

Dietary factors protecting women from urinary tract infection¹⁻³

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ABSTRACT

Background: Because urinary tract infections (UTIs) are caused by bacteria in the stool, dietary factors may affect the risk of contracting a UTI by altering the properties of the fecal bacterial flora.

Objective: We studied dietary and other risk factors for UTI in fertile women in a case-control setting.

Design: One hundred thirty-nine women from a health center for university students or from the staff of a university hospital (mean age: 30.5 y) with a diagnosis of an acute UTI were compared with 185 age-matched women with no episodes of UTIs during the past 5 y. Data on the women's dietary and other lifestyle habits were collected by questionnaire. A risk profile for UTI expressed in the form of adjusted odds ratios (ORs) with 95% CIs was modeled in logistic regression analysis for 107 case-control pairs with all relevant information.

Results: Frequent consumption of fresh juices, especially berry juices, and fermented milk products containing probiotic bacteria was associated with a decreased risk of recurrence of UTI: the OR for UTI was 0.66 (95% CI: 0.48, 0.92) per 2 dL juice. A preference for berry juice over other juices gave an OR of 0.28 (95% CI: 0.14, 0.56). Consumption of fermented milk products ≥ 3 times/wk gave an OR of 0.21 (95% CI: 0.06, 0.66) relative to consumption < 1 time/wk. Intercourse frequency was associated with an increased risk of UTI (OR for ≥ 3 times/wk compared with < 1 time/wk: 2.7; 95% CI: 1.16, 6.2).

Conclusion: Dietary habits seem to be an important risk factor for UTI recurrence in fertile women, and dietary guidance could be a first step toward prevention. *Am J Clin Nutr* 2003;77:600-4.

KEY WORDS Urinary tract infection, cystitis, risk, diet, women, lactobacilli, probiotics, milk, berry, fruit, juice

INTRODUCTION

More than half of all women experience at least one urinary tract infection (UTI) during their lifetime (1). Sexual activity and contraception methods have been found to be important risk factors for such infections and their recurrences (2-10). Genetic circumstances, such as belonging to blood groups AB or B, constitute independent risk factors in some but not all studies (6-8). UTI risk is also related to age, so that recurrences are most common in the age groups of 25-29 y and > 55 y and among those who get a first UTI at an early age (7, 9). This is thought to reflect sexual activity in the younger fertile age group, the lack of estrogens among the older women (9), and genetic or long-term environmental factors in those getting a first UTI at an early age (7). In postmenopausal women, UTI risk factors also include urinary incontinence (6). Bacterial virulence properties may affect the risk of recurrence as well (11).

UTIs are an ascending infection caused by bacteria in the stool, and dietary changes can affect the bacterial flora involved. It is thus logical to assume that diet may affect the risk of contracting a UTI. This assumption is supported by reports that cranberry and cranberry-lingonberry juices are effective in preventing UTI recurrence (12, 13). Other aspects of diet have been evaluated only occasionally in risk factor surveys (14-16).

All in all, there is no truly definitive explanation for why only some women get UTIs, and why recurrences tend to accumulate in the same subjects (10, 16). We hypothesized that diet may explain some of this association and conducted a case-control study in women to evaluate dietary factors (especially the consumption of berries, fruit, and milk products), factors influencing energy consumption, and previously established UTI risk factors.

SUBJECTS AND METHODS

Study population and design

The subjects were recruited between 1993 and 1997 at 2 centers: the Finnish Student Health Service at the University of Oulu and the occupational health center for the staff of Oulu University Hospital. The cases were women who had had acute symptomatic UTI (symptoms of urination frequency, urination urgency, dysuria, hematuria, nocturia, fever, and back or flank pain) caused by *Escherichia coli* ($\geq 10^5$ colony forming units/mL in clean-voided midstream urine). The women entered the study within 2 wk of the culture-confirmed UTI episode. Subjects were excluded from the study if they received long-term antimicrobial prophylaxis at the time of the index UTI. The controls were selected from lists of all female students and hospital workers from the corresponding center of the case; invitations were sent to the next 2 women on the alphabetical list who were born in the same year as the case. The control was accepted if she had not experienced a UTI and had not taken any antimicrobial prophylaxis during the past 5 y. If neither of the controls replied within 2 wk or both of those chosen

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TABLE 1

Baseline characteristics of the subjects according to place of recruitment: the Finnish Student Health Service at the University of Oulu (FSHS) or the occupational health center for the staff of Oulu University Hospital (OUH)

Characteristic	FSHS (n = 216)		OUH (n = 108)	
	Cases	Controls ¹	Cases	Controls ¹
Age group, y (%)				
<25	65 [60] ²	64 [79]	2 [1]	3 [2]
25–29	31 [29]	32 [39]	11 [5]	11 [7]
30–54	4 [4]	4 [5]	80 [37]	79 [49]
≥55	0	0	7 [3]	6 [4]
Unmarried (%)	59 [55]	46 [57]	28 [13]	24 [15]
Average no. of previous urinary tract infections	4.8	0.7	4.2	1.2

¹In pairs with more than one control, comparison was made between the case and the mean value of the controls. There were 93 cases with 123 controls in the FSHS group and 46 cases with 62 controls in the OUH group.

²n in brackets.

had to be excluded, 2 more controls were selected, up to 6 per case, so that at least one acceptable control was available for each case. There were a total of 139 case-control pairs, with a mean (\pm SD) age of 30.5 ± 10.5 y; 45 cases had an additional control and 1 had 2 additional controls (**Table 1**). One hundred nine of the cases (81%) had had more than one UTI episode. The protocol was evaluated by the Ethical Committee of the Medical Faculty of the University of Oulu and was found to be ethically acceptable.

Questionnaire

The subjects were asked to complete a questionnaire regarding their dietary habits during the past month (**Table 2**), estimating the amounts of milk products (eg, milk, sour milk, yogurt, cheese, and ice cream) and fruit and berries (both fresh and prepared) consumed as well as the frequency of consumption. Pictures were provided as an aid to answering. Additionally, daily fluid intake was ascertained by means of questions on the amounts of drinks of various kinds consumed and estimates of fluid intake meal by meal. Subjects were asked to report all UTI episodes in their past history as well as the time of their first and last UTI episode. The questionnaire included detailed questions on vitamin, mineral, and calcium intakes; herbal supplement use; marital status; contraception use; coital frequency; exercise; constipation; previous morbidity; and medication use.

Fresh juice was defined as a freshly squeezed juice or a juice made from concentrate to resemble 100% freshly squeezed juice with no added sweeteners. Other juices were drinks diluted with water or sweetened with sucrose or other sweeteners.

Statistics

The statistical analyses were based on 139 case-control pairs. If a case had more than one control, the mean value for the controls was used. All variables were first analyzed separately. Next, the frequency of consumption of all milk products, fermented milk products containing probiotic bacteria (yogurt, sour milk, and cheese), fruit products (fresh or prepared), and berry products (fresh or prepared) was first summed, and the resulting sum variables were recoded as <1 time/wk, 1 to <3 times/wk, and ≥ 3 times/wk. Recoding was done because the number of

TABLE 2

Questionnaire on dietary habits

Variable	Classification
Frequency of consumption during the past month	
Milk (fresh or fermented with probiotics)	Never, <1 time/wk, 1 to
Berries or fruit (fresh or prepared)	<3 times/wk, ≥ 3 times/wk
Average consumption of the products during the past month	
Milk, sour milk, and yogurt ¹	Glasses (2 dL)/d
Cheese (fresh or fermented)	g/d
Other milk products (which?)	dL/wk
Milk products in other foods	dL/wk
Berries and fruit (fresh or prepared) ²	No. of portions (≈ 100 g)/wk
Juices (fresh or concentrate) ³	Glasses (2 dL)/d
Soft drinks (normal, diet, or sport)	Glasses (2 dL)/d
Coffee, tea, or cocoa	Cups (1.5 dL)/d
Use of any drink	dL/d
Sweeteners in foods and drinks	
Sucrose	tsp/d ⁴
Fructose	tsp/d ⁴
Other, what?	
Preferred juice	What?
Any disease or special diet	No, yes (if yes, what?)
Vitamin, mineral, and herbal supplement use	No, yes (if yes, what?)

¹Subjects were asked to report *Lactobacillus acidophilus*, *Lactobacillus GG*, and other specific probiotics separately.

²Subjects were asked to report apple, banana, blueberry, cloudberry, cranberry, currant, lingonberry, raspberry, strawberry, orange, pineapple, and other fruit or berries separately.

³Subjects were asked to report apple, banana, blueberry, cloudberry, cranberry, currant, lingonberry, raspberry, strawberry, orange, pineapple, and other fruit or berry juices separately.

⁴1 teaspoon (tsp) = 4.93 mL.

subjects in the “never” category was practically zero after summing. Calcium intake was estimated by summing calcium from milk products and supplementary products such as calcium tablets as grams per day. These summary variables were used as estimates for both the amounts and frequencies in the analyses.

This case-control study was the first stage of our controlled randomized intervention trial, the results of which have already been published (12). The sample size was calculated on the basis of the requirements for that clinical trial, and no a priori estimates of the odds ratios (ORs) likely to be found in this case-control study were decided. Univariate logistic regression was used to calculate ORs with 95% CIs separately for all the variables among the 139 pairs, and a risk profile was then constructed in terms of adjusted ORs with 95% CIs by multivariate forward stepwise logistic regression. All the necessary information was available for 107 of the 139 case-control pairs, and these were used for the modeling analyses. The statistical analyses were performed by using SPSS for WINDOWS, version 10.1.4 (SPSS Inc, Chicago).

RESULTS

The multivariate modeling showed an enhanced consumption of fresh fruit or berry juice to be associated with a lower risk of UTI recurrence, an effect that was enhanced by a preference for berry juice over other juices (**Table 3**). Frequent consumption of fermented milk products containing probiotic bacteria such as *Lactobacillus acidophilus* or *Lactobacillus GG* was more

TABLE 3

Risk factors for urinary tract infection estimated as odds ratios (ORs) with 95% CIs in a multivariate forward stepwise logistic regression model including 107 case-control pairs with all relevant information

Variable	Cases	Controls ¹	OR (95% CI)	P ²
Decreased risk				
Mean daily use of fresh juice (fruit or berry) (dL)	1.84	2.24	0.66 (0.48, 0.92) ³	0.011
Fresh berry juice preferred over other fresh juices				0.001
No (comparison)	82	63	1	
Yes	25	44	0.28 (0.14, 0.56)	
Milk products with probiotics (yogurt, sour milk, cheese)				0.003
< 1 time/wk (comparison)	19	4	1	
1 to < 3 times/wk	12	18	0.12 (0.03, 0.47)	
≥ 3 times/wk	76	85	0.21 (0.06, 0.66)	
Increased risk				
Intercourse frequency				0.031
< 1 time/wk (comparison)	24	35	1	
1 to < 3 times/wk	48	54	1.12 (0.55, 2.28)	
≥ 3 times/wk	35	18	2.70 (1.16, 6.2)	

¹In pairs with more than one control, comparison was made between the case and the mean value of the controls.

²Indicates the significance of each variable in the multivariate logistic regression model.

³OR calculated per 2 dL.

common among the controls than among the cases, whereas frequent intercourse was associated with an increased risk of UTI (Table 3).

Variables that appeared as significant risk factors for UTI in univariate modeling but that were not included in the risk profile obtained by multivariate modeling included several factors associated with an increased risk of UTI (Table 4). The amount or frequency of the consumption of fresh milk products, coffee, tea, and soft drinks had no significant effect on UTI risk. The total volume of daily fluids was ≈ 1.6 L in both groups, and this was not associated with UTI risk. Also not associated with UTI risk were intake of vitamins (including vitamin C), minerals (including calcium), and herbal preparations; other diseases; constipation; contraception methods; menstrual hygiene; exercise; and age at the first UTI.

DISCUSSION

The consumption of fresh juices, especially juices prepared from berries, was more common among the women who had not experienced a UTI recently. This protective effect was not associated with the total volume of liquid consumed, which was virtually equal in both groups. Our finding agrees with earlier intervention trials in which cranberry and cranberry-lingonberry juices were found to provide protection from bacteruria and UTI recurrence (12, 13). It is notable that during the time of this trial in our country, no recommendations were given to patients with UTIs to consume cranberry juice or any other juices to prevent UTI, which obviously would have weakened the protective association found here. Most berries, especially those of the genus *Vaccinium*, are rich in flavonols, such as epicatechin (17), which is a potent inhibitor of the adhesion of coliform bacteria to human cells (18, 19). Plants produce flavonols in response to microbial infection, suggesting a role for these substances in antimicrobial defense (20). Some fruit such as apples, cherries, and plums are rich in epicatechin, but in general the flavonol content of berries is higher (17), which may explain their association with reduced UTI recurrence. It is impossible from our results to make any

comparisons between different berries or fruit in terms of their capacity to prevent UTI because some of the products were consumed only seasonally.

Frequent consumption of fermented milk products containing probiotics was associated with a low incidence of UTI recurrence, whereas no such association was found for fresh milk products. Thus, it is possible that the protective effect is related more to the probiotics in these products than to the milk itself. Lactobacilli of the kind found in fermented milk can colonize the human intestine and replace coliform bacteria (21, 22) and have been shown to be effective in preventing UTI recurrence when administered intravaginally (23) and to restore urogenital flora when administered orally (24). We failed, however, in a randomized controlled intervention trial to ascribe any clinical efficacy to oral ingestion of a *Lactobacillus* GG drink as protection against UTI (13). This may indicate differences between the lactobacilli strains in their preventive effect, or it may mean that the additional dose used in our intervention trial was too low to cause any significant difference between the intervention and control groups. In the present survey, most of the women consumed fermented milk products containing probiotics several times per week. The variation in the doses reported by the present respondents was great enough to demonstrate the protective effect of such products. In particular, there were more women avoiding milk products with probiotics or using them only occasionally among the cases than among the controls.

In line with earlier findings (4, 5), intakes of vitamins, minerals, and herbal supplements; methods of menstrual hygiene; or constipation were not associated with the risk of UTI. Contrary to the report of Apicella et al (25), we did not find daily calcium intake to have any effect on UTI risk. Total daily drinking volume had no effect on UTI risk and was practically the same in both groups, which also agrees with earlier reports (4, 5). The UTI-promoting effects of sweetened juice concentrates and added sucrose that were apparent when analyzed separately but that disappeared in the multivariate model may merely reflect the fact that these products are consumed as alternatives to fresh juices.

Frequent intercourse remained the only nondietary factor affecting the risk of UTI. This was documented previously (2–10).


TABLE 4Risk factors for urinary tract infection (UTI) estimated as odds ratios (ORs) with 95% CIs and *P* values for 139 case-control pairs¹

Variable	OR (95% CI)	<i>P</i>
Decreased risk		
Raspberry, fresh		<0.001
Never (comparison)	1.0	
<1 time/wk	0.31 (0.18, 0.53)	
<1 to <3 times/wk	0.43 (0.16, 1.16)	
≥3 times/wk	86 (0, 1 × 2.7 ¹²)	
Lingonberry, fresh		0.001
Never (comparison)	1.0	
<1 time/wk	0.31 (0.17, 0.57)	
1 to <3 times/wk	0.27 (0.12, 0.62)	
≥3 times/wk	0.63 (0.16, 2.5)	
Strawberry, fresh		0.002
Never (comparison)	1.0	
<1 time/wk	0.24 (0.11, 0.54)	
1 to <3 times/wk	0.19 (0.08, 0.46)	
≥3 times/wk	0.28 (0.04, 2.3)	
Raspberry, prepared		0.002
Never (comparison)	1.0	
<1 time/wk	0.37 (0.22, 0.62)	
1 to <3 times/wk	0.38 (0.14, 1.02)	
≥3 times/wk	0.39 (0.82, 1.8)	
Currant, fresh		0.003
Never (comparison)	1.0	
<1 time/wk	0.34 (0.19, 0.6)	
1 to <3 times/wk	0.35 (0.15, 0.83)	
≥3 times/wk	0.9 (0.10, 1.9)	
Cranberry, prepared		0.03
Never (comparison)	1.0	
<1 time/wk	0.48 (0.25, 0.92)	
1 to <3 times/wk	No cases	
≥3 times/wk	No cases	
Cloudberry, prepared		0.04
Never (comparison)	1.0	
<1 time/wk	0.54 (0.33, 0.89)	
1 to <3 times/wk	0.31 (0.09, 1.1)	
≥3 times/wk	0.004 (0, 1 × 10 ⁸)	
<i>Lactobacillus acidophilus</i> yogurt		0.003
Never (comparison)	1.0	
<1 time/wk	0.41 (0.24, 0.69)	
1 to <3 times/wk	0.33 (0.14, 0.76)	
≥3 times/wk	0.75 (0.22, 2.6)	
<i>Lactobacillus GG</i> sour milk		0.02
Never (comparison)	1.0	
<1 time/wk	0.47 (0.25, 0.86)	
1 to <3 times/wk	0.18 (0.04, 0.86)	
≥3 times/wk	0.81 (0.11, 5.9)	
Light yogurt		0.048
Never (comparison)	1.0	
<1 time/wk	0.55 (0.33, 0.92)	
1 to <3 times/wk	0.38 (0.14, 0.99)	
≥3 times/wk	1.1 (0.31, 4.2)	
Increased risk		
Previous no. of UTIs, per episode	1.5 (1.4, 1.8)	<0.001
Previous gynecologic infections, per episode	1.5 (1.1, 1.9)	0.003
Amount of sweetened juice concentrate, per 2 dL	1.3 (1.04, 1.6)	0.02
Added sucrose, per tsp ²	1.1 (1.01, 1.3)	0.03

¹Variables expressed here were significant in the univariate logistic regression model but not in the multivariate model with 107 pairs.²1 teaspoon (tsp) = 4.93 mL.

The number of gynecologic infections increased the risk of UTI when analyzed separately, but this effect disappeared in the multivariate model. It is thus probable that gynecologic infections reflect sexual activity in these women and, thus, that multivariate modeling excludes these women from the final risk profile. None of the subjects in our survey used a diaphragm or spermicides, which were found earlier to increase the risk of UTI (4, 5, 7, 10); condom use or the other contraceptive methods used here were not associated with risk.

The risk for UTI recurrence is highest for ≈3 mo after the initial UTI episode, and recurrences tend to accumulate to the same individuals (10, 16). This has been suggested to reflect changes in the periurethral bacterial flora, possibly resulting from antimicrobial use (10, 16). The relation could be also genetic, reflecting urinary tract anatomy or immunologic differences suggested by ABO blood group dependency (7, 8). An association of previous UTIs and the risk of recurrence was found in this survey also but disappeared in the multivariate analysis, suggesting that the accumulation of UTIs to the same persons could be due to the long-term existence of dietary and hygienic factors affecting UTI risk.

In conclusion, we found several dietary factors to be associated with a lowered risk of UTI, including the amount of fresh juice consumed, especially berry juice. The effect of berries in preventing UTI may thus be even greater than was seen in intervention trials. Fermented milk products containing probiotic bacteria also appeared to be associated with a lower risk of UTI. Thus, dietary guidance may be a first step toward preventing UTIs in women. 

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MU initiated and coordinated the formulation of the primary study hypothesis. Together with JL, LJ, KS, and TK, he discussed core ideas, designed the study protocol, and participated in the data analysis, interpretation of the results, and writing of the paper. TK participated in the formulation of the study hypothesis and design, was responsible for coordinating patient collection, was responsible for data entry, and participated in the analysis and interpretation of the results and the writing of the paper. Both MU and TK are guarantors of the content of the paper. KS recruited the study subjects at the Finnish Student Health Service and participated in the formulation of the study hypothesis and design and interpretation of the results and contributed to the paper. LJ and JL formulated the dietary questionnaires and participated in their interpretation. TP was responsible for the statistical analysis of the data and participated in the interpretation of the results and contributed to the design and writing of the paper. There were no conflicts of interest.

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