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Are Physical Activity, Smoking and Alcohol Drinking Associated with the Development of Lower Urinary Tract Symptoms in Men or Women? Results from a Population-Based Observational Study

Nancy N. Maserejian, ScD^a, Varant Kupelian, PhD^a, Gavin Miyasato, MS^a, Kevin T. McVary, MD^b, and John B. McKinlay, PhD^a

^aNew England Research Institutes, 9 Galen St. Watertown, MA 02472, USA

^bDepartment of Urology, Feinberg School of Medicine, Northwestern University Chicago, IL

Abstract

Purpose—Lower Urinary Tract Symptoms (LUTS) are highly prevalent and reduce quality of life. Lifestyle behaviors and LUTS development are largely unexamined. The objective of this study was to investigate physical activity, smoking, and alcohol drinking and LUTS development in men and women.

Materials and Methods—Data were from a longitudinal observational study, the Boston Area Community Health Survey. Baseline (2002–2005) in-person interviews assessed activity, smoking and alcohol. Five-year follow-up interviews (2006–2010, N=4,145) assessed new reports of moderate-to-severe LUTS, defined by the American Urological Association Symptom Index (AUASI). Analysis used multivariable logistic regression.

Results—LUTS developed among 7.7% and 12.7% of at-risk men and women, respectively. Women were 68% less likely to develop LUTS (OR=0.32, 95% CI: 0.17–0.60, $P<0.001$) if they had high vs. low physical activity. Although the association was similar among men, it was not statistically significant upon adjustment for medical or sociodemographic characteristics in the multivariable model. Women smokers were twice as likely to develop LUTS, particularly storage symptoms (OR=2.15, 95% CI: 1.30–3.56, $P=0.003$), compared to never-smokers. Among men, smoking was not associated with LUTS. Results for alcohol intake were inconsistent by intake level and symptom subtype.

Conclusions—Low physical activity was associated with 2–3 times higher likelihood of LUTS development. Smoking may contribute to LUTS development in women, but not men. Clinicians

Corresponding Author: Nancy Nairi Maserejian, ScD, New England Research Institutes, 9 Galen Street, Watertown, MA 02472, USA, Tel.: 617.972.3229, Fax: 617.926.0144, nmaserejian@neriscience.com.

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should continue to promote physical activity and smoking cessation noting the additional potential benefits of LUTS prevention, particularly for women.

MeSH Keywords

Exercise; Smoking; Alcohol drinking; Urinary bladder; overactive; Nocturia; Epidemiology; Bladder Outlet Obstruction

Other Keywords

Physical activity; Lower urinary tract symptoms; Voiding dysfunction; Observational

Introduction

Lower urinary tract symptoms (LUTS) are prevalent in approximately 20% of men and women and are associated with considerable reductions in quality of life and interference with daily activities.¹ Epidemiological evidence indicates that lifestyle behaviors may be important to LUTS etiology.² In particular, behaviors that may affect metabolism and inflammatory processes have been linked to prevalent LUTS in numerous studies of men. For example, physical activity has repeatedly been associated with decreased odds of LUTS or BPH in cross-sectional studies of men,^{3–5} though longitudinal studies have been contradictory.^{6, 7} Alcohol intake, which may reduce inflammation in moderate doses and alters testosterone profiles, has been shown to reduce the odds of higher-severity LUTS or BPH surgery,^{8–12} but otherwise increased the odds of moderate LUTS in other studies.^{7, 13–15} Results regarding cigarette smoking have been inconsistent; some studies show no associations,^{11, 14–16} whereas others show greater LUTS among smokers.^{9, 13}

Despite providing insight on the potential importance of lifestyle behaviors in LUTS, the available scientific evidence to support these associations has noteworthy limitations. The majority of prior studies were cross-sectional, and almost all were limited to men. One study of women and urgency symptoms, the Leicestershire MRC Incontinence Study, found an inverse association with physical activity, positive association with smoking, and no association with alcohol.¹⁷ All other prior studies in women have only examined urine leakage, neglecting other common bothersome voiding and storage symptoms. No population-based studies including men and women of various ages and backgrounds have examined common lifestyle factors in relation to the incidence of LUTS over time.

The objectives of this analysis were to investigate whether physical activity, alcohol, and smoking are associated with new reports of LUTS, including voiding and storage subtypes, in a population-based longitudinal random-sample survey.

Materials and Methods

Study Design and Population

Data were obtained from an observational, longitudinal cohort study of men and women, the Boston Area Community Health (BACH) Survey. BACH recruited a random sample of 5,502 residents (2,301 men, 3,201 women) aged 30–79 years from three racial/ethnic groups in Boston, MA. Participants completed an in-person interview at baseline (occurring between 2002 and 2005) and approximately 5 years later (2006–2010). At both time points, a home visit was conducted for anthropometric measurements (e.g., height, weight, and waist circumference) and interview regarding urologic symptoms, comorbidities, and lifestyle. Details on BACH's methods have been published.¹⁸ All participants provided

written informed consent. The study was approved by the New England Research Institutes' Institutional Review Board.

Completed follow-up interviews were obtained for 4,145 individuals (1,610 men; 2,535 women), resulting in an overall response rate of 80.5%. The mean (SD) time to follow-up was 4.8 (0.6) years. The response rates were lower in men and minorities mostly due to non-contact. Of those lost to follow-up, 654 people were unable to be reached, 350 refused to participate, and 348 were ineligible (deceased, pregnant/post-partum <6 months, or incompetent to provide informed consent). Those who were lost to follow-up were more likely to be Hispanic, >70 y old, lower socioeconomic status, and male gender. Current smoking, lower physical activity, and abstaining from alcohol were also more common among those lost to follow-up, but there were no significant differences by presence/absence of LUTS at baseline.

This analysis excluded participants who, at the start of the study, reported prevalent LUTS (18.7% of men and 18.6% of women at baseline), prior surgery on the prostate or bladder (n=63), or surgery for urinary incontinence (n=67 women) (see Tables 1 and 2 for final numbers in analyses).

Measurement of Lower Urinary Tract Symptoms

During the in-home interviews, LUTS was assessed by the American Urological Symptom Index (AUASI).¹⁹ The AUASI was originally developed and validated for benign prostatic hyperplasia in men,¹⁹ but has been validated²⁰ and repeatedly shown to capture LUTS in women. The presence of total moderate-to-severe LUTS is identified by AUASI score ≥ 8. Voiding symptoms are identified by a score ≥ 5 (of total possible 20) based on responses to four AUASI questions regarding incomplete bladder emptying, intermittency, weak urinary stream, and hesitancy. Storage symptoms are identified by a score ≥ 4 (of possible 15) on three storage symptom questions assessing frequency, urgency, and nocturia.

Assessment of Lifestyle Factors and Covariates

Physical Activity was measured using the Physical Activity Scale for the Elderly (PASE),²¹ a 12-item questionnaire that assesses participation in leisure-time, household, and occupational activity during the prior 7 days. PASE provides a total activity score, which is computed by multiplying the amount of time spent in each activity (hrs/week) or participation (yes/no) by the empirically-derived item weights and summing over all activities. The score was categorized as low (<100), medium (100–249) or high (≥ 250) physical activity.

Smoking status was self-reported and categorized as never (smoked <100 cigarettes lifetime and not currently smoking), former, or current. Alcohol intake was assessed by type and amounts of beverage (12 oz beer, 5 oz. wine, or 1.5 oz liquor) consumed over the past 30 days, and categorized as 0, <1 and 1+ drinks/day. Socioeconomic status was determined as a combination of education and income, and categorized into low (lower quartile), medium (mid two quartiles) and high (upper quartile).

Statistical Analysis

Analyses were conducted separately for men and women, because prior research has found different risk factors for LUTS by gender, suggesting differing etiology.^{7, 16, 22, 23} Multivariable logistic regression models were used to calculate odds ratios (OR) as estimates of relative risk and 95% confidence intervals (CI) for the associations between independent variables (physical activity, smoking, and alcohol) and newly report LUTS. Separate models were created for total LUTS, voiding and storage symptoms. Factors

considered for inclusion in multivariable models were based on prior scientific evidence of associations with the outcomes of interest: age, race/ethnicity, socioeconomic status, total daily non-alcoholic fluid intake, cigar smoking, waist circumference, body mass index, the presence of diabetes, cardiac disease, asthma, arthritis/rheumatism, or depressive symptoms, and the use of diuretic, alpha blockers, 5-alpha reductase inhibitors, antispasmodics, anticholinergics, or tricyclic antidepressant medications; for women, menopausal status and vaginal child delivery were also considered. Variables that affected the odds ratio between activity, smoking, or alcohol and LUTS by more than 5% at $p < 0.10$ were retained in the multivariable models (listed in Table 1 and 2 footnotes). Tests for two-way interactions between activity, smoking and alcohol drinking for the outcome of LUTS were conducted, but no statistically significant interactions were found (data not shown).

Observations were weighted inversely to their probability of selection at baseline and weights were post-stratified to the Boston census population in 2000. Multiple imputation was used to impute values for variables with missing values; less than 1% of participants were missing data relevant to this analysis, with the exception of socioeconomic status (5.5% missing). All statistical tests were two-sided, performed at $\alpha = 0.05$, and conducted in SAS v.9.2 (SAS Institute, Cary, NC) and SUDAAN v.10.0.1 (Research Triangle Park, NC).

Results

Among men and women who did not report LUTS at baseline and were therefore included in this analysis, the percentage who had developed LUTS at follow-up was 7.7% of men and 12.7% of women. Moderate-to-severe storage symptoms appeared in 17.6% of men and 23.5% of women, and voiding symptoms in 7.1% of men and 6.7% of women. The presence of LUTS at follow-up was substantially lower among men and women with high baseline physical activity and among never-smokers, while alcohol drinking had no consistent trend (Figure 1). For both genders, the most common storage symptom was nocturia (defined as getting up from bed to urinate more than once per night; 24.7% of men, 30.8% of women). The most common voiding symptom among men was a weak urinary stream (6.1%) and among women was the feeling of incomplete emptying (5.9%).

In multivariable analyses, physical activity was significantly associated with total LUTS in women (Table 1), but the association was not statistically significant in men (Table 2). Women with high physical activity were 68% less likely to develop LUTS (OR=0.32, 95% CI: 0.17, 0.60) and 61% less likely to develop voiding symptoms (OR=0.39, 95% CI: 0.17, 0.89) compared to those with low activity. No association was observed between activity and storage symptoms in women ($P=0.29$). Among men, physical activity had inverse associations with voiding and storage symptom subtypes, indicating decreased risks of approximately 40–45%, but associations were not statistically significant in the multivariable model.

Cigarette smoking was not associated with LUTS in men. Women who were current smokers were over twice as likely to develop storage symptoms (OR=2.15, 95% CI: 1.30, 3.56, $P=0.003$) compared to never smokers. A positive association with voiding symptoms was also suggested but not statistically significant.

Among men, light-to-moderate drinkers (<1 alcoholic drink/day) were over twice as likely to develop storage symptoms or total LUTS compared to non-drinkers. However, men who drank one or more drinks/day were not at increased risk of LUTS. Sensitivity analyses of specific storage symptoms indicated that the positive association with alcohol was driven by increased risk of urgency, rather than frequency or nocturia, and the association between

alcohol drinking and urgency symptoms was apparent for higher alcohol drinking levels as well. Women drinkers, on the other hand, were half as likely to develop storage symptoms (OR=0.55, 95% CI: 0.31, 0.97), yet three times as likely to develop voiding symptoms (OR=3.12, 95% CI: 1.41, 6.90, $P=0.005$) when consuming 1+ drinks/day, compared to non-drinkers. Given the opposing directions of associations between storage and voiding, there was no association between alcohol and total LUTS in women. Sensitivity analyses of specific storage symptoms revealed that the inverse association was driven by nocturia (OR=0.46, 95% CI: 0.26, 0.83), while no associations were observed for symptoms of frequency or urgency.

Discussion

In this observational, population-based longitudinal study, low physical activity and current smoking status were significantly associated with development of LUTS in women. An inverse association for physical activity was also apparent in men, though not as robust. Alcohol intake had no direct association with LUTS in men or women. Although the study's observational nature does not demonstrate causality, these results indicate that certain lifestyle factors may affect the development of LUTS, more so for women than for men.

While the prevalence of LUTS is generally similar for men and women,¹ it is plausible that contributing causes vary by sex. Some factors (e.g., previous urinary tract infections, increased autonomic nervous system activity, depression) may be common to both, while others (e.g., age-course, body mass index, dietary factors) have been shown to differ by gender, likely owing to physiological sex differences.^{7, 16, 22–24}

The current results indicated that smoking may be a sex-specific contributor to LUTS. Smoking was not associated with incident LUTS among men in this study, corroborating prior studies^{6, 7, 11, 14–16}. In women, current smokers were twice as likely to develop storage LUTS compared to never smokers. The prior study of overactive bladder in U.K. women also found an increased risk among smokers.¹⁷ Smoking can cause hormonal and nutrient imbalances affecting the bladder and collagen synthesis,²⁵ and it has antiestrogenic effects in women.²⁶ Thus, a speculative explanation for the gender difference in findings regarding smoking and storage symptoms is that smoking affects bladder wall strength and detrusor instability in women more so than in men.

Meanwhile, one finding that was generally consistent for men and women – though stronger in women – was the inverse associations between high physical activity and total LUTS or voiding symptoms. Theoretically, physical activity may protect against LUTS development in both genders by decreasing resting sympathetic muscle tone, reducing systemic inflammation, and changing certain hormonal factors, particularly those relevant to metabolic syndrome.⁴ Physical activity also helps maintain weight over time. Given that body mass index and waist circumference are associated with LUTS in women,^{16, 17} weight maintenance effects may partly explain beneficial associations with physical activity. Although it is unclear why activity was not associated with storage symptoms, this finding is supported by the only other prospective cohort study of physical activity and overactive bladder symptoms in women, which found no association between participation in vigorous physical activity and one-year incidence of urgency symptoms.¹⁷ In men, our results for physical activity had wide confidence intervals, and the associations may reflect an underlying better health of men who are capable of physical activity, rather than direct effects of physical activity itself. However, it is possible that the lack of statistically significant findings in men was due to the smaller sample sizes.

The findings regarding alcohol intake and LUTS development were unclear, with differences by intake levels as well as LUTS subtype and gender. Among men, light drinking (<1/day) increased the likelihood of LUTS, whereas moderate-to-heavy drinking had no associations with LUTS. Urgency symptoms were the exception, as they were more likely to occur among all alcohol drinkers. A recent review of prior studies in men concluded that daily drinking might increase the likelihood of LUTS, while decrease the risk of BPH.²⁷ Indeed, of two prior prospective studies examining LUTS using the AUASI, one found that daily drinking increased the risk of moderate-to-severe LUTS over a 4-yr follow-up,⁷ whereas the other showed that heavier drinking decreased the risk of high-moderate-to-severe LUTS or medically-treated BPH over 7 years.¹² It is plausible that light alcohol intake increases LUTS by a diuretic effect²⁸ or increasing sympathetic nervous system activity,²⁹ while moderately-high alcohol intake decreases the risk of BPH and concurrent higher-severity LUTS by altering androgen levels.³⁰

A limitation of this study is that the observational design precludes judgment of causality between lifestyle factors and LUTS. Given the lack of randomization to lifestyle behaviors and the use of self-report, we cannot rule out the possibility that unmeasured or unknown confounding factors contributed to these findings. In addition, LUTS have been shown to be dynamic, with progression and remission of symptoms over time; thus, some participants classified as symptom-free at follow-up may have previously experienced LUTS and were in remission for more than the 30-day window of the AUASI assessment. Strengths of the study include BACH's comprehensive field survey methods, which prevented diagnostic bias by evaluating bothersome LUTS among men and women from various socioeconomic backgrounds, including those without access to health care. The use of a racially and ethnically diverse community-based sample and detailed information on numerous relevant covariates further strengthens these findings.

Conclusions

This prospective, population-based cohort study found that women who were smokers or had low levels of physical activity were considerably more likely to newly report LUTS approximately five years later, whereas the importance of these factors was less apparent for men. If these observational findings are confirmed by additional studies and clinical trials, then, in addition to their established widespread health benefits, physical activity and smoking cessation may be recommended also with the targeted benefit of LUTS prevention.

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Abbreviations used in this manuscript

AUASI	American Urological Association Symptom Index
BACH	Boston Area Community Health
BPH	Benign prostatic hyperplasia
LUTS	Lower urinary tract symptoms
MRC	Medical Research Council
PASE	Physical Activity Scale for the Elderly

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Figure 1. Incidence Proportions for Overall Lower Urinary Tract Symptoms (AUASI ≥ 8), by Baseline Physical Activity, Smoking and Alcohol Drinking, among Men and Women in the Boston Area Community Health Survey (2002–2010)

Table 1

Multivariable Model Odds Ratios and 95% Confidence Intervals for Incident LUTS among **Women** in the Boston Area Community Health Survey (2002–2010)^a

	Total LUTS N = 1,961		Storage Symptoms N = 1,588		Voiding Symptoms N = 2,198	
	N cases	OR (95% CI)	N cases	OR (95% CI)	N cases	OR (95% CI)
Physical activity						
Low	125	1.00	142	1.00	66	1.00
Medium	107	0.74 (0.45, 1.23)	180	0.97 (0.63, 1.50)	73	0.92 (0.50, 1.72)
High	25	0.32 (0.17, 0.60)***	50	0.69 (0.41, 1.14)	11	0.39 (0.17, 0.89)*
Cigarette smoking						
Never	127	1.00	200	1.00	67	1.00
Former	81	1.22 (0.71, 2.09)	90	1.18 (0.72, 1.95)	45	1.18 (0.51, 2.72)
Current	49	1.62 (0.87, 3.03)	82	2.15 (1.30, 3.56)**	38	1.99 (0.89, 4.44)
Alcohol intake						
0 drinks/day	142	1.00	199	1.00	84	1.00
0.1–1	91	1.13 (0.70, 1.83)	138	0.95 (0.63, 1.46)	47	1.26 (0.66, 2.42)
1+	25	1.47 (0.75, 2.86)	35	0.55 (0.31, 0.97)*	19	3.12 (1.41, 6.90)**

* $P < 0.05$ ** $P < 0.01$ *** $P < 0.001$

^a All multivariable models adjusted for age (5-year categories), and categorical physical activity, smoking, and alcohol drinking; models for total LUTS and voiding symptoms additionally adjusted for waist circumference (quartiles), depression symptoms (yes/no) and ever giving birth vaginally (yes/no); and models for voiding symptoms additionally adjusted for ever giving birth vaginally. Exclusion criteria for women with moderate-to-severe symptoms at baseline were applied for each LUTS outcome separately, resulting in the different sample sizes noted in the top row of the Table.

Table 2

Multivariable Model Odds Ratios and 95% Confidence Intervals for Incident LUTS among **Men** in the Boston Area Community Health Survey (2002–2010)^a

	Total LUTS N = 1,275		Storage Symptoms N = 1,112		Voiding Symptoms N = 1,378	
	N cases	OR (95% CI)	N cases	OR (95% CI)	N cases	OR (95% CI)
Physical activity						
Low	60	1.00	81	1.00	54	1.00
Medium	68	1.12 (0.60, 2.11)	101	0.53 (0.29, 0.98)*	52	0.60 (0.28, 1.26)
High	27	0.72 (0.35, 1.52)	52	0.60 (0.26, 1.36)	25	0.55 (0.22, 1.38)
Cigarette smoking						
Never	50	1.00	85	1.00	45	1.00
Former	46	0.91 (0.51, 1.63)	64	1.22 (0.66, 2.26)	42	1.02 (0.43, 2.45)
Current	59	1.01 (0.55, 1.84)	85	1.12 (0.61, 2.04)	44	0.73 (0.36, 1.46)
Alcohol intake						
0 drinks/day	53	1.00	81	1.00	51	1.00
0.1–1	58	2.42 (1.24, 4.75)**	85	2.19 (1.10, 4.38)*	46	1.08 (0.56, 2.08)
1+	44	1.73 (0.87, 3.43)	68	1.49 (0.77, 2.87)	34	1.05 (0.54, 2.05)

* $P < 0.05$

** $P < 0.01$

*** $P < 0.001$

^a All multivariable models adjusted for age (5-year categories), and categorical physical activity, smoking, and alcohol drinking. Models for total LUTS additionally adjusted for socioeconomic status (low/medium/high), depression symptoms (yes/no), use of diuretic medication (yes/no), use of BPH medication (yes/no) and presence of arthritis (yes/no). Models for storage symptoms additionally adjusted for socioeconomic status, depression symptoms, and body mass index (categorical). Models for voiding symptoms additionally adjusted for cigar smoking (yes/no), total non-alcoholic average daily fluid intake (categorical) and presence of diabetes (yes/no). Exclusion criteria for men with moderate-to-severe symptoms at baseline were applied for each LUTS outcome separately, resulting in the different sample sizes noted in the top row of the Table.