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Urodynamic Characterization of Obese Women with Urinary Incontinence Undergoing a Weight Loss Program:

The Program to Reduce Incontinence by Diet and Exercise (PRIDE) Trial

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Abstract

Introduction—The purpose of this study was to describe urodynamic characteristics of overweight or obese women with urinary incontinence and explore the relationship between urodynamic parameters, body mass index (BMI), and abdominal circumference (AC).

Materials & Methods—One hundred ten women underwent a standardized cough stress test and urodynamic study.

Results—86% of women had urodynamic stress incontinence and 15% detrusor overactivity. Intraabdominal pressure (Pabd) at maximum cystometric capacity (MCC) increased 0.4 cm H_2O per kg/m^2 unit of BMI (95% confidence interval (CI): 0.0,0.7, p=0.04) and 0.4 cm H_2O per 2 cm increase in AC (CI: 0.2, 0.7, p<0.01). Intravesical pressure (Pves) at MCC increased 0.4 cm H_2O per 2 cm increase in AC (CI: 0.0, 0.8, p=0.05), but was not associated with BMI (p=0.18).

Conclusion—BMI and AC had a stronger association with Pabd than with Pves, suggesting a possible mechanism for the association between obesity and urinary incontinence.

Keywords

mechanism; obesity; urinary incontinence; urodynamics; weight loss

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Summary: In obese women with urinary incontinence, BMI and abdominal circumference were associated with Pabd, suggesting a possible mechanism for the relationship between obesity and incontinence.

Introduction

There is an increasing worldwide obesity epidemic with significant associated morbidity and mortality. [1,2] In epidemiologic and clinical studies, urinary incontinence (UI) is one of the many medical comorbidities associated with increased body mass index (BMI). [3-6] Increased BMI has been found to be associated with both prevalent and incident UI, as well as severity of incontinence. [7-9] A large cross-sectional study showed that each 5-unit increase in BMI was associated with approximately a 60% increase of daily UI, and obesity had the largest attributable risk for daily UI compared to other risk factors. [3]

Suggested mechanisms by which obesity may contribute to UI include increased mechanical impact of central adiposity on intra-abdominal and intravesical pressures, decreased transmission of pressure to the urethra, and decreased leak point pressures. [10-14] Obesity may also effect incontinence through systemic mechanisms including oxidative stress resulting in vascular damage leading to pelvic floor and detrusor and sphincter muscle damage. Increased urine production associated with diabetes and pre-diabetes may lead to urinary frequency and urge incontinence. [15] In addition, obesity induced neurogenic effects on the pelvic floor may also contribute to urethral dysfunction and the development of UI. [10] Conversely, both surgically and behaviorally induced weight reduction have been associated with improvement of UI symptoms. [14,16,17]

There is a dearth of information characterizing UI symptoms and objective urodynamic parameters in overweight (BMI 25-29.9 kg/m^2) and obese (BMI ≥30 kg/m^2) women with urinary incontinence. It is also unclear whether there is a direct relationship between increases in intra-abdominal pressure, body mass index (BMI), and abdominal circumference. [11,18]

Our objective was to describe the baseline characteristics of a group of overweight and obese women with UI participating in a urodynamic sub-study of the “Program to Reduce Incontinence by Diet and Exercise” (PRIDE) clinical trial. A second objective was to explore the relationship between urodynamic parameters, BMI and abdominal circumference.

Materials & Methods

Between July 2004 and April 2006, 338 overweight and obese women with symptoms of UI were enrolled in the PRIDE study, a multi-center randomized clinical trial sponsored by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), to evaluate the effects of weight loss on symptoms of UI. Inclusion criteria included being community-dwelling, BMI of 25-50 kg/m^2 and at least 10 incontinent episodes per week on a 7-day bladder diary. Exclusion criteria included current urinary tract infection or ≥ 4 urinary tract infections in the preceding year, history of incontinence of neurological or functional origin, prior anti-incontinence or urethral surgery, pelvic cancer or pelvic irradiation and significant medical conditions of the genitourinary tract (genitourinary fistula, interstitial cystitis). At two clinical sites, women were randomized to either a six-month, intensive lifestyle and behavioral weight reduction program or to a structured education program, in which general information was presented about weight loss and lifestyle. All study procedures were approved by the institutional review board at each clinical center and the coordinating center, and written consent was obtained from all women before enrollment.

Demographic characteristics, medical, behavioral and incontinence histories were ascertained using self-reported questionnaires. Incontinence frequency was recorded by participants using a 7-day bladder diary, a validated measure of incontinence frequency, with each incontinent episode classified by clinical type (urge, stress, other). [19] Stress or stress predominant incontinence was defined as the number of stress UI episodes ≥ 2/3 of total episodes; urge or urge predominant incontinence as the number of urge episodes ≥ 2/3 of total episodes; and mixed incontinence as no predominant type (at least two types but no type is ≥ 2/3 of total episodes). Participants also completed a 24-hour pad test. Body weight was measured on a digital scale and recorded to the nearest 0.5 kg; height was measured to the nearest centimeter and BMI was calculated as weight in kg/height in meters^2 (kg/m^2). Abdominal circumference (AC) was measured to the nearest 0.1 cm with a Gulick spring tension tape.

This paper reports on baseline characteristics of a subgroup of 110 (32%) women who volunteered to undergo baseline pelvic floor evaluation and urodynamic studies (UDS) using a standardized research protocol. The UDS participants were similar to non-UDS participants in incontinence frequency and Urogenital Distress Inventory (UDI) score. [20] Participants in the UDS study, however, had more urge incontinence episodes per week (16±16, median 11, IQR 6 to 21; p=0.05) on the bladder diary compared to the non-UDS participants.

Methods, definitions and units conform to standards recommended by the International Continence Society (ICS) and the Society of Female Urology and Urodynamics. [21] The UDS protocol was adapted from the protocol utilized by the Urinary Incontinence Treatment Network in the Stress Incontinence Surgical Treatment Efficacy Trial (SISTEr). [22] Examiners underwent centralized training in the performance of all aspects of the pelvic and urodynamic examination and the urodynamic water-based systems were calibrated per protocol. UDS assessment was conducted by examiners masked to group assignment. A pelvic floor physical examination was performed prior to the UDS and included the Brinks score to measure pelvic floor strength, [23] Q-tip cotton swab test, and Pelvic Organ Prolapse Quantification (POP-Q) examination. [24]

Cough Stress Test

Following retrograde bladder fill, a standardized cough stress test was performed at 300mL or maximum cystometric capacity (MCC), if lower than 300mL. All evaluations were performed in dorsolithotomy position in 45 degree recline. The participant was asked to bear down and cough. If no leakage was observed, she was asked to stand and the provocations repeated. A positive stress test was based on examiner observation of fluid loss with stress provocation.

Free Uroflowmetry

After the retrograde fill for the cough stress test, or on presentation to the clinic with a full bladder, participants voided into a uroflowmetry collection device in the sitting position. A time-flow curve was recorded using a standard urodynamic recorder. Parameters measured included maximum flow rate (Qmax, ml/sec), mean flow rate (Qmean, ml/sec), time to maximum flow (sec) and voided volume (ml). If the initial voided volume was <150 mL, uroflowmetry was repeated after mechanical or spontaneous filling. After voiding, the participant was catheterized to measure a post-void residual (PVR) urine volume and perform a urine dipstick. Using ICS guidelines [21], normal flow patterns were defined as high amplitude and continuous.

Filling Cystometrogram (CMG)

Filling CMG was performed with participants at a 45-degree reclined angle in a birthing chair. A dual lumen, fluid-filled column-type tubing ≤ 8 French catheter was used to measure intravesical pressure (Pves). A rectal catheter was used to measure intra-abdominal pressure (Pabd). The bladder was filled with room temperature saline or sterile water at a rate of 50 ml/min. Three bladder sensation parameters were determined using standardized instructions: first desire to void, strong desire to void and MCC.

Eliciting Valsalva leak point pressure (VLPP) was first attempted at 200 ml and then at 100 ml increments until leakage or MCC. If the participant reached MCC without urodynamic stress incontinence, she was instructed to cough maximally and observed for fluid loss. If no leakage was observed with the catheter in place, the catheter was removed and the cough procedure repeated. The mean of three VLPP values was calculated.

For participants with POP-Q Stage 0, I and II, only unreduced VLPP measures were obtained. For participants with POP-Q stages III (N=3), VLPPs were measured without and then with reduction of the prolapse using a ring forcep. Because there were only 3 participants with greater than Stage II prolapse, and the reduced and non-reduced results were similar, their data were pooled with the other participants' data in the analyses.

The following data were collected: pre-filling Pves (cm H_2O), pre-filling Pabd (cm H_2O), bladder volume at first desire to void (mL) and strong desire to void (mL), bladder volumes for each VLPP (mL), bladder volume at MCC (mL), Pves at MCC (cm H_2O), Pabd at MCC (cm H_2O), urodynamic stress incontinence (yes/no), detrusor overactivity (yes/no), the volume at each occurrence (mL), and detrusor activity incontinence (yes/no). Bladder compliance was calculated as MCC/(Pves at MCC — Pre-filling Pves).

Analysis

Baseline parameters are presented as mean±SD or median and 25% to 75% inter-quartile range (IQR) for skewed data. To estimate the reliability of the VLPP, we calculated the intra-class correlation coefficient using the Weiner reliability score. [25] In addition, we compared BMI and AC using Pearson's correlation coefficient and investigated the relationship of BMI and AC with urodynamic parameters (MCC, Pves, and Pabd). Parameters and 95% confidence intervals were estimated from multivariable general linear models for BMI and AC separately, controlling for age, race and parity. All analyses were preformed using SAS Version 9.1 (Cary, NC).

Results

Characteristics of Participants

The 110 participants had a mean (SD) age of 55±10 years, weight of 96±18 kg and BMI of 36 ±6 kg/m^2 (Table 1). Eighty-five percent of participants were white and 13% were African American. Ninety-nine women (90%) reported at least one stress incontinent episode and 102 (93%) women at least one urge incontinent episode on the 7-day diary. Eighty three participants (75%) had a positive cough stress test. Lower urinary tract symptoms, physical examination findings, bladder diary variables, and incontinence-specific quality of life data are presented in Table 1.

Uroflowmetry

Four of the 110 participants did not void at least 150 ml on uroflowmetry at the initial evaluation visit, which was then repeated after a retrograde bladder fill. Participants had a mean flow rate of 12±6 ml/sec and a mean maximum flow (Qmax) of 24±10 ml/sec (median, 24, range, 5 to 57 ml/sec, Table 2). Over 70% of participants had an intermittent or prolonged urinary stream [21].The mean PVR was less than 20 ml, with a maximum of 120 ml.

Cystometrogram (CMG)

Mean baseline Pves and Pabd were 22±9 and 19±9 cm H_2O, respectively. Bladder sensation parameters revealed a mean first desire to void of 165±89 ml, strong desire to void at 280±142 ml and MCC of 433±152 ml. The median first desire to void was observed at 39% of MCC and a strong desire to void at 64% of MCC.

Ninety-five (86%) participants demonstrated urodynamic stress incontinence on CMG and 83 (75%) had a positive cough stress test (Table 2). Four women with a positive cough stress test did not exhibit urodynamic stress incontinence and 5 women had urodynamic stress incontinence at 300 ml or less, but did not have a positive cough stress test. The majority of participants who had urodynamic stress incontinence leaked with Valsalva (n=71; 75%) and 18 (19%) leaked only with cough at MCC. Among women who leaked with Valsalva, nearly 50% experienced leakage at 200 ml and 18% only at MCC.

VLPP measurements were reproducible, with an intra-class correlation coefficient for the 3 VLPP measurements of 0.88. Fifty percent of the participants had a VLPP intra-patient range of <15 cm H_20. In addition, there was only a 10 cm H_20 difference between the mean VLPP (112 cm H_20) and the mean lowest raw Pves (103 cm H_20). Median bladder compliance was 39 mL/cm H_20.

Detrusor overactivity (DO) was observed in 16 (15%) of participants. Twelve women with DO (75%) had detrusor overactivity incontinence with a mean lowest volume of leakage of 193 ml±119 ml, and 4 (25%) had detrusor overactivity without leakage.

BMI and AC were highly correlated (R = 0.83; p<0.001) and on average, for each kg/m^2 increase in BMI we observed a 1.9 (±0.1) cm increase in AC. For BMI, each kg/m^2 increase was associated with a 0.3 cm H_2O increase in Pabd (95% CI 0.0, 0.6; p=0.05), and a 0.3 cm H_2O increase in Pves (95%CI 0.0, 0.6; p=0.08). For AC, with every 2 centimeter increase, Pabd increased by 0.3 cm H_2O (95% CI 0.0, 0.5; p=0.05), and Pves increased by 0.2 cm H_2O (95% CI 0.0, 0.5; p=0.09). Pabd at MCC increased 0.4 cm H_2O per kg/m^2 unit of BMI (95% CI 0.0, 0.7; p=0.04), and 0.4 cm H_2O per 2 centimeter increase in AC (95% CI 0.2, 0.7; p<0.01). Pves at MCC increased 0.4 cm H_2O per 2 centimeter increase in AC (95% CI 0.0, 0.8; p=0.05), but was not associated with BMI (p=0.18). Thus, controlling for age, race, and parity, BMI and AC had a stronger association with Pabd than with Pves.

Discussion

The PRIDE urodynamic sub-study is being performed to explore potential mechanisms of improved UI after weight loss. In this report, we present baseline observations. In the ongoing study, the same baseline measures will be repeated at 6 months post- randomization to investigate potential mechanisms by which weight loss improves continence, by examining the relationship of changes in urodynamic measures and UI symptoms.

We observed associations between increased intravesical pressure at MCC and higher abdominal circumference, as well as increased intraabdominal pressure at MCC and both higher BMI and abdominal circumference. Prior studies have been inconclusive on the association of BMI and intraabdominal pressure with some hypothesizing that higher BMI leads to greater incontinence due to increased intra-abdominal pressure (Pabd). [11,13,18] In theory, increased Pabd “stresses” the muscle, connective tissue and innervation of the pelvic floor that may lead to overt structural damage or neurologic dysfunction with resultant UI. Previous studies in patients undergoing significant weight loss showed improvements in stress UI with decreases in Pves, cough pressure transmission, and urethral mobility, supporting the theory of a role for increased abdominal pressure [13,26]. In univariate analysis, Noblett et al [11] observed a significant association between intraabdominal and intravesical pressure with BMI. However, Bai et al [18] found no association between obesity and stress UI among all women in multivariable analyses of obesity and urodynamic parameters among women with stress UI. They did find a significantly higher intraabdominal pressure in the obese group compared to the control group (27 versus 19 cm H_2O, p=0.009). Bump et al [13] reported that among 12 women who underwent surgical weight loss, statistically significant changes were observed in measures of intravesical pressure, the magnitude of bladder pressure increases with coughing, and bladder to urethra pressure transmission. We reported small incremental increases of Pabd and Pves with each unit of increasing AC or BMI in this overweight and obese cohort. Therefore, with increasing weight, women may be closer to their threshold for UI events, even if their intrinsic continence mechanisms are comparable. Further mechanistic understanding will need comparative data from normal and overweight incontinent women, especially to elucidate differences in intrinsic continence mechanisms.

Other pathophysiologic explanations may exist as well. In one study obese workers had a 3.5-fold greater risk for median nerve conduction delays as compared to workers of normal weight [27]. Further, Heliovaara [28] reported a higher incidence of lumbar disk herniation in obese men as compared to normal weight controls. These studies suggest that neurogenic disease caused by obesity may also contribute to dysfunction of the pelvic floor, bladder and urethra, placing women at a greater risk for incontinence.

The association of BMI and waist-to-hip ratio with intraabdominal pressure has been described in the surgical literature. [29,30] These relationships are also associated with other medical comorbidities, such as abdominal compartment syndrome, respiratory dysfunction, gastroesophogeal reflux, venous stasis, as well as stress UI.

Limitations of this study include that data are from overweight and obese women who meet the PRIDE inclusion criteria and volunteered to participate in the PRIDE randomized trial, as well as the UDS sub-study. Participants were self selected, therefore potentially representing a proportion of the PRIDE participants with more or less severe incontinence. However, UI frequency, distribution of UI by type and total UDI scores of the non-UDS PRIDE participants were similar to UDS participants.

Strengths of this study include the standardized urodynamic protocol, standardized interpretation of UDS parameters, and use of validated measures to describe UI characteristics in an overweight and obese population. Women were recruited from the community for weight loss and not from a urinary continence clinic. Thus, the participants may represent the level and type of incontinence of women with moderate incontinence, making it more generalizable to all overweight and obese women.

In summary, increased intraabdominal and intravesical pressures were associated with abdominal circumference and intraabdominal pressure was associated with body mass index. We plan to determine if decreases in both BMI and abdominal circumference that occur with weight loss correspond with changes in urodynamic parameters, in order to increase our understanding of possible mechanisms involved in the development as well as treatment of incontinence.

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Table 1

Selected Patient Characteristics (N = 110)

Characteristic	N (%) or Mean (±SD)
Demographic	
Age, years	55 (±10)
Race and ethnicity group	
White	93 (85)
African American	14 (13)
American Indian/Alaska Native	1 (1)
Don't know/Other	2 (2)
Clinical Characteristics	
Weight (kg)	96 (±18)
Body mass index, kg/m^2	36 (±6)
Abdominal circumference, cm	108 (±14)
Number of births (n = 100)	2.4 (±1)
Nulliparous	4 (4)
1 births	19 (19)
2 births	38 (38)
3 or more	39 (39)
Characteristics of Bladder Symptoms	
Number of total incontinent episodes per week*	28 (±22)
Number of stress incontinent episodes per week*	10 (±12)
Number of urge incontinent episodes per week*	16 (±16)
UI Type	
Stress/Stress Predominant	21 (19)
Urge/Urge Predominant	47 (43)
Mixed	42 (38)
Urinary frequency (void every two hours or more)	64 (58)
Nocturia (2 or more voids per night)	59 (54)
Urinary urgency (weekly or more frequent)	79 (72)
Pad weight (grams in 24 hours)	40 (±54)
Physical Examination	
Q-Tip test	
Resting angle	18 (±16)
Straining angle	47 (±21)
Delta	30 (±15)
Brink's total score,(Range 3-12)	8.8 (±2)
Stage of prolapse,**	
Stage I	64 (58)
Stage II	43 (39)
Stage III	3 (3)

*Reported on 7-day diary

** Reported by Pelvic Organ Prolapse Quantification System [26]

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Table 2

Urodynamic Study Measures (N=110)

Characteristic	Mean±SD or N (%)
Stress test	
Positive 300 cc stress test, n (%)	83 (75)
Non-instrumented Uroflow (N=110)	
Maximum flow rate, ml/sec	24 (±10)
Mean flow rate, ml/sec	12 (±6)
Flow pattern, n (%)	
Normal	32 (29)
Abnormal	77 (71)
Time to maximum flow, sec	12 (±16)
Voided volume, ml	303 (±60)
Post-void residual volume, ml	18 (±22)
CMG Parameters	
Bladder volume at first desire (ml)	165 (±89)
Bladder volume at strong desire (ml)	280 (±142)
Bladder volume at MCC (ml)	433 (±152)
Pves, baseline (cm H_2O)	22 (±9)
Pabd, baseline (cm H_2O)	19 (±9)
Pves, MCC (cm H_2O)	34 (±15)
Pabd, MCC (cm H_2O)	25 (±12)
Bladder Compliance, ml/cm H_2O	42 (±103)
VLPP Mean (cm H2O)	112 (±37)
Detrusor overactivity n (%)	16 (15%)
Mean lowest volume of DO among those who leaked, ml (N=12)	165 (±107)
Mean lowest volume of DO among those who did not leak, ml (N=4)	193 (±119)

MCC = maximum cystometric capacity; Pves = intravesical pressure; Pabd = intraabdominal pressure; VLPP = valsalva leak point pressure