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The Association of Adiposity and Overactive Bladder Appears to Differ by Gender: Results from the Boston Area Community Health (BACH) Survey

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Abstract

Purpose—We investigate the association of different measures of adiposity (waist circumference, hip circumference, waist-to-hip ratio, body mass index (BMI)) with overactive bladder (OAB) (urinary frequency and urgency) and whether the association varies by gender or age and if it persists when models are adjusted for other confounders.

Materials and Methods—Data are from the Boston Area Community Health (BACH) epidemiologic survey, a random sample of 5503 Boston, MA residents aged 30 to 79 years with equal representation from three race/ethnic groups (Black, Hispanic, and White). Statistical analyses involved nonparametric loess models and multivariable logistic regression.

Results—We show distinct patterns by gender for the association of various adiposity measures and OAB. Waist-to-hip ratio is not significantly associated with OAB in either gender. For women, the prevalence of OAB increases as waist (odds ratio (OR) adjusted for other confounders = 1.10 per 10 cm increase) or hip (OR=1.12 per 10 cm increase) circumference or BMI (OR=1.03 per kg/m² increase) increases. For men, the prevalence of OAB decreases as adiposity increases (OR=0.65 per 10 cm increase in waist circumference, OR=0.71 per 10 cm increase in hip circumference, OR=0.87 per kg/m² in BMI), but only to a certain point (waist circumference=100 cm, hip circumference=115 cm, BMI=27.5 kg/m²). At that point, the prevalence of OAB increases with increasing adiposity (OR=1.19 per 10 cm increase in waist circumference, OR=1.16 per 10 cm increase in hip circumference, OR=1.08 per kg/m² in BMI).

Conclusion—The relationship between adiposity and OAB varies by gender.

Keywords

overactive bladder; urinary frequency; urgency; urge leakage; obesity

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Introduction

Lower urinary tract symptoms (LUTS) including urinary urgency, frequency, and leakage are common among men and women^{1, 2}, adversely affect a person's quality of life³ and their prevalence increases with age⁴. There has been considerable interest recently in lifestyle risk factors for LUTS including physical activity, alcohol intake, and obesity⁵. The importance of excess weight has received particular attention given the substantial increase in the prevalence of obesity in the U.S. over the past two decades⁶. A number of studies have shown that being overweight or obese increases the risk of LUTS associated with benign prostatic hyperplasia (BPH) in men⁵, urinary incontinence in women⁷, and overactive bladder (OAB)⁸. In addition, a recent clinical trial of lifestyle modification, including weight loss, reduced the number of incontinence episodes in overweight and obese women⁷. Although a number of measures of adiposity are available including waist or hip circumference, waist-to-hip ratio, and body mass index (BMI) which account for different aspects of obesity, they have rarely been evaluated together for their association with urologic symptoms in a community-based sample.

The Boston Area Community Health (BACH) survey is examining the population prevalence and risk factors for a broad range of urologic symptoms. This community-based sample includes both genders and is racially and ethnically diverse with approximately equal numbers of Black, Hispanic, and White participants. A wide range of potential risk factors have been obtained by participant self-report and adiposity has been directly measured by interviewers.

OAB is a common, costly condition in the U.S. that adversely affects quality of life and work productivity^{9, 10}. The questions of interest for this study are: (1) Is there an association between various measures of adiposity and OAB; (2) Does this association vary by age or gender; (3) Is there a dose-response effect with higher levels of adiposity being associated with higher levels of OAB?; and (4) Is the association robust to adjustment by various potential confounders?

Methods

The Boston Area Community Health (BACH) survey is a prospective epidemiologic survey of Boston, Massachusetts residents aged 30–79 years at baseline. Detailed methods of the study design have been described elsewhere¹¹. A stratified two-stage cluster sample was used to randomly sample residents of Boston with the goal of approximately equal number of participants by gender, race/ethnicity (Black, Hispanic, White), and age group (30–39, 40–49, 50–59, 60–79). In total, 5503 adults were recruited and provided baseline data (1767 Black, 1877 Hispanic, 1859 White; 2301 men and 3202 women) from 2002–2005. The response rate was 63.3% of screened eligible participants, which is typical of an epidemiologic field survey requiring a lengthy in-home interview and phlebotomy. After obtaining written informed consent, data were collected during a two hour interview (in English or Spanish), usually in the respondent's home. All protocols and procedures were approved by the New England Research Institutes' Institutional Review Board.

Anthropometrics

Following well-tested field methods¹², the interviewer measured the respondent's height, weight, waist, and hip circumference. BMI and waist-to-hip ratio were calculated.

Urologic symptoms

Urologic symptoms were assessed over the last month prior to the survey administration. We define overactive bladder as urinary frequency and urgency or urge leakage. A

respondent was said to have urinary frequency if they reported urinating more frequently than every two hours or had frequent urination during the day (fairly often, usually, or almost always), or reported urinating eight or more times per day; and urgency if they reported having difficulty postponing urination or had a strong urge to urinate (fairly often, usually, or almost always) in the last month, or reported a strong urge to urinate in the last seven days (four or more times). A respondent was said to have urge leakage if they reported 1 or more occasions that they “accidentally leaked urine in the last week when you had the strong feeling that you needed to empty your bladder but you couldn’t get to the toilet fast enough”.

Socio-demographics

Race/ethnicity was determined by self-report using the Office of Management and Budget classifications (Executive Office of the President of the United States, Federal Register Notice, 1997). Socioeconomic status (SES) was determined as a combination of education and income, and categorized such that ¼ of the study population was lower, ½ middle, and ¼ upper¹³.

Co-morbidities

Co-morbid conditions (heart disease, cardiac arrhythmias, diabetes, hypertension, high cholesterol, arthritis, asthma, allergies, vascular disease, cancer, neurologic disease, pelvic prolapse, hysterectomy) were assessed by self-report. Depressive symptoms were assessed using an abridged Center for Epidemiologic Studies depression scale where a respondent was considered to be depressed if they reported at least 5 of the 8 symptoms¹⁴.

Prescription drug use

Interviewers inventoried all medications used by the participant in the last month and also asked about medications for specific indications. These medications were coded using the Slone drug dictionary¹⁵. We considered as covariates medications for OAB, LUTS/BPH, hormone replacement therapy (HRT), and lipid lowering.

Lifestyle

Smoking history was categorized as never, former or current smoker. Physical activity was assessed and categorized into low, moderate, or high¹⁶. Alcoholic beverage consumption was categorized as none, <1, 1–3, or 3+ drinks per day. Non-alcoholic beverage consumption was categorized into 0–3, 4–9, 10–14, and 15+ 8 ounce servings per day.

Abuse

Because of the reported association of abuse and somatic symptoms¹⁷, respondents were asked about abuse experienced as a child (age 13 or younger) or as an adolescent / adult (age 14 or older) using a validated scale¹⁸.

The probability density function of each measure and correlations between the four adiposity measures were calculated by gender. In addition, nonparametric analyses, by gender, consisted of fitting nonparametric loess curves (locally estimated smoothing splines) requiring no assumptions about the form of the association to the age and one adiposity measure¹⁹. Parametric analyses consisted of three sets of logistic regression by gender: (1) models with age decade and one adiposity measure, (2) models with age decade and significant confounders (all covariates with the exception of adiposity) using backward elimination and a p value of 0.06 or less, and (3) models with age decade, an adiposity measure, and significant confounders from the second set of models. Two-way interactions of an adiposity measure and significant confounders in the second set of models were

considered. In order to avoid over fitting the model, two-way interactions were only considered if their p value was less than 0.01 and it involved at least 100 respondents.

Multiple imputation was used to generate plausible values for missing observations using SAS 9.1.3 (SAS Institute, Cary, NC). Twenty-five multiply imputed data sets were created by gender and race/ethnicity. For most variables less than one percent of the data were missing. The only exceptions were income for which 4/11/3 and abuse for which 10/16/6 percent was missing for Black/Hispanic/White participants. To be representative of the city of Boston, observations were weighted inversely to their probability of selection and weights were post-stratified to the Boston census population in 2000. Nonparametric analyses were conducted in S-Plus 7.0 (Insightful Corporation, Seattle, WA) and parametric analyses were conducted in SUDAAN 10.0.1 (Research Triangle Institute, Research Triangle Park, NC).

Results

A Venn diagram shows the distribution and overlap of frequency, urgency, and urge leakage by gender, Figure 1, with a shaded area for our OAB definition (10.3% in men and 19.7% in women). Similar to the national average, about one third of BACH participants are obese ($\text{BMI} \geq 30 \text{ kg/m}^2$). The distribution of the adiposity measures are shown in Figure 2. Women tend to have smaller waists, resulting in smaller waist-to-hip ratios. Men appear to have less variability of BMI and hip circumference. Most adiposity measures are highly correlated (Table 1), therefore only one will be included in any model.

The prevalence of OAB tends to increase with age, Figure 3 (left panel). A similar pattern of the prevalence plot can be seen using nonparametric loess fit curves, Figure 3 (right panel). Using a nonparametric loess fit, we can visualize the association of OAB and the four adiposity measures, Figure 4. These figures reveal distinct patterns for men and women with the probability of OAB increasing with increasing adiposity for women, but a V or U shaped pattern for men for all adiposity measures other than waist-to-hip ratio. The association of OAB with both age, adiposity, and interaction between age and adiposity measures using nonparametric loess fits (Figure 5) was also examined. We see distinct patterns for men and women, with a V or U shaped association with all adiposity measures for men, while there is generally an increasing likelihood of OAB with increased adiposity in women.

We use logistic regression to model the association of OAB and adiposity parametrically. Using visual inspection of figures 4 and 5, we choose a cut-point of 100 cm for waist circumference, 115 for hip circumference, .95 for waist-to-hip ratio, and 27.5 kg/m^2 for men. Using these cut-points we fit models (two segments in men and a line without a cut-point in women) for the effect of adiposity on the likelihood of OAB. We also determined that there were no consistent interaction of age and any adiposity measure. Model 1 of Table 2 contains the odds ratios for models with one adiposity measure and age decade. Significant associations ($p < 0.05$) are observed with the exception of waist-to-hip ratio and the right hand segment for hip circumference in men. Table 3 gives the logistic regression models without an adiposity variable showing potential confounders by gender with. There were no significant interactions of confounders and adiposity. Model 2 of Table 2 adds these potential confounders to the adiposity/age Model 1's. The adiposity coefficients for women (other than that for waist-to-hip ratio) remain statistically significant. For men, the left hand segment remains statistically significant for all measures other than waist-to-hip ratio. However, the right hand segment only remains statistically significant for BMI. Pseudo R square²⁰ values (that present an approximate value for the proportion of variance explained) for these models are presented in Table 4 and are typical of these types of models.

Discussion

Using a community-based sample, we consider the relationship of several measures of adiposity and OAB. We have shown distinct patterns by gender for these relationships. For men, it appears that as a man's adiposity increases, the prevalence of OAB decreases, to a certain point (waist circumference=100 cm, hip circumference=115 cm, BMI=27.5 kg/m²) after which as a man's adiposity increases the prevalence of OAB increases. This is in contrast to women, where an increase in adiposity generally is associated with an increase in the prevalence of OAB. Therefore, in women there is a dose-response association between adiposity and OAB, whereas for men this association is after 100/115 cm of waist/hip circumference or 27.5 kg/m² BMI.

Other studies have shown an increase in the incidence of OAB with increasing body weight in women^{21, 22}. While the overall association was insignificant in men²³, there was an increased incidence if the man was obese. Other studies have found conflicting results when looking at urge incontinence and increasing obesity with one study suggesting an increase in urge incontinence with increasing obesity in women but not in men² but another suggesting a decrease in stress incontinence with weight loss in women but not urge incontinence⁷. The lack of an association of urologic symptoms and adiposity in men from other studies may be due to assumptions of linearity across the adiposity range.

The mechanisms which underlie the association between increased adiposity and LUTS remain uncertain but may include mechanical or neuroendocrine factors. The relationship between obesity and OAB in women has been attributed to mechanical factors²¹. Increased abdominal pressure resulting from abdominal obesity (waist circumference) raises intravesical pressure and exerts increased force on the pelvic floor. Increased intravesical pressure could in turn augment bladder afferent firing leading to urgency and frequency; whereas, increased stretch of the pelvic floor could cause prolapse or urethral hypermobility. Stress induced urine entering the urethra could reflexly trigger detrusor overactivity triggering urgency and frequency. Men with their greater fixation of the pelvic floor may be less susceptible to these forces, thus avoiding symptoms with increasing weight until a certain set point or significant obesity.

Aside from mechanical mechanisms, neuroendocrine processes could be the link between adiposity and OAB. Adipose tissue produces leptin which can increase autonomic nervous activity especially noradrenergic sympathetic nerves²⁴. Sympathetic overactivity in animal models (e.g. spontaneously hypertensive rat) or humans with increased sympathetic activity exhibit urinary frequency²⁵. Therefore, significant adipose tissue could increase circulating leptin and produce OAB as a result of changes in autonomic nervous activity.

Visceral fat is often estimated by waist circumference. Increased pelvic, perivesical fat in its extreme and pathologic form known as pelvic lipomatosis can cause inflammation within the bladder that could lead to urinary frequency and urgency²⁶. Perhaps increasing pelvic visceral fat could produce inflammatory cytokines that lead to urothelial irritation and produce symptoms.

Obesity is also associated with cardiovascular disease through complex mechanisms. The net result could cause vascular endothelial dysfunction. It has been demonstrated experimentally that increasing ischemia to the bladder can lead to detrusor overactivity²⁷. More difficult to explain is our finding of reduced OAB with increasing weight up to a certain cut point in men. It is possible that other factors produced by adipose tissue could exert inhibitory effects on bladder function in men, while pelvic floor laxity in women overcome this effect and mechanical factors differentially lead to OAB. With obesity in men, not only could vascular factors or leptins play a role, but conversion of androgens to

estrogens by adipose tissue could lead to OAB²⁸. Thus the mechanisms underlying our findings although speculative are quite diverse.

Our study has several strengths. The BACH survey is a community-based random sample of men and women over a broad age range with substantial minority representation, not a convenience sample of patients. Urologic symptoms rather than variously diagnosed conditions were assessed and may better represent population burden. Measures of adiposity were made by interviewers rather than self-report and information on a large number of potentially confounding lifestyle and medical factors was collected and considered. We have found that the prevalence of many co-morbidities in BACH subjects to be similar to national surveys²⁹. Thus with suitable modifications (due to different demographics) our findings could be extended nationally. Our results should be considered within the context of the limitation of a cross-sectional report. Since BACH is transitioning to a longitudinal study the progression/remission of OAB and other LUTS will be able to be examined in light of changes in adiposity.

Conclusion

We have shown that OAB is associated with increased BMI at the upper end of the adiposity distribution for both men and women. Apparent differences in the association by gender suggests separate pathophysiological pathways and warrants further investigation. Our findings have important implications for both primary and secondary prevention efforts to reduce the prevalence and burden of OAB. Since the BACH study has transitioned to a longitudinal cohort design, it will be possible to examine the progression and/or remission of OAB with changes in adiposity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Venn diagrams showing the prevalence (percent) of urinary frequency, urgency, and urge leakage by gender. The shaded area shows our definition of overactive bladder.

Figure 2. Density functions of the four adiposity measures by gender. The vertical axis is not given as it is a function of the range of the variable. The area under each curve is one.

Figure 3. Prevalence of overactive bladder by decade for men and women (left panel). Probability of overactive bladder by age for men and women using a nonparametric loess fit (right panel).

Figure 4. Probability of overactive bladder by waist circumference, hip circumference, waist-to-hip ratio, and body mass index (BMI) for men and women using a nonparametric loess fit.

Figure 5.

The association of age and various adiposity measures (waist circumference, hip circumference, waist-to-hip ratio, body mass index (BMI)) with OAB for men and women using loess fits which allow an interaction between age and the adiposity measure. The curves for men are in the top row and for women in the bottom row. The curves (from the bottom) are age 30 (dark blue), age 40 (dark red), age 50 (green), age 60 (orange), age 70 (light blue), and age 80 (light red).

Table 1

Pearson's Product Moment Correlations of Four Adiposity Measures by Gender

Gender	Adiposity Measure	Hip Circumference	Waist-to-Hip Ratio	Body Mass Index
Men	Waist Circumference	0.85	0.73	0.88
	Hip Circumference		0.26	0.85
	Waist-to-Hip Ratio			0.51
Women	Waist Circumference	0.85	0.70	0.88
	Hip Circumference		0.22	0.90
	Waist-to-Hip Ratio			0.41

Table 2

Logistic regression models for OAB including an adiposity variable with odds ratios (OR), 95 percent confidence intervals (95% CI), and p values. Model 1 includes age decade and one measure of adiposity. Model 2 includes age decade, adiposity, and confounders from Table 3.

	Men				Women			
	OR	Model 1 95% CI	P	OR	Model 1 95% CI	P	OR	Model 2 95% CI
Waist circumference (per 10 cm)								
< 100 cm	0.64	0.46, 0.89	.0086	0.65	0.49, 0.88	.0050		
≥ 100 cm	1.27	1.04, 1.55	.0171	1.19	0.96, 1.48	.1045		
All					1.18	1.09, 1.28	.0001	1.10, 1.19
Hip circumference (per 10 cm)								
< 115 cm	0.69	0.50, 0.94	.0189	0.71	0.53, 0.94	.0158		
≥ 115 cm	1.22	0.93, 1.61	.1506	1.16	0.87, 1.54	.3029		
All					1.20	1.10, 1.32	.0001	1.12, 1.23
Waist-to-hip ratio (per 0.1 unit)								
< 0.95	0.88	0.57, 1.36	.5661	0.93	0.60, 1.46	.6511		
≥ 0.95	1.20	0.77, 1.86	.4261	1.09	0.69, 1.75	.7643		
All					1.15	0.99, 1.34	.0692	0.91, 1.24
Body mass index (per unit)								
< 27.5 kg/m ²	0.85	0.76, 0.94	.0018	0.87	0.80, 0.95	.0029		
≥ 27.5 kg/m ²	1.07	1.04, 1.11	.0001	1.08	1.02, 1.10	.0035		
All					1.04	1.02, 1.06	.0001	1.00, 1.08

Table 3

Multivariable logistic regression models for OAB by gender excluding adiposity variables including odds ratios (OR), 95 percent confidence intervals (95% CI), and p values.

	Men (N=2301, 269 cases of OAB)			Women (N=3202, 657 cases of OAB)		
	OR	95% CI	p	OR	95% CI	p
Age decade			<.0001			.1028
30–39	1.00	reference		1.00	reference	
40–49	2.50	1.27, 4.93		1.71	1.07, 2.73	
50–59	5.55	2.64, 11.66		1.66	1.06, 2.59	
60–69	9.14	4.29, 19.47		1.78	1.11, 3.47	
70–79	12.99	5.62, 30.06		1.97	1.11, 3.47	
Cardiac arrhythmias ¹	1.57	0.98, 2.50	.0588	1.76	1.19, 2.59	.0046
Arthritis/rheumatism				2.04	1.51, 2.77	<.0001
Depression	2.86	1.96, 4.16	<.0001	2.09	1.48, 2.97	<.0001
Fluid intake (cups/day)			.0079			
0–3	0.28	0.09, 0.90				
4–9	0.48	0.29, 0.79				
10–14	0.60	0.37, 0.96				
15+	1.00	reference				
Physical activity						.0431
Low				1.00	reference	
Moderate				1.18	0.87, 1.61	
High				0.66	0.40, 1.09	
Per type of abuse ²	1.21	1.07, 1.36	.0017	1.24	1.15, 1.34	<.0001
Medications for LUTS/BPH ³	1.77	0.99, 3.15	.0549			
Medications for OAB ³				7.17	3.65, 14.10	<.0001
Medications for HRT ³				1.72	0.99, 2.98	.0539
Statins ³	0.57	0.34, 0.95	.0300			

¹ Cardiac arrhythmias include an irregular heartbeat or arrhythmia requiring insertion of a pacemaker or heart-rhythm disturbance; neurologic disease includes stroke, transient ischemic attack (TIA), Parkinson's disease, multiple sclerosis; pelvic prolapse includes prolapsed bladder, rectum, or uterus

- ² Sexual abuse was present if any of the following experiences occurred, the perpetrator was an adult, and the experiences were unwanted: exposed sex organs of their body (childhood only), threatened to have sex with you, touched the sex organs of your body, made you touch the sex organs of their body, forced you to have sex, or other unwanted sexual experience. Physical abuse was present if an adult physically hit, kicked, beat you (occasionally or often) or an adult seriously threatened your life (seldom, occasionally, or often). Emotional abuse was present if an adult emotionally abused, humiliated, or insulted you (occasionally or often). The number of types of abuse (0–6) was a sum of childhood sexual, physical, or emotional abuse, and adult sexual, physical, or emotional abuse.
- ³ Medications for overactive bladder (OAB) include oxybutynin, tolterodine tartrate, propantheline bromide, and hyoscyamine sulfate; medications for hormone replacement therapy (HRT) include non-birth control estrogens and progesterone ; medications for BPH included doxazosin, terazosin, alfuzosin, tamsulosin, and finasteride; Statins included lovastatin, simvastatin sodium, fluvastatin, atorvastatin, rosuvastatin calcium.

Table 4

Pseudo R square values from adiposity models. Model 1 includes adiposity and age decade. Model 2 includes adiposity, age decade, and potential confounders from Table 3.

	Men		Women	
	Model 1	Model 2	Model 1	Model 2
Waist circumference	.060	.099	.037	.119
Hip circumference	.060	.098	.037	.119
Waist-to-hip ratio	.053	.094	.027	.116
BMI	.065	.101	.039	.120