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Study Need and Importance: It is well known that an elevated body mass index (BMI) is associated with pelvic floor disorders and urinary incontinence (UI). However, no prior study has evaluated the long-term impact of the duration of overweight or obesity status on development of UI in a dose-dependent fashion. This current study aims to better characterize the cumulative impact of obesity over a woman's lifetime and determine whether the chronicity of obesity leads to an increased risk in the development of UI.

What We Found: First, we found that an increased duration of being either overweight or obese was significantly associated with the development of UI in a dose-dependent fashion. That is, the greater number of overweight/obese years a subject had would increase the likelihood they would develop UI in their later years. Second, those who had greater durations of being overweight/obese also reported more frequent episodes of UI and higher volumes of urinary leakage, which led to increased activity limitations and associated bother. Lastly, it appears that being overweight or obese at age 35+ years resulted in an increased risk of developing UI and urge UI later in life, and that an increase in BMI from age 18 to 50 years was associated with higher rates of developing UI.

Limitations: As with all large-scale national population studies, there were some limitations utilizing data from the Women's Health Initiative study. To assess new incidence of UI in the sample size, we could only capture data to a time frame of 3 years, hindering our ability to delineate the progression of UI and its subtypes over a greater course of time. This observational study was primarily questionnaire based, so data regarding UI and associated symptoms were based on a limited set of questions. In addition, body weight information may be hindered by patient's recall, and BMI may not be an ideal measure to assess body fat percentage.

Interpretation for Patient Care: Our study showed that chronic, increased BMI is associated with an elevated risk of UI later in life, even after taking into account other known risk factors. Furthermore, symptom severity and bother also appear to be worsened with duration of increased BMI status. It appears that weight management should be supported throughout one's lifetime, as it may impact UI even in later stages.

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Impact of Lifetime Obesity on Urinary Incontinence in the Women's Health Initiative

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Purpose: We assessed the impact of lifetime obesity on the development of urinary incontinence (UI).

Materials and Methods: Using data from the Women's Health Initiative, we evaluated the cumulative impact of obesity over a postmenopausal woman's lifetime on the development of UI. Analyses using logistic models assessed the relationship between overweight/obesity duration and the development of UI during the Women's Health Initiative study at year 3.

Results: Of the 15,420 women aged 50–79 years, 4,568 (30.0%) developed UI by year 3. When controlling for covariates, the duration of overweight years (OWY) and obese years (OBY) was significantly associated with overall UI. The number of OWY was associated with an increased risk of developing UI postmenopausally (OR 1.17, 95% CI 1.13–1.22) compared to those with 0 OWY. The number of OBY was associated with a higher risk of developing UI postmenopausally (OR 1.28, 95% CI 1.18–1.39). Severity of UI was also associated with higher OWY/OBY. Compared to participants who maintained normal weight, those who gained weight from age 18 to 50 years were more likely to report increased UI (OR 1.26, 95% CI 1.16–1.37), as did those who remained overweight/obese (OR 1.27, 95% CI 1.04–1.55). Those who lost weight reported no difference in rates of any UI.

Conclusions: Chronic, increased body mass index status is associated with an elevated risk of UI later in life. Symptom severity also appears to be worsened with duration of increased body mass index status. Weight management should be supported throughout one's lifetime, as it may impact UI in later stages of life.

Key Words: obesity, body mass index, urinary incontinence

Abbreviations and Acronyms

BMI = body mass index
MUI = mixed urinary incontinence
OBY = obese years
OS = observational study
OWY = overweight years
SUI = stress urinary incontinence
UI = urinary incontinence
UUI = urge urinary incontinence
WHI = Women's Health Initiative

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Ethics Statement: In lieu of a formal ethics committee, the principles of the Helsinki Declaration were followed.

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Editor's Note: This article is the fifth of 5 published in this issue for which category 1 CME credits can be earned. Instructions for obtaining credits are given with the questions on pages 1167 and 1168.

See Editorial on page 956.

Obesity is a growing issue facing the United States with several health implications and associated health care costs. An estimated 70% of adults in the United States are overweight (body mass index [BMI] of 25.0 to <30 kg/m^2) and 36% are obese (BMI of 30.0 or higher), with the majority being female.[1] Obesity has been shown to be a risk factor in the development of pelvic floor disorders in general, with a great deal of literature focusing on its association with urinary incontinence (UI).

UI is characterized as an involuntary loss of urine and is a common complaint among women.[2] UI is often classified into stress urinary incontinence (SUI), urgency urinary incontinence (UUI) and mixed urinary incontinence (MUI).[3] SUI is the involuntary loss of urine related to an increase in intra-abdominal pressure, commonly seen with any physical

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exertion, sneezing or coughing, while UUI is the involuntary loss of urine associated with a sudden need to urinate. MUI has elements of both SUI and UUI.

SUI is the most common subtype, followed by MUI and then UUI.[4] Approximately 50% of women reporting urinary leakage describe SUI, a slightly lower percentage describe MUI and even fewer describe UUI.[5] However, prevalence figures are influenced by the study population, with younger women reporting more SUI than UUI and older populations describing UI of all types.[5] Data suggest that the prevalence of UI has risen somewhat during the past decade from 49% in 2001 to 53% in 2008.[6]

Multiple studies have examined various risk factors for women.[7,8] Aging,[5] pregnancy,[9] mode of obstetric delivery,[10] race and ethnicity,[11] estrogen use,[12] diabetes,[13] smoking,[14] hysterectomy status,[15] depression[16] and obesity[17,18] have all been found to be positively correlated with UI. An elevated BMI has been shown to be a risk factor in the development of pelvic floor disorders in general,[17] with a great deal of literature focusing on its association with UI.[18]

Initiated in 1992, the Women's Health Initiative (WHI) is a large, national and comprehensive prospective cohort study designed to investigate strategies for the prevention and control of common causes of morbidity and mortality among postmenopausal women.[19] With its large cohort and extensive long-term followup, the WHI data were utilized to evaluate the dose-dependent effects of obesity on urinary incontinence. The current study aims to better characterize the cumulative impact of obesity over a woman's lifetime and determine whether the chronicity of obesity leads to an increased risk in the development of UI. These findings can be used to counsel patients on weight loss interventions and reducing the risk of developing UI.

MATERIALS AND METHODS

Study Population

Data from the WHI were utilized to examine the role of cumulative impact of obesity over a woman′s lifetime on the development of UI. Postmenopausal women ranging in age from 50 to 79 years were enrolled at 1 of 40 WHI clinical centers nationwide into either a clinical trial or an observational study (OS).[20] Only participants from the OS cohort were included. Baseline recruitment for the study was conducted between 1993 and 1998, and participants were followed until 2005 for the initial WHI study. Among 93,676 women in the OS cohort, those who reported incontinence at baseline (answered "yes" to the question "If ever leaked urine" in the baseline questionnaire; 71,860), strokes/transient ischemia attacks, dialysis, multiple sclerosis or Parkinson's disease (6,576) were excluded. The final study population included 15,240 women without incontinence at baseline. In lieu of a formal ethics committee, the principles of the Helsinki Declaration were followed.

Outcomes

At 3-year followup, participants were again asked about UI (question "Ever leaked urine?"), SUI (questions "Leak urine when cough, laugh?") and UUI (question "Leak when can't get to toilet?"). Those with both SUI and UUI were deemed to have MUI. The year 3 questionnaire also asked about incontinence duration, amount of leakage, the need for leakage protection, whether the leakage limited activities and how bothersome the leakage was.

Covariates

BMI at ages 18, 35 and 50 years was obtained from retrospective self-reports at baseline. Weight and height measurements at baseline and year 3 were used to calculate BMI at baseline and at year 3. BMI trajectories for each participant were modeled using individual growth models with random intercept and random slope. Covariates related to BMI were chosen for the mixed model using stepwise selection. BMI at ages 18, 35, 50 years, baseline and year 3, race/ethnicity, education, baseline information about diabetes diagnosis and smoking status were included in the final growth model. Using the individual growth model, BMI values were predicted for each participant for each year from 18 years old until year 3 of followup in the study.

The predicted age-specific BMI values were used to calculate 2 sets of parameters:

1) Cumulative overweight/obese duration years of each participant was calculated by summing up the number of years they were overweight/obese (overweight: $30>BMI\geq25$ kg/m^2; obese: BMI ≥30 kg/m^2). Overweight/obese duration years were assessed as a continuous variable per 10 years. Overweight/obese duration years were then categorized; those having 0 years served as the reference group, while the rest of the participants were equally divided into 3 groups for overweight years (OWY) or 2 groups for obese years (OBY).

2) Weighted cumulative OWY and OBY were computed by multiplying the duration of overweight and obesity in years by the difference (in BMI units) above 25 kg/m^2 for overweight and above 30 kg/m^2 for obesity for each age. This approach allowed for the degree of each participant's overweight/obese status to be taken into account. The merit and details of this approach has been described in other publications.[21] OWY and OBY were used as continuous variables per 100 units. Categorical OWY and OBY were obtained using the same approach as for the calculation of cumulative duration years.

We selected covariates that are correlated with incontinence based on prior reports. Covariates included baseline information regarding age,[5] race/ethnicity,[11] marital status, number of living births,[9] history of hysterectomy and oophorectomy status,[15] history of hormone therapy,[12] diabetes status[13] and smoking history.[14]

Statistical Analysis

Logistic regression models were used to assess the relationship between overweight/obesity duration and the development of UI during the WHI study at year 3. The logistic models were fitted for UI, SUI, UUI and MUI, and adjusted for established risk factors for UI and covariates that were significantly associated with UI in univariate analysis. The odds ratios and 95% confidence intervals for different approaches of obesity duration measurements were assessed. The final multivariate logistic model includes age at baseline as strata and is adjusted for covariates. Results are considered to be statistically significant if the p value is <0.05. All analyses were performed on SAS® 9.4 (SAS, Cary, North Carolina).

RESULTS

Of the 15,420 women included in the study, 4,568 (30.0%) participants developed UI by year 3 (table 1). Among the study population, the majority of subjects were age 60–69 years (43.7%), White (80.1%), had a health care provider (91.6%) and had 2–4 children (62.7%). In accordance with prior studies, age, race, parity, hysterectomy and oophorectomy status, and hormone therapy were found to be significantly associated with UI, based on univariate analysis.

Table 2 describes the distribution of the study population based on their overweight/obesity duration measurements and the development of UI at year 3 of the study. Cumulative overweight/obese duration year category, number in OWY and OBY category, and BMI change from age 15 to 50 years were all assessed along with their associated incontinence status at year 3. Chi-square tests were performed to test the association of patient characteristics and outcomes.

Of the 15,240 participants, 6,784 (44.5%) had no history of being overweight (0 OWY). An increased number of OWY and OBY was significantly associated

Table 1. *Baseline characteristics of study population by their incontinence status at year 3*

	Pts without Incontinence at Baseline (15,240)		Pts with UI at Yr 3 (4,568)*											
			Overall			SUI			UUI			MUI		
Characteristics	No.	%	No.	%	p Value†	No.	%	p Value†	No.	%	p Value†	No.	%	p Value†
Yrs age at baseline (continuous in model):					<0.0001			0.0006			<0.0001			NS
<50–59	5,371	35.2	1,509	28.1		709	14.0		653	12.9		86	1.7	
60–69	6,653	43.7	1,999	30.0		870	13.8		964	15.3		136	2.2	
70–79+	3,216	21.1	1,060	33.0		338	11.2		630	20.9		63	2.1	
Race/ethnicity:					<0.0001			<0.0001			NS			NS
White	12,207	80.1	3,768	30.9		1,614	14.0		1,830	15.9		245	2.1	
Black	1,616	10.6	384	23.8		109	7.2		229	15.2		17	1.1	
Hispanic	591	3.9	180	30.5		82	15.1		77	14.2		10	1.8	
Asian/Pacific Islander	605	4.0	169	27.9		88	15.2		72	12.4		7	1.2	
Marital status:					NS			NS			NS			NS
Married	9,163	60.1	2,706	29.5		1,144	13.2		1,303	15.1		168	1.9	
Not married (never, divorced, separated, widowed etc)	6,018	39.5	1,842	30.6		768	13.5		937	16.5		117	2.1	
No. living births:					0.0019			NS			0.002			NS
0	2,465	16.2	665	27.0		278	11.9		323	13.8		45	1.9	
1	1,509	9.9	462	30.6		198	14.1		209	14.9		27	1.9	
2–4	9,557	62.7	2,887	30.2		1,219	13.5		1,417	15.7		180	2.0	
5+	1,615	10.6	528	32.7		212	13.9		285	18.7		31	2.0	
Hysterectomy:					<0.0001			0.0086			<0.0001			0.0457
No	10,043	65.9	2,883	28.7		1,206	12.7		1,391	14.7		169	1.8	
Yes	5,182	34.0	1,680	32.4		708	14.5		854	17.5		116	2.4	
Oophorectomy:					0.0141			0.004			0.0069			NS
No	12,365	81.1	3,645	29.5		1,515	13.0		1,773	15.2		217	1.9	
Yes	2,589	17.0	838	32.4		374	15.3		419	17.1		62	2.5	
Hormone therapy:					<0.0001			<0.0001			NS			0.0101
Never used	5,661	37.1	1,531	27.0		564	10.5		821	15.3		85	1.6	
Past hormone user	3,060	20.1	920	30.1		376	13.0		475	16.4		59	2.0	
Current hormone user	6,221	40.8	2,039	32.8		951	16.3		913	15.6		139	2.4	
Diabetes:					NS			NS			0.0013			NS
No	14,700	96.5	4,396	29.9		1,855	13.4		2,138	15.4		268	1.9	
Yes	528	3.5	169	32.0		62	12.4		106	21.3		17	3.4	
Smoking:					NS			NS			NS			NS
Nonsmoker	8,103	53.2	2,371	29.3		978	12.8		1,198	15.6		146	1.9	
Past smoker	6,034	39.6	1,879	31.1		802	14.1		893	15.7		120	2.1	
Current smoker	938	6.2	273	29.1		120	13.6		131	14.9		16	1.8	

NS, not statistically significant.
* Of 14,372 patients at year 3. Total of 868 participants with unknown type of incontinence at baseline were excluded.
† Chi-square test for different distribution of incontinence status in characteristics categories.

Table 2. *Overweight/obesity status and incontinence status at year 3*

	Pts without Incontinence at Baseline (15,240)		Pts with UI at Yr 3 (4,568)*											
			Overall			SUI			UUI			MUI		
Characteristics	No.	%	No.	%	p Value†	No.	%	p Value†	No.	%	p Value†	No.	%	p Value†
Overweight duration category:					<0.0001			0.0287			<0.0001			0.0392
0 yrs	6,784	44.5	1,865	27.5		811	12.6		874	13.6		109	1.7	
1–16 yrs	2,830	18.6	857	30.3		356	13.4		415	15.6		56	2.1	
17–28 yrs	2,756	18.1	885	32.1		387	15.0		417	16.1		50	1.9	
≥29 yrs	2,870	18.8	961	33.5		363	13.5		541	20.1		70	2.6	
Obese duration category:					<0.0001			0.0208			<0.0001			0.0044
0 yrs	12,237	80.3	3,557	29.1		1,496	13.0		1,716	14.9		211	1.8	
1–12 yrs	1,520	10.0	497	32.7		213	14.8		253	17.5		31	2.1	
≥13 yrs	1,483	9.7	514	34.7		208	15.1		278	20.2		43	3.1	
Weighted cumulative OWY:					<0.0001			0.0427			<0.0001			0.0203
0	6,784	44.5	1,865	27.5		811	12.6		874	13.6		109	1.7	
0.1–18.8	2,818	18.5	850	30.2		347	13.1		417	15.8		55	2.1	
18.9–78.7	2,819	18.5	905	32.1		374	14.1		448	16.9		50	1.9	
≥78.8	2,819	18.5	948	33.6		385	14.6		508	19.2		71	2.7	
Weighted cumulative OBY:					<0.0001			0.0174			<0.0001			0.0033
0	12,237	80.3	3,557	29.1		1,496	13.0		1,716	14.9		211	1.8	
0.1–18.4	1,501	9.8	485	32.3		207	14.5		248	17.4		30	2.1	
≥18.5	1,502	9.9	526	35.0		214	15.4		283	20.3		44	3.2	
BMI change from age 18 to 50 yrs:					0.0005			NS			0.0003			NS
Stay normal weight	9,792	64.3	2,822	28.8		1,208	13.0		1,368	14.7		172	1.9	
Gain weight (normal at 18 and overweight to obese at 50)	4,268	28.0	1,375	32.2		556	13.9		702	17.6		90	2.3	
Lost weight (overweight or obese at 18 and normal at 50)	204	1.3	67	32.8		32	16.8		28	14.7		6	3.2	
Stay overweight or obese	499	3.3	157	31.5		59	12.7		82	17.6		13	2.8	

NS, not statistically significant.
* Of 14,372 patients at year 3. Total of 868 participants with unknown type of incontinence at baseline were excluded.
† Chi-square test for different distribution of incontinence status in characteristics categories.

with UI in a dose-dependent fashion ($p < 0.0001$ for both OWY and OBY). SUI, UUI and MUI were largely seen to be positively correlated with a higher number of OWY and OBY. These findings held true when evaluating the incidence of UI and its subtypes with the weighted cumulative OWY and OBY; all $p < 0.05$). Subjects with higher BMI reported at age 35 years were also noted to have an increased risk of UI, UUI, and MUI (all $p < 0.01$), and those who reported higher BMI at age 50 years were found to have higher rates of UI and UUI ($p < 0.0001$). Those in whom the BMI increased from the age of 18 to 50 were noted to have a significantly increased risk of both UI and UUI ($p = 0.0005$ and $p = 0.0003$, respectively).

When taking into account the degree of overweight/obesity status, there was a dose-dependent increase in those with higher OWY and OBY regarding frequency, severity, activity limitation and degree of bother related to UI ($p < 0.0001$, table 3). In those subjects reporting new onset UI over the study period, those in the obese category reported a higher frequency of UI compared to those in the overweight category. Similar effects were seen with severity of UI, as well as the effect of UI on activity limitation and associated bother. We also examined overweight duration category and obese duration category, and the distribution is similar to OWY and OBY.

Table 4 and the figure depict the effect of duration of OWY and OBY on overall UI, SUI, UUI and MUI on multivariate analysis after controlling for all confounding factors. When evaluated as a continuous variable per 10 years, the duration of elevated BMI was found to be significantly associated with UI for both overweight duration (OR 1.10, 95% CI 1.07–1.13) and obesity duration (OR 1.18, 95% CI 1.12–1.23). The same was true for SUI, MUI and UUI for both overweight and obese categories.

After subdividing the overweight/obesity duration into tiers of duration (0 years, 1–16 years, 17–28 years, ≥29 years for the overweight category; 1–12 years, ≥13 years for the obese category), a significant dose-dependent increase in likelihood of UI was noted.

The same was shown when utilizing cumulative OWY and OBY data. The number of OWY was associated with a higher odds risk of developing UI postmenopausally (OR 1.17, 95% CI 1.13–1.22) compared to those with 0 OWY. The number of OBY was associated with a higher risk of developing UI postmenopausally (OR 1.28, 95% CI 1.18–1.39).

Finally, we evaluated whether the change in BMI from age 18 to 50 years was associated with a higher risk of developing UI. Compared to participants who maintained normal weight, those who gained

Table 3. *Distribution of severity and frequency of incontinence by obesity category among participants who had incontinence symptoms at year 3*

	Weighted Cumulative OWY Category									Weighted Cumulative OBY Category						
	0		0.1–18.8		18.9–78.7		≥78.8			0		0.1–18.4		≥18.5		
	No.	%	No.	%	No.	%	No.	%	p Value*	No.	%	No.	%	No.	%	p Value*
How often leaked urine:									<0.0001							<0.00001
Not once during past yr	163	8.8	67	7.9	78	8.7	56	6.0		298	8.4	35	7.2	31	6.0	
Less than once per mo	1,075	57.9	462	54.7	446	50.0	450	48.1		1,953	55.3	241	49.9	239	46.4	
More than once per mo	401	21.6	194	23.0	223	25.0	226	24.2		805	22.8	119	24.6	120	23.3	
1 or more times per wk to daily	217	11.7	122	14.4	145	16.3	203	21.7		474	13.4	88	18.2	125	24.3	
How much urine do you lose:									<0.0001							<0.0001
Barely noticeable on underpants	1,569	94.5	712	93.2	731	90.0	770	88.5		2,958	93.0	391	89.1	433	88.7	
Soaked underpants to outer clothing	92	5.5	52	6.8	81	10.0	100	11.5		222	7.0	48	10.9	55	11.3	
Leak limit activities:									<0.0001							<0.0001
Never	1,472	88.5	673	87.9	696	85.9	715	82.2		2,788	87.6	375	85.2	393	80.7	
Almost never	161	9.7	73	9.5	90	11.1	110	12.6		322	10.1	49	11.1	63	12.9	
Sometimes to very often	30	1.8	20	2.6	24	3.0	45	5.2		72	2.3	16	3.6	31	6.4	
How much does leakage bother:									<0.0001							<0.0001
Not at all disturbing	800	48.1	334	43.8	343	42.3	376	43.2		1,450	45.6	194	44.0	209	42.9	
A little disturbing	712	42.8	335	43.9	369	45.6	361	41.4		1,390	43.7	177	40.1	210	43.1	
Somewhat to extremely disturbing	151	9.1	94	12.3	98	12.1	134	15.4		339	10.7	70	15.9	68	14.0	

* Chi-square test for different distribution of incontinence symptoms in different obesity category.

weight from age 18 to 50 were more likely to report increased UI (OR 1.26, 95% CI 1.16–1.37), as did those who remained overweight/obese (OR 1.27, 95% CI 1.04–1.55). Those who lost weight reported no difference in rates of any UI.

DISCUSSION

Our study evaluated the long-term impact of an elevated BMI on late-onset UI in postmenopausal women and had 3 major findings. First, we found that an increased duration of being either overweight

Table 4. *Odds ratios of obesity categories on likelihood of developing incontinence at year 3 from multivariate adjusted logistic models*

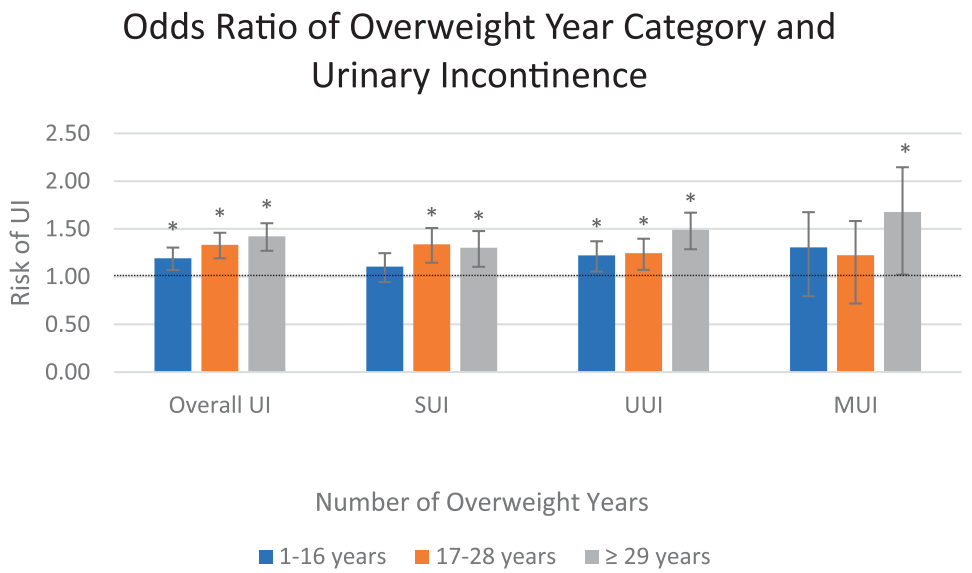
	Outcome at Yr 3			
Obesity Duration Measurements	UI (OR, 95% CI)	SUI (OR, 95% CI)	UUI (OR, 95% CI)	MUI (OR, 95% CI)
Overweight duration (continuous by 10 yrs)	1.10 (1.07, 1.13)*	1.08 (1.04, 1.12)*	1.10 (1.07, 1.13)*	1.12 (1.03, 1.21)†
Overweight duration category (0 yrs as referent group):				
1–16 yrs	1.19 (1.08, 1.32)*	1.11 (0.96, 1.27)	1.22 (1.08, 1.39)†	1.31 (0.94, 1.82)
17–28 yrs	1.33 (1.21, 1.47)*	1.34 (1.17, 1.53)*	1.25 (1.09, 1.42)†	1.22 (0.87, 1.73)
≥29 yrs	1.42 (1.28, 1.57)*	1.30 (1.13, 1.50)*	1.49 (1.31, 1.69)*	1.68 (1.21, 2.33)†
Obese duration (continuous by 10 yrs)	1.18 (1.12, 1.23)*	1.16 (1.09, 1.24)*	1.18 (1.11, 1.25)*	1.29 (1.13, 1.48)*
Obese duration category (0 yrs as referent group):				
1–12 yrs	1.26 (1.12, 1.41)*	1.29 (1.10, 1.51)†	1.21 (1.05, 1.41)‡	1.26 (0.86, 1.87)
≥13 yrs	1.42 (1.26, 1.60)*	1.43 (1.21, 1.68)*	1.42 (1.22, 1.64)*	1.93 (1.36, 2.75)*
OWY (continuous by 100 units)	1.17 (1.13, 1.22)*	1.15 (1.09, 1.21)*	1.17 (1.12, 1.23)*	1.25 (1.13, 1.38)*
OWY category (0 as referent group):				
0.1–18.8	1.18 (1.07, 1.30)†	1.09 (0.95, 1.25)	1.21 (1.06, 1.38)†	1.28 (0.92, 1.79)
18.9–78.7	1.32 (1.19, 1.45)*	1.25 (1.09, 1.44)†	1.29 (1.13, 1.46)*	1.18 (0.83, 1.67)
≥78.8	1.47 (1.33, 1.63)*	1.43 (1.24, 1.65)*	1.47 (1.29, 1.68)*	1.79 (1.29, 2.48)*
OBY:				
OBY (continuous by 100 units)	1.28 (1.18, 1.39)*	1.21 (1.10, 1.34)*	1.29 (1.18, 1.41)*	1.38 (1.18, 1.61)*
OBY category (0 as referent group):				
0.1–18.4	1.23 (1.09, 1.38)*	1.26 (1.07, 1.48)†	1.18 (1.02, 1.38)‡	1.23 (0.83, 1.82)
≥18.5	1.45 (1.29, 1.64)*	1.45 (1.23, 1.71)*	1.45 (1.25, 1.68)*	1.97 (1.39, 2.79)*
BMI change from age 18 to 50 category (stay normal as referent group):				
Gain wt (normal at 18 and overweight to obese at 50)	1.26 (1.16, 1.37)*	1.19 (1.07, 1.34)†	1.25 (1.12, 1.39)*	1.31 (0.99, 1.71)
Lost wt (overweight or obese at 18 and normal at 50)	1.25 (0.93, 1.68)	1.39 (0.94, 2.06)	1.02 (0.68, 1.54)	1.68 (0.73, 3.86)
Stay overweight or obese	1.27 (1.04, 1.55)‡	1.12 (0.84, 1.49)	1.28 (0.99, 1.64)	1.72 (0.96, 3.08)
BMI change from age 18 to 50 category (stay normal as referent group, controlling for BMI at yr 3):				
Gain wt (normal at 18 and overweight to obese at 50)	1.05 (0.95, 1.15)	0.97 (0.85, 1.11)	1.04 (0.92, 1.18)	1.03 (0.75, 1.40)
Lost wt (overweight or obese at 18 and normal at 50)	1.22 (0.90, 1.64)	1.35 (0.92, 2.00)	0.99 (0.66, 1.50)	1.62 (0.70, 3.73)
Stay overweight or obese	0.96 (0.78, 1.19)	0.83 (0.61, 1.12)	0.98 (0.75, 1.28)	1.19 (0.63, 2.25)

Covariates include participant's baseline characteristics of age, race, marital status, education, income, health care provider, number of living births, hysterectomy, oophorectomy, hormone therapy, diabetes and smoking status.

* $p < 0.001$.

† $p < 0.01$.

‡ $p < 0.05$.



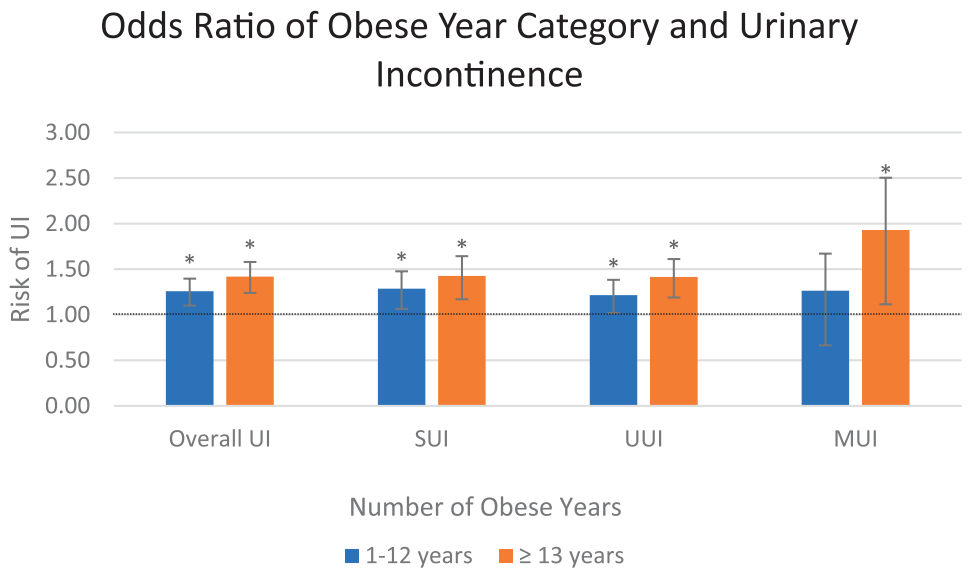


Figure. Odds ratio of overweight/obesity duration on urinary incontinence. Asterisk indicates $p < 0.05$ compared to reference group.

or obese was significantly associated with the development of UI in a dose-dependent fashion. That is, the greater number of OWY/OBY a subject had would increase the likelihood they would develop UI in their later years. Second, those who had greater durations of being overweight/obese also reported more frequent episodes of UI and higher volumes of urinary leakage, which led to increased activity limitations and associated bother. Lastly, it appears that being overweight or obese at age 35+ years resulted in an increased risk of developing UI and UUI later in life, and that an increase in BMI from age 18 to 50 was associated with higher rates of developing UI.

The comprehensive nature of data collection in the WHI allowed us to assess elevated BMI and UI in a diverse and large study population. Our initial univariate analysis aligned with the results from prior studies, in which age, race, parity, hysterectomy and oophorectomy status, and hormone therapy were found to be significantly associated with UI.

By using the multivariate logistic models, we could correct for those established confounding factors and focus on the effect of BMI on UI. BMI trajectories were created for each subject, allowing us to quantify the duration of increased BMI status and associate it with the development of UI during the study period, rather than utilizing cross-sectional BMI information alone.

There is no shortage of studies evaluating the association of obesity with UI.[18] A proposed mechanism for obesity-associated UI has been put forth by Swenson et al, in which increased intravesical pressure as a

result of obesity leads to increased demand on continence mechanisms.[22] Most compelling, Subak et al reported a clear dose-response effect of BMI on UI; for each 5-unit increase in BMI, the risk of UI was found to increase between 20% and 70%.[23] Furthermore, the odds of developing UI increased by 30%–60% for each 5-unit increase in BMI over the span of 5 to 10 years.

Other studies have demonstrated the effect of weight loss and corresponding improvement in UI in obese women.[24] An important study by Subak et al reported that patients who had undergone a 6-month behavioral weight loss program had a significant 70% reduction in the frequency of all incontinence episodes and SUI episodes as well as UUI episodes.[25] These reports were similarly seen in another study by Wing et al, who reported that a decrease in body weight of 5% to $\leq$10% or 10% had significantly reduced UI episodes, and the effect on UI was sustained at 6, 12 and 18 months.[26] Surgical weight loss via bariatric surgery has also been shown to have a positive effect on UI.[27] Interestingly, our study did not find a decrease in rates of UI with weight loss. We believe this is due to a few factors. First, we note a small sample size of patients who lost weight; only 1.3% of the patients in this cohort lost weight from the age of 18 to 50 years. Second, our reference group included women who maintained their weight rather than solely overweight women.

Of interest, our study showed that a decrease in BMI from age 18 to 50 years led to no difference in rates of any UI, compared to those who maintained a BMI within the normal range through their adulthood. Our data therefore suggest that earlier monitoring and surveillance of BMI status should be advocated for the potential delayed effects that may occur with elevated BMI on UI throughout an individual's lifespan.

As with all large-scale national population studies, there were some limitations utilizing data from the WHI study. To assess new incidence of UI in the sample size, we could only capture data to a time frame of 3 years, hindering our ability to delineate the progression of UI and its subtypes over a greater course of time. The OS was primarily questionnaire based, so data regarding UI and associated symptoms were based on a limited set of questions. In addition, body weight information may be hindered by patient recall, and BMI may not be an ideal measure to assess body fat percentage.

CONCLUSIONS

By utilizing the data from the large, comprehensive, prospective WHI study, we were able to assess the role of an elevated BMI over a person's lifetime in the development of UI. The relationship between BMI and UI has been examined extensively in prior studies, but we were able to analyze the effect of degree and duration of increased BMI on those who developed UI over a time frame of 3 years. Our study showed that chronic increased BMI is associated with an elevated risk of UI later in life, even after taking into account other known risk factors. Furthermore, symptom severity and bother also appear to be worsened with duration of increased BMI status. It appears that weight management should be supported throughout one's lifetime, as it may impact UI even in later stages.

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