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The association between global and prime diet quality scores and the risk of bacterial vaginosis: a secondary analysis of case-control study

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Abstract

Introduction The present aimed to examine the relationship between Global Diet Quality (GDQ) and Prime Diet Quality (PDQ) scores and the likelihood of bacterial vaginosis (BV) among women.

Methods This case-control study was conducted among patients referred to a gynecological clinic in Tehran using the convenience sampling method. All the participants were examined by a gynecologist to rule out BV based on the presence of three or four of Amsel criteria. A valid semi-quantitative food frequency questionnaire (FFQ) containing 168 food items was used to estimate participants' dietary intake. To calculate the GDQ score, 25 food groups were considered, while 21 food groups were used for the PDQ score, based on the of daily consumption (in grams). All statistical analysis were performed using SPSS, and the association between GDQ and PDQ scores and the odds of BV was evaluated using binary logistic regression.

Results After adjusting for age, energy intake, fat intake, BMI, physical activity, familial history of BV, pregnancy history, menstrual cycle, smoking history, and the number of sexual partners in the previous month, significant associations remained between highest tertile of GDQ total (odds ratio (OR) = 0.219, confidence interval (CI) 95%: 0.101–0.475) and positive score (OR = 0.235, CI 95%: 0.103–0.533), as well as PDQ total (OR = 0.277, CI 95%: 0.131–0.583) and healthy score (OR = 0.397, CI 95%: 0.185–0.854) with the odds of BV, compared to the first tertile.

Conclusion A high diet quality, as indicated by high GDQ and PDQ scores, was associated with decreased risk of BV. These findings suggest that dietary intervention may be a viable strategy for the prevention and management of BV.

Keywords Diet, Diet quality, Global diet, Prime diet, Bacterial vaginosis

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Introduction

Bacterial vaginosis (BV) often presents with vaginal discharge, odor, and discomfort in women of childbearing age [1]. It is associated with various gynecological and obstetric complications, including pelvic inflammatory disease, spontaneous abortion, preterm birth, early pregnancy loss in IVF, and an increased risk of acquiring and transmitting HIV/STIs [2–6]. The global prevalence of BV is significant, affecting a considerable number of individuals worldwide, with reported occurrence rate ranging from 23 to 29% in different regions [7].

The clinical presentation of BV often includes a vaginal pH greater than 4.5, a thin and homogeneous whitish discharge, the presence of "clue" cells, and an amine odor upon the application of 10% potassium hydroxide [8, 9]. Treating BV presents challenges, as the condition recurs in a significant number of women—approximately 60%—after antibiotic treatment [10]. BV is characterized by a decline in the abundance of healthy vaginal bacteria and a concomitant overgrowth of pathogenic bacteria [11, 12]. While sexual activity is associated with imbalances in the vaginal flora, other nonsexual risk factors can also contribute to BV development [13].

There are evidences linking BV to nutritional status and diet [14, 15]. For instance, prior research has revealed an inverse association between the intake of certain micronutrients, such as vitamins, folate and calcium, and the risk of sever BV [16]. Another recent study found a positive association between adherences to an unhealthy dietary pattern and BV risk, while an inverse association was observed between adherences to an ovo-vegetarian dietary pattern and the odds of BV [17].

To assess dietary quality, the use of a dietary metric is necessary. The two dietary scores commonly used for this purpose are the Prime Diet Quality Score (PDQS) and the Global Diet Quality Score (GDQS). The PDQS, developed by Fung et al. [18], is a simple, food-based diet quality score that differentiate healthy foods from unhealthy ones based on two main criteria: (1) evidence from the literature regarding the relationship between food and the risk of non-communicable diseases, and (2) the global contribution of nutrients. The association between PDQS and several non-communicable diseases, such as dyslipidemia, hypertension, diabetes, and depression, has been previously investigated [19–21].

Additionally, the GDQS was designed as an easy-to-use cost-effective tool to monitor nutritional deficiencies and assess the risks of non-communicable diseases based on diet [22]. According to the GDQS, 25 food groups are categorized into three groups: (1) "unhealthy foods," which lower the overall diet quality score; (2) "healthy foods," which enhance the overall diet quality score; and (3) two food groups classified as "unhealthy in excessive amounts," which increase the diet quality score when consumed in moderation but lower it when consumed in excess [23].

Previous research has suggested that a high-quality diet, characterized by high scores in both the Prime and Global Diet Quality Scores, is associated with a decreased likelihood of developing several health-related conditions [24, 25]. However, no research has examined the correlation between diet quality, as assessed through GDQ and PDQ scores, and the risk of BV.

Therefore, the present study was designed to assess the relationship between GDQ and PDQ scores and the probability of BV among women. This study may provide important insight into the role of dietary quality in the BV risk and contribute to improving reproductive health among woman.

Methods and materials

Sample size

The sample size of the present study was calculated based on dietary pattern exposure using the case-control study formula by Fahim et al. [26]. Previous data indicated that 73% of the Iranian population adheres to unhealthy diets [27]. Assuming an odds ratio (OR) 2.5 for BV in women with unhealthy dietary patterns compared to those who do not adhere, and to achieve 80% statistical power with a 5% alpha error [26], we recruited 151 women with BV for the case group and 143 healthy women for the control group.

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). Informed consent was obtained from all participants after they had read and signed the consent form. Some details of this study have been previously published [17, 28, 29].

Study population

We conducted this case-control study among patients referred to the gynecological clinic of Imam Hossein hospital in Tehran, Iran, using the convenience sampling method. All participants were examined by a gynecologist to diagnose or rule out BV based on the presence of three or four Amsel criteria, which include: (1) a homogenous and diluted vaginal discharge, (2) a vaginal pH greater than 4.5, (3) the presence of at least 20% clue cells during saline microscopy, and (4) a fishy odor upon adding 10% potassium hydroxide to the discharge slide [8].

Eligible participants met the following inclusion criteria: willingness to participate in the study and signing the consent form; an age range of 15–45 years; not being pregnant or menopausal; not using antibiotics, probiotics, hormonal contraceptives, vaginal douches, or immunosuppressive medications; and not suffering

from systemic illnesses, immune system diseases, chronic infections, diet-related chronic diseases (such as diabetes and cardiovascular disease), or any uterine cavity abnormalities (such as fibroids and polyps), as well as no history of hysterectomy. The only differing inclusion criteria were a diagnosis of BV 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 failed to complete 60% or more of the food frequency questionnaire (FFQ), if their reported energy intake deviated by more than ±3 standard deviations (SD) from the average energy intake, or if they were unwilling to continue participation.

A socio-demographic questionnaire was used to collect information on participants' age, family history of BV, education level, occupational status, smoking habits, and number of sex partners. Questions about alcohol and opium were excluded due to the specific religious and cultural beliefs of Iranians.

For anthropometric assessments, a trained examiner measured participants' weight while wearing light clothing a reliable scale with a precision of 100 g. Height in a straight standing position without shoes, with an accuracy of 1 mm. Waist circumference (WC) was assessed to determine central adiposity using a non-stretched tape, measured to the nearest 1 mm. Body Mass Index (BMI) was calculated by dividing weight (kg) by the square of height (meter).

Dietary intake assessment

A valid semi-quantitative food frequency questionnaire (FFQ) containing of 168 food items [30] was used to estimate participants' dietary intake during the year prior to the interview. Each item had a standard and commonly used serving size for Iranians, following the Willet method [31].

Global diet quality score (GDQS)

For the calculation of GDQS index, daily consumption (in grams) of food items was categorized into 25 food groups. These included 16 healthy food groups (fish and shellfish, poultry and game meats, eggs, low fat dairy, whole grains, cruciferous vegetables, dark green leafy vegetables, deep orange vegetables, other vegetables, deep orange fruits, citrus fruits, other fruits, deep orange tubers, nuts and seeds, legumes, and liquid oils), two optimal food groups (red meats and high fat dairy), and seven unhealthy food groups (refined grains and baked goods, white roots and tubers, juices, sugar-sweetened beverages, sweets and ice creams, fried foods, and processed meats). Each food group was categorized into three or four intake levels.

For the healthy food groups, the scoring system assigned:

- 0 points for lower intake of all 16 food groups.
- 0.25 points for moderate intake and 0.5 points for higher intake of cruciferous vegetables, deep orange vegetables, other vegetables, and deep orange tubers.
- 1 point for moderate intake and 2 points for higher intake of citrus fruits, deep orange fruits, other fruits, whole grains, liquid oils, fish and shellfish, poultry and game meats, and low-fat dairy.
- 2 points for moderate intake and 4 points for higher intake eggs, dark green leafy vegetables, deep orange vegetables, nuts and seeds, legumes.

For the optimal food groups:

- 0 points were assigned for lower or very high intake (gram per day).
- 1 point was assigned for moderate intake.
- 2 points were assigned for higher intake of red meats and high-fat dairy.

For the unhealthy food groups:

- 2 points were given for lower intake.
- 1 point for moderate intake.
- 0 points for higher intake of refined grains and baked goods, white roots and tubers, juices, sugar-sweetened beverages, sweets and ice creams, fried foods, and processed meats.

Finally, the total GDQS score was obtained by summing the scores of all 25 food groups, yielding a range from 0 to 49 [32].

Prime diet quality score (PDQS)

The PDQS contains 21 food groups, categorized into two groups: healthy and unhealthy. Initially, all 21 food groups were classified into tertiles. For healthy food groups—low fat dairy, poultry, whole grains, fish and shellfish, legumes and soy, nuts and seeds, liquid vegetable oils, deep orange fruits, citrus fruits, other fruits, deep orange vegetables, cruciferous vegetables, dark green leafy vegetables, and other vegetables—points were assigned as follow: 0 for lower intake, 1 for moderate intake, and 2 for higher intake.

Conversely, for healthy food groups—low fat dairy, poultry, whole grains, fish and shellfish, legumes and soy, nuts and seeds, liquid vegetable oils, deep orange fruits, citrus fruits, other fruits, deep orange vegetables, cruciferous vegetables, dark green leafy vegetables, and other vegetables—points were assigned in reverse: 2 for lower intake, 1 for moderate intake, and 0 for higher intake. The

PDQS comprises 21 food groups, with a total ranging from 0 to 42 total [33].

Statistical analysis

All statistical analysis were preformed using SPSS (Statistical Package for the Social Sciences program; version 23; Chicago, IL, United States). The Chi-square was used to compare categorical variables, while Mann-Whitney U test and independent sample t-test were employed to compare non-parametric and parametric variables between the case and control groups.

Median (confidence interval (CI) 25th -75th) or mean ± SD were used for continues variables, and percentage were reported for categorical variables. To evaluate the association between GDQS and PDQS with the odds of BV, binary logistic regression was conducted using two models: a crude model and an adjusted model. The OR with a CI 95% was calculated.

In the adjusted model, potential confounders—including age (years), energy intake (kcal/day), fat intake (g/day), BMI (kg/m^2), physical activity (MET/h/day), familial history of BV (yes/no), pregnancy history (yes/no), menstrual cycle (yes/no), smoking history (yes/no), and number of sexual partners in previous month—were controlled.

Results

The baseline characteristics of the study population between the healthy and bacterial vaginosis groups are presented in Table 1. The median age (p-value = 0.019), the percentage of familial history of BV (p-value < 0.001), and smoking (p-value < 0.001) were significantly different between the two groups. Additionally, the median intake of total fat was significantly higher in the case group (p-value = 0.022), while fiber intake was higher in the control group (p-value = 0.013).

The food group intake of the study population between the healthy and bacterial vaginosis groups is shown in Table 2. The mean total GDQ and PDQ scores, as well as their components, were significantly higher in the control group compared to the case group (p-value < 0.001 for all, except for healthy and unhealthy PDQ scores).

The median intake of other fruits (p-value = 0.028), deep dark leafy vegetables (p-value < 0.001), other vegetables (p-value = 0.006), deep orange tubers (p-value = 0.018), legumes (p-value < 0.001), and poultry and game meats (p-value = 0.034) were significantly higher in the control group. However, the median intake of refined grains and baked goods (p-value = 0.004), processed meats (p-value = 0.008), sugar-sweetened beverages (p-value < 0.001), and fried foods (p-value = 0.003) was higher in the case group.

The association between tertiles of Global and Prime Diet Quality Scores and the odds of bacterial vaginosis is presented in Table 3, based on two models: crude and adjusted.

In the crude model, compared to the first tertile, lower odds of BV were observed in the highest tertile of the total GDQ score total (OR = 0.246, CI 95%: 0.136–0.444), positive GDQ score total (OR = 0.367, CI 95%: 0.205–0.658), negative GDQ score total (OR = 0.432, CI 95%: 0.249–0.750), total PDQ score total (OR = 0.237, CI 95%: 0.128–0.437), healthy PDQ score total (OR = 0.457,

Table 1 Baseline characteristics and nutrients intake in the study population: comparison between healthy and bacterial vaginosis groups

Variables	Case (*n* = 143)	Control (*n* = 151)	*P*-value
Baseline characteristics			
Age (year) [1]	30.0 (25.0-33.5)	32.0 (24.0–37.0)	0.201
BMI (kg/m^2) [1]	26.1 (23.3–28.7)	24.6 (22.2–27.9)	**0.019**
Physical activity (MET/h/day) [1]	25.0 (15.0–50.0)	25.0 (15.0–60.0)	1.000
Familial history of BV, yes, % [2]	77 (53.8)	37 (24.5)	**<0.001**
Pregnancy history, yes, % [2]	80 (55.9)	81 (53.6)	0.726
Menstrual cycle, irregular, % [2]	49 (34.3)	49 (32.5)	0.805
Smoking history, yes, % [2]	25 (17.5)	2 (1.3)	**<0.001**
Number of sexual partners in previous month, more than 2, % [2]	6 (4.5)	4 (3.0)	0.800
Dietary intakes			
Energy (kcal/day) [1]	2481.12 (1718.84-3274.81)	2223.33 (1761.26-3042.55)	0.306
Protein (g/day) [1]	76.16 (58.96–99.12)	80.75 (59.77-110.86)	0.234
Total fat (g/day) [1]	99.91 (68.04-124.86)	83.46 (62.14-107.95)	**0.022**
Carbohydrate (g/day) [1]	325.73 (216.73-449.23)	307.47 (217.77–412.20)	0.463
Fiber (g/day) [1]	20.09 (14.50-27.05)	23.75 (15.83–37.27)	**0.013**

Abbreviation: BMI, body mass index; kg, kilogram; m, meter; MET, metabolic equivalent of task; kcal, kilocalorie; g, gram; BV, bacterial vaginosis, kcal, kilocalorie; g, gram

[1]Using the Mann-Whitney U-test, values are presented as median (25th -75th)

[2]Using chi-square tests for categorical variables, values are presented as percentage

Table 2 Food group intake in the study population: comparison between healthy and bacterial vaginosis groups

Variables	Case (*n* = 143)	Control (*n* = 151)	*P*-value
Positive GDQ score [1]	14.37 ± 4.51	16.72 ± 5.41	**<0.001**
Negative GDQ score [1]	9.64 ± 1.82	10.47 ± 1.86	**<0.001**
Total GDQ score [1]	24.02 ± 5.08	27.19 ± 5.37	**<0.001**
Healthy PDQ score [1]	12.92 ± 4.63	14.86 ± 5.94	**0.002**
Unhealthy PDQ score [1]	8.59 ± 3.14	12.92 ± 4.63	**0.003**
Total PDQ score [1]	20.38 ± 5.11	23.45 ± 6.04	**<0.001**
Citrus fruits (g/day) [2]	60.00 (28.81-104.78)	53.83 (27.08-116.75)	0.795
Deep orange fruits (g/day) [2]	72.69 (36.93–110.90)	74.25 (44.40-158.45)	0.245
Other fruits (g/day) [2]	56.10 (29.79-109.48)	83.86 (41.18-158.87)	**0.028**
Deep dark and leafy vegetables (g/day) [2]	25.36 (12.57–45.46)	45.22 (22.20-82.73)	**<0.001**
Cruciferous vegetables (g/day) [2]	3.10 (0.75–6.20)	3.92 (0.76–12.61)	0.103
Deep orange vegetables (g/day) [2]	3.69 (1.35-11.00)	2.67 (0.90–9.04)	0.227
Other vegetables (g/day) [2]	156.42 (109.92-236.62)	203.88 (118.60-308.70)	**0.006**
Deep orange tubers (g/day) [2]	4.86 (1.21–10.52)	7.30 (2.43–14.07)	**0.018**
Legumes (g/day) [2]	18.64 (7.41–34.24)	29.79 (12.09–70.64)	**<0.001**
Nuts and seeds (g/day) [2]	5.97 (2.01–14.55)	5.74 (1.51–14.28)	0.369
Whole grains (g/day) [2]	2.14 (0.41-4.00)	1.06 (0.16–5.21)	0.984
Refined grains and backed goods (g/day) [2]	421.00 (288.15-605.94)	337.04 (240.20-474.83)	**0.004**
White roots and tubers (g/day) [2]	14.25 (5.70-36.64)	24.42 (5.70-36.64)	0.391
Liquid oils (g/day) [2]	11.50 (4.28-18.00)	12.00 (6.00–18.00)	0.508
Red meats (g/day) [2]	44.58 (19.15–64.31)	42.66 (23.31–82.85)	0.113
Processed meats (g/day) [2]	2.01 (0.30–5.78)	0.71 (0.00-4.34)	**0.008**
Fish and selfish (g/day) [2]	2.95 (0.60–8.66)	5.51 (1.52–14.38)	**0.004**
Poultry and game meats (g/day) [2]	12.85 (8.57–25.71)	17.14 (8.57-30.00)	**0.034**
Eggs (g/day) [2]	22.92 (7.64–38.21)	22.92 (15.28–38.21)	0.108
Low fat dairy products (g/day) [2]	224.25 (87.72-369.33)	246.87 (77.34-446.42)	0.563
High fat dairy products (g/day) [2]	58.33 (21.42-145.52)	48.60 (19.33-134.95)	0.159
Sweets and ice creams (g/day) [2]	49.31 (29.17–68.35)	38.42 (21.36-71.00)	0.067
Sugar-sweetened beverages (g/day) [2]	24.50 (7.41-176.39)	8.16 (0.69-35.00)	**<0.001**
Juices (g/day) [2]	2.71 (0.00-10.28)	3.39 (0.00-16.53)	0.410
Fried foods (g/day) [2]	14.00 (6.00–30.00)	8.90 (3.00-21.14)	**0.003**

Abbreviation: GDQ, global diet quality; PDQ, prime diet quality; g, gram

[1]Using an independent sample t-test, values are presented as mean ± SD

[2]Using the Mann-Whitney U-test, values are presented as median (25th -75th)

CI 95%: 0.261–0.801) and healthy PDQ score total (OR = 0.509, CI 95%: 0.289–0.897).

After adjusting for age, energy intake, fat intake, BMI, physical activity, familial history of BV, pregnancy history, menstrual cycle, smoking history, and number of sexual partners in previous month, the associations remained significand for the highest tertile of the total GDQ score (OR = 0.219, CI 95%: 0.101–0.475), positive GDQ score (OR = 0.235, CI 95%: 0.103–0.533), total PDQ score (OR = 0.277, CI 95%: 0.131–0.583), and healthy PDQ score (OR = 0.397, CI 95%: 0.185–0.854) with the odds of BV, compared to the first tertile.

Discussion

The result of the current study demonstrated that the last tertile of the GDQ total score, positive GDQ score, PDQ total score, and healthy PDQ score was associated lower odds of BV compared to the first tertile. Additionally, the total GDQ and PDQ score, along with their components, were significantly higher in the control group than in the BV group.

Healthy and unhealthy food groups of PDQ and GDQ scores may explain this association. The consumption of certain food groups, including fruits, vegetables, whole grains, and legumes, is included in the positive GDQ score and a healthy PDQ score, where higher intake is assigned higher points. Increased consumption of these food groups is associated with greater fiber intake. The current study showed that fiber intake was higher in the control group compared to BV subjects.

An earlier study indicated that women with a higher fiber intake had a lower risk of molecular BV [34]. Additionally, it was demonstrated that a plant-based diet rich in high-fiber foods such as legumes, fruits and vegetables reduced the odds of BV [17]. The ecology of vaginal microbiota, particularly a high proportion of

Table 3 Association between tertiles of global and prime diet quality score and the odds of bacterial vaginosis

Variables	T_1	T_2	T_3	P_{trend}
		OR (CI 95%)	OR (CI 95%)	
GDQ score (case/control)	63/35	49/46	31/70	
Crude	Ref.	0.592 (0.332–1.054)	**0.246 (0.136–0.444)**	**<0.001**
Adjusted	Ref.	0.497 (0.240–1.029)	**0.219 (0.101–0.475)**	**<0.001**
Positive GDQ score (case/control)	58/40	52/49	33/62	
Crude	Ref.	0.732 (0.418–1.282)	**0.367 (0.205–0.658)**	**0.001**
Adjusted	Ref.	0.493 (0.238–1.018)	**0.235 (0.103–0.533)**	**0.001**
Negative GDQ score (case/control)	53/38	43/35	47/78	
Crude	Ref.	0.881 (0.478–1.622)	**0.432 (0.249–0.750)**	**0.002**
Adjusted	Ref.	1.186 (0.560–2.513)	0.550 (0.252–1.202)	0.104
PDQ score (case/control)	61/33	54/54	28/64	
Crude	Ref.	**0.541 (0.307–0.954)**	**0.237 (0.128–0.437)**	**<0.001**
Adjusted	Ref.	0.601 (0.300-1.202)	**0.277 (0.131–0.583)**	**0.001**
Healthy PDQ score (case/control)	56/49	52/35	35/67	
Crude	Ref.	1.300 (0.732–2.310)	**0.457 (0.261–0.801)**	**0.007**
Adjusted	Ref.	1.213 (0.585–2.515)	**0.397 (0.185–0.854)**	**0.014**
Unhealthy PDQ score (case/control)	56/41	46/51	41/59	
Crude	Ref.	0.660 (0.375–1.164)	**0.509 (0.289–0.897)**	**0.02**
Adjusted	Ref.	0.920 (0.438–1.932)	0.673 (0.276–1.644)	0.383

Abbreviation: OR, odds ratio; CI, confidence interval; T, tertile; BV, bacterial vaginosis; GDQ, global diet quality, PDQ, prime diet quality

Significant values are presented in bold

Values are expressed as odds ratio (95% CIs)

Obtained from logistic regression analysis

Adjusted model: adjusted for age (years), energy intake (kcal/day), fat intake (g/day), BMI (kg/m^2), physical activity (MET/h/day), familial history of BV (yes/no), pregnancy history (yes/no), menstrual cycle (yes/no), smoking history (yes/no), and number of sexual partners in previous month

Lactobacillus species, decreases vulnerability to BV and inhibits pathogen invasion [35]. The *Lactobacillus* genus, the predominant bacteria found in the human vaginal microbiome, creates an acidic environment that is believed to protect women against sexually transmitted pathogens and risk of infections [36].

A Diet rich in fiber may lower the risk of bacterial infections linked to BV by impacting the vaginal microflora, increasing the abundance of *Lactobacillus* bacteria, and enhancing overall vaginal health [34]. Moreover, an in vitro study revealed that prebiotic dietary fibers promoted the proliferation of primary *Lactobacillus* species monocultures [37]. Previous studies have shown a certain level of agreement between the types of *Lactobacillus* species found in both the rectum and the vagina [38, 39]. The gut microbiota can influence the vaginal microbiome [40], and change in gut microbiota composition may contribute to BV development.

A study among BV patients demonstrated that oral intake of a mixture of three *Lactobacillus* species prolonged the time to recurrence and lowered the percentage of BV recurrences in women who had recently received treatment [41]. Additionally, a meta-analysis revealed that probiotics used as an adjuvant therapy alongside antibiotics were more effective than antibiotic treatment alone in BV patients. Furthermore, a high dose of probiotics administered orally, particularly *Lactobacillus rhamnosus*, was found to be more effective than a low dose or vaginal administration of *Lactobacillus rhamnosus* for BV treatment [42].

Growing evidence suggests that the vaginal microbiome can be influenced by gut microbiota, as bacterial strains can transfer from the gut to the vagina [40]. Vaginal dysbiosis can be improved through probiotics via several mechanisms, including the production of lactic acid, which helps maintain normal vaginal pH. A study using a yogurt drink containing *Lactobacillus* strains found that vaginal pH decreased in the intervention group compared to the placebo group after four weeks of treatment [43]. Additionally, probiotics help reduce pathogenic organisms by competing for adhesion sites [44, 45] and promote immune defense by increasing anti-inflammatory cytokines while decreasing inflammatory cytokines [46].

Moreover, short-chain fatty acids (SCFAs) are produced through the fermentation of dietary non-digestible carbohydrates by gut microbiota. A deficiency in SCFA-producing bacteria and their metabolites—such as acetate, propionate, and butyrate—can lead to the leakage of endotoxins like lipopolysaccharides into systemic circulation (leaky gut), resulting in systemic inflammation. This inflammation or the transfer of these pathogens to the genital tract increases the risk of genital tract infections and inflammation [40].

In addition to their fiber content, fruit and vegetables may play a protective role against BV due to their other beneficial components. The current study showed that the consumption of certain fruits and vegetables was higher in the control compared to the case group.

Fruits and vegetables—particularly green leafy vegetables, whole grains, and eggs—are important dietary sources of folate [47]. A previous study found a negative association between dietary folate intake and BV risk [48]. It is possible that folate consumption enhance the immune function, thereby reducing the likelihood of severe BV [48].

Folic acid has been shown to sustain or improve natural killer (NK) cell activity, which strengthens innate, nonspecific immune function, thereby improving immunity and lowering the prevalence of BV [49]. Additionally, folic acid plays a key role in antibody synthesis and supports the Th1-mediated immune response, which stimulates the body's adaptive immune system and further reduces the risk of BV [49].

Another micronutrient that may explain the association between higher GDQ and PDQ scores and lower odds of BV is vitamin E. This vitamin is found in various dietary sources, including vegetable oils, as well as fresh fruits, vegetables, and nuts. A previous study reported a correlation between increased vitamin E consumption and a reduced likelihood of severe BV [48].

The role of vitamin E as a potent antioxidant is well established. Excessive production of reactive oxygen species (ROS) beyond the cellular antioxidant scavenging capacity can contribute to BV development [50]. As a fat-soluble antioxidant, vitamin E helps neutralize excess free radicals and regulates gene expression in the immune system, potentially reducing the risk of BV [51].

Moreover, women with insufficient levels of micronutrients such as beta-carotene and vitamins D, C, A, and E are at a higher risk of developing BV. This inadequacy in essential nutrients may be linked to a diet low in fruits and vegetables.

Additionally, flavonoid-rich foods—such as vegetables, fruits, nuts, and legumes—have been found to possess anti-inflammatory properties that can effectively inhibit the activation of nuclear factor kappa-light-chain-enhancer of activated B cells (NF-κB) [52]. NF-κB plays a crucial role in pro-inflammatory signaling pathways, and its activation has been observed in various cell types present in the vaginal secretions of women with BV [53].

Furthermore, previous studies have shown an association between vitamin D deficiency and increased odds of BV [54]. Adequate vitamin D levels have been demonstrated to protect against BV by promoting the synthesis of cathelicidins, antimicrobial peptides found in the lysosomes of neutrophils and macrophages [55].

A recent study also found that higher serum levels of carotenoids were associated with a lower prevalence of BV [56]. As strong antioxidants, carotenoids help reduce the accumulation of reactive oxygen species. Additionally, sufficient carotenoid and vitamin A levels have been shown to be essential for maintaining the integrity of vaginal epithelial cells [57]. Moreover, carotenoids enhance the activity of neutrophils, natural killer cells, and other innate immune cells, further supporting immune function [58, 59].

On the other hand, a lower intake of certain food groups—such as red meat, processed foods, refined grains, fried foods, and sugar-sweetened beverages (SSBs)—along with higher GDQ and healthy PDQ scores may explain the observed association. The result of the current study showed that the intake of refined grains, processed meat, SSBs, and fried food was higher in BV subjects compared to control individuals.

The excessive fat content in processed and fried foods has been identified as a potential contributing factor to the increased odds of BV. Naggers et al. provided evidence suggesting that a diet high in saturated fat may increase the likelihood of severe BV [60]. Consuming excessive amounts of fat can lead to an elevated vaginal pH by altering the vaginal microflora, thereby increasing the risk of BV development [48, 60]. Furthermore, a high intake of saturated fats may negatively impact the effectiveness of the mucosal immune response, further contributing to BV susceptibility [60].

Another key characteristic of higher GDQ and PDQ scores is a lower intake of high-glycemic-index and glycemic-load-low-carbohydrates, including refined grains, SSBs, sweets, and ice cream. Previous research has established a link between the consumption of ultra-processed sweets, dietary glycemic index (GI), and dietary glycemic load (GL) with an increases risk of developing BV [14, 61].

Excessive consumption of high-GI/GL foods, as part of an unhealthy diet, may contribute to BV development by inducing oxidative stress and compromising the immune system's response [38, 62].

Although the primary goal of the current study was to investigate the association between GDQ and PDQ scores and the odds of BV, the findings have potential implications for public health and clinical practice. Given the high prevalence of BV among women and its substantial economic burden [7], implementing dietary interventions to modify eating patterns may be a valuable strategy for preventing and managing the disease.

If future studies confirm these findings, the role of diet quality in the onset and progression of BV could be emphasized in public health education to raise awareness among women and help reduce BV risk. Based on GDQ and PDQ scores, increasing the consumption of

high-fiber foods—such as fruits, vegetables, whole grains, and legumes—along with antioxidant-rich foods, while reducing the intake of sugar and processed foods, may help lower the odds of BV among women.

his study has several strengths. One notable advantage is the use of a comprehensive and globally recognized diet quality score, which provides valuable insights into the potential impact of overall diet quality on BV risk. Additionally, accounting for potential confounding factors—such as age, energy intake, fat intake, BMI, physical activity, and family history of bacterial vaginosis—enhances the reliability of the findings. Furthermore, to minimize the risk of information bias, a qualified nutritionist administered the questionnaires without prior knowledge of the study outcomes.

Nevertheless, this study has several limitations that should be considered. One major limitation is its case-control design, which inherently restricts the ability to establish causality. While our findings indicate associations, we cannot conclude that one factor directly leads to another. Establishing causality would require alternative research designs, such as randomized controlled trials.

Additionally, despite efforts to minimize bias, case-control studies are susceptible to selection bias, measurement bias, and recall bias, which may affect the accuracy of the results. Moreover, diet quality was assessed using a FFQ, a method prone to recall bias since participants report their dietary intake retrospectively.

Another limitation is the use of convenience sampling, which may affect the generalizability of our findings. Since participants were not selected randomly, the sample may not fully represent women with BV [63].

It is also important to consider the long-term impact of diet quality on BV recurrence. Conducting studies with longer follow-up periods could provide more valuable insights into the relationship between diet and BV risk and recurrence. Furthermore, future research should explore the correlation between dietary quality indices and the composition of vaginal microbiota. Such studies could offer a deeper understanding of the potential impact of diet on the vaginal microbial community.

Conclusion

A high diet quality, as indicated by high GDQ and PDQ scores, was associated with a decreased risk of BV. These findings suggest that dietary interventions may serve as an effective strategy for the prevention and management of BV.

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

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

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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