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Dietary Macronutrient Intake and Lower Urinary Tract Symptoms in Women

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Abstract

Purpose—To examine associations between macronutrient and total energy intakes with lower urinary tract symptoms (LUTS) in women.

Methods—Cross-sectional analysis of 2,060 women aged 30–79 years in the population-based Boston Area Community Health Survey (2002–2005). Data were collected by validated food frequency questionnaire and in-person interviews. Outcomes for multivariate logistic regression were moderate-to-severe total LUTS, storage, voiding, and post-micturition symptoms.

Results—Greater total energy intake was positively associated with LUTS, specifically among women with lower waist circumferences (<76 cm, P=0.005, $p_{interaction}$=0.01). Increased saturated fat intake was associated with post-micturition symptoms (Quintile 5 vs. 1, OR 3.94, 95% CI 1.57, 9.89, p_{trend} =0.04). High protein intake was positively associated with storage symptoms (p_{trend} =0.03), particularly nocturia. No consistent associations were observed for carbohydrate, monounsaturated or polyunsaturated fat intakes.

Conclusions—Among women with low waist circumferences, high total daily calorie intake was associated with moderate-to-severe LUTS. While greater saturated fat intake was linked to post-micturition symptoms, the possibility that post-micturition symptoms in women represent more extensive or severe conditions should be explored in future research. These novel results indicate that dietary contributors to LUTS in women are distinct from those in men and may depend on symptom subtype and body size.

Keywords

Diet; Energy intake; Nutrition; Urination disorders; Lower urinary tract symptoms; Urinary tract; Fatty acids; saturated; Dietary fats; Dietary proteins

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INTRODUCTION

Lower urinary tract symptoms (LUTS) have been shown to have a negative impact on quality of life for millions of adults across age, sex, and race/ethnic groups (1,2). Although LUTS are often associated with benign prostatic hyperplasia in men, assessments of LUTS in women using similar symptom scales have repeatedly shown comparable prevalence estimates and associations with impaired quality of life (1,3–5). The pathogenesis of LUTS in women is not well understood; studies suggest various origins, including increased autonomic nervous system activity, detrusor sensitivity, endothelial dysfunction, chronic inflammation, and oxidative damage (6–13).

Major dietary constituents hold potential to influence LUTS through these pathways (14–20). Among men, previous epidemiological research has shown that greater total energy and fat intake increased the likelihood of LUTS (21–24), while diets high in protein (21,23) may be beneficial, although results are not consistent across studies. Women may have unique pathophysiology of urological symptoms, and prior nutritional research in women with LUTS is scarce. The U.K. Leicestershire MRC Incontinence Study of overactive bladder found an inverse association with protein, but no associations with other macronutrients or total energy (25). However, their multivariate models did not consider potentially relevant factors, such as waist circumference or comorbidities (26,27). Using detailed data from the Boston Area Community Health (BACH) survey, we found significant links between urinary incontinence (UI) in women with both high total energy intake and high saturated fat relative to polyunsaturated fat intake, suggesting possible roles for autonomic nervous system activity or inflammation (28). Whether dietary factors have a role in other LUTS, including storage, voiding, and post-micturition symptoms, has not been thoroughly examined in women.

Our objective was to investigate the associations between macronutrients and moderate-to-severe symptoms of the lower urinary tract among women, using cross-sectional data from a population-based survey.

METHODS

The Boston Area Community Health (BACH) survey is a community-based survey of urologic symptoms. Details on BACH methods have been published (29). Briefly, from 2002–2005, BACH used a stratified random sample to recruit 3,202 women aged 30–79 years from three racial/ethnic groups in Boston, MA. Information about urologic symptoms, comorbidities, lifestyle, and anthropometrics was obtained by in-person interview. Participants were mailed an English or Spanish version of the Block food frequency questionnaire (FFQ), which has been validated in various settings showing acceptable validity and reliability (30–32). Participants provided written informed consent. The study was approved by the New England Research Institutes' Institutional Review Board.

The final sample size for this analysis was 2,060 women. Women were excluded from analysis if they did not complete the FFQ (n=615), reported an implausible daily energy intake (outside 600–3,500 kcal/day) or omitted ≥60 of the 103 dietary questions (n=423), or had surgery for UI or on the bladder (n=104). Compared to the larger BACH sample, the resulting analytic sample had fewer Hispanics (26.7 vs. 34.7%) and more whites (39.7 vs. 32.0%), but there were no appreciable differences in age, physical activity, body mass index (BMI), waist circumference, alcohol, or LUTS prevalence.

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Measurement of Lower Urinary Tract Symptoms

Urologic symptoms were assessed during the in-home interview. The symptoms included in this analysis were selected and defined based on validated assessment measures and fundamentals from the International Continence Society (ICS) standardization of terminology, which divide LUTS into storage, voiding and post-micturition symptoms (33). Table 1 describes the outcome measure assessment methods. The AUA Symptom Index (AUA-SI) is a 7-item scale originally developed and validated for benign prostatic hyperplasia in men (34), but has repeatedly been shown to capture LUTS in women (1,3–5,35). AUA-SI subscales of voiding and storage symptoms have been shown to have internal consistency both previously(36) as well as in our data (Cronbach's alpha: voiding 0.72, storage 0.57). The AUA-SI voiding score includes a question on incomplete emptying, which is classified as a post-micturition symptom by the ICS. Still, these operational definitions of voiding and storage symptoms are common and have been used in prior research (21,37,38), allowing our results to be compared to other epidemiological studies and be clinically relevant.

Data Analysis

Nutrient intakes were adjusted for total energy intake using residuals.(43) Participants were grouped into quintiles (Q1–Q5) of daily intake. To minimize the influence of outliers, linear tests for trend were assessed using the median values of deciles of intake to represent the exposure of all participants in the same decile (44).

We used logistic regression to calculate odds ratios (OR) and 95% confidence intervals (CI) for each symptom outcome and its association with nutrient intake. Initial models (not shown) were adjusted for age and total energy intake. Full multivariate models additionally adjusted for race/ethnicity, physical activity (45), waist circumference, cigarette smoking, alcohol intake, depression symptoms (46), diabetes, cardiac disease, asthma, and antispasmodic or anticholinergic prescription medication use; models for storage, post-micturition symptoms and overall LUTS additionally adjusted for total fluid intake, and models for type of fat additionally adjust for the other types of fat (see Table 3 footnotes). We also considered the following factors, but did not include them in the main models because they did not affect the final results: menopausal status, vaginal child delivery, body mass index, socioeconomic status, dietary fiber intake, arthritis/rheumatism, cancer, Parkinson's disease, multiple sclerosis, history of urinary tract infection, stroke, use of a bladder catheter, and use of diuretics or tricyclic antidepressants. We examined interactions between total energy intake and waist circumference, which was an important predictor of LUTS in previous studies (27,47). Because our prior work in this population found that high total energy intake was associated with UI (28), in additional analyses we created separate multivariate models for women who had both LUTS and UI (N=162), and women who had LUTS without co-occurring UI (N=262), with further adjustment for UI-relevant factors of menopausal status, history of delivering a child vaginal, and arthritis/rheumatism. Analyses of LUTS with or without UI have lower power due to the smaller sample size and fewer cases, but allow us to explore whether dietary associations are specifically related to LUTS alone or to more severe or extensive overlapping symptoms.

BACH's sampling design requires weighting observations inversely proportional to their probability of selection for results to be generalizable to the base population. Weights were post-stratified to the Boston population 2000 census. Statistical analyses were conducted in SAS v.9.2 (Cary, NC) or SUDAAN v.10.0 (Research Triangle Park, NC).

RESULTS

Of the 2,060 women included in this analysis, 425 (17.6% weighted) had an AUA-SI score ≥ 8 (AUA-SI+) and were therefore considered to have moderate-to-severe overall LUTS. As assessed by the AUA-SI, voiding symptoms were present in 8.3% and storage symptoms in 35.2% of all women. The most common ICS voiding symptom was intermittency (3.5% of all women; 47.9% of women with moderate-to-severe voiding symptoms). Among women with storage symptoms, frequency (66.1%) was most common. Nocturia (52.0%) was also common. Post-micturition symptoms were present in 7.4% of women, with a greater prevalence of feeling incomplete emptying (4.9%) than post-micturition dribble (3.5%). Figure 1a presents the overlap in the operational definitions of moderate-to-severe storage, voiding, and post-micturition symptoms in the total analytical sample. Just under 4% of women reported all three symptom subtypes, and few women reported post-micturition symptoms or voiding symptoms alone. Figure 1b presents the overlap between total LUTS, UI, and post-micturition symptoms.

Weighted means and prevalences of characteristics that may be associated with LUTS are shown in Table 2. Women who scored as having moderate-to-severe LUTS were less likely to be physically active or to drink alcohol, but more likely to have had diabetes, cardiac disease, cancer, arthritis/rheumatism, asthma, or depression symptoms. The factors that influenced estimates of diet-LUTS associations most in multivariate models were diabetes, alcohol intake, and waist circumference.

Results of the multivariate analyses are presented in Table 3. Total energy intake showed a statistically significant (p=0.01) positive linear trend towards increased odds of moderate-to-severe overall LUTS. The increased odds was predominantly due to women in the highest caloric intake group, who were ~80 percent more likely to report LUTS as those in the lowest intake group (OR=1.77, 95% CI 1.01, 3.09, p=0.047). Given prior findings that high total energy intake is associated with UI (28), in additional models we evaluated the impact of co-occurring UI by analyzing women who had both LUTS and UI (N=162), separately from women who had LUTS without co-occurring UI (N=262). Results showed that high caloric intake was strongly associated with co-occurring LUTS and UI (Q5 vs. Q1, OR=2.67, 95% CI 1.34–5.35, p_{trend} =0.002), but the association between high caloric intake and LUTS without co-occurring UI was weaker and not statistically significant (Q5 vs. Q1, OR=1.41, 95% CI 0.73–2.72, p_{trend}=0.39). However, even in analyses of LUTS alone (without co-occurring UI), there was a statistically significant interaction between waist circumference and total energy intake ($p_{interaction}$ =0.01), indicating that greater total energy intake was predictive of LUTS specifically among women with low waist circumferences. Among women with low waist circumference, increased caloric intake was positively associated with LUTS without UI (e.g., <70 cm, OR for 500 kcal/day increase=3.19 [95% CI 1.42, 7.14], p=0.005; <76.2 cm, OR for 500 kcal/day increase=1.54 [95% CI 1.09, 2.18], p=0.01), in a similar magnitude as it was associated with LUTS with co-occurring UI (e.g. <76.2 cm, OR for 500 kcal/day increase=1.53 [95% CI 0.84, 2.80]). In women with high waist circumferences (≥90 cm), total energy intake was not associated with LUTS (p=0.42).

Of the macronutrients, total fat and saturated fat had positive associations with LUTS. The association was notably strong for saturated fat and post-micturition symptoms: women in the highest saturated fat intake quintile had approximately four times the odds of post-micturition symptoms. In analyses of post-micturition symptoms occurring with and without UI, the positive trend was notably stronger for women with combined post-micturition symptoms and UI (p_{trend}=0.004), and attenuated for women without co-occurring UI (p_{trend}=0.40). However, power for the latter exploratory analysis was low because of few cases; when sample weights were not applied to evaluate increased power, estimates were comparable between the two case groups, and high saturated fat intake was associated with post-micturition symptoms even without co-occurring UI (unweighted adjusted OR=2.07, 95% CI 1.00–4.28). Of the two symptoms classified as post-micturition symptoms, post-micturition dribbling was more strongly associated with saturated fat intake (Q5 vs. Q1, OR=9.42, 95% CI 3.00–29.6, p_{trend}=0.004) than was incomplete emptying (Q5 vs. Q1, OR=2.28, 95% CI 0.86–6.03, p_{trend}=0.40). Post-micturition dribbling also had stronger associations with the ratio of saturated to polyunsaturated fat (p_{trend}=0.04, vs incomplete emptying p_{trend}=0.12). In exploring the role of each specific voiding symptom assessed in the AUA-SI, no particular one dominated the association with fat intake; rather, the final voiding symptom score was most relevant.

No consistent or statistically significant associations were observed for intakes of monounsaturated fat or carbohydrates and any of the LUTS outcomes, nor for intakes of cholesterol or sodium (data not shown). Women with high polyunsaturated fat intake were about half as likely to report overall LUTS, but the association just bordered statistical significance (Q5 vs. Q1, OR=0.54, 95% CI 0.28, 1.04, p=0.06). Protein intake was unrelated to most symptoms, with the exception of a significant positive trend with overall storage symptoms as assessed by the AUA-SI (Q5 vs. Q1, OR=1.66, 95% CI 1.05, 2.62, P=0.03, p_{trend}=0.03). To help understand this finding, we explored specific storage symptoms in their relation to protein intake. Results showed that nocturia (whether defined as ≥ 1 episode or ≥ 2 episodes per night) was significantly associated with protein intake in both the unadjusted and multivariate models (p_{trend}=0.005). A positive association between protein and frequency symptoms was also suggested, but was not robust in the multivariate model (unadjusted p_{trend} =0.04, multivariate model p_{trend}=0.10). Urgency symptoms were not associated with protein intake.

DISCUSSION

In this population-based cross-sectional study of women, two major dietary constituents had associations with LUTS that were consistent internally as well as with prior studies of urologic symptoms. High total energy intake was predictive of overall LUTS specifically among women with low waist circumferences. Increased saturated fat intake was associated with LUTS, particularly among women reporting post-micturition symptoms and post-void dribbling. No associations were found between dietary carbohydrate, cholesterol or sodium and total LUTS, voiding, storage, or post-micturition symptoms. Overall, these findings for dietary macronutrient correlates to LUTS in women contrast to findings reported from studies in men,(21–24) which suggests that certain pathways to symptom subtypes are gender-specific.

While our observed positive association between total energy intake and LUTS is consistent with studies of LUTS in men and our prior analysis of UI in women (21,22,28), distinctions are noted. For example, in men, the role of total energy intake did not depend on waist circumference or BMI (21), whereas in women, there were statistically significant interactions between energy intake and waist circumference. For LUTS, the interaction indicated that energy intake affects LUTS only in women with low waist circumferences; however, for UI, energy intake remained predictive of UI in women in upper strata of waist circumference as well (with a significantly smaller magnitude of association compared to lower strata) (28). One possible explanation for the interaction is that leaner women may have fewer competing causes of LUTS compared to women with more abdominal fat mass, whose symptoms may be more related to intra-abdominal pressure, inflammatory processes or comorbidities (20,48,49). A plausible mechanism of energy intake among leaner women is that it increases autonomic nervous system activity (6,7,11,13,50).

Our analysis showed that women with high saturated fat intake were approximately four times as likely to report post-micturition symptoms compared to those with low intake. Incremental increases in saturated fat intake raised the likelihood of reporting post-micturition symptoms, particularly post-void dribbling. A significant role for saturated fat intake was also observed in prior analysis of UI in women (28,51), but not in studies of men and LUTS (21,22). It is important to note that post-micturition symptoms rarely occurred in isolation of other LUTS. Thus, reports of post-micturition symptoms may represent more severe or distinct LUTS pathophysiology. The notion that saturated fat is associated with severity is supported by our prior analysis of UI, where saturated fat intake was more strongly associated with UI severity than with UI presence/absence (28). Plausible mechanisms of saturated fat include inflammation and endothelial dysfunction (8–11); saturated fat and postprandial lipoproteins have been shown to affect both (17–20), and evidence has emerged that inflammatory markers are positively associated with LUTS in female BACH participants (12) as well as in studies of men (52,53).

A novel finding of this analysis was the positive trend between protein intake and storage symptoms. This finding is in contrast to a study of urgency symptoms conducted in the U.K., which found an inverse association for protein and urgency symptoms in women (25). A speculative explanation for a positive association between protein and storage symptoms is that high protein diets have greater osmolar concentrations, which increase water loss and may increase urination frequency (22). Indeed, of all storage symptoms, only frequency and nocturia were associated with protein intake. Furthermore, only nocturia remained significantly associated after adjustment for fluid intake. It is possible that timing of fluid intake (e.g., evening consumption) is more relevant for nocturia, but this was not assessed in the baseline survey.

A limitation of the current analysis is that the observational design does not allow an assessment of causality between dietary factors and LUTS. We cannot exclude the possibility that confounding by other dietary constituents or unknown factors associated with both diet and LUTS account for the observed associations. An additional limitation is that cross-sectional analyses cannot assess the temporality of relationships between exposures and outcomes. However, it is unlikely that women had changed their dietary macronutrient intakes because of preexisting LUTS, particularly given the novelty of our understanding of associations between diet and LUTS. Lastly, we acknowledge that our findings regarding post-micturition symptoms may be related to extensive overlapping symptoms. The high degree of overlap leaves uncertainty as to whether associations are specific to post-micturition symptoms or to a broader condition represented by their presence. Also, estimates for associations were imprecise due to fewer cases and restricted sample sizes in analyses of saturated fat and post-micturition symptoms, as well as dietary associations for LUTS with or without overlapping UI.

Strengths of the current analysis include the racially and ethnically diverse population-based sample, in-person standardized interviews to assess LUTS status and detailed data on important covariates. Response rates to the FFQ were comparable to other large population-based surveys (54,55), and mean dietary intakes of nutrients were similar to results from the third National Health and Nutrition Examination Survey (data not shown). Thus, our analytic sample is likely to be representative of the general US population in dietary consumption patterns and urologic symptoms, and our results can be directly applied to the general population.

In summary, we found that high total energy intake was associated with overall LUTS among women with low waist circumferences, and increased saturated fat intake was predictive of post-micturition symptoms. These associations were strong in magnitude, exhibited a dose-response pattern, and are biologically plausible. However, additional research, including longitudinal observations and interventions, is required to confirm specificity to LUTS subtypes and verify our novel findings. In addition, whether the observed positive association between protein intake and nocturia is related to osmolar concentrations and urinary output should be examined in future work. Our results suggest the potential for different etiologies of LUTS in women based on urinary symptom subtypes and waist circumference.

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Abbreviations

AUA	American Urological Association
AUA-SI	American Urological Association Symptom Index
BACH	Boston Area Community Health survey
CI	Confidence interval
ICS	International Continence Society
LUTS	Lower urinary tract symptoms
OR	Odds ratio
UI	Urinary incontinence

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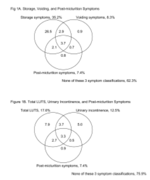

Figure 1.

Overlap in the operational definitions used for moderate-to-severe lower urinary tract symptoms (LUTS), weighted prevalence percent estimates among all 2,060 women in the analysis.

Table 1

Assessment and Operational Definitions of Moderate-to-Severe Lower Urinary Tract Symptoms

Lower Urinary Tract Symptoms (LUTS)	Assessment and Operational Definitions
Total LUTS	• AUA-SI score ≥ 8 (of total possible 35 points) • Continuous AUA-SI score (secondary outcome).
Voiding symptoms	• AUA-SI score ≥ 5 (of total possible 20 points) on four questions regarding intermittency, weak urinary stream, hesitancy, and incomplete bladder emptying • Continuous voiding symptom score (secondary outcome) • For exploratory analyses of individual AUA-SI voiding symptoms, response of "fairly often," "usually" or "almost always" to the respective AUA-SI question
Storage symptoms	• AUA-SI score ≥ 4 (of total possible 15 points) on three questions regarding frequency, urgency, and nocturia • Continuous storage symptom score (secondary outcome) • For exploratory analyses of individual symptoms: – Frequency: "frequent urination during the day" or "to urinate again less than two hours after you finished urinating" fairly often or more in the last month – Urgency: "a strong urge or pressure to urinate that signals the need to urinate" four or more times in the last 7 days, or "difficulty postponing urination" fairly often or more in the last month – Nocturia was defined in two ways based on number of times respondent gets out of bed at night after falling asleep to urinate: 1) at least once, 2) at least twice.
Post-micturition symptoms	• Feeling of incomplete emptying and/or post-micturition dribble, as assessed by a positive response to at least one of the following (experienced fairly often, usually or almost always): – Sensation of not completely emptying the bladder after having finished urinating, and/or – Experiencing dribbling after urination. • Continuous symptom score, created by summing responses to two questions above indicating how frequently symptoms occur (possible range, 0–10)
Urinary incontinence	• Score > 3 on the Sandvik severity index (39), which assesses urine leakage frequency (< once/month, one or more times per month, one or more a times per week, or everyday) and amount (drops, small splashes, or more), resulting in a composite score ranging from one to twelve. A severity score ≥ 3 indicates moderate-to-severe UI and corresponds to at least weekly leakage or monthly leakage of volumes more than a few drops in the past 12 months (40–42).

Abbreviations: AUA-SI=American Urological Association-Symptom Index; LUTS=lower urinary tract symptoms

Table 2

Weighted characteristics, overall and by LUTS status (AUA Symptom Index)[1], among 2,060 women in the Boston Area Community Health survey (2002–2005).

	Total N=2,060	Moderate-to-Severe LUTS[1] n=425	None-to-Mild LUTS n=1,635
Total symptom score, mean (se)	4.3 (0.1)	12.1 (0.3)	2.6 (0.1)
Voiding symptoms[2], %	8.3	43.0	0.9
Mean score (se)	1.2 (0.1)	4.6 (0.2)	0.4 (0.04)
Storage symptoms[3], %	35.2	94.6	22.6
Mean score (se)	3.1 (0.1)	7.4 (0.2)	2.2 (0.1)
Post-micturition symptoms[4], %	7.4	33.9	1.8
Mean score (se)	0.8 (0.04)	2.8 (0.1)	0.4 (0.3)
Age, mean (se) y	48.9 (0.6)	51.4 (1.1)	48.3 (0.6)
Race, %			
Black	30.2	36.1	28.9
Hispanic	13.0	10.5	13.6
White	56.8	53.5	57.5
Cigarette smoker, %			
Never	50.6	46.6	51.4
Former	26.5	28.0	26.2
Current	22.9	25.5	22.4
Alcohol intake, mean (se) g/day	5.7 (0.4)	3.8 (0.5)	6.2 (0.5)
BMI, mean (se) kg/m^2	28.9 (0.3)	30.6 (0.6)	28.6 (0.3)
Waist circumference, mean (se) cm	89.6 (0.6)	92.6 (1.4)	89.0 (0.6)
Physical activity, %			
Low	26.6	37.5	24.3
Medium	53.4	52.0	53.7
High	19.9	10.5	21.9
Menopausal Status			
Premenopausal	24.1	11.5	26.8
Perimenopausal	21.1	22.0	20.9
Nonsurgically postmenopausal	22.4	24.5	22.0
Surgically postmenopausal	14.5	21.8	12.9
Hormone use	15.5	16.7	15.2
Undetermined	2.5	3.5	2.2
Vaginal child delivery ever, %	78.3	81.3	77.6
Urinary tract infection ever, %	46.1	42.4	63.4
Medical Conditions			
Diabetes, %	8.2	13.0	7.1
Cardiac disease, %	7.3	12.3	6.3
History of cancer, %	9.2	11.9	8.6

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	Total N=2,060	Moderate-to-Severe LUTS[1] n=425	None-to-Mild LUTS n=1,635
Arthritis or rheumatism, %	28.3	45.7	24.6
History of stroke, %	1.3	1.7	1.2
Asthma, %	18.2	30.9	15.4
Depression symptoms, %	18.4	30.8	15.7
Any of the above, %	56.5	75.4	52.5
Three or more of the above, %	7.6	15.6	5.9
Diuretic use, %	13.0	17.1	12.1
Antispasmodic or anticholinergic use, %	1.4	5.9	0.5
Total energy intake[5], mean (se), kcal/day	1,589 (19)	1,719 (57)	1,561 (21)
Energy-adjusted dietary intake, mean (se)			
protein, g/day	82.7 (0.6)	82.3 (1.4)	82.8 (0.7)
carbohydrates, g/day	239 (1.8)	241 (3.3)	239 (2.0)
saturated fat, g/day	25.0 (0.2)	25.7 (0.4)	24.9 (0.3)
monounsaturated fat, g/day	30.1 (0.3)	30.9 (0.5)	29.9 (0.3)
polyunsaturated fat, g/day	13.8 (0.2)	13.6 (0.4)	13.9 (0.2)
saturated:polyunsaturated fat	2.0 (0.03)	2.1 (0.06)	2.0 (0.04)
cholesterol, mg/day	297 (6)	305 (10)	295 (6)
sodium, mg/day	2,621 (23)	2,633 (54)	2,618 (24)
fiber, g/day	14.2 (0.2)	13.8 (0.5)	14.3 (0.2)

[1]Lower urinary tract symptoms, defined as present if score ≥ 8 (moderate-to-severe) on the American Urological Association-Symptom Index (AUA-SI).

[2]Voiding symptoms defined as present if score ≥ 5 (of total possible 20; moderate-to-severe) on AUA-SI voiding symptoms questions.

[3]Storage symptoms defined as present if score ≥ 4 (of total possible 15; moderate-to-severe) on AUA-SI storage symptoms questions.

[4]Post-micturition symptoms defined as present if the participant reported the feeling of incomplete emptying or post-void dribbling at least fairly often; the continuous score was calculated based on responses to those two questions.

[5]Total energy intake does not include energy from alcohol consumption.

Table 3

Multivariate odds ratios and 95% confidence intervals for moderate-to-severe LUTS (n=425), voiding (n=216), storage (n=744), and post-micturition (n=204) symptoms, by macronutrient intakes in BACH survey women (N=2,060) [1]

Macronutrient	Quintile of intake: 1	2		3		4		5		*P* trend	*P* trend with continuous symptom score
Total energy intake, ***median***	*840 kcal/d*	*1,171 kcal/d*		*1,494 kcal/d*		*1,860 kcal/d*		*2,453 kcal/d*			
Total LUTS	1.00	0.97	(0.53, 1.78)	0.75	(0.42, 1.32)	1.08	(0.59, 1.98)	**1.77***	**(1.01, 3.09**	**0.01**	0.14
Voiding symptoms	1.00	0.78	(0.34, 1.81)	1.06	(0.52, 2.19)	0.43*	(0.21, 0.91)	1.26	(0.65, 2.44	0.79	0.15
Storage symptoms	1.00	1.13	(0.72, 1.78)	0.89	(0.56, 1.43)	1.04	(0.66, 1.65)	1.03	(0.63, 1.69	0.95	0.21
Post-micturition symptoms	1.00	1.02	(0.48, 2.15)	0.71	(0.36, 1.41)	0.98	(0.46, 2.10)	1.42	(0.71, 2.85)	0.16	**0.01**
Carbohydrates, ***median***	*188 g*	*221 g*		*244 g*		*267 g*		*305 g*			
Total LUTS	1.00	0.72	(0.44, 1.18)	0.91	(0.54, 1.52)	0.97	(0.56, 1.70)	0.84	(0.48, 1.48)	0.81	0.40
Voiding symptoms	1.00	0.68	(0.34, 1.35)	0.97	(0.51, 1.83)	0.90	(0.49, 1.66)	0.93	(0.44, 1.96)	0.80	0.85
Storage symptoms	1.00	0.76	(0.49, 1.19)	0.71	(0.42, 1.18)	0.81	(0.51, 1.30)	0.75	(0.47, 1.20)	0.11	0.24
Post-micturition symptoms	1.00	0.53	(0.27, 1.05)	0.58	(0.29, 1.16)	0.73	(0.30, 1.77)	0.62	(0.30, 1.28)	0.26	0.45
Protein, ***median***	*57 g*	*71 g*		*81 g*		*91 g*		*110 g*			
Total LUTS	1.00	0.98	(0.54, 1.78)	1.50	(0.85, 2.67)	0.86	(0.48, 1.55)	1.03	(0.57, 1.86)	0.90	0.58
Voiding symptoms	1.00	1.27	(0.63, 2.57)	1.55	(0.75, 3.23)	1.36	(0.66, 2.81)	1.08	(0.49, 2.36)	0.95	0.64
Storage symptoms	1.00	1.23	(0.72, 2.11)	1.30	(0.81, 2.07)	1.30	(0.81, 2.07)	**1.66***	**(1.05, 2.62)**	**0.03**	0.19
Post-micturition symptoms	1.00	1.77	(0.85, 3.71)	1.50	(0.72, 3.10)	1.26	(0.61, 2.62)	1.65	(0.85, 3.20)	0.37	0.43
Total fat, ***median***	*55 g*	*67 g*		*76 g*		*84 g*		*97 g*			
Total LUTS	1.00	1.77	(0.98, 3.18)	1.52	(0.89, 2.61)	**1.75***	**(1.00, 3.06)**	1.52	(0.91, 2.53)	0.41	0.16
Voiding symptoms	1.00	**2.84****	**(1.42, 5.66)**	**2.35****	**(1.23, 4.47)**	**2.05***	**(0.99, 4.25)**	1.90	(0.94, 3.86)	0.62	0.51
Storage symptoms	1.00	1.42	(0.93, 2.17)	0.90	(0.57, 1.41)	1.14	(0.71, 1.82)	1.52	(0.96, 2.40)	0.19	0.13
Post-micturition symptoms	1.00	2.02	(0.98, 4.15)	**1.97***	**(1.00, 3.89)**	1.63	(0.82, 3.26)	**2.20***	**(1.11, 4.36)**	0.23	0.16
Saturated fat, ***median***	*16.5 g*	*21.2 g*		*24.6 g*		*27.8 g*		*33.0 g*			
Total LUTS	1.00	1.38	(0.77, 2.50)	0.97	(0.53, 1.77)	0.88	(0.36, 2.20)	1.23	(0.59, 2.60)	0.48	0.21
Voiding symptoms	1.00	1.56	(0.78, 3.12)	1.91	(0.80, 4.54)	0.84	(0.36, 1.96)	1.39	(0.58, 3.29)	0.82	0.99
Storage symptoms	1.00	1.26	(0.75, 2.11)	0.80	(0.48, 1.31)	1.07	(0.58, 1.98)	1.36	(0.77, 2.41)	0.14	**0.04**
Post-micturition symptoms	1.00	**2.20***	**(1.07, 4.53)**	**2.40***	**(1.08, 5.34)**	**3.92****	**(1.43, 10.8)**	**3.94****	**(1.57, 9.89)**	**0.04**	**0.04**

Macronutrient	Quintile of intake 1	2		3		4		5		*P* trend	*P* trend with continuous symptom score
<u>Monounsaturated fat</u>, *median*	*20.3 g*	*25.6 g*		*29.6 g*		*33.5 g*		*39.8 g*			
Total LUTS	1.00	1.60	(0.88, 2.91)	1.59	(0.78, 3.28)	1.58	0.72, 3.48	2.04	(0.84, 4.94)	0.54	0.52
Voiding symptoms	1.00	1.32	(0.56, 3.07)	1.36	(0.54 3.43)	1.04	0.44, 2.47	1.49	(0.52, 4.21)	0.41	0.33
Storage symptoms	1.00	1.15	(0.70, 1.87)	1.09	(0.65, 1.80)	1.13	0.64, 2.03	1.27	(0.68, 2.39)	0.85	0.92
Post-micturition symptoms	1.00	1.45	(0.57, 3.67)	0.81	(0.31, 2.11)	0.61	0.19, 1.91	0.92	(0.28, 3.00)	0.76	0.96
<u>Polyunsaturated fat</u>, *median*	*7.7 g*	*10.6 g*		*12.8 g*		*15.3 g*		*19.8 g*			
Total LUTS	1.00	0.60	(0.34, 1.05)	0.61	(0.36, 1.05	0.67	0.39, 1.15	0.54	0.28, 1.04	0.21	0.19
Voiding symptoms	1.00	1.36	(0.67, 2.74)	1.03	(0.52, 2.07	0.72	0.35, 1.47	0.86	0.39, 1.87	0.37	0.29
Storage symptoms	1.00	1.02	(0.62, 1.69)	0.94	(0.60, 1.48	0.72	0.44, 1.17	0.94	0.59, 1.51	0.71	0.28
Post-micturition symptoms	1.00	**0.54***	**(0.29, 1.00)**	0.67	(0.34, 1.31	0.60	0.30, 1.17	0.71	0.34, 1.46	0.62	0.57
<u>Ratio of Saturated to Polyunsaturated fat</u>, *median*	*1.1*	*1.6*		*1.9*		*2.3*		*3.0*			
Total LUTS	1.00	1.18	(0.70, 1.97)	1.21	(0.69, 2.12)	**1.79***	**1.03, 3.12**	1.45	0.83, 2.53	0.21	0.14
Voiding symptoms	1.00	0.91	(0.45, 1.84)	1.29	(0.64, 2.58)	1.32	0.66, 2.65	1.24	0.64, 2.41	0.82	0.59
Storage symptoms	1.00	1.00	(0.63, 1.57)	0.81	(0.51, 1.28)	1.08	0.68, 1.71	1.10	0.72, 1.68	0.26	0.06
Post-micturition symptoms	1.00	0.85	(0.38, 1.93)	1.42	(0.66, 3.04)	1.59	0.81, 3.10	1.72	0.82, 3.61	0.06	0.18

[1]The multivariate models included age (5-year categories), race (black, Hispanic, or white), waist circumference (quintiles), physical activity (low, medium, or high), cigarette smoking (never-smoker, < 2.5, 2.5–10, 10–20, or ≥ 20 pack-years), alcohol intake (quintiles of g/day), diabetes, cardiac disease, asthma, antispasmodic or anticholinergic medication use, and total energy intake (quintiles). Models for total LUTS, storage and post-micturition symptoms also controlled for total daily (non-alcoholic) fluid intake (quintiles). Models for saturated fat, monounsaturated fat, and polyunsaturated fat additionally adjusted for each other type of fat.

* $p \leq 0.05$

** $p \leq 0.01$