Dietary Macronutrients, Cholesterol, and Sodium and Lower Urinary Tract Symptoms in Men

Published in final edited form as:
Eur Urol. 2009 May ; 55(5): 1179–1189. doi:10.1016/j.eururo.2008.07.058.

Dietary Macronutrients, Cholesterol, and Sodium and Lower Urinary Tract Symptoms in Men

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Abstract

Background—Little is known about dietary correlates of lower urinary tract symptoms (LUTS).

Objective—To examine associations between dietary intakes of total energy, carbohydrates, protein, fats, cholesterol, and sodium and LUTS in men.

Design, setting, and participants—Cross-sectional study of 1545 men aged 30–79 yr in the Boston Area Community Health study (2002–2005), a random population-based sample. Dietary data were assessed by validated self-administered food frequency questionnaire. LUTS and covariate data were collected during in-person interviews. Primary analyses used multivariate logistic regression.

Measurements—Outcomes were moderate to severe LUTS, storage symptoms, and voiding symptoms as measured by the American Urological Association Symptom Index.

Results and limitations—Greater total energy intake was associated with higher LUTS symptom score ($p_{trend} < 0.01$) and increased likelihood of storage symptoms. No associations were observed

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Acquisition of data: McKinlay
Analysis and interpretation of data: Maserejian, Giovanucci
Drafting of the manuscript: Maserejian
Critical revision of the manuscript for important intellectual content: Maserejian, Giovanucci, McKinlay
Statistical analysis: Maserejian
Obtaining funding: McKinlay
Administrative, technical, or material support: Maserejian
Supervision: McKinlay
Other (specify): none

Financial disclosures: I certify that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: none

with total, saturated, or monounsaturated fat intake or carbohydrates. Men who consumed more protein were less likely to report LUTS, particularly voiding symptoms (quintile 5 vs quintile 1 OR = 0.35; 95% CI, 0.17–0.74; $p = 0.006$). Sodium intake had positive linear associations with LUTS ($p_{trend} = 0.01$) and storage symptom score ($p_{trend} = 0.004$); this finding should be confirmed by studies using biomarkers of sodium exposure. Storage symptoms increased slightly with greater polyunsaturated fat intake ($p_{trend} = 0.006$). Data on specific polyunsaturated fats were unavailable.

Conclusions—This community-based study of men found that total energy and sodium intake were positively associated with LUTS, whereas greater protein intake was inversely associated with LUTS.

Keywords

Diet; Dietary fats; Dietary proteins; Energy intake; Nutrition; Prostatic hyperplasia; Sodium; dietary; Urination disorders

1. Introduction

Lower urinary tract symptoms (LUTS) are a source of daily bother and lower the quality of life for millions of adults [1]. Although LUTS is often associated with benign prostatic hyperplasia (BPH) in men, studies suggest various origins for LUTS, including increased sympathetic nervous system (SNS) activity, detrusor sensitivity, and oxidative damage [2–4].

These possible origins of LUTS are affected by macronutrient intake [5–8], yet the extent to which macronutrients are associated with LUTS in men remains unclear. Previous research has focused on older men and BPH, accounting for only a subset of the larger population suffering these symptoms. Two case-control studies of surgically treated cases of BPH showed inconsistent results regarding macronutrients [9,10]. One prospective study found a positive association between total fat and an inverse association between protein intake and BPH, defined by BPH treatment or a high symptom score [11]. Yet a separate prospective study showed that the role of protein differed by outcome definition; a positive association was observed for BPH surgery, but no association was found with high or moderate to severe LUTS [12]. Similarly, total energy and polyunsaturated fats were positively associated with BPH, as defined by BPH surgery or high symptom score, yet when the researchers separated these outcomes, they found that the associations held only for LUTS [12]. These results indicate that the pathophysiological mechanisms of LUTS are not completely aligned with BPH, and studies on more widespread LUTS, thoroughly considering voiding and storage symptoms, are necessary.

Our objective was to investigate the associations between macronutrients, dietary cholesterol and sodium intake, and moderate to severe symptoms of the lower urinary tract among men using cross-sectional data from a unique community-based random-sample survey.

2. Methods

2.1. The Boston Area Community Health study

The Boston Area Community Health (BACH) survey is a community-based survey of urologic symptoms and risk factors. From 2002–2005, BACH used a multistage stratified random sample to recruit 2301 men aged 30–79 yr from three racial/ethnic groups in the Boston area. Information about urologic symptoms, comorbidities, lifestyle, and anthropometrics was obtained by in-person interview. Details on BACH's methods have been published [13]. Participants provided written informed consent, approved by the New England Research Institutes' Institutional Review Board.

Participants were mailed an English or Spanish version of the Block food frequency questionnaire (FFQ) [14]. Eighty-one percent of men returned the FFQ and were therefore potentially eligible for nutritional analysis. We further excluded men from nutritional analysis if they reported an implausible daily energy intake (outside the range of 800–4200 kcal/d) or omitted ≥60 of the 103 dietary questions (17.4% of men). After exclusions, 1545 men remained in the analysis. Compared to the larger BACH sample, the resulting dietary data sample had fewer Hispanics (10.7% vs 13.0%), more whites (67.0 vs 61.9%), and slightly higher LUTS prevalence (20.0% vs 18.7%), but there were no differences in age, physical activity, body mass index (BMI), alcohol intake, or smoking status.

2.2. Assessment of diet

Participants completed the Study of Women's Health Across the Nation (SWAN) 01/02 version of the 1995 Block FFQ [14]. Both English and Spanish versions of the SWAN/Block FFQ have been validated in various settings with moderate to high validity and reliability [14–16]. Compared to four 24-h dietary recalls, deattenuated energy-adjusted correlation coefficients obtained from the men were 0.61 for protein, 0.64 for carbohydrates, and 0.55 for fat [17]. The SWAN FFQ performed similarly well in Hispanics: deattenuated correlation coefficients were 0.61 for protein, 0.61 for carbohydrates, and 0.78 for fat [15].

2.3. Assessment of lower urinary tract symptoms

During the in-home interview, LUTS was assessed by the American Urologic Association Symptom Index, a validated 7-item scale originally developed as a BPH symptom index but shown to be nonspecific to BPH [18–20]. In the primary analyses, the presence of LUTS was defined by a symptom score ≥8 (moderate to severe LUTS). Additional analyses evaluated the continuous symptom score as the outcome.

To help elucidate pathophysiologic mechanisms, we also assessed the two components of the Index—voiding and storage symptoms—separately as outcomes. Voiding symptoms were based on responses to four questions regarding incomplete bladder emptying, intermittency, weak urinary stream, and hesitancy. Scoring ≥5 (of 20) on these questions identified moderate to severe voiding symptoms. Similarly, scoring ≥4 (of 15) on three storage symptom questions (assessing frequency, urgency, and nocturia) identified moderate to severe storage symptoms. The internal consistency of these subscales has been established [21] and was acceptable in our data (Cronbach's alpha: voiding 0.79, storage 0.66). These voiding and storage classifications have been used elsewhere [22,23]; thus, our results can be compared to other epidemiological studies.

2.4. Data analysis

Nutrient intakes were adjusted for total energy intake using residuals [24]. Participants were grouped into quintiles of daily intake of each nutrient. 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.

We used logistic regression to calculate odds ratios and 95% confidence intervals for each symptom outcome and its association with nutrient intake. Initial models were adjusted for age and total energy intake. Full multivariate models additionally adjusted for race, physical activity [25], waist circumference, tobacco, diabetes, cardiac disease, and surgery on the prostate or bladder; models for storage symptoms additionally adjusted for total fluid intake (Table 3 footnotes). We also considered boy mass index (BMI), alcohol, diuretic use, cancer, symptoms of depression, socioeconomic status, interactions between waist circumference and age or BMI as potential covariates, and interactions between total energy intake and BMI or physical activity, but these factors did not affect results, so were not included in the final analyses. In sensitivity analyses, we excluded men who reported ever having prostate cancer or surgery on the prostate, bladder, or penis (n = 144; 33.6% had moderate to severe LUTS).

BACH's sampling design requires weighting observations inversely proportionally to their probability of selection. Weights were poststratified to the Boston population 2000 census. All statistical tests were two-sided, performed at alpha = 0.05, and conducted in SAS v.9.1 (Cary, NC, USA) or SUDAAN v.9.0.1 (Research Triangle Park, NC, USA).

3. Results

Of the 1545 men, 322 (20.0%) had a symptom score 8 and were therefore considered to have moderate to severe LUTS. Voiding symptoms were present in 13.4% (n = 214) and storage symptoms in 29.5% (n = 481) of all men. Voiding and storage scores were moderately correlated (r = 0.59). Among men with storage symptoms, 29.7% also had voiding symptoms. Among men with voiding symptoms, 65.2% also had storage symptoms. The most common symptoms were, for voiding, a sensation of incomplete bladder emptying, and for storage, frequent urination (reported at least "fairly often" by 6.6% and 18.7% of all men, respectively).

Weighted means and prevalence of characteristics that may be associated with LUTS are shown in Table 1, overall and by LUTS status. Men who reported LUTS were more likely to be white, less physically active, and to have had diabetes, cardiac disease, cancer, or surgery on the bladder or prostate. Table 2 presents characteristics by dietary intake.

Results of the multivariate analyses are presented in Table 3. The covariates that were most influential in multivariate models were waist circumference and diabetes. Total energy intake had no statistically significant association with moderate to severe LUTS; however, it had a significant positive linear trend with the continuous symptom score (p = 0.008). Results for total energy intake were unchanged in sensitivity analyses and consistent when LUTS was separated by voiding or storage symptoms. For storage symptoms, the increased risk of LUTS was statistically significant in both the analysis of moderate to severe LUTS (p_{trend} = 0.01) and the continuous symptom score (p_{trend} = 0.02).

No statistically significant or consistent associations were observed for carbohydrate or total fat intake and LUTS outcomes. In contrast, protein intake was inversely associated with LUTS, particularly voiding symptoms. For total LUTS, men in the highest quintile of protein intake were half as likely to report LUTS (OR = 0.50; 95% CI, 0.26–0.96; p = 0.04). This inverse association was stronger for voiding symptoms (OR = 0.35; 95% CI, 0.17–0.74; p = 0.006), with a statistically significant linear trend (p_{trend} = 0.02). Protein had no significant association with storage symptoms. The additional adjustment for sodium intake in these protein models strengthened associations with LUTS and voiding symptoms (see Table 3 footnote), but did not affect tests for linear trend. Results were similar but weaker in sensitivity analyses (eg, voiding symptoms: quintile 5 vs quintile 1 OR = 0.46; 95% CI, 0.21–1.00; p_{trend} = 0.09).

Analyses of types of fat found little or no role for saturated or monounsaturated fats. Saturated fat and cholesterol intakes tended to be positively associated with voiding symptoms (eg, saturated fat: p_{trend} = 0.05), but no clear trends emerged. Polyunsaturated fat intake was associated specifically with storage symptoms (p_{trend} = 0.006; sensitivity analysis: p_{trend} = 0.05), indicating a slight increase in risk with greater intake.

Sodium intake had a significant positive association with LUTS (p_{trend} = 0.007) and the continuous symptom score (p_{trend} = 0.02). Men in the highest quintile of sodium intake were more than twice as likely to report LUTS as men in the lowest quintile (OR = 2.25; 95% CI, 1.26–4.03; p = 0.006; sensitivity analyses: OR = 2.11; 95% CI, 1.15–3.84; p = 0.02). The difference between the highest and lowest quintiles, which was on average approximately 1500 mg of sodium (approximately two-thirds of a teaspoon of salt), was associated with an increase in symptom score of 1.1 points ($p = 0.03$). The linear trend was particularly strong for storage symptoms ($p_{trend} = 0.004$). No consistent association emerged between sodium intake and voiding symptoms.

4. Discussion

In these cross-sectional analyses of a diverse, community-based sample of men, we found that greater total energy and sodium intake were positively associated with LUTS, whereas greater protein intake was inversely associated with LUTS. Protein intake was predominantly associated with voiding symptoms and sodium intake with storage symptoms. We also observed a modest positive trend between polyunsaturated fat and storage symptoms. Results were generally consistent when we examined the continuous symptom score and were particularly strong for total energy and sodium intake, indicating that these factors may be important for the development of mild symptoms as well as moderate to severe LUTS.

Although little comparable research on LUTS is available, prior studies have examined a common cause of LUTS in men, BPH, in relation to diet [9,10,12]. Our finding of a positive association between LUTS and total energy intake is consistent with results from the Health Professionals Follow-up Study for BPH, defined by high or moderate to severe LUTS [12]. A plausible mechanism by which high energy intake may adversely affect lower urinary tract function is by increasing SNS activity [3,5]. An alternate explanation for the positive trend with total energy intake is that it represents mechanisms involving body size or physical activity. However, the positive association between total energy intake and LUTS remained in lower strata of BMI, waist circumference, or physical activity (data not shown), and we adjusted for body size and activity in the multivariate models. Thus, although the exact mechanism by which high energy intake may be associated with increased LUTS risk is unclear, increased SNS activity may be involved.

Our results showed a positive linear trend between polyunsaturated fat and storage symptoms and no associations between LUTS and carbohydrates, total fat, saturated fat, or monounsaturated fat. These findings are consistent with the Health Professionals Follow-up Study, although there polyunsaturated fat was associated with total LUTS [12]. The Prostate Cancer Prevention Trial also observed a positive trend between polyunsaturated fat and BPH, but total fat intake proved to be the better predictor of incident BPH [11]. Our results regarding polyunsaturated fat were not overly robust. The association is complicated by the potential for polyunsaturated fats to have both beneficial and harmful properties regarding LUTS. Prevention of LUTS may result because polyunsaturated fats have essential roles in proper neuronal structure and function [26] and may suppress SNS activity [27]. On the other hand, polyunsaturated fats are highly prone to oxidative damage [28], which may theoretically increase LUTS [4]. Furthermore, specific types of fatty acids may differ in their associations with LUTS [12]. A limitation of the current study is that data on specific dietary fatty acids were unavailable.

We observed that greater protein intake was associated with a statistically significantly decreased odds of LUTS and voiding symptoms. This finding is consistent with a recent prospective study of BPH [11], although a prior longitudinal examination of high/moderate to severe LUTS found no association with protein [12]. An inverse association with protein intake is supported by evidence that high-protein diets suppress SNS activity [29,30]. Another conceivable mechanism is a hormonal pathway, in which dietary protein could lower plasma testosterone concentrations [31–33] or affect estradiol levels [34,35]; however, a recent investigation of sex-steroid levels in BACH men found no associations with LUTS [36]. Our observed association with total LUTS was affected by adjustment for sodium intake, which is relatively difficult to measure with FFQs and so can lead to spurious and unpredictable results as a covariate. The association between protein and voiding symptoms was more robust.

The positive association between sodium intake and LUTS is worthy of further attention. Men in the highest intake quintile were twice as likely to report LUTS, with significant linear trends for both LUTS and storage symptoms. Most men in our study reported consuming more than the “achievable” daily maximum 2300 mg that is recommended by the American Heart Association [37]. A plausible explanation for an increased odds of LUTS is that high sodium intake increases blood pressure and SNS activity [38]. Because average daily sodium intake is relatively difficult to capture with FFQs, studies measuring urinary sodium excretion as an indicator of sodium intake are necessary to confirm these results.

The observed positive association between dietary cholesterol and voiding symptoms is theoretically plausible [7,8,39]. However, there was no indication of a trend across quintiles of intake, and it is unlikely that there is such a strong threshold effect, for example, at 200 mg/d; thus, these results may be due to chance.

Overall, most of our results were consistent using either the definition of moderate to severe outcome or the continuous symptom score; however, using the latter method, the differences in adjusted mean scores were small and of little clinical significance. The definition of moderate to severe LUTS was based on numerous tests of the American Urological Association’s Symptom Index [18–20]. Moderate or severe symptoms are associated with significantly lower quality of life across cultures [1]. In our study, the association between polyunsaturated fat and storage symptoms was significant only with moderate to severe symptoms, not with the continuous symptom score. Thus, our results highlight the importance of a clinically meaningful outcome to define sufficiently bothersome or ominous symptoms.

A primary strength of this study is that the data were gathered in a community-based, random sample of various ages and racial/ethnic groups. Furthermore, the survey assessed symptoms rather than diagnosed conditions, thereby capturing the broader spectrum of the population who may suffer, not just those who seek and receive treatment. Thus, diagnostic bias was avoided, and our results are applicable to various socioeconomic groups. That Hispanic men were less likely to provide useable FFQs, despite the option of a validated Spanish version, was consistent with results from other nationwide epidemiological investigations of diet [17, 40]. It is unlikely that the relationship between nutrients and LUTS differs among men who did not provide useable FFQs. It is further reassuring that in our final dietary sample, the weighted energy-adjusted mean dietary intakes of various nutrients were strikingly similar to results from the third National Health and Nutrition Examination Survey (NHANES), and participants consumed close to the recommended dietary intakes for most nutrients (data not shown). Therefore, the BACH sample is likely to be representative of the general US population in dietary consumption patterns and urologic symptomatology.

These cross-sectional analyses leave us to question temporality and whether observed associations represent causal effects of nutrient intake. In support of these results, intake of total energy and macronutrients are relatively stable over time within-person, and it is unlikely that a man experiencing LUTS will consequently alter his intake of, for example, protein. The fact that our results were mostly consistent with a longitudinal study of BPH in older men spanning 14 yr indicates that our analyses may indeed elucidate effects of dietary factors on LUTS [12]. As such, the concern that observed associations are due to the possibility that LUTS affects diet is alleviated. Furthermore, it is plausible that there is a prompt temporal nature of nutrient–LUTS associations; for example, if dietary factors act through the SNS, effects would be fairly immediate. Thus, the cross-sectional methodology may be quite relevant for current symptoms, compared to evaluating nutrients consumed a few years prior.

5. Conclusions

This community-based study of men found that total energy and sodium intake were associated with increased LUTS, whereas greater protein intake was inversely associated with LUTS. Results differed when separately examining voiding and storage symptoms. While there are possible pathophysiologic explanations, these remain speculative until further experimental and epidemiological research is conducted to confirm our results.

Acknowledgments

Funding/Support and role of the sponsor: The National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) was involved in the design and conduct of the study, which was funded by NIDDK grant DK56842.

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Table 1

Weighted characteristics, overall and by LUTS[1] status, among 1545 men in the Boston Area Community Health survey

	Total (*n* = 1545)	Moderate to severe LUTS (*n* = 322)	None to mild LUTS (*n* = 1223)
Symptom score, mean (SEM)	4.3 (0.2)	12.0 (0.3)	2.4 (0.1)
Voiding symptoms[2], %	13.4	56.9	2.6
Voiding score, mean (SEM)	1.6 (0.1)	5.6 (0.3)	0.6 (0.1)
Storage symptoms[3], %	29.5	87.0	15.2
Storage score, mean (SEM)	2.7 (0.1)	6.4 (0.3)	1.8 (0.1)
Age in years, mean (SEM)	47.9 (0.5)	53.9 (1.1)	46.5 (0.5)
Age group, %			
30–39	34.8	15.0	39.8
40–49	27.0	27.0	27.0
50–59	18.8	24.2	17.4
60–69	12.2	23.2	9.5
≥70	7.2	10.6	6.4
Race, %			
Black	22.2	20.0	22.8
Hispanic	10.7	9.4	11.1
White	67.0	70.6	66.1
Cigarette or cigar use, %			
Never	38.2	35.1	39.0
Former	30.6	36.8	29.0
Current	31.2	28.1	31.9
Alcohol intake in grams per day, mean (SEM)	15.4 (1.4)	15.1 (2.6)	15.4 (1.6)
BMI in kilograms per square meter, mean (SEM)	28.5 (0.3)	28.9 (0.5)	28.4 (0.4)
Waist circumference in centimeters, mean (SEM)	97.7 (0.9)	100.4 (1.5)	97.1 (1.0)
Physical activity, %			
Low	27.0	38.0	24.3
Medium	46.6	45.1	50.0
High	26.4	16.9	28.8
Diabetes, %	9.2	19.9	6.6
Cardiac disease, %	9.5	21.6	6.5
History of cancer, %	6.7	11.9	5.4
Surgery on bladder or prostate, %	4.3	10.2	2.8
Total energy intake[4] in kilocalories per day mean (SEM)	1948 (28)	2008 (69)	1934 (29)
Energy-adjusted dietary intake, mean (SE)			
Protein, grams per day	83.8 (0.9)	83.6 (1.8)	83.9 (1.0)
Carbohydrates, grams per day	237 (2)	237 (3)	236 (2)
Saturated fat, grams per day	24.7 (0.3)	24.9 (0.5)	24.6 (0.3)
Monounsaturated fat, grams per day	29.1 (0.3)	29.5 (0.5)	29.0 (0.3)
Polyunsaturated fat, grams per day	12.9 (0.2)	13.1 (0.4)	12.8 (0.2)
Cholesterol, milligrams per day	312 (6)	312 (15)	312 (6)

	Total (n = 1545)	Moderate to severe LUTS (n = 322)	None to mild LUTS (n = 1223)
Sodium, milligrams per day	2634 (23)	2685 (43)	2622 (27)

[1] Lower urinary tract symptoms defined as present if score ≥8 on the American Urological Association symptom index.

[2] Voiding symptoms defined as present if score ≥5 (of total possible 20) on voiding symptoms questions.

[3] Storage symptoms defined as present if score ≥4 (of total possible 15) on storage symptoms questions.

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

Abbreviations: BMI, body mass index.

Table 2

Weighted characteristics for the highest and lowest quintiles of selected energy-adjusted nutrient intakes among 1545 men in the Boston Area Community Health survey

	Carbohydrates		Protein		Saturated fat		Polyunsaturated fat	
Characteristic	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**	**Q1**	**Q5**
LUTS[1], %	19.5	20.7	25.5	19.5	22.0	19.9	21.2	23.2
Symptom score, mean (SEM)	4.4 (0.4)	3.8 (0.3)	4.7 (0.5)	4.4 (0.4)	4.1 (0.3)	4.6 (0.4)	4.3 (0.4)	4.6 (0.3)
Voiding symptoms, %	15.1	11.8	18.7	11.1	9.9	12.8	12.8	15.4
Voiding score, mean (SEM)	1.7 (0.2)	1.3 (0.2)	1.9 (0.3)	1.6 (0.3)	1.3 (0.2)	1.7 (0.2)	1.5 (0.2)	1.7 (0.2)
Storage symptoms, %	26.1	24.6	34.0	28.0	32.8	29.8	28.6	37.4
Storage score, mean (SEM)	2.7 (0.2)	2.5 (0.2)	2.8 (0.2)	2.7 (0.3)	2.7 (0.2)	2.9 (0.2)	2.9 (0.2)	3.0 (0.2)
Age in years, mean	47.9	49.2	51.0	47.4	50.5	47.7	50.1	48.3
Race, %								
Black	18.9	29.8	27.9	20.0	21.8	19.0	23.4	22.9
Hispanic	8.5	19.9	13.0	7.4	16.0	8.3	17.8	6.2
White	72.7	50.3	59.1	72.7	62.2	72.7	58.9	70.8
Cigarette or cigar use, %								
Never	24.0	47.7	34.9	37.1	52.2	20.5	41.8	38.5
Former	27.7	31.0	33.7	31.9	34.8	33.0	34.6	38.2
Current	48.3	21.3	31.5	31.0	13.1	46.6	23.6	23.3
Alcohol intake in grams per day, mean	20.0	9.5	23.5	11.4	14.1	11.2	16.4	10.1
BMI in kilograms per square meter, mean	29.0	27.5	26.9	29.7	27.5	28.8	27.8	28.2
Waist circumference in centimeters, mean	98.9	94.6	94.6	100.3	95.0	98.6	96.1	97.3
Physical activity, %								
Low	24.4	22.8	26.8	32.5	24.1	28.6	28.7	26.3
Medium	50.3	46.9	50.3	42.4	48.4	42.1	38.6	54.6
High	25.3	30.3	22.9	25.0	27.5	29.3	32.7	19.1
Diabetes, %	12.3	5.8	6.3	13.2	7.3	13.1	6.4	13.6
Cardiac disease, %	10.4	10.8	9.1	8.7	13.1	11.0	10.5	10.9
Prostate or bladder surgery, %	2.4	6.7	6.0	2.9	4.7	3.4	4.6	4.0
Energy-adjusted intake, mean								
Protein, grams per day	99.0	69.8	57.2	111	79.6	89.9	80.6	84.5
Carbohydrates, grams per day	176	306	271	202	283	192	264	213
Saturated fat, grams per day	31.0	17.5	22.1	26.4	15.8	34.0	22.0	26.2

Characteristic	Carbohydrates Q1	Carbohydrates Q5	Protein Q1	Protein Q5	Saturated fat Q1	Saturated fat Q5	Polyunsaturated fat Q1	Polyunsaturated fat Q5
Monounsaturated fat, grams per day	35.6	21.1	27.1	30.5	21.3	35.6	23.7	33.0
Polyunsaturated fat, grams per day	15.0	9.7	12.2	13.5	10.8	13.9	7.5	19.3
Cholesterol, milligrams per day	428	215	225	393	218	404	306	313
Sodium, milligrams per day	2843	2364	2190	2897	2463	2884	2455	2676

[1] LUTS defined as scoring ≥8 on the American Urological Association Symptom Index.

Abbreviations: BMI, body mass index; LUTS, lower urinary tract symptoms; Q, quintile.

Table 3

Odds ratios and 95% confidence intervals of total LUTS (n = 322), voiding symptoms (n = 214), and storage symptoms (n = 481) by macronutrient, cholesterol, and sodium intakes in the BACH study men (n = 1545)

	Quintile of intake									
Macronutrient	**1**	**2**		**3**		**4**		**5**		***p* trend**	***p* trend with continuous symptom score**
TEI, median	1089 kcal/d	1457 kcal/d		1818 kcal/d		2268 kcal/d		3100 kcal/d			
Total LUTS											
Age-adjusted OR	reference	1.00		0.93		1.48		1.37			
Multivariate OR[1], 95% CI		0.92	0.49, 1.73	0.86	0.48, 1.54	1.57	0.86, 2.86	1.30	0.68, 2.49	0.11	0.008
Voiding symptoms											
Age-adjusted OR		1.18		1.14		2.56*		1.72			
Multivariate OR[1], 95% CI		1.17	0.55, 2.46	1.19	0.56, 2.54	2.75*	1.20, 6.30	1.62	0.71, 3.71	0.06	0.13
Storage symptoms											
Age-adjusted OR		1.24		1.31		1.78**		1.73			
Multivariate OR[2], 95% CI		1.16	0.68, 1.99	1.31	0.77, 2.23	1.88**	1.16, 3.05	1.59	0.92, 2.77	0.01	0.02
Carbohydrates, median	183 g/d	219 g/d		241 g/d		264 g/d		302 g/d			
Total LUTS											
Age & TEI-adjusted OR	Reference	1.06		0.98		1.21		1.05			
Multivariate OR[1], 95% CI		1.09	0.62, 1.90	1.06	0.60, 1.89	1.37	0.74, 2.53	1.32	0.75, 2.33	0.23	0.42
Voiding symptoms											
Age & TEI-adjusted OR		1.09		0.62		0.83		0.68			
Multivariate OR[1], 95% CI		1.05	0.47, 2.38	0.67	0.32, 1.43	0.96	0.41, 2.21	0.89	0.42, 1.88	0.89	0.63
Storage symptoms											
Age & TEI-adjusted OR		1.63*		1.25		1.36		0.88			
Multivariate OR[2], 95% CI		1.77*	1.11, 2.82	1.33	0.83, 2.16	1.36	0.85, 2.18	0.97	0.60, 1.56	0.91	0.44
Protein, median	59 g/d	71 g/d		81 g/d		91 g/d		107 g/d			
Total LUTS											
Age & TEI-adjusted OR	reference	0.78		0.60		1.00		0.84			
Multivariate OR[3], 95% CI		0.61	0.32, 1.17	0.36**	0.20, 0.68	0.61	0.34, 1.10	0.50*	0.26, 0.96	0.12	0.68
Voiding symptoms											
Age & TEI-adjusted OR		0.74		0.66		0.79		0.60			

Macronutrient	Quintile of intake 1	2		3		4		5		p trend	p trend with continuous symptom score
Multivariate OR[3], 95% CI		0.58	0.27, 1.26	0.43**	0.22, 0.85	0.47*	0.23, 1.00	0.35**	0.17, 0.74	0.02	0.51
Storage symptoms											
Age & TEI-adjusted OR		0.79		0.86		1.12		0.91			
Multivariate OR[3], 95% CI		0.77	0.48, 1.23	0.73	0.42, 1.28	0.85	0.53, 1.37	0.71	0.39, 1.28	0.37	0.88
Total fat, median	52.8 g/d	65.3 g/d		73.6 g/d		81.5 g/d		94.5 g/d			
Total LUTS											
Age & TEI-adjusted OR	reference	1.73		0.97		1.36		1.34			
Multivariate OR[1], 95% CI		1.44	0.79, 2.65	0.76	0.41, 1.41	1.14	0.60, 2.14	0.96	0.51, 1.81	0.95	0.35
Voiding symptoms											
Age & TEI-adjusted OR		1.22		1.72		1.64		1.46			
Multivariate OR[1], 95% CI		1.00	0.52, 1.94	1.24	0.63, 2.42	1.40	0.71, 2.77	1.06	0.52, 2.17	0.92	0.82
Storage symptoms											
Age & TEI-adjusted OR		1.31		1.07		1.23		1.49			
Multivariate OR[2], 95% CI		1.15	0.68, 1.97	1.01	0.57, 1.77	1.15	0.65, 2.06	1.32	0.74, 2.34	0.37	0.33
Saturated fat, median	16.2 g/d	21.0 g/d		24.2 g/d		27.2 g/d		32.1 g/d			
Total LUTS											
Age and TEI-adjusted OR	reference	0.96		0.95		0.93		0.97			
Multivariate OR[1], 95% CI		0.86	0.41, 1.80	0.85	0.39, 1.86	0.72	0.35, 1.50	0.79	0.38, 1.62	0.91	0.18
Voiding symptoms											
Age and TEI-adjusted OR		1.13		2.03		1.98*		1.57			
Multivariate OR[1], 95% CI		1.19	0.54, 2.62	2.54*	1.03, 6.26	2.04	0.90, 4.64	1.69	0.68, 4.21	0.05	0.19
Storage symptoms											
Age and TEI-adjusted OR		0.89		0.78		1.18		0.96			
Multivariate OR[2], 95% CI		0.80	0.45, 1.43	0.62	0.34, 1.13	0.84	0.45, 1.54	0.74	0.40, 1.37	0.69	0.51
Monounsaturated fat, median	20.0 g/d	25.2 g/d		29.0 g/d		32.4 g/d		38.1 g/d			
Total LUTS											
Age and TEI-adjusted OR	reference	1.23		1.26		1.19		1.10			
Multivariate OR[1], 95% CI		1.41	0.69, 2.89	1.34	0.59, 3.02	1.29	0.58, 2.86	1.16	0.49, 2.76	0.64	0.41
Voiding symptoms											

Macronutrient	1	2		3		4		5		p trend	p trend with continuous symptom score
					Quintile of intake						
Age and TEI-adjusted OR		0.74		1.63		1.08		1.07			
Multivariate OR[1], 95% CI		0.49	0.21, 1.11	0.74	0.31, 1.75	0.52	0.23, 1.16	0.48	0.19, 1.24	0.11	0.45
Storage symptoms											
Age and TEI-adjusted OR		1.15		1.09		1.41		1.13			
Multivariate OR[2], 95% CI		1.38	0.75, 2.52	1.27	0.65, 2.46	1.45	0.75, 2.81	1.13	0.55, 2.31	0.65	0.63
Polyunsaturated fat, median	7.6 g/d	10.0 g/d		11.9 g/d		14.4 g/d		18.4 g/d			
Total LUTS											
Age and TEI-adjusted OR	reference	1.20		0.72		0.84		1.17			
Multivariate OR[1], 95% CI		0.93	0.47, 1.81	0.55	0.27, 1.13	0.79	0.37, 1.69	0.90	0.42, 1.95	0.58	0.75
Voiding symptoms											
Age and TEI-adjusted OR		1.06		1.78		0.75		1.42			
Multivariate OR[1], 95% CI		0.95	0.44, 2.07	1.48	0.72, 3.04	0.73	0.33, 1.59	1.34	0.54, 3.30	0.38	0.91
Storage symptoms											
Age and TEI-adjusted OR		1.09		0.86		1.13		1.65*			
Multivariate OR[2], 95% CI		0.85	0.49, 1.48	0.66	0.37, 1.19	1.13	0.64, 1.99	1.44	0.85, 2.44	0.006	0.39
Cholesterol, median	155 mg/d	230 mg/d		289 mg/d		366 mg/d		496 mg/d			
Total LUTS											
Age and TEI-adjusted OR	reference	2.09*		0.62		1.24		1.28			
Multivariate OR[4], 95% CI		1.96*	1.09, 3.54	0.59	0.30, 1.18	1.45	0.72, 2.90	1.22	0.57, 2.59	0.89	0.14
Voiding symptoms											
Age and TEI-adjusted OR		3.16***		1.38		2.54**		2.21			
Multivariate OR[4], 95% CI		3.10***	1.58, 6.08	1.52	0.76, 3.05	3.70***	1.73, 7.91	2.68*	1.03, 6.99	0.17	0.43
Storage symptoms											
Age and TEI-adjusted OR		1.40		0.92		1.16		1.10			
Multivariate OR[4], 95% CI		1.26	0.76, 2.11	0.97	0.55, 1.72	1.20	0.67, 2.17	1.12	0.62, 2.01	0.94	0.31
Sodium, median	1828 mg/d	2258 mg/d		2529 mg/d		2851 mg/d		3342 mg/d			
Total LUTS											
Age and TEI-adjusted OR	reference	1.00		1.44		1.31		1.93**			
Multivariate OR[4], 95% CI		1.20	0.62, 2.32	1.81	0.90, 3.65	1.49	0.76, 2.91	2.25**	1.26, 4.03	0.007	0.02

	Quintile of intake										
Macronutrient	**1**	**2**		**3**		**4**		**5**		***p* trend**	***p* trend with continuous symptom score**
Voiding symptoms											
Age and TEI-adjusted OR		0.87		1.77		1.10		1.19			
Multivariate OR[4], 95% CI		1.07	0.51, 2.25	2.12*	1.05, 4.30	1.35	0.61, 3.01	1.59	0.77, 3.29	0.34	0.24
Storage symptoms											
Age and TEI-adjusted OR		1.00		0.91		1.40		1.48			
Multivariate OR[4], 95% CI		1.14	0.67, 1.95	1.01	0.58, 1.74	1.30	0.76, 2.22	1.49	0.89, 2.49	0.05	0.004

* $p \leq 0.05$

** $p \leq 0.01$

*** $p \leq 0.001$

[1] The multivariate models included age (5-yr 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 packs per year), cigar smoking (never, former, or current), diabetes, cardiac disease, surgery on the prostate or bladder (yes or no), and total energy intake (quintiles). Models for saturated fat, monounsaturated fat, and polyunsaturated fat additionally adjusted for each other type of fat (quintiles).

[2] The multivariate models included those in footnote 1 plus total fluid intake (quintiles).

[3] The multivariate models included those in footnote 1 plus sodium intake (quintiles). Without adjustment for sodium, OR (95% CI) estimates were: for total LUTS: Q5 0.65 (0.35–1.19), Q4 0.77 (0.45–1.33), Q3 0.45, (0.25–0.83), Q2 0.73 (0.38–1.39); for voiding symptoms: Q5 0.42 (0.21–0.85), Q4 0.56 (0.28–1.13), Q3 0.53 (0.29–1.00), Q2 0.68 (0.32–1.46). Linear tests for trends and results for storage symptoms were similar for sodium-adjusted or sodium-unadjusted models. Models for storage symptoms also included total fluid intake (quintiles).

[4] The multivariate models included those in footnote 1 plus protein intake (quintiles). Models for storage symptoms also included total fluid intake (quintiles).

Abbreviations: BACH, Boston Area Community Health; CI, confidence interval; LUTS, lower urinary tract symptoms; OR, odds ratio; TEI, total energy intake.