The effects of a strong desire to void on gait for incontinent and continent older community-dwelling women at risk of falls

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ABSTRACT

Aims: The fall rate in urgency (UUI) and mixed urinary incontinent (MUI) older women is higher when compared with that of continent women. One hypothesis is that a strong desire to void (SDV) could alter gait parameters and therefore increase the risk of falls. The aim of this study was to investigate and compare the effect of SDV on gait parameters in UUI/MUI and continent older women who experienced falls. The secondary aim was to determine the relationship between UI severity and gait parameters in incontinent women.
Methods: A quasi-experimental pilot study was conducted with two groups of healthy community-dwelling women who experienced at least one fall in the last year: continent (n=17; age: 74.1±4.3) and UUI/MUI (n=15; age: 73.5±5.9). We recorded, analyzed and compared spatiotemporal gait parameters for participants in each group with both SDV and no desire to void condition.
Results: A pattern of reduced velocity (P=0.05) and stride width (P=0.02) was observed in both groups with SDV. Incontinence severity was correlated with reduced velocity (r_s=-0.63, P=0.01), increased stance time (r_s=0.65, P=0.01) and stance time variability (r_s=0.65, P=0.01) in no desire to void condition and with reduced velocity (r_s=-0.56, P=0.03) and increased stride length variability (r_s=0.54, P=0.04) in SDV condition.
Conclusions: SDV reduced gait velocity and stride width regardless of continence status in older women at risk of falls. Further, UI severity in the UUI/MUI women was correlated to reduced gait velocity and increased variability. Our findings could explain the higher fall rate in this population.

1. INTRODUCTION

One in three adults over the age of 65 experience a fall at least once per year, and women are at a higher risk than men.[1] Another major problem for older women is urinary incontinence (UI). UI affects up to 42% of women, and its prevalence and severity increase with age.[2] There are three types of UI: stress UI (SUI) (leakage related to effort, coughing and sneezing), urgency UI (UUI) (leakage related to an urgent need to urinate) and mixed UI (MUI) (leakage related to effort and urgency). The prevalence of UUI and MUI increases with age while SUI decreases.[2] Older women with UI are at a higher risk of falls (odds ratio (OR): 1.45, confidence interval 95%: [1.36-1.54]).[3,4] Moreover, the risk of falls in older women is higher for those with UUI (OR: 1.54, [1.41-1.69]) and MUI (OR: 1.92, [1.69-2.18]) than SUI (OR: 1.11, [1.00-1.23]).[4]

Few studies have investigated the link between UI and falls.[4] Some studies suggest incontinent women show an alteration of their gait when they rush to the toilet with an urge to urinate.[4,5] This proposed change in gait parameters could increase the risk of falling. One study, by Booth et al. in 2013, showed gait alterations in a condition of strong desire to void in a continent adult population.[5] To our knowledge, there are no studies assessing the effect of a strong desire to void on gait in older incontinent women at risk of falls.[4,5]

The primary aim of the study was to investigate the effect of a strong desire to void on gait parameters in UUI/MUI and continent community-dwelling women who are at risk of falls. The secondary aim was to determine the relationship between UI severity and gait parameters in the UUI/MUI subgroup.

2. METHODS

2.1 Study Design

A two-group quasi-experimental pilot study was undertaken. The study was approved by the ethics committees of the Montreal Geriatric Institute Research Center (CRIUGM) and the Centre for Interdisciplinary Research in Rehabilitation of Greater Montreal (CRIR).

2.2 Subjects

Recruitment of the participants took place in Montreal, between May 16, 2015 and February 14, 2017. The participants were recruited through advertisements in the Montreal Metropolitan area's community centers, hospitals and through the CRIUGM's participant database. Two groups of healthy community-dwelling women (with and without UI) over the age of 65, who experienced at least one fall in the past year, took part in the study. No previous study had been conducted in this population. Our goal was therefore to include 20 participants per group, based on a similar study in younger continent women (Booth, 2013)[5].

2.2.1 Inclusion criteria:

Participants included in the UI group had moderate-to-severe UUI/MUI. To confirm UI severity, we used the International Consultation on Incontinence Questionnaire on UI Short Form (ICIQ-UI SF). A score of $\geq$6 (score 0-21) on the ICIQ-UI SF questionnaire was considered moderate-to-severe UI.[2,6] Participants filled a 7-day bladder diary to assess UI severity and UI circumstances. Participants included in the UI group had at least three urinary incontinence episodes per week in their 7-day bladder diary (with at least one urge-related incontinence episode).[2,6] Participants included in the continent group had an ICIQ-UI SF score equal to zero, no urine incontinence reported in the past year and none reported in the 7-day bladder diary before assessment.

2.2.2 Exclusion criteria:

Participants with a body mass index (BMI) over 35, and any health conditions or medications likely to influence gait or urinary continence during the experimentation were excluded.[2] Participant with walking pain or lameness were excluded.

To further document the continence status for both groups, we used a 24-hour pad test to measure the amount of urinary leakage in a preweighed protective continence pad. Participants continued their usual activities while wearing the continence pad continuously for 24 hours.[2,7] We used the ICIQ-overactive bladder (ICIQ-OAB) questionnaire to document urinary urgency, urgency incontinence, frequency and nocturia symptoms and their related impact. A higher score (score 0-16) indicates increased symptom severity.[2,8] In addition, we used Geriatric self-efficacy (GSE) to describe the participant's level of confidence in holding urine. A higher score (score 0-120) indicates a higher confidence.[2,9]

2.3 Procedures

We used a standardized telephone interview, including the ICIQ-UI SF questionnaire, to assess general health, medication use and eligibility. If eligibility was confirmed, we scheduled a gait laboratory experimentation at the CRIR. In addition, a 7-day bladder diary and a 24-hour pad test kit were sent by mail.

After confirming the eligibility of the participants based on the 7-day bladder diary, we recovered the completed 24-hour pad tests and participants signed the consent form. Each woman took part in a 3-hour (maximum) gait laboratory experimentation while wearing a preweighed pad. The participants completed questionnaires on sociodemographic factors, cognition, history of falls, balance confidence and continence status/severity.

Desire-to-void was determined using a validated scale, recommended by the International Consultation on Incontinence: the Urinary Sensation Scale (USS).[10,11] A score of 3/5 (moderate urgency: enough urgency to experience discomfort, stop the usual activity or task, and go immediately to the bathroom) on the USS was considered as a strong desire to void condition. In the 2011 Shiu-Dong study, a 3/5 threshold score on the USS was correlated to a strong desire to void as measured by an increase in detrusor activity.[12] A score of 1/5 (no urgency: no feeling of urgency; can continue activities until it is convenient to use the bathroom) was considered a no desire to void condition.

After drinking water until they experienced a strong desire to void as determined by a score of three on the Urinary Sensation Scale (USS),[10] we asked participants to walk on a computerized gait analysis mat (GAITRite©, Franklin, NJ, USA) on their way to the toilet. After emptying their bladder, i.e. with no desire to void, they were asked to walk again on the mat.

After gait analysis, questionnaires were completed if not completed before, and we took anthropometric measurements (weight and height). At the end of the experimentation, participants were asked to report any urine incontinence during the session and the pad worn during the assessment was weighed to document leakage.

2.4 Outcome measures

2.4.1 Sociodemographic data, history of falls and cognitive status

We gathered sociodemographic data, including age, history of falls, general health status and medication use via custom questionnaires. We also measured participants' weight and height (to calculate BMI)[13] and screened for cognitive impairment with the Montreal Cognitive Assessment Test (MOCA, V.7.2).[14] A score of 26/30 and above is considered normal (sensitivity 90%, specificity 53%).[14]

2.4.2 Balance confidence

We assessed balance confidence via the Activities-specific Balance Confidence Scale (ABC scale) (score 0-100%). A score of 67% and under on the ABC scale (84% sensitivity, 87% specificity) has been linked to a higher risk of falls.[15]

2.4.3 Gait analysis

The computerized gait analysis mat (GAITRite©) records the spatiotemporal walking parameters associated with the positions of the feet on the mat by means of built-in pressure sensors.[16] It has excellent psychometric properties and has been used in similar studies on the effect of gait on SDV in a younger continent female population.[5,16]

All participants practiced on GAITRite© before the beginning of the experiment in order to familiarize themselves with the gait data collection procedure. For each gait assessment, participants were asked to walk approximately 1.5 m before stepping on the mat and to stop 1.5 m after stepping off the mat to avoid acceleration and deceleration gait data. We asked them to walk at their self-selected speed, without talking, for each experimental condition. They walked on the mat until they completed about 28 steps for each condition.

We recorded and analyzed seven main spatiotemporal gait parameters for both conditions: velocity (calculated by dividing the distance walked by the ambulation time [cm/s]), stride width (lateral distance from heel center of one footprint to the line of progression formed by two consecutive footprints of the opposite foot), stride length (anterior-posterior distance between the heels of two consecutive footprints of the same foot) and stance time (time elapsed between the initial contact and the last contact of a single footfall). We calculated variability using the formula: (Standard Deviation(*SD*)/mean) X 100 for stride width, stride length and stance time. Figure 1 presents all gait parameters. According to a literature review, these gait parameters could be linked to falling.[17]

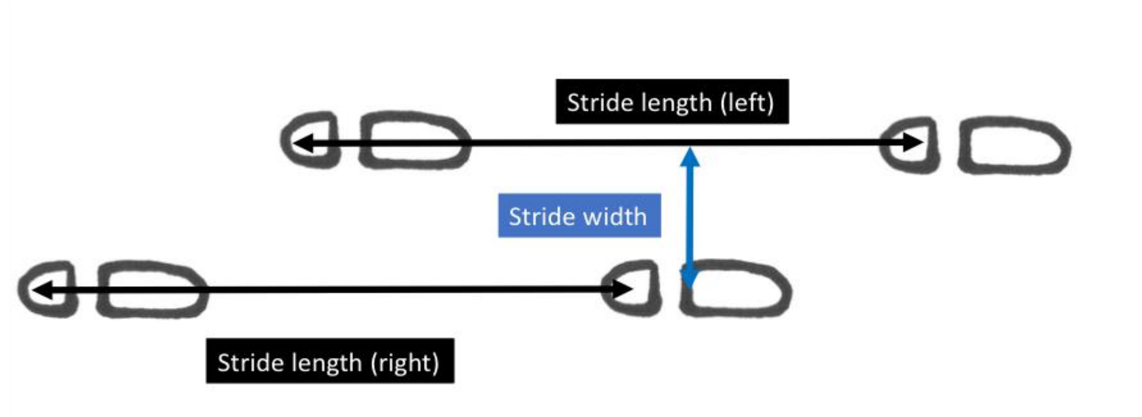

FIGURE 1: The spatiotemporal walking parameters associated with the positions of the feet on the mat

2.5 Statistical Analysis

We performed the statistical analyses using the Statistical Package for the Social Sciences software (SPSS©v.20). First, a normality analysis (Shapiro-Wilk) of all variables was conducted to determine the use of parametric or nonparametric statistical tests.

We obtained descriptive statistics for sociodemographic factors, cognition, balance confidence, continence status/UI severity and gait data. To compare groups, independent t-tests were used for continuous outcomes with a normal distribution, we used a Mann-Whitney test for continuous outcomes with non-parametric distribution. Chi-square tests were used for categorical outcomes.

For gait outcomes with a normal distribution, an analysis of variance (ANOVA) with repeated measures was conducted to explore the differences between the two groups (continent/incontinent) for the two conditions (no desire to void/strong desire to void). BMI ($<25/\geq 25$) was included as a covariate in the analysis because it is a factor known to influence urinary continence and gait.[2]

To quantify the impact and measure the effect size of the desire to void (no desire to void vs strong desire to void), the Eta square effect size (η^2) was also calculated for each of the gait parameters. A value of $0.06 \leq \eta^2 < 0.13$ was considered as a moderate effect and $\eta^2 \geq 0.13$ was considered a strong effect on gait parameters.

For gait outcomes showing a non-normal distribution, a Kruskall-Wallis test was used. To include BMI in those analyses, we divided our two groups (continents/incontinents) into four according to BMI: continents BMI <25, continents BMI≥25, incontinents BMI <25, incontinents BMI ≥25.

For the secondary aim, which involves the incontinent subgroup only, we computed the correlation using Spearman Correlations (r_s), between incontinence severity, as determined by ICIQ-UI SF, and gait parameters. A *P value* <0.05 was considered significant for all analyses.

3. RESULTS

Thirty-two women took part in the study: 17 continent (age: 74.1±4.3) and 15 incontinent (UUI/MUI) (age: 73.5±5.9). There was one missing data point in the continent group with no desire to void condition because of technical problems with the gait assessment procedure.

Sociodemographic factors, cognition, history of falls, balance confidence, continence status/UI severity outcomes for each group are presented in Table 1. Both groups were in good general health, with no pathologies or medications that could have affected walking or continence. Participants in both groups presented normal results for MOCA cognitive testing. However, a significantly higher BMI was observed in the incontinent group compared with the continent group. In fact, 12 of the incontinent and eight of the continent participants had a BMI equal to or higher than 25 while three of the incontinent and nine of the continent participants had a BMI lower than 25.

Incontinent participants had a significantly higher fall rate than continent participants. In fact, 66.7% of incontinent participants reported over two falls in the last year compared to 29% of continent participants. Incontinent participants showed a significantly lower confidence in keeping their balance when compared to the continent participants. According to the ABC scale results, 6/15 (40%) of incontinent participants scored less than 67%, the cutoff score for prediction of falls, as opposed to none (0/17) of the continent participants (Table 1).

The questionnaires (ICIQ-UI SF, ICIQ-OAB, GSE) and tests results (24-hour pad test, 7-day bladder diary) confirmed that continent participants had no UI, showed no urgency-related symptoms and had a good level of confidence in retaining urine. In the incontinent group, ICIQ-UI SF and the 7-day bladder diary results confirmed moderate-to-severe UI.[6,18] Furthermore, on the 24-hour pad test, mean leakage amount was light to moderate at 9.2±10.9g[7]. Incontinent participants showed urgency-related symptoms according to the results of the ICIQ-OAB questionnaire and had a significantly lower level of confidence in their capacity to retain urine according to GSE questionnaire results (see Table 1).

Table 1: Sociodemographic factors, cognition, number of falls, balance confidence and continence status/UI severity outcomes

	Continent Mean (SD) n=17	Incontinent Mean (SD) n=15	*P value*
Age (years)[a]	74.1 (4.3)	73.5 (5.9)	*0.72*
BMI (kg/m²)[a]	25.11 (2.71)	28.42 (3.19)	***<0.01****
MOCA (/30)[a]	27 (2)	27 (2)	*1.00*
Number of falls in the last year N (%)[b]:			
1	12 (70.6%)	5 (33.3%)	***0.03****
2	5 (29.4%)	6 (40%)	
3 and +	0 (0%)	4 (26.7%)	
Activities-specific Balance Confidence scale (%)[a]	87.7 (9.4)	72.4 (18.5)	***0.01****
Continence status/UI severity			
ICIQ-UI SF (/21)[c]	0 (1)	12 (3)	***<0.01****
24-hour pad test (g)[c,d]	0.61 (0.45)	9.25 (10.88)	***<0.01****
Number of urine leakages/7-day (mean)[c]	0	11 (8)	***<0.01****
ICIQ-OAB (/16)[a]	3 (2)	7 (3)	***<0.01****
GSE (/120)[c]	106 (20)	71 (23)	***<0.01****

*SD: Standard deviation *: significant: P<0.05 a: t-test b: Chi-square test c: Mann-Whitney test d: negative pad test if < 2 g*

Gait parameters are presented in Tables 2 and 3. All participants walked a mean of 28 (*SD*: 6) steps on GaitRITE© in both conditions. There was no group or interaction effect in gait parameters and in gait variability. However, a statistically significant main effect between conditions on stride width was observed. Stride width was reduced when experiencing a strong desire to void in both groups. In both groups, the mean stride width in no desire to void condition was under 15.7cm (threshold known to be predictor of falls)[19]. Velocity was reduced, in both groups, when experiencing a strong desire to void (not significant but a large effect size was observed). Interestingly, our post hoc Chi-square analysis results showed that, in strong desire to void condition, a significantly higher number of incontinent (7/15 (47%)) compared to continent women (2/17 (12%)) walked at a velocity under or equal to 100 cm/s (P=0.03) (velocity threshold known to be a predictor of falls[17]). In no desire to void condition, 2/16 (12%) of continent and 5/15 (33%) of incontinent women walked at a velocity under or equal to 100 cm/s (P=0.17). Furthermore, stride length was significantly shorter in participants with a BMI $\geq$25 in both conditions (Table 2). BMI had no effect on other gait parameters in both conditions.

Table 2: ANOVA outcomes of gait parameters in both groups in strong desire to void and no desire to void conditions

		Descriptives Mean (*SD*)		BMI effect (0= BMI<25 vs 1= BMI≥25)	Condition effect (0=Strong desire to void vs 1=No desire to void)		Group effect (0=Continent vs 1= Incontinent)		Interaction effect (Condition by group)	
		Strong desire to void	**No desire to void**	**F (*P*)**	**F (*P*)**	**η^2**	**F (*P*)**	**η^2**	**F (*P*)**	**η^2**
Velocity (cm/sec)	**Continent n=16**	118 (5)	120 (4)	1.24 (0.28)	4.06 (0.05)	0.13	1.46 (0.24)	0.05	1.57 (0.22)	0.06
	Incontinent n=15	106 (4)	107 (5)							
Stride width (cm)	**Continent n=16**	9.9 (2.4)	10.5 (2.0)	3.40 (0.08)	**5.74* (0.02)**	0.18	0.00 (0.95)	0.00	0.76 (0.39)	0.03
	Incontinent n=15	10.8 (2.6)	10.9 (2.5)							
Stride length (cm)	**Continent n=16**	126.3 (12.7)	127.4 (12.9)	**4.83* (0.04)**	1.95 (0.17)	0.07	1.93 (0.18)	0.07	0.82 (0.37)	0.03
	Incontinent n=15	114.2 (12.9)	114.5 (16.9)							
Stance time (sec)	**Continent n=16**	0.68 (0.02)	0.67 (0.02)	0.00 (0.96)	3.75 (0.06)	0.12	0.10 (0.76)	0.00	2.08 (0.16)	0.07
	Incontinent n=15	0.69 (0.02)	0.69 (0.01)							

SD: Standard deviation *: significant $P<0.05$

Effect size (η^2): A value $0.06 \le \eta^2 < 0.13$: moderate effect, $\eta^2 \ge 0.13$: large effect

Urinary incontinence was reported by three incontinent participants during the gait laboratory experiment. One was not aware when the leakage occurred, and the two others had urine leakage on strong desire to void condition while walking to the toilet. An increase in pad weight in these incontinent participants confirmed urine incontinence.

Correlations results are presented in Table 4. In both conditions, velocity was strongly negatively correlated with UI severity. In no desire to void condition, stance time variability and stance time was strongly positively correlated with UI severity. In strong desire to void condition, stride length variability was moderately positively correlated with UI severity.

Table 3: Kruskall-Wallis test outcomes of gait variability parameters in both groups in strong desire to void and no desire to void conditions

	Descriptives **Mean (SD)**				**Condition effect**			
	Continent		**Incontinent**		**Strong desire to void**		**No desire to void**	
	Strong desire to void **(1) n=9** **(2) n=8**	**No desire to void** **(1) n=8** **(2) n=8**	**Strong desire to void** **(1) n=3** **(2) n=12**	**No desire to void** **(1) n=3** **(2) n=12**	**K**	***P value***	**K**	***P value***
Stride width variability (%) **(1) BMI<25** **(2) BMI≥25**	(1) 27.87 (13.80) (2) 21.34 (9.44)	(1) 25.86 (13.66) (2) 18.40 (5.13)	(1) 29.72 (11.48) (2) 20.21 (7.50)	(1) 21.64 (6.16) (2) 21.70 (5.49)	4.78	*0.19*	2.32	*0.51*
Stride length variability (%) **(1) BMI<25** **(2) BMI≥25**	(1) 2.44 (0.68) (2) 3.25 (1.98)	(1) 2.31 (0.70) (2) 2.62 (0.86)	(1) 3.97 (1.75) (2) 2.86 (0.93)	(1) 1.83 (0.97) (2) 3.48 (2.46)	3.46	*0.33*	3.74	*0.29*
Stance time variability (%) **(1) BMI<25** **(2) BMI≥25**	(1) 5.87 (8.59) (2) 3.48 (1.09)	(1) 2.35 (0.42) (2) 2.65 (0.95)	(1) 4.56 (1.99) (2) 3.48 (0.95)	(1) 3.06 (0.24) (2) 3.18 (1.11)	1.12	*0.77*	5.55	*0.14*

SD: Standard deviation*: significant P<*0.05*
(1) BMI<25(2) BMI≥25

Table 4: Spearman coefficient (r_s) and *P* value results of correlation between ICIQ-UI SF and gait parameters in the incontinent group (n=15) in desire to void and a strong desire to void conditions

	Strong desire to void		No desire to void	
	r_s	*P value*	r_s	*P value*
Velocity (cm/sec)	-0.56 strong	***0.03****	-0.63 strong	***0.01****
Stride width (cm)	0.36 moderate	*0.19*	0.15 small	*0.60*
Stride width variability (%)	-0.29 small	*0.30*	-0.05 small	*0.87*
Stride length (cm)	-0.47 moderate	*0.08*	-0.48 moderate	*0.07*
Stride length variability (%)	0.54 strong	***0.04****	0.49 moderate	*0.06*
Stance time (sec)	0.44 moderate	*0.10*	0.65 Strong	***0.01****
Stance time variability (%)	0.49 moderate	*0.07*	0.65 strong	***0.01****

*: significant $P<0.05$

r_s from 0.10 to 0.29= small, r_s from 0.30 to 0.49=moderate, r_s from 0.50 to 1.0= strong correlation

4. DISCUSSION

To our knowledge, this is the first study on UUI/MUI and continent community-dwelling women who experienced falls to report the influence of a strong desire to void on gait parameters.

Gait parameters were influenced by a strong desire to void, regardless of the group (UUI/MUI or continent). We observed a reduced walking velocity and shorter stride width when participants were experiencing a strong desire to void. However, in usual gait conditions, when older adults reduce gait velocity, they usually increase stride width.[17,20,21] A possible explanation for reduced stride width is the synergistic association between adductors and pelvic floor muscles (PFM).[22] In fact, contraction of the adductors muscles are known to reduce the space between the legs and reduce stride width.[23] To prevent urinary leakage, women may have tried to co-contract the PFM and its synergist adductors, thereby reducing their stride width.[22] However, reduced stride width is also linked to a smaller base of support and has been correlated with a higher risk of falls.[17,19,21]

Only one other research group has studied the effect of a strong desire to void on gait, in young adult continent women.[5] As observed in our study, continent women with a strong desire to void reduced their velocity. However, no change in stride width was observed in Booth et al.'s study. This may be because younger continent women's PFMs are stronger than older women's and they do not need to rely on the synergistic effect of the adductors to help to retain urine.[22]

A possible explanation for the reduced velocity observed in women with strong desire to void condition, reported also by Booth et al., is that holding urine and walking could be perceived as a dual task.[4] A dual task, such as counting backward and walking, has been shown to reduce gait speed.[24] The attention required to hold urine while walking could decrease the resources attributed to the walking task and therefore reduce velocity. Also, incontinent women had a significant lower confidence in their balance than continent women and it could be an explanation for the slower velocity observed with strong desire to void condition in the incontinent subgroup. Decreased confidence in balance is related to slower gait parameters and increased variability.[15,25] A significant larger number of incontinent women compared to continent participants walked at a velocity lower or equal to 100 cm/s in strong desire to void condition. Slow walking speed, i.e. under or equal 100 cm/s, is related to increased gait variability. Slower gait and increased variability are related to a higher risk of falls.[17,20]

Regardless of the desire to void, UI severity was correlated with slower velocity and increased gait variability. Increased variability, decreased velocity and stride width are linked to a higher risk of falls.[17] When walking to the toilet with a strong desire to void, incontinent women with more severe UUI/MUI further reduced their velocity (which was already slow) and stride width (which was already small), which could increase the risk of falling. Further, incontinent participants presented overactive bladder (OAB) symptoms, which in addition to urinary urgency and urgency incontinence includes frequency and nocturia symptoms.[8] The reduced velocity and stride width during strong desire to void condition combined with more frequency and nocturia in the incontinent group could explain their higher fall rate.

4.1 Limitations of the study and future research

We did not observe any group effect in walking conditions, probably because both groups were healthy and active. Even though we observed an influence of a strong desire to void on gait, we assessed a perceived strong desire to void only with a subjective scale in a laboratory environment. This could have caused some participants to fear UI and therefore not attain true strong desire to void, especially for the incontinent women with a reduced confidence in holding urine. Also, our groups were small (15 incontinent/17 continent) which could have caused insufficient statistical power to observe differences between groups. However, it was sufficient to observe a condition effect. Despite the fact that we were not able to recruit our pre-established sample size, we still found a large effect size and significant P-value for some gait parameters. We hypothesize that with a larger sample, we could have seen even a larger effect.

As opposed to Booth et al.'s study, we did not observe any differences in gait variability between groups and conditions.[5] To include BMI in the gait variability analyses, we separated our two groups into four smaller groups, which could have been the cause of insufficient statistical power for this analysis.

A future study is necessary to analyze hip adductors and PFM muscle activation and synergistic contractions using electromyography and dynamometry in a walking situation in SDV condition. Additionally, future studies could assess the effect of a strong desire to void in a more ecological environment by including variables such as distractions and obstacles while walking to the toilet.

Finally, one of the major issues facing older adults who experience falls are the many comorbidities that may affect walking and were an exclusion criterion in the present study. Future studies may consider including participants with comorbidities to increase generalizability.

5. CONCLUSION

Strong desire to void condition reduced gait velocity and stride width, regardless of continence status in older women at risk of falls. Further, UI severity in women with UUI/MUI was correlated to a slower gait and increased variability. Our findings could explain the higher fall rate in this population.

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