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ORIGINAL ARTICLE

Urethral pressure response patterns induced by squeeze in continent and incontinent women

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Abstract Our aim was to compare the urethral pressure response pattern to pelvic floor muscle contractions in 20–27 years old, nulliparous continent women (n=31) to that of continent (n=28) and formerly untreated incontinent (n=59) (53–63 years old) women. These women underwent urethral pressure measurements during rest and repeated pelvic muscle contractions. The response to the contractions was graded 0–4. The young continent women showed a mean urethral pressure response of 2.8, the middle-aged continent women 2.2 (NS vs young continent), and the incontinent women 1.5 (p<0.05 vs middle-aged continent, p<0.001 vs young continent). Urethral pressures during rest were significantly higher in the younger women than in both groups of middle-aged women. The decreased ability to increase urethral pressure on demand seen in middle-aged incontinent women compared to continent women of the same age as well as young women seems to be a consequence of a neuromuscular disorder rather than of age.

Keywords Urethral pressure response · Pelvic floor muscle contraction · Urinary incontinence · External urethral sphincter

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Introduction

Urinary continence is maintained as long as the intraurethral pressure exceeds the bladder pressure. Urethral resting pressure depends on both striated slow-fiber urethral muscles and on a smooth muscle component. The urethral muscles have not only to balance the demands from an increasing degree of filling of the bladder but it must also be able to compensate for fast changes of the abdominal pressure, i.e., during physical exertion, coughing, and sneezing [1]. The ability to quickly respond with a raise of the intraurethral pressure and also to hold it for a short while is important to maintain continence [2]. During fast changes of the intra-abdominal pressure, fast type-II fibers of the striated urethral sphincter are activated in addition to the slower type-I fibers that normally are responsible for the maintenance of the striated sphincter activity and thus continence at rest during the filling phase [3]. Other factors of importance for a successful closure of the urethra seem to be pelvic floor muscle activation as well as a bending or kinking of the urethra [4, 5].

We have found in previous studies that incontinent women have a decreased ability to increase the urethral pressure during squeeze when compared to continent women of the same age, a finding which supports that a disorder rather than age-dependent changes in urethral pressure should be expected to explain the differences [6]. These findings are in agreement with the previously reported progressively decreased pelvic floor activity, measured with vaginal surface EMG, which has been described to occur in incontinent women and also found to decrease with age. Continent women on the other hand maintained a normal pelvic floor function [7]. We asked ourselves if the ability of the urethra to react to a provocation similarly could be maintained in continent

women with increasing age but then perhaps found to be decreased only in those women who had developed urinary incontinence.

Materials and methods

A total of 118 women in three groups were recruited to the study. Two of the groups comprised continent women who were young (n=31) and middle-aged (n=28). The third group were middle-aged women (n=59) with treatment-naïve incontinence. All of the middle-aged women were recruited during the last phase of a large observational study in the south of Sweden, Women's Health in the Lund Area (WHILA, 1995–2000) [8]. WHILA invited all women between 50 and 59 years of age in 1995 in the Lund area to a screening visit where a questionnaire covering questions about general health, education status, QOL, HRT, and parameters included in the metabolic syndrome was run through. One of the questions screened for urinary leakage causing a social or hygienic problem. Thirty-two percent reported urinary incontinence according to this definition. The characteristics of these two groups have been described in detail previously [9] (Table 1). Based on history retrieved during their first visit in the study combined with a short local incontinence questionnaire, the incontinent women were categorized as 29 women having stress incontinence, and 30 having an urge component, 25 of whom with mixed urinary incontinence. The women had not formerly received surgical or conservative treatment including pelvic floor exercises for their incontinence. They had not undergone vaginal prolapse surgery nor had they any history of neurological disease. The group of young continent women comprised 20–27 years old, healthy nulliparous women, who were denying any urinary incontinence. The study was approved by the local ethics committee at Lund University. Written informed consent was given by all participants.

Table 1 Characteristics of the continent and the incontinent middle-aged women

	Continent (n=28)	Incontinent (n=60)
Age (years)	56.5±2.7	57.4±2.7
Parity	2.2±1.0 (0–4)	1.8±0.8 (0–4)
Body mass index (kg/m^2)	24.6±3.3	26.7±5.9
Premenopausal (n)	0	4 (7%)
Hormonal therapy users	20 (71%)	32 (53%)
Cystocele ≥ stage II	1 (4%)	2 (3%)

The groups do not differ significantly in any of the variables. Age, parity, and BMI are expressed as mean±SD. One of the women in the incontinent group dropped out before the urodynamic investigation due to lack of motivation.

The women recruited from the WHILA study were examined during 1999–2000 with a Lifetech 1106 (Houston, TX, USA) equipment and microtip catheters Ch 6 or Ch 7 (Medtronic, Skovlunde, Denmark) according to the recommended standards [10]. For investigation of the group of young women (June 2002–January 2004), a Duet MultiP (Medtronic, Denmark) with double-lumen, 8 Ch fluid catheters was used. Three consecutive urethral pressure profiles were recorded with the woman in the supine lithotomy position, and the mean maximum urethral pressure, maximum urethral closure pressure, and functional profile length were calculated. During continuous measurement of the intraurethral pressure in the high-pressure zone, the woman, lying flat on her back with straight legs, was asked to squeeze repeatedly. Three pelvic floor contractions, each at least 2 s long, were performed with an interval of 15–20 s. The resulting amplitude of the intraurethral pressure increase was measured, and the mean was calculated. The amplitude, shape, and visually estimated area under the squeeze-induced "pressure-rise curve" were used for a semiquantitative classification of the response on a scale from 0 to 4. The lowest grade represented the absence of pressure rise during squeeze, 1 a low but distinguishable rise, 2 a prominent peak with duration shorter than the squeeze itself, 3 a peak with a slope during the rest of the squeeze, and 4 an instant pressure rise remaining at the same level as a plateau throughout the squeeze (Fig. 1). Because there was a moment of learning during the three attempts to squeeze, and in several cases a shift of baseline between the squeezes, we chose to use the result of the first squeeze for classification. The method has been described and illustrated more in detail in a previous study [6]. During that study, we were unable to find any differences in the urethral pressure parameters between the different subgroups of incontinent women and therefore chose to use the whole group instead of merely those with stress incontinence.

The investigators (PT and AM) were blinded in the analysis of the middle-aged women, not being able to identify continent from incontinent, or in the incontinent group stress—mixed—or urge incontinent women. Due to change of urodynamic equipment at the lab, the paper prints of the results of the young women were not similar to those of the middle-aged women. Blinding between the young and the middle-aged groups was thus not possible.

Continuous data are expressed as mean±SEM unless otherwise stated. Comparisons between groups were made by Mann–Whitney U test.

Results

The characteristics of the two middle-aged groups are shown in Table 1. The group of young, nulliparous continent

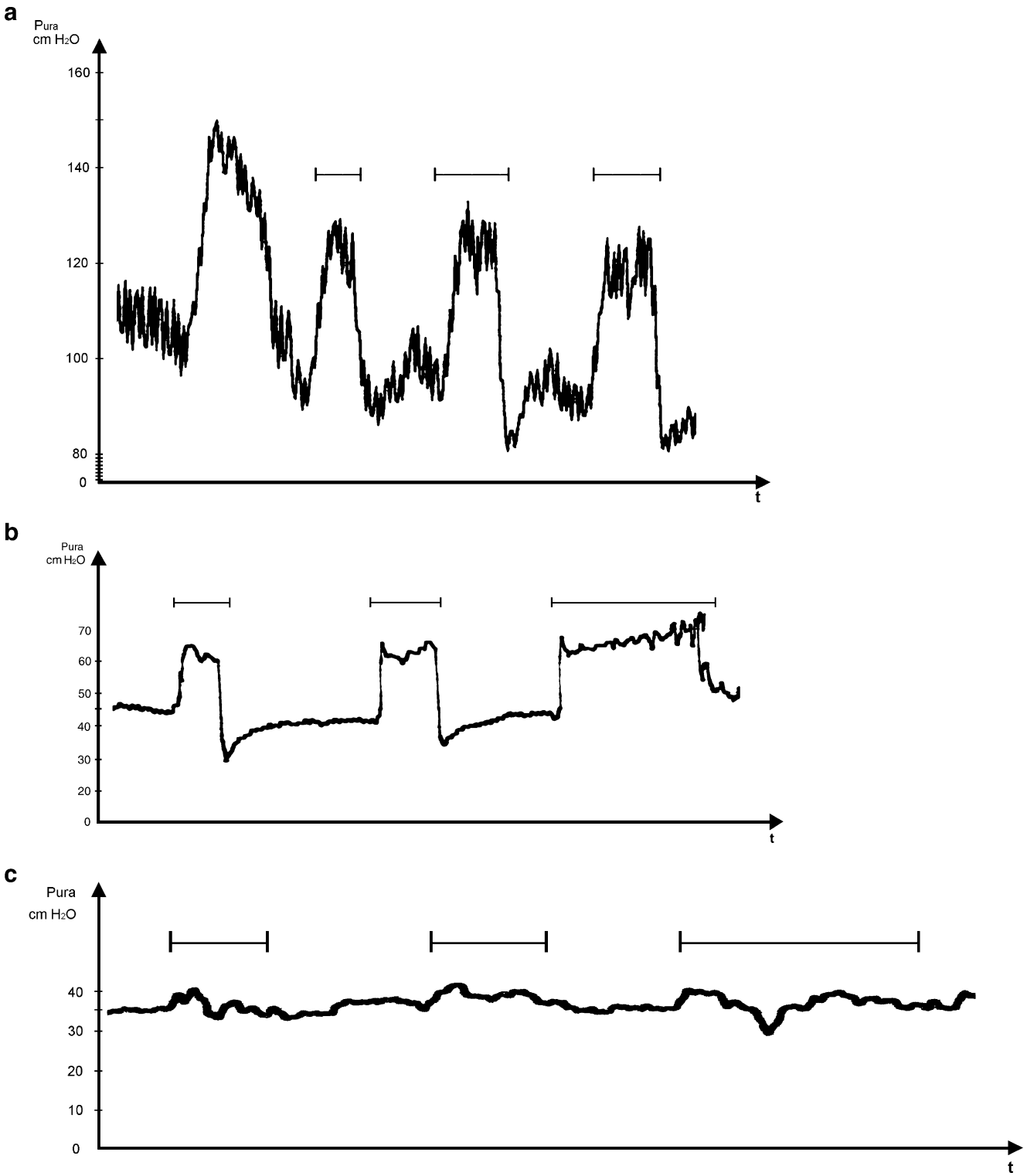

Fig. 1 Intraurethral pressure rise (Pura) during repeated pelvic floor muscle squeezes in **a** continent, nulliparous young woman **b** continent middle-aged woman, and **c** incontinent middle-aged woman

women were in average 22.9±1.7 years (mean±SD). The results of the urethral pressure measurements at rest and on provocation with squeeze are shown in Table 2. Due to technical failure, five of the urethral pressure curves had to be excluded from the study, and therefore, the results from 113 of the recruited 118 women are included in the results.

The intraurethral pressure rise on squeeze was significantly better in the group of young continent women as

Table 2 Results of conventional resting urethral pressure profile with maximum urethral pressure (MUP), maximum urethral closure pressure (MUCP), and functional profile length (FPL) and of urethral pressure rise during pelvic floor muscle contraction (amplitude and semiquantitative classification)

	Continent young	Continent middle-aged (n=28)	P value vs young	Incontinent middle-aged (n=57)	P value vs young	P value vs continent middle-aged
Urethral pressure rise semiquantitative scale	2.8±0.2 (n=28)	2.2±0.3	0.24	1.5±0.2	<0.001	0.03
Amplitude of urethral pressure rise (cm H_2O)	33.3±4.2 (n=28)	22.4±4.0	0.035	13.6±2.2	<0.001	0.02
MUP (cm H_2O)	114.0±4.6 (n=31)	67.2±3.5	<0.001	66.2±1.9	<0.001	0.94
MUCP (cm H_2O)	107.1±4.4 (n=31)	52.0±3.2	<0.001	48.1±1.9	<0.001	0.32
FPL (mm)	31.4±0.8 (n=31)	28.9±1.5	0.10	27.8±0.7	0.009	0.44

Results are expressed as means±SEM. Comparisons between groups are made by the Mann–Whitney U test.

estimated semiquantitatively compared to the findings in the group of the middle-aged women with incontinence (2.8±0.2 vs 1.5±0.2, p<0.001) (Fig. 1). When the young continent women were compared with the middle-aged continent group, no significant differences were found in intraurethral pressure increase ability during squeeze (2.8± 0.2 vs 2.2±0.3). When the continent and incontinent middle-aged women were compared, significant differences were found in the ability to raise the urethral pressure as also has been previously reported [6].

In the group of young women, both the maximum urethral pressure (MUP) and the maximum urethral closure pressure (MUCP), as well as the increase in amplitude of urethral pressure during squeeze, were significantly higher than in both of the groups of middle-aged women. On the other hand, there were no significant differences in MUP or MUCP in continent and incontinent middle-aged women. The functional profile length in young women was also significantly longer than in the incontinent middle-aged women.

Discussion

Young continent and middle-aged continent women in this study were able to increase their intraurethral pressure during pelvic floor contraction significantly better than the group of incontinent middle-aged women. Even if the intraurethral pressure at rest decreases with age in normal women, it seems that the ability to increase and hold the pressure on provocation and thus improve the ability to maintain continence is unchanged in middle-aged women as compared to the young group of continent women in this study. This finding is in agreement with previous observations of pelvic floor muscle activation on squeeze as measured with vaginal EMG. In the group of women with naïve, i.e., untreated, mild to moderate degrees of incontinence, the impaired ability to respond to squeeze with an increase of the intraurethral pressure indicates the presence of a neuromuscular disorder, i.e., an inability to activate the pelvic floor and/or the urethral muscles. The reasons for that can be several, including neuromuscular lesions, fatigue, and/or inactivity. Notably, differences were found in the intraurethral pressure only on provocation and not during rest in continent as compared to incontinent middle-aged women.

That two different techniques for urethral pressure measurement, which were used in the same study, seemed to be of minor importance because the pressure response patterns were very similar. The fact that semiquantitative evaluation also was used as a primary measure also contributes to our impression that comparisons indeed could be made successfully in spite of the use of two similar, but different, techniques [11–13]. Concordant with previous studies, young continent women were found to have higher intraurethral pressures at rest than the middle-aged continent and incontinent women [14, 15]. One drawback, however, was that blinding between the young and middle-aged groups was not possible. The significant differences in amplitude of pressure rise during squeeze, and most of all in urethral pressure during rest between young and middle-aged women, may also be influenced by the change of urodynamic equipment.

In this study, urethral pressure changes during voluntary muscle activation were recorded. Does this reflect what happens during provocation, and does it give any information as to what muscles are activated: the paravaginal muscles in the levator ani and/or the striated urethral sphincter? Thind et al. [16] concluded that urethral pressure during stress episodes was generated by intra- and/or periurethral structures. Bö and Stien [17] showed that the striated urethral muscles and the pelvic floor muscles were activated simultaneously. In a previous study [6], we saw a clear correlation between the ability to activate paravaginal/pelvic floor muscles and the ability to raise the intraurethral pressure. On the other hand, Kenton and Brubaker [18] suggested that the ability to contract the levator ani muscle was not related to the ability to activate the urethral

sphincter and suggested different roles for the two structures in maintaining continence. In addition, Miller et al. [19] showed that a considerable number of women without any pubococcygeal muscles visible on MRI were able to voluntarily raise their urethral pressure. The present study does not address the question as to what muscles are activated and contribute to the intraurethral pressure increase during squeeze. Whether the way we used to provoke activation of the pelvic floor and/or urethral muscles is comparable with the repeated everyday provocation that occurs in normal women is another issue that remains to be solved. Both the urethral sphincter mechanism and the pelvic floor with levator ani contribute to the closure of the urethra, and this might also include a certain ability for the levator to compensate for a weak sphincter.

Conclusion

Continent young women can easily increase the intraurethral pressure during repeated short squeezes of the pelvic floor/urethral sphincter. This ability is maintained in continent middle-aged women, whereas incontinent middle-aged women show a significant reduction of the pressure increase in response to squeeze. These findings correspond well with the previously reported pelvic floor EMG findings made in different age groups of continent and incontinent women. Finally, the intraurethral pressure at rest does not seem to be different in continent middle-aged women as compared to those with treatment-naïve incontinence. A loss of active urethral closure on provocation seems to be one of the first changes in the chronic female neuromuscular disorder that eventually leads to significant urinary incontinence.

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