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Urinary incontinence in older women: the role of body composition and muscle strength from the Health, Aging, and Body Composition Study

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Abstract

Objectives—To evaluate prospective relationships between body composition and muscle strength with predominantly stress- and urgency urinary incontinence (SUI and UUI) in older women.

Design—Prospective community-dwelling observational cohort study (Health, Aging, and Body Composition study).

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Author Contributions:
Suskind: involved in study concept/design, analysis/interpretation of data, preparation of manuscript
Cawthon: involved in study concept/design, analysis/interpretation of data
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Cauley: analysis/interpretation of data, preparation of manuscript
Harris: preparation of manuscript
Huang: involved in study concept/design, analysis/interpretation of data, preparation of manuscript

Participants—Women initially aged 70 to 79 years recruited from Pittsburgh, PA and Memphis, TN.

Measurements—Urinary incontinence was assessed by structured questionnaires. Body mass index (BMI), grip strength, quadriceps torque and walking speed were assessed by physical examination and performance testing. Appendicular lean body mass (ALM) and whole-body fat mass were measured using dual-energy x-ray absorptiometry.

Results—Of 1475 women, 212 (14%) and 233 (16%) reported at least monthly predominantly SUI and UUI at baseline, respectively. At 3 years, there were 1137 women, 164 (14%) with new/persistent SUI and 320 (28%) with new/persistent UUI. Women had increased odds of new/persistent SUI if they demonstrated ≥5% decrease in grip strength, (adjusted OR [AOR] 1.60, p=0.047). Alternatively, women had decreased odds of new/persistent SUI if they demonstrated ≥5% decrease in BMI (AOR 0.46; p=0.014), ≥5% increase in ALM corrected for BMI (AOR 0.17; p=0.004), or ≥5% decrease in fat mass (AOR 0.53; p=0.010). Only a ≥5% increase in walking speed was associated with new/persistent UUI over 3 years (AOR 1.54; p=0.040).

Conclusion—Among women 70 years and older, changes in body composition and grip strength were associated with changes in SUI frequency over time. In contrast, changes in these factors did not influence UUI. Findings suggest that optimization of body composition and muscle strength is more likely to modify SUI than UUI risk among older women.

Introduction

Elevated body mass index (BMI) is a strong and independent risk factor for urinary incontinence in young and middle-aged adults.[1–3] Within this age group, there is a clear dose effect of weight on incontinence, with each 5-unit increase in BMI associated with a 20% to 70% increase in incontinence risk.[4] Among overweight and obese women, weight loss has also been shown to decrease incontinence frequency,[5,6] leading to widespread recommendations for weight loss as a first-line treatment for this condition.[7]

With aging, however, the relationship between BMI and incontinence may become more complex, with changes in body composition and adipose tissue distribution playing an increasing role in determining incontinence risk. Among older adults, lower BMI can be paradoxically associated with an increased risk of other adverse outcomes such as disability and death,[8–10] if the decreased weight mainly represents decreased lean muscle mass rather than or in addition to decreased fat mass.[11] Decreased weight may in turn be associated with an increased risk of incontinence if it is associated with decline in upper and lower body strength that contributes to frailty in older adults and interferes with normal toileting habits.[12] Low muscle mass and strength in the extremities may also be associated with lower pelvic floor muscle strength and function that may increase older patients' susceptibility to leakage of urine.

Further, even if overweight or obese women are more likely to experience urinary incontinence in older age, it does not necessarily follow that weight loss will be effective in improving incontinence in this age group. Among older women, urinary incontinence may reflect the cumulative effects of increased weight on the urinary tract over their lifetime. These effects may not be reversible with weight loss in the 8th or 9th decades of life.

Currently, there is little evidence to indicate that clinical recommendations for weight loss as a treatment for urinary incontinence in younger women are also applicable to older women, especially given the complex association between weight and other adverse outcomes such as mortality in older adults.

To advance understanding of the direction, strength and persistence of relationships between body composition, muscle strength, walking speed and urinary incontinence, we analyzed data from a large, community-dwelling cohort of older women. Our goal was to guide clinicians in counseling older women effectively about how changing their weight, body composition and muscle strength may affect their risk of developing incontinence or contribute to progression of incontinence over time.

Materials and Methods

Study population

The Health, Aging and Body Composition (Health ABC) Study is a prospective, multicenter, biracial cohort study of body composition and aging in older adults. Study participants were men and women between the ages 70 to 79 years who did not have difficulty with activities of daily living, walking a quarter-mile, or climbing 10 steps without resting at enrollment. Exclusionary criteria included recent treatment for cancer, participation in a clinical trial, or intention to relocate from the areas of the study within 3 years. Participants were recruited from a random sample of Medicare beneficiaries and through community recruitment of Black individuals in the areas around Pittsburgh, Pennsylvania and Memphis, Tennessee.[13] All procedures were in accordance with ethical standards of the institutional review boards of the participating institutions and all participants signed informed consent. From this population, we identified all women who contributed data on urinary incontinence and underwent assessment of body weight, composition, muscle strength and walking speed at baseline (1997–1998) and 3-year follow up (2000–2001). See Supplemental Figure 1 for details of this cohort. Of note, all measurements were collected during the same visit, both at baseline and again at follow up.

Measurements

Urinary incontinence—The presence, frequency and type of urinary incontinence were assessed at baseline (Y1) and after three years (Y4) using structured-item questionnaire measures adapted from previous large-scale epidemiologic studies of older women.[4] Participants were first asked, “In the past 12 months, how often have you leaked urine?” and possible responses included: (1) less than once per month, (2) one or more times per month, (3) one or more times per week, (4) every day and (5) don’t know. To distinguish clinical type of incontinence, participants were then asked, “In the past 12 months, when does your leakage of urine usually occur?” and possible responses included: (1) with an activity like coughing, lifting, standing up or exercise, (2) when you have the urge to urinate and can’t get to a toilet fast enough, (3) you leak unrelated to coughing, sneezing, lifting or urge and (4) don’t know. Participants could only choose one response to each question, so that classifications of incontinence frequency and type were mutually exclusive. For this analysis, women were classified as having at least monthly predominantly stress urinary incontinence (SUI) if they answered that they leaked at least once per moth and that this leakage usually occurred with an activity like coughing, lifting, standing up or exercise. They were classified as having predominantly urgency urinary incontinence (UUI) if they answered that they leaked at least once per month and that this leakage usually occurred when they had the urge to urinate and couldn't get to the toilet fast enough at least once per month. Women who could not classify their symptoms or who reported incontinence that was not predominantly stress- or urgency-type were excluded from analyses.

Body mass and composition measures—Weight in kilograms (kg) and standing height to the nearest mm were measured in order to calculate body mass index (BMI) in kg/m^2 at both Y1 and Y4. Height was measured with wall-mounted stadiometers and weight with balance beam or digital scales per centralized study protocols.[13]

Appendicular lean mass (ALM) was measured by whole-body dual-energy x-ray absorptiometry (DXA) scans (Hologic QDR4500A with software version 8.21 for analysis, Hologic, Waltham, MA). The amount of lean mass was calculated, excluding fat and bone tissue.[14] ALM was calculated as the sum of lean mass in the arms and legs. Consistent with the Foundations of the National Institutes of Health (FINH) guidelines for assessment of age-associated muscle wasting, ALM/BMI was calculated to represent a measure of ALM corrected for BMI.[15,16] Fat was measured both in kg, expressed as total fat, and as percent total fat using DXA scan technology described above.

Grip strength—Maximum grip strength, as an established marker of total body muscle strength,[17] was measured in kg using handheld dynamometers (JAMAR Technologies, Inc., Hatfield, PA). Two trials were performed in each hand and an average of the trials performed on the strongest hand was used for the analyses.[18] If a participant had limitations with one hand, such as osteoarthritis, they used their stronger hand to measure grip strength. A measure of grip strength corrected for BMI was calculated as maximum grip strength/BMI, consistent with consensus guidelines.[16]

Quadriceps torque—Quadriceps torque, or concentric knee extensor torque, was measured on the right leg at 60 degrees per second (Kin-Con Isokinetic Dynameter, TN). If a participant had a knee replacement or pain on the right side, the left side was used for testing. Patients were excluded from torque testing if they had a history of cerebral aneurysm, cerebral bleeding within the last 6 months, blood pressure >199/109, or bilateral knee pain or joint replacement.[19] A measure of quadriceps torque corrected for BMI was calculated as quadriceps torque/BMI based on prior literature.[20]

Walking speed—Walking speed was measured in meters/second over a distance of 6 meters, where each individual was asked to walk at their usual speed.

Other variables—Participants self-rated their health as poor, fair, good, very good, or excellent.[21,22] Participants were considered to have diabetes mellitus if they reported prior clinician diagnosis of diabetes. Age and race were also collected from self-report via questionnaire.

Statistical analyses

Baseline distributions of age, race, general health, diabetes, body composition and grip strength measures were examined separately in women with at least monthly SUI, at least monthly UUI, and less than monthly or no urinary incontinence. We then examined the baseline prevalence of monthly predominantly SUI and UUI across quintiles of body composition and grip strength parameters at baseline (Q1 lowest to Q5 highest). Quintiles were chosen over quartiles or tertiles in order to show as much granularity as possible, while at the same time having adequate sample size per group. Prevalence figures were expressed as both unadjusted and as adjusted for age, race, health status and diabetes. Tests of heterogeneity were performed to assess for differences across quintiles at baseline.

Among women who provided data on urinary incontinence and at least one body composition or grip strength parameter at baseline (Y1) and after three years (Y4), we examined the proportion with new or persistent incontinence over three years. Women were considered if to have new or persistent predominantly SUI or UUI if they reported: 1) less than monthly incontinence at baseline but at least monthly symptoms of predominantly SUI or UUI at follow-up, or 2) at least monthly SUI or UUI at baseline and either equally frequent or more frequent SUI or UUI at follow-up.

Logistic regression models were developed to examine associations between 3-year changes in body composition and grip strength and the outcomes of 1) new or persistent predominantly SUI and 2) new or persistent predominantly UUI. For these models, women with ≥5% decrease and ≥5% increase in each body composition or muscle strength parameter were each compared to women with less than 5% change in that parameter as the reference group. Adjusted models included age, race, health status and diabetes, as factors previously identified as influencing incontinence risk in older community-dwelling women. Tests for interactions with race were performed for all adjusted models, and race-stratified analyses were performed in cases where $p < 0.05$ for interaction by race.

Results

Baseline characteristics of 1475 women with monthly SUI, UUI, and less than monthly or no urinary incontinence are presented in Table 1 and Supplemental Figure 1. There were 212 women (14.4% of total) with at least monthly predominantly SUI (37.3% leaked once per month, 33.0% leaked once or more per week, and 29.7% leaked every day) and 233 (15.8% of total) women with at least monthly predominantly UUI (40.8% leaked once per month, 36.5% leaked once or more per week, and 22.7% leaked every day). A total of 1030 women reported less than monthly or no urinary incontinence. Most baseline characteristics were similarly distributed across the three groups with the exception of race, where the proportion of Black women was lower among those with baseline predominantly SUI (30.7%) compared to those with predominantly UUI (40.3%) and neither monthly predominantly SUI nor UUI (52.2%).

Baseline

The baseline unadjusted and multivariable adjusted prevalence of monthly predominantly SUI and UUI among women across different quintiles of body composition, muscle grip strength and walking speed parameters are shown in Tables 2 and 3, respectively. The proportion of women reporting at least monthly SUI increased with increasing quintile of BMI, ALM, and total fat mass (p for trend of heterogeneity = 0.006, <0.001, and 0.025, respectively) (Table 2). In particular, the prevalence of predominantly SUI was at least twice as high for women in the highest quintile of adjusted BMI, ALM, total fat mass and quadriceps torque compared to women in the lowest quintile of these parameters. In contrast, there were no significant differences in the prevalence of predominantly SUI by quintile of ALM corrected for BMI, percent fat mass, maximum grip strength, maximum grip strength corrected for BMI, quadriceps torque or walking speed corrected for BMI at baseline (all p's >0.05).

The adjusted prevalence of at least monthly predominantly UUI (Table 3) also differed across quintiles of BMI, total body fat mass and walking speed (p=0.003, p=0.044 and 0.003 for heterogeneity, respectively). Specifically, the prevalence of predominantly UUI was at least twice as high for women in the highest quintile of adjusted BMI and total fat mass and the fastest quintile of walking speed compared to women in the inverse quintile of these parameters. No significant differences in the prevalence of predominantly UUI by adjusted quintile of ALM, ALM corrected for BMI, percent fat mass, maximum grip strength, maximum grip strength corrected for BMI, quadriceps torque and quadriceps torque corrected for BMI were detected (all p's >0.05).

Three-year follow-up

Of the 1475 women who provided data at baseline, 1137 women (77%) provided follow-up data on urinary incontinence and at least one body composition or muscle strength parameter at Y4. Of these women, 164 (14%) reported *new or persistent SUI*, and 320 (28%) reported *new or persistent* UUI (Supplemental Figure 1). Women with and without follow-up data at visit 4 did not differ significantly with regard to either BMI (p=0.12) or urinary incontinence (p=20). A higher percentage of Black women (27.7%) were lost to follow up compared to White women (17.6%) (p<0.001), however, further analysis did not detect evidence of race interactions for most associations between body composition, muscle strength, and urinary incontinence. Therefore, participants with missing data at visit 4 were excluded from longitudinal analyses.

Women who demonstrated a ≥ 5% decrease in BMI (adjusted OR (AOR) 0.46, p=0.014) or fat mass (AOR 0.53, p=0.010), or a ≥5% increase in ALM adjusted for BMI (AOR 0.17, p=0.004), were less likely to report new or persistent predominantly SUI over 3 years. In contrast, maximum grip strength, both by itself (AOR 1.60, p=0.047) and adjusted for BMI (AOR 1.94, p=0.004), was associated with new or persistent predominantly SUI after adjusting for age, race, health status and diabetes (Table 4). Changes in body composition, grip strength and quadriceps torque, however, were not associated with changes in new or persistent predominantly UUI in multivariate-adjusted models (Table 5), while a ≥5%

increase in walking speed was associated with an increased odds of new/persistent UUI in the adjusted model only (adjusted OR 1.54, p=0.040).

No significant interactions with race were detected for any multivariate models except for the association between grip strength and predominantly UUI over 3 years (p=0.020), where the age- and race-adjusted OR for Whites were 0.93 (p=0.753) for a ≥5% decrease and 0.74 (p=0.229) for a ≥5% increase. Likewise, for Blacks, the age and race adjusted ORs were 1.11 (p=0.729) for a ≥5% decrease and 1.88 (p=0.031) for a ≥5% increase (data not shown).

Discussion

In this cohort of community-dwelling older women, we found that women with higher BMI and greater adiposity were more likely to report predominantly SUI and UUI at baseline. Specifically, the adjusted prevalence of predominantly SUI and UUI was at least two-fold higher among women in the highest quintile of BMI or fat mass, compared to the lowest quintile. These findings suggest that higher BMI and greater adiposity are important markers of risk for both predominantly SUI and UUI in older women, just as they are for younger women.[1,23]

For predominantly SUI, we found that *change* in BMI or fat mass over 3 years was also associated with *change* in SUI over time. That is, women who lost at least 5% of their BMI or fat mass were significantly less likely to experience new or persistence of their SUI over 3 years, compared to women with less than 5% change in BMI or fat mass. These findings suggest that among women aged 70 years or older, the effects of increased BMI and fat mass on SUI risk may still be at least partially reversible through weight loss, in agreement with weight loss recommendations for younger women with SUI.[5–7]

In contrast, no changes in body composition or muscle strength were significantly associated with changes in predominantly UUI prevalence or frequency over 3 years. These findings suggest that for UUI, the effects of BMI and/or adiposity on UUI risk may not be as modifiable after women reach a certain age. The only statistically significant association found over time for new or persistent predominantly UUI was for walking speed, where a ≥5% increase in walking speed was associated with an increased odds of new or persistent UUI (p=0.040). While this finding was statistically significant, we would like to emphasize that it was not strongly statistically significant (p=0.040) and that the association did not meet significance for the unadjusted model. Furthermore, these findings should be considered with caution. Further studies with larger sample sizes are warranted to further define and characterize this relationship.

Our findings may reflect important underlying differences in the role of BMI and adiposity in the pathophysiology of SUI versus UUI. Prior studies suggest that the increased risk of SUI in overweight and obese women may be mediated directly by increased abdominal pressure, resulting in increased intravesical pressure and urethral sphincter mobility.[23] As a result, reduction in weight and abdominal fat may translate directly into decreased bladder pressure and decreased SUI in women, regardless of age. In contrast, the increased prevalence of UUI among older women who are overweight or obese may result from the sustained effects of oxidative stress over time, resulting in bladder ischemia and detrusor muscle instability that may not be easily reversible.[24,25] As a result, late-stage weight loss or improvement in adiposity may not be capable of reducing detrusor muscle dysfunction and UUI symptoms in older age.

We detected similar trends in the relationship of grip strength, which serves as a widely recognized indicator of overall muscle strength,[17] to SUI and UUI risk over three years. Decline in grip strength over three years, with or without adjustment for BMI, was associated with an increased risk of new persistent predominantly SUI. In contrast, changes in grip strength over 3 years were not associated with changes in predominantly UUI over time. Taken together, these findings suggest that improvements in muscle strength as reflected by grip strength may protect older women against development or progression of predominantly SUI, but may not reduce the risk of new-onset or progressive predominantly UUI in this age group.

This study benefits from a large, community-based, biracial cohort of women, assessment of both stress and urgency-type urinary incontinence, evaluation of multiple body composition and muscle strength parameters, and longitudinal follow-up for almost 80% of participants. Despite these strengths, several limitations should be considered when interpreting these data. First, incontinence symptoms were assessed using simple structured-item questionnaire measures, rather than voiding diaries or detailed histories, and participants did not undergo physical examination or other clinical evaluation to confirm the clinical type of incontinence. Based on these questions, patients had to choose their predominant type of urinary incontinence and could not report "equally mixed" type of urinary incontinence. However, these measures have been used in other large-scale epidemiologic studies of older adults and found to be associated with other important aging-associated factors. The items used to distinguish clinical type have also been shown to have generally good agreement with a 7-voiding diary among women with frequent incontinence.[4,26] Also due to the use of an existing database, we were unable to include information on changes in health status over time including development of new medical conditions and administration of new medication. However, we believe that our use of self-rated health serves as a good surrogate measure for this issue. Second, the Health ABC study sampled only White and Black older adults, and results may not be generalizable to other racial/ethnic groups that may have different predispositions to weight loss and/or urinary incontinence in older age. Third, follow-up data on both incontinence and body composition were not available past 3 years, and thus we could not assess effects of body composition on incontinence risk over a longer time frame. Additionally, participants in Health ABC were generally well-functioning at baseline, and few of them were underweight using standard BMI thresholds. Findings may not be generalizable to other populations older adults with higher rates of disability or low body weight.

In this population of older women, changes in body composition and grip strength were associated with changes in predominantly SUI, but not predominantly UUI, over 3 years. These findings suggest that among women aged 70 years or older, optimization of body composition may be protective against incidence, persistence or worsening of predominantly SUI, but not necessarily of predominantly UUI. This information is important in counseling female patients about modifiable and non-modifiable risk factors for SUI and UUI in older age.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Sponsor's Role: "none"

Appendix

Conflict of Interest Checklist:

Elements of Financial/Personal Conflicts	Ilse Reinders None		Peggy Cawthon None		Sanae Nakagawa None		Leslee L. Subak None	
	Yes	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Employment or Affiliation		x		x		x		x
Grants/Funds		x		x		x	Mid-Career Investigator Award in Patient Oriented Research	
Honoraria		x		x		x		x
Speaker Forum		x		x		x		x
Consultant		x		x		x		x
Stocks		x		x		x		x
Royalties		x		x		x		x
Expert Testimony		x		x		x		x
Board Member		x		x		x		x
Patents		x		x		x		x
Personal Relationship		x		x		x		x

Elements of Financial/Personal Conflicts	Ilse Reinders None		Suzanne Satterfield None		Steve Cummings None		Jane A. Cauley None	
	Yes	No	Yes	No	Yes	No	Yes	No
Employment or Affiliation		x		x		x		x
Grants/Funds		x		x		x		x
Honoraria		x		x		x		x
Speaker Forum		x		x		x		x
Consultant		x		x		x		x
Stocks		x		x		x		x
Royalties		x		x		x		x
Expert Testimony		x		x		x		x
Board Member		x		x		x		x
Patents		x		x		x		x
Personal Relationship		x		x		x		x

Elements of Financial/Personal Conflicts	Jane A. Cauley None		Tamara Harris None		Alison Huang None			
	Yes	No	Yes	No	Yes	No	Yes	No
Employment or Affiliation		x		x		x		
Grants/Funds		x		x	NIA			
Honoraria		x		x		x		
Speaker Forum		x		x		x		
Consultant		x		x		x		
Stocks		x		x		x		
Royalties		x		x		x		
Expert Testimony		x		x		x		
Board Member		x		x		x		
Patents		x		x		x		
Personal Relationship		x		x		x		

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Table 1

Baseline participant characteristics, by urinary incontinence status.

	Monthly predominantly stress predominant urinary incontinence (N=212)	Monthly predominantly urgency predominant urinary incontinence (N=233)	Less than monthly or no urinary incontinence (N=1030)
Age, years	73.2 (±2.8)	73.9 (±2.9)	73.4 (±2.9)
Race			
White	147 (69.5)	139 (59.7)	492 (47.8)
Black	65 (30.7)	94 (40.3)	538 (52.2)
Self-reported general health (N, %)			
Excellent	19 (9.0)	25 (10.7)	144 (14.0)
Very Good	72 (34.3)	54 (23.2)	313 (30.4)
Good	86 (41.0)	110 (47.2)	420 (40.8)
Fair	31 (14.8)	43 (18.5)	145 (14.1)
Poor	2 (1.0)	1 (0.4)	7 (0.7)
Diabetes mellitus (N, %)	31 (14.6)	40 (17.2)	131 (12.8)
Frequency of incontinence (N, %)			
Once per month	79 (37.3)	95 (40.8)	--
Once or more per week	70 (33.0)	85 (36.5)	--
Every day	63 (29.7)	53 (22.7)	--
Body mass and composition			
Body mass index (BMI), kg/m2	28.0 (±5.2)	28.3 (±5.9)	27.5 (±5.4)
Appendicular lean mass (kg)	16.8 (±3.1)	16.8 (±3.3)	16.6 (±3.2)
Appendicular lean mass corrected for BMI	0.6 (±0.1)	0.6 (±0.1)	0.6 (±0.1)
Total fat (kg)	29.8 (±8.9)	29.9 (±9.7)	28.9 (±9.4)
Total % fat	40.8 (±5.4)	40.7 (±6.0)	40.3 (±5.8)
Grip Strength			
Maximum grip strength (kg)	25.1 (±5.6)	24.3 (±5.6)	25.3 (±6.6)
Maximum grip strength corrected for BMI	0.9 (±0.2)	0.9 (±0.3)	0.9 (±0.3)
Quadriceps torque			
Quadriceps torque (Nm/kg)	86.3 (±21.2)	80.5 (±20.6)	80.9 (±22.7)
Quadriceps torque corrected for BMI	3.1 (±0.8)	3.0 (±0.8)	3.0 (±0.9)
Walking speed (M/sec) over 6 M	1.1 (±0.2)	1.1 (±0.2)	1.1 (±0.2)

Categories are mutually exclusive. Values are mean ± standard deviation or number (percent).

Table 2

Baseline prevalence of monthly predominantly stress urinary incontinence (SUI) by quintile of body mass, body composition, and muscle strength parameters*

	Q1	Q2	Q3	Q4	Q5	P-value+
Body mass index (BMI)(kg/m^2) - range	15–23	23–26	26–28	28–32	32–48	
Unadjusted prevalence, %	12.4 %	18.7 %	17.9 %	16.5 %	20.0 %	0.178
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	9.5%	15.5%	16.4%	16.4%	22.4%	0.006
Appendicular Lean Mass (kg) - range	6–14	14–15	15–17	17–19	19–30	
Unadjusted prevalence, %	17.1 %	15.0 %	18.4 %	13.8 %	20.9 %	0.240
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	11.7%	10.8%	15.7%	14.4%	27.3%	<0.001
Appendicular Lean Mass corrected for BMI - range	0.19–0.54	0.54–0.58	0.58–0.62	0.62–0.68	0.68–0.95	
Unadjusted prevalence, %	14.3 %	21.0 %	18.7 %	16.9 %	14.2 %	0.197
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	12.4%	18.7%	16.6%	16.2%	15.1%	0.382
Total Body Fat Mass (kg) - range	7–21	21–26	26–30	30–36	36–70	
Unadjusted prevalence, %	13.3 %	16.5 %	19.9 %	16.1 %	19.9 %	0.226
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	11.0%	14.1%	18.0%	15.4%	21.8%	0.025
Percent Fat Mass, % - range	17–36	36–39	39–42	42–45	45–46	
Unadjusted prevalence, %	12.4 %	18.0 %	20.4 %	19.2 %	16.8 %	0.156
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	11.0%	16.6%	18.5%	17.9%	16.8%	0.133
Maximum Grip Strength (kg) - range	6–20	21–23	24–26	27–29	30–80	
Unadjusted prevalence, %	15.9 %	19.3 %	17.9 %	17.2 %	15.6 %	0.827
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	13.5%	16.8%	15.7%	17.4%	16.9%	0.780
Maximum Grip Strength corrected for BMI - range	0.18–0.71	0.71–0.85	0.85–0.99	0.99–1.15	1.15–3.12	
Unadjusted prevalence, %	16.3 %	17.1 %	22.0 %	17.5 %	12.1 %	0.065
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	15.3%	16.8%	19.3%	15.9%	11.8%	0.216
Quadriceps torque (Nm/kg) – range	15–63	64–77	77–87	87–99	99–165	
Unadjusted prevalence, %	10.1%	18.6%	20.1%	15.5%	20.3%	0.017
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	9.1%	16.2%	18.6%	14.6%	20.5%	0.011
Quadriceps torque corrected for BMI (Nm/kg) - range	0.57–2.34	2.34–2.80	2.81–3.23	3.23–3.73	3.74–6.33	
Unadjusted prevalence, %	11.4%	19.2%	20.1%	14.1%	19.4%	0.048

	Q1	Q2	Q3	Q4	Q5	P-value+
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	11.3%	18.0%	18.7%	12.9%	17.7%	0.106
Walking speed (M/sec) over 6M	.00–0.94	.00–0.94	.00–0.94	.00–0.94	.00–0.94	
Unadjusted prevalence, %	18.2%	13.8%	16.5%	20.2%	17.3%	0.439
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	20.7%	13.5%	15.8%	17.1%	13.2%	0.200

Table 3

Baseline prevalence of monthly predominantly urgency urinary incontinence (UUI) by quintile of body mass, body composition, and muscle strength parameters*

	Q1	Q2	Q3	Q4	Q5	P-value+
Body mass index (BMI)(kg/m^2) - range	15–23	23–26	26–28	28–32	32–48	
Unadjusted prevalence, %	15.1 %	20.6 %	14.2 %	18.5 %	23.9 %	0.033
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	13.0%	18.6%	13.4%	18.2%	26.2%	0.003
Appendicular Lean Mass (kg) - range	6–14	14–15	15–17	17–19	19–30	
Unadjusted prevalence, %	15.4 %	20.6 %	20.7 %	16.5 %	19.0 %	0.420
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	12.8%	18.2%	19.1%	17.2%	22.0%	0.146
Appendicular Lean Mass corrected for BMI - range	0.19–0.54	0.54–0.58	0.58–0.62	0.62–0.68	0.68–0.95	
Unadjusted prevalence, %	22.1 %	16.5 %	17.4 %	21.7 %	14.5 %	0.106
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	20.7%	15.1%	16.6%	21.2%	15.4%	0.202
Total Body Fat Mass (kg) - range	7–21	21–26	26–30	30–36	36–70	
Unadjusted prevalence, %	17.2 %	17.8 %	16.3 %	17.8 %	23.5 %	0.281
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	15.7%	16.6%	15.0%	17.1%	25.2%	0.044
Percent Fat Mass, % - range	17–36	36–39	39–42	42–45	45–46	
Unadjusted prevalence, %	17.6 %	19.0 %	14.6 %	20.2 %	19.9 %	0.486
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	17.0%	18.2%	13.4%	19.5%	20.5%	0.273
Maximum Grip Strength (kg) - range	6–20	21–23	24–26	27–29	30–80	
Unadjusted prevalence, %	21.1 %	18.9 %	18.3 %	20.3 %	15.3 %	0.456
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	19.2%	17.1%	17.2%	20.1%	16.9%	0.888
Maximum Grip Strength corrected for BMI - range	0.18–0.71	0.71–0.85	0.85–0.99	0.99–1.15	1.15–3.12	
Unadjusted prevalence, %	24.6 %	18.5 %	17.7 %	17.5 %	14.5 %	0.064
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	23.5%	17.8%	16.6%	16.8%	14.8%	0.128
Quadriceps torque (Nm/kg) – range	15–63	64–77	77–87	87–99	99–165	
Unadjusted prevalence, %	15.2%	22.1%	18.2%	20.1%	14.5%	0.200
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	14.0%	19.8%	17.1%	19.8%	16.3%	0.410
Quadriceps torque corrected for BMI (Nm/kg) - range	0.57–2.34	2.34–2.80	2.81–3.23	3.23–3.73	3.74–6.33	

	Q1	Q2	Q3	Q4	Q5	P-value[+]
Unadjusted prevalence, %	18.3%	19.2%	16.0%	20.3%	15.9%	0.697
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	17.5%	17.7%	15.5%	19.9%	16.2%	0.800
Walking speed (M/sec) over 6M	0.00–0.94	0.95–1.05	1.06–1.17	1.18–1.29	1.30–1.98	
Unadjusted prevalence, %	25.2%	17.5%	18.4%	16.6%	14.3%	0.028
Age/Race/Health Status/Diabetes-Adjusted prevalence, %	26.4%	17.8%	17.9%	14.6%	12.4%	0.003

[*] Q1 is lowest and Q5 is highest percentile.

[+] P values are from chi-square tests for non-adjusted models and from omnibus tests obtained from logistic regression models for adjusted models.

Table 4

Unadjusted and adjusted associations between 3-year changes in body mass, body composition, and muscle strength parameters with new or persistent predominantly stress urinary incontinence (SUI).*

	Unadjusted			Adjusted for age, race, health status, diabetes		
	N used	OR (95% CI)	p value	N used	OR (95% CI)	p value
Body Mass Index (BMI)(kg/m²)						
≥5% decrease	127	0.42 (0.23, 0.77)	0.005	126	0.46 (0.25, 0.85)	0.014
<5% decrease or increase	567	Reference	.	566	Reference	.
≥5% increase	123	1.19 (0.75, 1.88)	0.459	122	1.19 (0.75, 1.91)	0.458
Appendicular Lean Mass (ALM)(kg)						
≥5% decrease	226	0.81 (0.54, 1.21)	0.311	224	0.90 (0.59, 1.37)	0.625
<5% decrease or increase	516	Reference	.	515	Reference	.
≥5% increase	66	0.93 (0.49, 1.76)	0.816	66	1.02 (0.53, 1.95)	0.963
ALM corrected for BMI						
≥5% decrease	218	1.07 (0.73, 1.57)	0.737	217	1.00 (0.68, 1.49)	0.980
<5% decrease or increase	526	Reference	.	524	Reference	.
≥5% increase	64	0.19 (0.06, 0.60)	0.005	64	0.17 (0.05, 0.57)	0.004
Fat Mass(kg)						
≥5% decrease	209	0.50 (0.31, 0.81)	0.005	208	0.53 (0.32, 0.86)	0.010
<5% decrease or increase	367	Reference	.	366	Reference	.
≥5% increase	231	1.08 (0.73, 1.59)	0.710	230	1.04 (0.69, 1.55)	0.863
Fat Mass(%)						
≥5% decrease	105	0.54 (0.29, 1.01)	0.053	104	0.54 (0.29, 1.02)	0.058
<5% decrease or increase	543	Reference	.	542	Reference	.
≥5% increase	123	1.41 (0.90, 2.21)	0.134	122	1.23 (0.78, 1.95)	0.376
Max Grip Strength (kg)						
≥5% decrease	366	1.58 (1.00, 2.49)	0.049	366	1.60 (1.01, 2.54)	0.047
<5% decrease or increase	188	Reference	.	186	Reference	.

	Unadjusted			Adjusted for age, race, health status, diabetes		
	N used	**OR (95% CI)**	**p value**	**N used**	**OR (95% CI)**	**p value**
≥5% increase	243	1.12 (0.68, 1.86)	0.661	242	1.13 (0.67, 1.89)	0.642
Max Grip Strength corrected for BMI						
≥5% decrease	341	2.01 (1.28, 3.14)	0.002	340	1.94 (1.23, 3.05)	0.004
<5% decrease or increase	211	Reference	.	210	Reference	.
≥5% increase	245	1.09 (0.66, 1.81)	0.735	244	1.09 (0.65, 1.82)	0.746
Quadriceps torque (Nm/Kg)						
≥5% decrease	409	1.00 (0.60, 1.67)	0.995	403	1.03 (0.61, 1.73)	0.918
<5% decrease or increase	117	Reference	.	117	Reference	.
≥5% increase	116	0.86 (0.45, 1.64)	0.642	115	1.00 (0.51, 1.95)	0.994
Quadriceps torque corrected for BMI						
≥5% decrease	412	1.29 (0.75, 2.21)	0.353	412	1.36 (0.76, 2.44)	0.299
<5% decrease or increase	111	Reference	.	111	Reference	.
≥5% increase	119	0.81 (0.40, 1.63)	0.556	110	1.00 (0.47, 2.13)	0.995
Walking speed (m/sec) over 6M						
≥5% decrease	438	0.84 (0.55, 1.28)	0.418	420	0.81 (0.52, 1.26)	0.341
<5% decrease or increase	191	Reference	.	185	Reference	.
≥5% increase	179	0.83 (0.50, 1.38)	0.476	167	0.84 (0.49, 1.44)	0.525

* A ≥5% decrease represents a 5% of greater decrease in the level of each variable from year 1 to year 4, a <5% decrease or increase represents a less than 5% change from year 1 to year 4, and a ≥5% increase represents a 5% of greater increase in each variable from year 1 to year 4.

Table 5

Unadjusted and adjusted associations between 3-year changes in body mass, body composition, and muscle strength parameters with new or persistent predominantly urgency urinary incontinence (UUI).*

	Unadjusted			Adjusted for age, race, health status, diabetes		
model	**N used**	**OR (95% CI)**	**p value**	**N used**	**OR (95% CI)**	**p value**
Body Mass Index (BMI) (kg/m^2)						
≥5% decrease	158	0.81 (0.55, 1.19)	0.277	157	0.82 (0.55, 1.21)	0.315
<5% decrease or increase	659	Reference	.	658	Reference	.
≥5% increase	156	1.42 (0.99, 2.03)	0.056	155	1.43 (1.00, 2.07)	0.053
Appendicular Lean Mass (ALM)(kg)						
≥5% decrease	280	1.10 (0.81, 1.48)	0.549	278	1.13 (0.83, 1.55)	0.425
<5% decrease or increase	596	Reference	.	595	Reference	.
≥5% increase	82	1.19 (0.73, 1.93)	0.487	82	1.21 (0.74, 1.98)	0.439
Appendicular Lean Mass corrected for BMI						
≥5% decrease	261	1.14 (0.84, 1.54)	0.414	260	1.12 (0.82, 1.52)	0.477
<5% decrease or increase	612	Reference	.	610	Reference	.
≥5% increase	85	0.84 (0.51, 1.38)	0.482	85	0.81 (0.49, 1.34)	0.417
Fat Mass(kg)						
≥5% decrease	262	0.89 (0.64, 1.25)	0.512	261	0.89 (0.64, 1.25)	0.504
<5% decrease or increase	424	Reference	.	423	Reference	.
≥5% increase	270	1.09 (0.79, 1.50)	0.605	269	1.11 (0.80, 1.53)	0.544
Fat Mass(%)						
≥5% decrease	130	0.93 (0.61, 1.40)	0.721	129	0.89 (0.58, 1.35)	0.572
<5% decrease or increase	623	Reference	.	622	Reference	.
≥5% increase	146	1.40 (0.96, 2.03)	0.080	145	1.38 (0.94, 2.01)	0.098
Max Grip Strength (kg)						
≥5% decrease	411	0.98 (0.69, 1.38)	0.896	411	0.95 (0.67, 1.35)	0.776

model	Unadjusted			Adjusted for age, race, health status, diabetes		
	N used	OR (95% CI)	p value	N used	OR (95% CI)	p value
<5% decrease or increase	233	Reference	.	231	Reference	.
≥5% increase	305	1.10 (0.77, 1.58)	0.604	304	1.10 (0.76, 1.59)	0.606
Max Grip Strength corrected for BMI						
≥5% decrease	379	1.13 (0.80, 1.58)	0.488	378	1.12 (0.79, 1.57)	0.527
<5% decrease or increase	260	Reference	.	259	Reference	.
≥5% increase	310	1.13 (0.80, 1.61)	0.491	309	1.16 (0.81, 1.66)	0.412
Quadriceps torque (Nm/Kg)						
≥5% decrease	480	1.06 (0.70, 1.59)	0.795	480	1.04 (0.68, 1.57)	0.860
<5% decrease or increase	135	Reference	.	134	Reference	.
≥5% increase	145	1.17 (0.71, 1.92)	0.549	144	1.15 (0.69, 1.91)	0.598
Quadriceps torque corrected for BMI						
≥5% decrease	475	0.97 (0.65, 1.46)	0.884	465	0.97 (0.64, 1.48)	0.895
<5% decrease or increase	136	Reference	.	136	Reference	.
≥5% increase	149	0.96 (0.59, 1.58)	0.875	148	0.99 (0.59, 1.66)	0.974
Walking speed (m/sec) over 6M						
≥5% decrease	522	1.18 (0.83, 1.67)	0.360	501	1.18 (0.82, 1.69)	0.379
<5% decrease or increase	209	Reference	.	202	Reference	.
≥5% increase	231	1.47 (0.99, 2.20)	0.059	218	1.54 (1.02, 2.34)	0.040

*A ≥5% decrease represents a 5% of greater decrease in the level of each variable from year 1 to year 4, a <5% decrease or increase represents a less than 5% change from year 1 to year 4, and a ≥5% increase represents a 5% of greater increase in each variable from year 1 to year 4.