterial vaginosis (BV) [1] and is believed to cause several complications for women of childbearing age [2]. The dysbiosis of the vaginal microbiota might pave the way for the contraction of sexually transmitted infections, urogenital infections, and pelvic inflammatory disease [3]. Moreover, up to 40% of preterm births are thought to be caused by some sort of vaginal or intrauterine infection [4]. Ethnical differences, sexual activities, vaginal douching, and fluctuations in estrogen levels are deemed to be the main risk factors. However, despite affecting 1 in every 3 women, many aspects of the disease, especially the dietary aspects, remain unknown and therefore there is still a call for further research.

Phytochemicals are organic compounds produced by plants, mainly to serve protective purposes and, therefore considered secondary metabolites [5]. So far, thousands of phytochemicals have been discovered, extracted, and carefully studied and are believed to exert many beneficial effects [6]. Some of the significant phytochemicals are alkaloids, saponins, tannins, flavonoids, and steroids which have also been shown to stimulate strong antioxidant, antimicrobial, antiallergic, and antiviral activities [7, 8]. Their antibacterial properties have especially been of notice. Despite being less potent than antibiotics, research has shown phytochemical supplementation in adjunction to antibiotics could strengthen the efficacy of antibiotic therapy, especially when they are beginning to fall short against bacteria due to their increased development of resistance [9]. Through a recently devised index, we can now estimate the approximate dietary intake of phytochemicals. Observational studies examining the benefits of dietary phytochemicals have shown their efficacy in reducing the risk of cancer, heart disease, and neurodegenerative diseases [10–12].

By studying the dietary habits of patients with BV and the controls, we aim to find out whether the dietary intakes of phytochemicals could reduce the odds of BV. To the best of our knowledge, no study has ever examined the matter before. Therefore, we decided to conduct this secondary analysis of case-control study to examine the association between dietary phytochemicals and BV.

Method and materials

Study population

This secondary analysis of case-control study was conducted at the gynecological clinic of Imam Hossein Hospital using a convenience sampling method from November 2020 to June 2021. The sample size was determined based on the study by Fahim et al. [13]. We enrolled 151 women with BV in the case group and 143 healthy women in the control group. This study was a secondary analysis and detailed information on the sample size calculation and other inclusion criteria can be found in previous studies [14–18]. To diagnose BV, all participants underwent examination by a gynecologist, assessing the presence of 3 or 4 criteria from the Amsel criteria, which include: a homogeneous and watery vaginal discharge, vaginal pH greater than 4.5, presence of 20% clue cells observed during saline microscopy, and a fishy odor detected after adding 10% potassium hydroxide to the discharge slide [19, 20].

Eligible participants met the following inclusion criteria: willingness to participate and signing the consent form, aged between 15 and 45 years, not pregnant, not in menopause, and not using antibiotics, probiotics, hormonal contraceptives, vaginal douches, or immunosuppressive medications. They also did not have systemic illnesses, autoimmune diseases, chronic infections, diet-related chronic diseases like diabetes and cardiovascular disease, or any uterine cavity issues such as fibroids, polyps, or hysterectomy. The only difference in inclusion criteria between the case and control groups was the presence of a BV diagnosis for the case group and the absence of ongoing or previous BV or BV treatment for the control group.

Participants in both groups were excluded if they did not complete 60% or more of the food frequency questionnaire (FFQ), if their reported energy intake deviated beyond ±3 standard deviations (SD) from the average energy intake, or if they expressed unwillingness to continue participating in the study.

A checklist was employed to gather data on participants' age, family history of BV, polycystic ovary syndrome, and pregnancy, pregnancy history, menstrual cycle, education level, occupational status, smoking habits, number of sexual partners, and monthly family income. Questions regarding alcohol and opium use were omitted due to specific religious and cultural beliefs among Iranians. Anthropometric assessments included weight measurement using a reliable scale with a precision of 100 g, height measurement in the standing position without shoes with 1 mm accuracy, and waist circumference (WC) measurement to assess central adiposity using a measuring tape accurate to the nearest 1 mm, conducted by a trained examiner. Body Mass Index (BMI) was calculated by dividing weight in kilograms by the square of height in meters. Physical activity levels were assessed using the International Physical Activity Questionnaire (IPAQ), the validity and reliability of which have been previously established in studies conducted in Iran [21].

Dietary intake assessment

A validated semi-quantitative FFQ consisting of 168 food items [22], each with a standard and commonly used serving size in Iran, was used to estimate the participants' dietary intake over the year preceding the interview. During the interview, participants were informed about the average size of each food item. They then reported how often they consumed each item, specifying the frequency on a daily, weekly, or monthly basis. The reported values for each food were converted to grams using a household scale guide. The average daily intakes of energy and nutrients were calculated using the Iranian food composition Table [23] and the USDA food composition Table [24].

Phytochemical index

The phytochemical index was determined using McCarty's method [25] as follows: [phytochemical index = (daily energy from phytochemicals- rich foods (kcal) / total daily energy intake (kcal)) × 100]. First, the energy intake from each phytochemical-rich food item was calculated based on their total gram intake. Then, the total energy intake from all phytochemical-rich foods was determined. These foods included whole grains, legumes, nuts, olives and olive oil, soy products, seeds, tea, coffee, and spices. Natural vegetable and fruit juices, along with tomato sauces, were included in the vegetable and fruit groups because of their high phytochemical content. However, potatoes and pickled vegetables were excluded from the vegetable groups due to their low phytochemical content [26, 27]. The total phytochemical index intake was then classified as either below or above the mean intake.

Statistical analysis

All statistical analyses were conducted using SPSS (Statistical Package for the Social Sciences, version 23, Chicago, IL, United States). The Chi-square and Kruskal-Wallis tests were used to compare categorical and non-parametric baseline variables between tertiles of the phytochemical index in both the case and control groups. Continuous variables were presented as medians (with 25th-75th confidence intervals), and categorical variables as percentages. To assess the association between dietary phytochemical intake and the odds of bacterial vaginosis (BV), binary logistic regression was utilized in both crude and adjusted models (using the Backward LR method for multivariate analysis), calculating odds ratios (OR) with 95% confidence intervals (CI). The second model adjusted for potential confounders, which were selected based on a *p*-value < 0.25 in the univariate analysis (adjusted for age (years), BMI (kg/m^2), fat intake (g/day), and familial history of BV (no/yes)).

Results

Table 1 shows significant differences in age (*p*-value = 0.032), BMI (*p*-value = 0.002), pregnancy history (*p*-value = 0.002), pregnancy number (*p*-value = 0.003), and menstrual cycle (*p*-value = 0.010) across phytochemical index tertiles within the case group. Additionally, all nutrient and food group intakes differed significantly across phytochemical index tertiles in both case and control groups (*p*-value < 0.001), except for seeds (*p*-value = 0.066) and legumes (*p*-value = 0.174) in the case group, and seeds (*p*-value = 0.178) in the control group. Other sources of phytochemical index did not show significant differences (*p*-value = 0.100) in the case group.

Table 2 presents the results of both univariate and multivariate regression models assessing the relationship between phytochemical index and other variables with the risk of BV. In the univariate analysis, compared to the lowest tertile of phytochemical index, the highest tertile showed significantly lower odds of BV (OR = 0.514, 95% CI: 0.290–0.909, *p*-value = 0.022). Additionally, a significantly higher odds of BV was observed in individuals with a positive family history of BV compared to the reference group (OR = 3.595, 95% CI: 2.190–5.900, *p*-value < 0.001).

After adjusting for potential confounders (variables with *p*-value < 0.25 in univariate analysis), the association between phytochemical index and BV remained significant (OR = 0.349, 95% CI: 0.176–0.695, *p*-value = 0.003). Furthermore, each unit increase in fat intake was associated with higher odds of BV (OR = 1.008, 95% CI: 1.002–1.014, *p*-value = 0.006), and a positive history of BV continued to show significantly increased odds of BV (OR = 3.442, 95% CI: 2.068–5.728, *p*-value < 0.001).

Discussion

In the current study, by investigating the dietary habits of patients with BV and controls, we found that a higher intake of dietary phytochemicals is associated with a lower risk of BV. The association remained significant even after adjustment for potential cofounders.

Research investigating the association between diet and BV is scarce. In a study on 208 Iranian women with BV, it was reported that participants who were supplemented daily with vitamin D responded better to the treatment compared to the placebo group [28]. A case-control study reported that the serum level of 25-hydroxy vitamin D was significantly lower in participants with BV compared to healthy participants [29]. It has been suggested that sufficient vitamin D could protect women against BV through the production of some antimicrobial peptides that exist in the lysosomes of macrophages and

Table 1 Baseline features of study papulation based on tertile of phytochemical index among case and control groups

Variables	Case ($n = 143$)				Control ($n = 151$)			
	T_1 ($n = 52$)	T_2 ($n = 55$)	T_3 ($n = 36$)	*P*-value	T_1 ($n = 46$)	T_2 ($n = 43$)	T_3 ($n = 62$)	*P*-value
Age (year) [1]	28.0 (24.0–32.0)	30.0 (27.0–34.0)	31.0 (28.2–36.7)	**0.032**	26.5 (23.7–36.5)	32.0 (25.0–36.0	32.5 (24.0–39.0)	0.175
BMI (kg/m^2) [1]	24.2 (21.8–27.9)	28.3 (24.4–30.0)	26.0 (25.0-28.1)	**0.002**	24.1 (21.9–27.0)	25.2 (22.3–28.3)	24.6 (21.9–28.2)	0.585
WHR [1]	0.82 (0.76–0.95)	0.87 (0.81–0.91)	0.85 (0.81–0.89)	0.412	0.81 (0.75–0.89)	0.87 (0.79–0.94)	0.84 (0.78–0.94)	0.280
PA (MET/h/day) [1]	30.0 (15.0–50.0)	20.0 (15.0–60.0)	15.0 (45.0-57.5)	0.141	15.0 (15.0–50.0)	30.0 (15.0–60.0)	25.0 (15.0–60.0)	0.096
Familial history of BV, yes, % [2]	29 (55.8)	33 (60.0)	15 (41.7)	0.216	10 (21.7)	11 (25.6)	16 (25.8)	0.872
History of PCOS, yes, % [2]	3 (5.8)	3 (5.5)	5 (13.9)	0.272	2 (4.3)	6 (14.0)	7 (11.3)	0.285
Pregnancy history, yes, % [2]	22 (42.3)	41 (74.5)	17 (47.2)	**0.002**	19 (41.3)	25 (58.1)	37 (59.7)	0.130
Pregnancy number, % [2] 0 1–2 ≥ 3	30 (57.7) 20 (38.5) 2 (3.8)	14 (25.4) 31 (56.4) 10 (18.2)	19 (52.7) 15 (41.7) 2 (5.6)	**0.003**	27 (58.7) 16 (34.8) 3 (6.5)	18 (41.9) 20 (46.5) 5 (11.6)	25 (40.3) 29 (46.8) 8 (12.9)	0.366
Menstrual cycle, irregular, % [2]	29 (55.8)	34 (61.8)	31 (86.1)	**0.010**	27 (58.7)	29 (67.4)	46 (74.2)	0.235
Education level, % [2] Under-diploma Diploma University degree	16 (30.8) 26 (50.0) 10 (19.2)	10 (18.2) 28 (50.9) 17 (30.9)	10 (27.8) 22 (61.1) 4 (11.1)	0.162	15 (32.6) 16 (34.8) 15 (32.6)	7 (16.3) 24 (55.8) 12 (27.9)	17 (27.4) 30 (48.4) 15 (24.2)	0.259
Smoking history, % [2] Never smoker Ex-smoker Current smoker	41 (78.8) 3 (5.8) 8 (15.4)	36 (65.5) 7 (12.7) 12 (21.8)	26 (72.2) 5 (13.9) 5 (13.9)	0.491	43 (93.5) 3 (6.5) 0 (0.0)	42 (97.7) 1 (2.3) 0 (0.0)	55 (88.7) 5 (8.1) 0 (0.0)	0.339
Number of sexual partners, previous month, % [2] 0 1 2	12 (27.9) 29 (67.4) 2 (4.7)	14 (25.5) 38 (69.1) 3 (5.4)	13 (36.1) 22 (61.1) 1 (2.8)	0.835	12 (30.8) 25 (64.1) 2 (5.1)	8 (21.1) 29 (76.3) 1 (2.6)	19 (32.8) 38 (65.5) 1 (1.7)	0.625
Monthly income, % [2] < 250 US $ ≥ 250 US $	39 (75.0) 13 (25.0)	42 (76.4) 13 (23.6)	29 (80.6) 7 (19.4)	0.825	39 (84.4) 7 (15.2)	37 (86.0) 6 (14.0)	45 (72.6) 17 (27.4)	0.150
Total energy (kcal/day) [1]	1605.29 (1205.41-2144.27)	2632.70 (2017.89-3673.71)	3091.42 (2677.45-3761.78)	**<0.001**	1649.0 (1268.7-1894.8)	1971.3 (1779.9-2248.6)	3040.0 (2626.5-3543.2)	**<0.001**
Energy from PI sources (kcal/day) [1]	355.35 (284.56-430.39)	677.32 (597.37–724.20)	1113.68 (936.15-1369.26)	**<0.001**	360.13 (279.17-439.35)	589.6 (533.39-731.61)	1214.08 (1035.86-1535.69)	**<0.001**
Protein intake (g/day) [1]	57.67 (34.28–71.47)	82.74 (69.35–110.30)	95.35 (80.53-115.01)	**<0.001**	58.22 (44.71–78.57)	77.63 (60.34–88.19)	106.66 (89.67-130.65)	**<0.001**

Table 1 (continued)

Variables	Case (*n* = 143)				Control (*n* = 151)			
	T_1 (*n* = 52)	T_2 (*n* = 55)	T_3 (*n* = 36)	*P*-value	T_1 (*n* = 46)	T_2 (*n* = 43)	T_3 (*n* = 62)	*P*-value
Carbohydrate intake (g/day) [1]	206.20 (157.69-300.44)	337.65 (245.79-446.91)	452.04 (372.02-534.68)	**<0.001**	201.20 (170.52-248.38)	275.99 (223.60-347.10)	414.27 (344.58-494.59)	**<0.001**
Fiber intake (g/day) [1]	13.89 (8.62–16.26)	24.23 (19.31–26.52)	29.65 (21.32–40.39)	**<0.001**	14.99 (11.24–19.04)	19.52 (15.57–25.55)	39.89 (28.57–47.66)	**<0.001**
Fat intake (g/day) [1]	65.23 (47.25–98.05)	113.70 (89.11-162.49)	105.15 (95.22-132.41)	**<0.001**	66.28 (46.24–78.73)	76.18 (60.75–89.21)	106.82 (93.45-153.49)	**<0.001**
Whole grains (kcal/day) [1]	22.27 (12.66–80.85)	86.45 (61.88-168.67)	253.45 (69.38-435.41)	**<0.001**	56.32 (18.02-120.58)	78.78 (18.43-169.66)	182.21 (71.51-297.58)	**<0.001**
Nuts (kcal/day) [1]	8.02 (4.17–15.63)	37.84 (9.02–80.07)	22.27 (3.07–90.49)	**<0.001**	7.45 (2.33–22.14)	14.14 (6.75–39.72)	56.91 (10.25-129.37)	**<0.001**
Seeds (kcal/day) [1]	4.62 (0.00-11.25)	5.62 (0.00-16.87)	8.43 (0.92–34.77)	0.066	0.92 (0.00-5.62)	4.62 (0.92–11.25)	4.20 (0.00-26.52)	0.178
Legumes (kcal/day) [1]	25.82 (8.58–34.08)	35.41 (11.48–58.25)	26.65 (12.37–43.92)	0.174	25.49 (13.25–46.31)	36.57 (24.30-81.42)	76.92 (32.83-186.17)	**<0.001**
Vegetables (kcal/day) [1]	95.46 (72.04-146.42)	157.63 (131.96-234.39)	160.56 (146.55-293.01)	**<0.001**	86.90 (55.35-141.34)	170.44 (87.99-216.18)	231.38 (165.91–345.90)	**<0.001**
Fruits (kcal/day) [1]	101.58 (68.28-141.91)	166.21 (115.16-338.75)	376.16 (228.90-467.87)	**<0.001**	111.49 (57.33-151.36)	216.41 (139.86-250.42)	461.28 (309.03-649.68)	**<0.001**
Other PI sources (kcal/day) [1]	7.41 (3.02–16.11)	12.01 (7.51–15.45)	12.97 (6.66–20.32)	0.100	6.19 (4.46–9.90)	7.64 (4.90–22.50)	10.01 (4.95–32.45)	**0.012**

Abbreviations: BMI, body mass index; kg, kilogram; m, meter; WHR, waist to hip ratio; PA, physical activity; MET, metabolic equivalent of task; BV, bacterial vaginosis; kcal, kilocalorie; g, gram, PI, phytochemical index

-Significant values are shown in bold

[1]Using Kruskal-Wallis u-test for continuous variables and values are median (25th -75th)

[2]Using chi-square tests for categorical variables and values are and values are

neutrophils [30]. Furthermore, It has also been shown that subclinical iron deficiency in early pregnancy might lead to BV [31]. Iron deficiency may weaken the host response against vaginal bacterial colonization [32]. Administration of probiotic supplements has also been proven efficient in treating BV patients [33]. Since probiotics produce beneficial metabolites, their impact goes beyond the well-known benefits to the intestines [34, 35]. They could lower cholesterol levels [36] and improve the absorption of magnesium and calcium [37], all of which are said to help reduce inflammation [38, 39].

Research abounds investigating the antimicrobial effects of phytochemicals and they were shown to be significantly efficient against a broad spectrum of bacteria. Among them, Flavonols, Flavonols, and phenolic acids are of significance. They were shown to be able to overcome the development of resistance in bacterial pathogens and fight off bacterial infections [40]. For instance, a certain flavonoid was reported to reverse the β-lactam antibiotic resistance of S. aureus [41]. Moreover, Zhao et al. investigated a specific phytochemical in green tea and found that it may inhibit the enzyme β-lactamase that blocks the effects of antibiotics such as cefotaxime and imipenem [42]. The proposed mechanisms through which they exert their impacts are as follows; they interact with the cytoplasmic membrane, alterations in the bacterial cell wall and cell membrane, reduce the pH values, suppress biofilm formation, and reduce the extracellular polysaccharide activity [43, 44].

However, all the mentioned studies have been conducted on a handful of phytochemicals in an in-vitro setting. Despite their accuracy, the process takes a lot of time and resources. Hence, there was still a need to investigate the matter in a wide population. Then came the phytochemical index, which measures the phytochemical content in food composition databases. Subsequently, more population-based studies have emerged to investigate the effects of these compounds on chronic diseases. Most of which, yielded positive results [45]. For once, Kim et al. showed that high consumption of phytochemical-rich foods is associated with lower inflammation [46]. A case-control study indicated that higher consumption of phytochemicals is related to lower risk of pre-diabetes [47]. Another case-control study revealed a reverse association between the consumption of phytochemicals and the risk of breast cancer [48]. Finally, a meta-analysis of nine cross-sectional studies revealed that a high consumption of phytochemicals is associated with a reduced risk of overweight and obesity [49].

Table 2 Association between phytochemical index and other variables with the risk of bacterial vaginosis

Variables	Case / Control	Univariate			Multivariate		
		OR	CI 95%	*P*-value	OR	CI 95%	*P*-value
Phytochemical index	52/46	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
T_1 (≤ 481.02 kcal)	55/43	1.131	0.645–1.986	0.667	0.819	0.438–1.532	0.533
T_2 (481.03-807.04 kcal)	36/62	**0.514**	**0.290–0.909**	**0.022**	**0.349**	**0.176–0.695**	**0.003**
T_3 (≥ 807.05 kcal)							
Age (year)	143/151	0.973	0.940–1.006	0.108	-	-	-
BMI (kg/m^2)	143/151	1.043	0.992–1.096	0.102	-	-	-
PA (MET/h/day)	143/151	1.001	0.990–1.012	0.839	-	-	-
Total energy (kcal/day)	143/151	1.000	1.000–1.000	0.334	-	-	-
Fat intake (g/day)	143/151	1.004	0.999–1.009	0.100	**1.008**	**1.002–1.014**	**0.006**
Familial history of BV	66/114	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
No	77/37	**3.595**	**2.190–5.900**	**<0.001**	**3.442**	**2.068–5.728**	**<0.001**
Yes							
Pregnancy history	63/70	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
No	80/81	1.097	0.693–1.738	0.692	-	-	-
Yes							
Menstrual cycle	94/102	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Irregular	49/49	1.085	0.668–1.763	0.741	-	-	-
Regular							
Education level	36/39	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Under-diploma	76/70	1.176	0.674–2.054	0.568	-	-	-
Diploma	31/42	0.800	0.418–1.529	0.499	-	-	-
University degree							
Number of sexual partners, previous month	39/39	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
0	89/92	0.967	0.569–1.645	0.903	-	-	-
1	6/4	1.500	0.392–5.733	0.553	-	-	-
2							
Monthly income	112/121	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
< 250 US $	33/30	1.210	0.693–2.114	0.503	-	-	-
≥ 250 US $							

Abbreviations: OR, odds ratio; CI, confident interval; Ref, reference; kcal, kilocalorie; BMI, body mass index, kg, kilogram; m, meter; PA, physical activity; MET, metabolic equivalent of task; g, gram; BV, bacterial vaginosis

-Obtained from logistic regression and using Backward LR method for multivariate analysis

-These values are odds ratio (95% CIs)

-Significant values are shown in bold

-Missing values in each variable were excluded from the analyses

-Adjusted for variables with p-value < 0.25 in multivariate analysis

- Adjusted for age (years), BMI (kg/m^2), fat intake (g/day), and familial history of BV (no/yes)

To the best of our knowledge, this is the first study to investigate the association between dietary-derived phytochemicals and BV which could provide further understanding of these compounds. The mentioned method for the calculation and evaluation of the dietary phytochemical index has been performed on another Iranian population study, so has been validated [50]. Though the method by which our results were generated is certainly more time and cost-efficient than in vitro studies, some limitations should be noted. First, since FFQ is a memory-dependent assessment tool, the chances of recall bias in reporting dietary intake are high. Moreover, FFQ lacks detailed information on how the food is prepared and is limited to a fixed list of foods, so it may not properly capture the eating patterns of the studied population. Second, the case-control nature of our study was another limitation, as it prevented us from inferring causality. Third, phytochemicals abound in plant foods, such as vegetables, fruit, whole grains, nuts, and legumes [51]. So the consumption of phytochemical-rich plant foods provides other beneficial nutrients such as fiber, B vitamins, folate, and Vitamin E [52–54]. Hence, pinning down the reported results only on phytochemicals may not be completely accurate, although we tried to nullify the effects of these nutrients by controlling for them. Finally, there might be a risk of selection bias as our subjects were enrolled from a hospital, thus, the study result might not be attributable to society as many patients may be undiagnosed or might resort to home remedies and not be hospitalized.

In summary, the findings of this study indicate that increased consumption of dietary phytochemicals is associated with a reduced risk of BV among Iranian women of reproductive age. Hence, regular intake of dietary phytochemicals could be introduced as a potentially effective approach in the prevention and management of BV. Additional research, especially longitudinal dietary studies, is required to explore the potential impact of dietary modifications on BV.

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Author contributions
A.K., M.N., M.H.M., M.M. and M.N.; Contributed to writing the first draft. M.N. and G.E.; Contributed to all data and statistical analysis and interpretation of data. S.E., M.N. and G.E.; Contributed to the research concept, supervised the work, and revised the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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 Ethics Committee of Shahid Beheshti University of Medical Sciences (IR.SBMU.NNFTRI.REC.1399.054). All participants read and signed the informed consent form.

Competing interests
The authors declare no competing interests.

Conflict of interest
No.

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