Differences in pelvic floor morphology between continent, stress urinary incontinent, and mixed urinary incontinent elderly women: An MRI study

Authors

Stéphanie Pontbriand-Drolet,
An Tang,
Stephanie J. Madill,
Cara Tannenbaum,
Marie-Claude Lemieux,
Jacques Corcos,
Chantale Dumoulin

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Abstract

Aims

To compare magnetic resonance imaging (MRI) of the pelvic floor musculature (PFM), bladder neck and urethral sphincter morphology under three conditions (rest, PFM maximal voluntary contraction (MVC), and straining) in older women with symptoms of stress (SUI) or mixed urinary incontinence (MUI) or without incontinence.

Methods

This 2008–2012 exploratory observational cohort study was conducted with community-dwelling women aged 60 and over. Sixty six women (22 per group), mean age of 67.7 ± 5.2 years, participated in the study. A 3 T MRI examination was conducted under three conditions: rest, PFM MVC, and straining. ANOVA or Kruskal–Wallis tests (data not normally distributed) were conducted, with Bonferroni correction, to compare anatomical measurements between groups.

Results

Women with MUI symptoms had a lower PFM resting position (M-Line P = 0.010 and PC/H-line angle P = 0.026) and lower pelvic organ support (urethrovesical junction height P = 0.013) than both continent and SUI women. Women with SUI symptoms were more likely to exhibit bladder neck funneling and a larger posterior urethrovesical angle at rest than both continent and MUI women (P = 0.026 and P = 0.008, respectively). There were no significant differences between groups on PFM MVC or straining.

Conclusions

Women with SUI and MUI symptoms present different morphological defects at rest. These observations emphasize the need to tailor UI interventions to specific pelvic floor defects and UI type in older women.

Patient summary

Older women with UI demonstrate different problems with their pelvic organ support structures depending on the type of UI. These new findings should be taken into consideration for future research into developing new treatment strategies for UI in older women.

INTRODUCTION

Urinary incontinence (UI), one of the most prevalent health conditions confronting older women, affects more than 30% of women aged 60 and over, incrementally increasing with age.[1] Stress urinary incontinence (SUI) and mixed urinary incontinence (MUI) predominate among older women; nearly 33% of those affected by UI have symptoms of SUI, while 44% have symptoms of MUI along with associated negative quality-of-life consequences.[2]

Given the increasing demographic of older women globally, there is a need to improve our understanding of the morphological defects associated with SUI and MUI in older women in order to appropriately target conservative or surgical interventions. Little has been published concerning the types and severity of pelvic floor (PF) defects that are specific to older women with SUI; even fewer studies have been published on older women with MUI.[3-8] In order to better tailor surgical treatments and conservative therapy—which consists of pelvic floor muscle training (PFMT) to increase PFM and urethral sphincter tone, strength, endurance, and coordination[9, 10]—a better understanding of PFM defects is required.

This study aims to compare and contrast PF (PFM, bladder neck, and urethral sphincter) morphology, using magnetic resonance imaging (MRI) under three conditions (at rest, PFM maximal voluntary contraction (MVC), and straining) in continent older women, and those with symptoms of SUI and MUI.

MATERIALS AND METHODS

Study Design and Population

Participants were women, aged 60 years and older, enrolled in an exploratory observational cohort study (2008–2012). This age cut-off was applied to identify a post-menopausal population as the UI profile in this cohort differs from that of reproductive-aged women.[11] Community-dwelling women with UI were recruited through newspaper advertisements, posters in urogynaecological clinics, and professional referrals; continent women were recruited through newspaper advertisements.

Women were included in the study if they were 60 years or older, either continent or with symptoms of SUI or MUI, independently ambulatory, had not changed their hormone prescription in the previous 6 months, and understood written and verbal instructions in French or English. Participants were excluded if they experienced perineal pain or genital prolapse POP-Q II,[12] had any other medical problems or major functional impairments likely to interfere with MRI scanning, or resided in an institution.

Urinary incontinence was defined as at least weekly episodes of involuntary urine loss during the preceding 3 months, as reported by the participant. This validated indicator of UI has been used previously in UI-focused cohort studies and randomized controlled trials.[13] The UI type was established by the Three Incontinence Questions (3IQ) questionnaire, a simple, quick, and noninvasive test with acceptable accuracy for classifying urgency and stress urinary incontinence.[14] Women with SUI symptoms had involuntary urine loss on effort, exertion, sneezing, or coughing (question 1a), but not on urgency. Women with MUI symptoms had involuntary urine loss on both effort and urgency (question1a and b). Continence was defined as the reported absence of any involuntary urine leakage in the past 3 months, verified by the 3IQ Questionnaire.[14]

Interested women were screened over the telephone and were informed of the study's objectives and procedures in detail. Women who met the inclusion criteria and who expressed a desire to participate were included. Ethical approval was given by the research ethics committee at the Institut Universitaire de Gériatrie de Montréal. Each participant provided written, informed consent prior to participating in the study. They then completed a 3 day bladder diary[13] and the UDI questionnaire[13] to objectify their UI symptoms.

MRI Assessment

After being taught by a physiotherapist (SL) to perform PFM contractions correctly using vaginal palpation, the participants completed an anatomical MRI examination in the supine position with an empty bladder. Conventional MRI was performed with a Siemens Magnetom Trio 3.0 T, using an iPAT torso/pelvis coil centered at the symphysis pubis. Images were acquired in the sagittal and axial planes. MRI image settings are summarized in Table I. Images were acquired in three conditions: (i) Rest: to evaluate PFM normal resting position; (ii) PFM MVC: to evaluate PFM response during a voluntary contraction; and (iii) Straining: to controllably reproduce the PFM response to an intra-abdominal pressure raise that could cause leakage in women with SUI and MUI symptoms, ex: load lifting, sneezing, coughing, etc. For the rest condition, participants were asked to relax and breathe normally. For the PFM MVC, participants were instructed to contract their pelvic muscles as hard as they could, as if they were holding back urine and gas. For the straining effort, participants were instructed to blow through a Guillarme's tube (exsufflation tip allowing to maintain constant intra-abdominal pressure during expiration) to standardize the effort and to push as if they were passing stool. These instructions have been shown, by Talasz et al. (2012), to best elicit PFM relaxation and PF descent.[15]

TABLE I. MRI Parameters

Plane	Sagittal	Sagittal	Axial	Axial
Status	Resting	PFM MVC and straining	Resting	PFM MVC and straining
Pulse sequence	T2-weighted FSE	T2-weighted SSFSE	T2-weighted FSE	PD-weighted SSFSE
Field of view (mm)	240×240	240×240	240×240	240×240
Matrix	512×256	256×256	512×256	192×192
Slice thickness/gap (mm)	6/1	6	5/1	10/0
Slice number	20	6 cine images	20	8
Repetition time (ms)	4980	3000	5120	560
Echo time (ms)	134	109	134	33
Bandwidth (Hz/pixel)	130	320	130	434
Number of excitations	1	1	1	1
Scan duration (s)	146	18	146	10

PD, proton density; PFM MVC, pelvic floor muscles maximal voluntary contraction; FSE, fast spin echo; SSFSE, single-shot fast spin echo.

Measurements

The MRI images were processed and analyzed using ImageJ v1.45 software (imagej.nih.gov, NIH, Bethesda, MD). The evaluators were blinded to each participant's continence status and UI type. All measurement descriptions are presented in Table II, with measurement illustrations available in the Supplemental Figures 1–4.

TABLE II. Morphological Measurements

	Measurements	Description
PFM and pelvic organ		
Sagittal plane	Pubococcygeal (PC) line	Drawn from the inferior edge of the pubic symphysis to the anterior aspect of the sacrococcygeal joint line.
	Anorectal angle	Measured at the intersection of the lines drawn along the posterior walls of the anus and rectum.
	H-line	Drawn from the inferior edge of the pubic symphysis to the apex of the anorectal angle.
	M-line	Drawn perpendicularly from the PC line to apex of the anorectal angle.
	PC/H-line angle	Measured as the angle between the H and the PC lines.
	Heights of the urethrovesical (UV) and the uterocervical (UC) junctions	Measured perpendicularly from the PC line to these junctions. In women who had undergone hysterectomies, the height of the vaginal apex was measured instead of the uterocervical junction.
	UV junction approximation-height	Measured as the perpendicular distance between the urethrovesical junction and the long axis of the pubis.
	Occurrence of a bladder prolapse	Assessed as the presence of any part of the bladder below the PC line.
Axial plane	Width and length of the urogenital hiatus	Measured as the greatest distance, along the frontal plane, between the medial edges of the PFMs, and along the sagittal plane, from the pubic symphysis to the PFMs taken from the caudal-most slice in which the pubic symphysis was visible.
	Presence of an avulsion or lack thereof	Assessed as the presence or absence of a muscle detachment from the pubic symphysis on the image where the pubic symphysis was the most visible.
Bladder neck		
Sagittal plane	Presence of a bladder neck funneling	Defined as a separation of the anterior and posterior urethral walls at the bladder neck.
	Posterior UV angle	Measured at the intersection of the lines drawn along the urethral lumen and bladder floor.
Urethral sphincter		
Axial plane	Striated urethral sphincter length	Calculated by multiplying the number of slices in which the striated urethral sphincter was present by their thickness and adding the thickness of the interslice gaps.
	Outer and inner striated urethral sphincter diameters	Measured on the two cephalad slices in which the striated urethral sphincter was first visible, from one side to the other of the striated urethral sphincter and its lumen, respectively.

Striated urethral sphincter thickness	Calculated as the difference between the outer and inner diameters divided by two.
Striated urethral sphincter area	Measured as the mean difference between outer and inner area, using the formula for the area of a circle (pr^2).
Striated urethral sphincter volume	Calculated by multiplying the length of the striated urethral sphincter by its area.

Pelvic floor morphological measurements were taken from the sagittal images acquired at rest using the mid-sagittal slice in which all reference structures were visible. For the images recorded during the PFM MVC and the straining tasks, the mid-sagittal images that demonstrated the greatest bladder-neck elevation and depression, respectively, were used. Nine measurements were taken in each of the three conditions: (i) the pubococcygeal (PC) line[4, 16]; (ii) the anorectal angle[17, 18]; (iii) the H-line[17, 19, 20]; (iv) the M-line[17-20]; (v) the PC/H-line angle[17]; (vi) the urethrovesical (UV) junction height; (vii) the uterocervical (UC) junction height[21, 22]; (viii) the UV junction approximation-height[21, 23]; and (ix) the occurrence of bladder prolapse past the PC line.[4]

Three pelvic floor morphological measurements were taken from the axial images acquired at rest, PFM MVC, and straining using the most caudal slice in which the pubic symphysis was visible: (i) the width; (ii) the length of the urogenital hiatus[18]; and (iii) the presence or absence of PFM avulsion.[20]

Bladder neck morphology and integrity parameters were measured on the sagittal images that demonstrated the greatest bladder-neck funneling at rest and during straining: (i) presence of bladder-neck funneling[24]; and (ii) the posterior UV angle.[7, 17, 25]

Urethral sphincter morphology was assessed from the axial plane MR images at rest and included: (i) the striated urethral sphincter length; (ii) the outer; (iii) the inner urethral sphincter diameters; (iv) the urethral sphincter thickness; (v) the urethral sphincter area; and (vi) the urethral sphincter volume.[8]

To control for the potential effect of pelvic size on study parameters, participants were matched across the three groups based on a pelvic inlet length (i.e., distance between the upper surface of the pubis and the first sacral vertebra ±5 mm).

Data Analysis

Frequency distributions and ranges for each measurement were analyzed to detect outliers, signaling potential errors. Data were analyzed as group data, without nominal identifiers. Either a one-way analysis of variances (ANOVA, for normally distributed data) or a Kruskal–Wallis test (for data not normally distributed) was conducted, with a Bonferroni correction, to compare measurements between the groups (continent group, SUI, and MUI symptom groups). $\chi 2$ tests were used for dichotomous variables. Significance was indicated by $P < 0.05$.

RESULTS

Intra- and inter-rater reliability evaluations for all 12 pelvic floor measurements (nine in the sagittal plane and three in the axial plane) were conducted by our research team prior to this study and found to be good to excellent. Both the methodological details and the results have been previously reported.[26] The reliability of the bladder neck (intra-rater) and the urethral sphincter measurements (intra and inter-rater) were assessed at the beginning of this study and found to be good to excellent (See Supplemental Tables I and II).

Sixty six women, mean age 67.7 ± 5.2, participated in the study: 22 per group. Table III presents the demographic characteristics of the three groups. There were no differences among the groups in terms of age, weight, BMI, number of vaginal deliveries, hysterectomies. For both UI conditions, the mean leakage episodes per day were not significantly different between groups The UDI score was significantly different between the three groups and the highest in the MUI group.

TABLE III. Demographic

	Continent (n ¼ 22)	SUI (n ¼ 22)	MUI (n ¼ 22)	P-value
One-Way ANOVA				
Age (years)	66.50 (4.95)	68.27 (5.71)	68.32 (5.08)	0.429
Vaginal deliveries	1.50 (1.60)	1.05 (1.09)	1.77 (1.48)	0.230
Weight (kg)	62.19 (10.83)	64.88 (8.17)	66.94 (11.32)	0.308
BMI (kg/m^2)	24.46 (3.88)	25.44 (2.72)	25.86 (4.16)	0.428
Pelvic Inlet Length (mm)	122.00 (10.48)	121.40 (8.92)	121.23 (8.42)	0. 959
Mean leakage (/day)	N/A	2.33 (2.05)	1.71 (1.03)	0.274
UDI score (/300)	17.25 (22.16)	104.27 (44.33)	139.01 (46.66)	0.003*
x^2				
Hysterectomies	7/22 (32%)	9/22 (41%)	9/22 (23%)	0.433

SUI, stress urinary incontinence; MUI, mixed urinary incontinence. Data are presented as the mean (SD) for the ANOVAs and number of positive (%) for the x^2 test. Significance level was set at $P < 0.05$. The UDI score pairwise comparison were as follows: C/SUI: P¼0.000; C/MUI: P¼0.000, and SUI/MUI: P¼0.015.

*Post hoc pairwise comparisons were made using the Bonferroni method.

Table IV shows the PFM morphological parameters assessed in the sagittal and axial planes. In the sagittal plane, the groups differed only in terms of the M-line, the PC/H-line angle and the urethrovesical junction height. At rest, women with MUI symptoms had a longer M-line (P = 0.010), a wider PC/H-line angle (P = 0.026), and a shorter urethrovesical junction height (P = 0.013) than the continent women and the women with SUI symptoms. In the axial plane, there were no significant differences between groups.

TABLE IV. Comparison of PFM and Pelvic Organ Morphological Parameters Between Groups

Parameters	Conditions	Continent (n ¼ 22)	SUI (n ¼ 22)	MUI (n ¼ 22[a])	P-value	Significant pairwise comparison
One-way ANOVA						
H-Line (mm)	Rest	55.9 (8.3)	58.5(7.3)	60.3 (8.5)	0.200	
	PFM MVC	49.0 (8.5)	49.9 (7.0)	51.8 (8.7)	0.511	
	Straining	55.0 (9.7)	55.1 (9.6)	60.8 (10.7)	0.105	
UV junction approximation (mm)	Rest	13.6 (2.2)	14.1 (3.1)	14.4 (3.0)	0.646	
	PFM MVC	13.7 (2.8)	16.0 (3.5)	15.6 (2.8)	0.040	
	Straining	11.0 (3.9)	12.1 (4.0)	11.0 (5.4)	0.632	
	Rest	115.8 (14.1)	120.3 (12.4)	118.8 (13.1)	0.518	
Anorectal angle(8)	PFM MVC	95.7 (16.9)	100.7 (15.0)	97.9 (19.9)	0.643	
	Straining	115.6 (21.2)	119.1 (19.6)	122.5 (23.2)	0.564	
	Rest	113.2 (9.5)	112.8 (7.6)	117.5 (9.7)	0.159	
PC Line (mm)	PFM MVC	113.8 (9.7)	112.7 (7.4)	117.4 (9.6)	0.191	
	Straining	113.2 (10.0)	112.8 (7.5)	118.0 (9.7)	0.119	
M-Line (mm)	Rest	19.4 (7.8)	18.3 (8.5)	26.2 (10.4)	0.010	2–3
	PFM MVC	8.2 (9.1)	9.3 (6.1)	12.8 (10.3)	0.195	
	Straining	25.8 (14.3)	21.6 (13.7)	27.4 (13.7)	0.373	
PC/H-line angle (8)	Rest	20.5 (7.4)	18.5 (8.3)	25.3 (9.4)	0.026	3
	PFM MVC	9.3 (11.0)	10.7 (6.8)	13.2 (9.5)	0.374	
	Straining	27.4 (12.8)	23.1 (12.1)	25.9 (11.4)	0.493	
UV junction height (mm)	Rest	14.2 (3.9)	13.9 (5.6)	10.0 (5.8)	0.013	2–3
	PFM MVC	19.2 (5.0)	18.4 (5.7)	16.6 (6.5)	0.326	
	Straining	6.4 (9.3)	8.1 (7.9)	4.4 (9.5)	0.392	
UC junction height (mm)	Rest	20.3 (7.0)	20.5 (8.1)	20.5 (8.1)	0.306	
	PFM MVC	27.3 (6.0)	26.8 (7.9)	26.8 (7.9)	0.848	

	Straining	9.1 (12.8)	14.4 (9.4)	14.4 (9.4)	0.359
x^2					
Bladder prolapse (number)	Rest	0/22 (0%)	1/22 (4.5%)	4/22 (18.2%)	0.060
	PFM MVC	0/22 (0%)	1/22 (4.5%)	1/22 (4.5%)	0.597
	Straining	9/22 (40.9%)	10/22(45.5%)	12/21 (57.1%)	0.548
Avulsion (number)	Rest	0/22 (0%)	1/22 (4.5%)	2/22 (9.1%)	0.351
Kruskal–Wallis					
Urogenital hiatus width (mm)	Rest	37.5 (23.4–47.8)	36.8 (29.1–48.8)	37.0 (31.4–75.0)	0.726
	PFM MVC	36.3 (27.9–52.5)[b]	34.6 (23.3–48.3)	35.8 (28.3–67.1)	0.542
Urogenital hiatus length (mm)	Rest	62.1 (44.2–76.3)	61.3 (44.5–75.0)	65.0 (49.4–81.2)	0.278
	PFM MVC	53.8 (37.9–72.9)[b]	53.1 (44.0–65.2)	56.5 (42.9–80.0)	0.197

SUI, stress urinary incontinence; MUI, mixed urinary incontinence; PFM MVC, pelvic floor muscles maximal voluntary contraction; UV, urethrovesical; PC, pubococcygeal; UC, uterocervical. The post hoc pairwise comparisons were made using the Bonferroni method, significant results are presented as 1 ¼ C/SUI; 2 ¼ C/ MUI; 3 ¼ SUI/MUI. Data are presented as mean (SD) for the ANOVAs, median (range) for the Kruskal–Wallis, and number of positive (%) for the x^2 test. Significance level was set at P < 0.05.

Bold denotes significant P value (< 0.05).

[a]Unclear image for one participant on sagittal straining, impossible to make the measurements.

[b]Unclear image for one participant on axial PFM MVC, impossible to make the measurements.

Table V shows the bladder neck and striated urethral sphincter morphological parameters. The occurrence of bladder-neck funneling at rest was significantly more frequent among women with SUI symptoms than the other groups (P = 0.026). The posterior urethrovesical angle was also significantly larger at rest in the SUI symptoms group (P = 0.008). There were no significant differences between groups in terms of striated urethral sphincter measurements.

TABLE V. Comparison of Bladder Neck and Urethral Sphincter Morphological Parameters Between Groups

Parameters	Conditions	Continent (n ¼ 22)	SUI (n ¼ 22)	MUI (n ¼ 22)	P-value	Significant pairwise comparison
Bladder neck						
x^2						
Funneling occurrence	Rest	10/22 (45.5%)	17/21[a] (81.0%)	10/22 (45.5%)	0.026	1–3
	Straining	17/22 (77.3%)	19/22 (86.4%)	17/21[a] (81.0%)	0.737	
One-way ANOVA						
Posterior UV angle (8)	Rest	138.67 (39.58)	169.81 (42.35)	134.56 (35.41)	0.008	1–3
	Straining	166.87 (31.27)	150.16 (32.47)	164.65 (35.53)	0.201	
Urethral sphincter						
Length (mm)	Rest	18.6 (1.9)	18.8 (2.1)	18.3 (1.1)	0.709	
Mean thickness (mm)		1.3 (0.5)	1.4 (0.4)	1.5 (0.4)	0.391	
Mean area (mm^2)		53.8 (23.0)	60.4 (16.9)	55.2 (19.8)	0.530	
Mean volume (mm^3)		1007.1 (457.2)	1136.0 (325.9)	1013.9 (369.81)	0.483	

SUI, stress urinary incontinence; MUI: mixed urinary incontinence; UV, urethrovesical. The post hoc pairwise comparisons were made using the Bonferroni method, significant results are presented as 1 ¼ C/SUI; 2 ¼ C/MUI; 3 ¼ SUI/MUI. Data are presented as mean (SD) for the ANOVA and number of positive (%) for the x^2 test. Significance level was set at P < 0.05.

Bold denotes significant P value (< 0.05).

[a]Unclear image for one participant, impossible to make the measurements.

DISCUSSION

In this MRI sub-study of an observational cohort of older women with UI, we compared PF (PFM, bladder neck, and urethral sphincter) morphology among continent women and those with SUI or MUI symptoms at rest, during PFM MVC and on straining. Characterization of pelvic floor morphology at rest revealed differences between continent women compared to both women with SUI and MUI symptoms, as well as differences between the two groups with UI symptoms. The latter finding was unexpected given that MUI is defined clinically as a combination of stress and urgency UI symptoms. Distinguishing PF features were not observed during the PFM MVC or straining conditions.

Differences in PFM Morphological Parameters

In the sagittal plane, women with MUI symptoms were observed to have both a longer M-line and a wider PC/H-line angle at rest. These findings suggest a lower PFM position and support a lax PFM hypothesis in women with MUI symptoms. Furthermore, the significantly lower UV junction height at rest reflects the lower anatomical position of the bladder in women with MUI symptoms, providing more support for a reduced pelvic-organ support hypothesis. Of interest, though not statistically significant, bladder prolapse below the PC line was more common in women with MUI symptoms than in the other groups, further supporting this hypothesis. Our results suggest two possible mechanisms for MUI symptoms in older women. First, and consistent with previous literature, a lower PFM position and a loss of support could result in decreased resting urethral closure pressure, which could explain leakage related to increased intra-abdominal pressure.[3, 27] The loss of bladder support could also increase stress on the stretch receptors in the lower part of the bladder. This stimulus would create a feedback loop to the brain, causing symptoms of overactive bladder (OAB) and eliciting urgency symptoms in women with MUI symptoms.[5] Concomitant stress and urgency symptoms in older women with MUI might, therefore, be explained by PFM laxity and a lower anatomical positioning of the bladder as per the Integral theory of incontinence.[5] Our results point to the possibility of a peripheral origin for the urgency experienced by women with MUI symptoms that might be quite different from either bladder-generated or brain-generated urgency.

Women with SUI symptoms demonstrated no significant differences in any of the PFM morphological parameters compared to continent women. Their PFM morphology seems to be similar to that of continent women; hence, our findings suggest that PFM morphological defects may not play as important a role in the pathophysiology of SUI in older women as originally believed[5] but are more in line with the finding in recent literature.[27]

Differences in Bladder Neck Morphological Parameters

Women with SUI symptoms were significantly more likely to demonstrate bladder-neck funneling at rest than the other groups (81 vs. 50% for MUI and continent). As funneling has been shown to be related to lower maximal-urethral-closure pressure[27] and has been hypothesized to stretch and weaken the striated urethral sphincter,[6] our findings support the theory that SUI in older women may be related to urethral sphincter deficiency.[3] However, the frequent occurrence of bladder-neck funneling in other UI groups suggests that additional factors are also involved in the pathophysiology of SUI.

A significantly wider posterior UV angle was observed at rest in participants with SUI symptoms, angles that were similar to those of continent women and women with MUI symptoms on straining (~165°). Our findings are consistent with the results of one MRI and two trans-perineal ultrasound studies, which report a significantly wider posterior UV angle in women with SUI symptoms.[7, 28, 29] This abnormal position could be related to decreased external support for either the urethra or the bladder neck.[5, 6]

Absence of Differences in Urethral Sphincter Morphological Parameters

No differences were observed in the urethral sphincter thickness, area, or volume among the three groups; thus, urethral sphincter morphology does not seem to be linked to either SUI or MUI pathophysiology in older women. These findings are contrary to Morgan et al. (2009) who found a significant difference in striated urethral sphincter volume between middle-aged women with SUI and controls.[8] The difference could be explained by the different study populations: middle-aged women with a mean age of 47.7 ± 9.3 years in

Morgan et al. versus older women with a mean age of 67.7 ± 5.2 years in our study. A normal decrease in sphincter volume with age could mask this difference. Perucchini reported an age-related decrease in the number and density of striated muscle fibers at the bladder neck and along the ventral urethral wall.[30]

Strengths and Limitations

The strengths and limitations of this study deserve consideration. By matching continent volunteers to volunteers with SUI and MUI symptoms by pelvic inlet length, we avoided the potential confounder of pelvic size. All MRI parameters were tested and demonstrated very good to excellent reproducibility either prior to or during this study. MRI provided clear, detailed images of PF anatomy, but also imposed limitations.

The slice thickness limited the sensitivity of measurements to 5 mm. MRI was conducted with subjects in the supine position, a position in which UI does not usually happen. It can be argued that PFM, bladder neck, and urethral deficits may not be seen in a gravity free position. However, studies by Fielding and et al. (1998) and Bertschinger et al. (2002) comparing PFM MRI data in both the supine and sitting position showed that PFM laxity related to IU or bladder descent can be seen with subjects in both the supine and the sitting positions.[29, 31] Furthermore, the supine position is commonly used in studies on UI or POP.[6, 8, 16-19] The decision to have the women void before MRI session was made to enhance the visibility of all the structures of interests in the abdominal and perineal region.[20] Moreover, this method is frequently used in imaging sessions.[17-19, 23] Finally, it can be argued that our small sample size may have hampered our research findings. Again, referring to Fielding's paper, differences between continent and SUI women were seen in only eight subjects per group.[29]

UI type was determined based on the valid 3IQ questionnaire and not urodynamic testing: however, simple questions have been shown to be reliable in determining UI type.[32] Future studies to advance our understanding of UI pathophysiology should use urodynamics in addition to symptom questionnaires to determine UI type. However, as this was an exploratory study in an older population, urodynamic evaluation was considered too invasive. The ICS standardized definitions were used to categorize the type of urinary incontinence.

The lack of significant differences in the contraction and straining conditions could be due to higher variability among participants for most of the parameters. For the straining condition, the lack of differences between groups could be due to participant reluctance to provide maximum effort out of fear of urinary leakage inside the MRI. Moreover, as some of our results in older women differed from those of the general population, future studies should also include and analyze data by age subgroup (older and younger).

CONCLUSION

Pelvic floor morphological defects are present in both older women expressing SUI and MUI symptoms, but the defects are different in the two. Since the PF morphological defects present in older women expressing SUI symptoms are not seen in women, of the same age group, expressing symptoms of MUI, MUI pathophysiology may not be a simple combination of morphological defects causing stress and urgency UI but a UI type with its own specific PFM morphological features. Our findings suggest that there may be a need for different interventions specifically targeted to the type and severity of the defects underlying SUI and MUI in older women.

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