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Original Article

Change in Urethral Pressure During Voluntary Pelvic Floor Muscle Contraction and Vaginal Electrical Stimulation

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Abstract: The purpose of the study was to compare the effect of voluntary pelvic floor muscle (PFM) contraction and vaginal electrical stimulation on urethral pressure. Twelve women with genuine stress incontinence, mean age 49.4 years (range 33–66) participated in the study. The urethral and bladder pressures were recorded simultaneously through a double-lumen 8 Ch catheter. The patients first performed three voluntary PFM contractions. Then two electrical stimulators, Conmax and Medicon MS 105, 50 Hz, were used in random order. A visual analog scale was used to measure pain and discomfort. Pain was reported to mean 6.8, SEM 0.64 (range 0.7–9.9) and mean 6.1, SEM 0.81 (range 0–9.1) with Conmax and Medicon MS 105, respectively. The mean paired difference in favor of voluntary contraction with Conmax was −8.0, SD 6.7, P=0.0067, and with Medicon MS 105 it was −12.2, SD 5.9, P=0.0022. The results demonstrated that voluntary PFM contraction increased urethral pressure significantly more than did vaginal electrical stimulation.

Keywords: Contraction; Electrical stimulation; Pain; Pelvic floor muscles; Physiotherapy; Strength; Urethral pressure

Introduction

Electrical stimulation is commonly used to treat both urge incontinence and genuine stress incontinence (GSI) [1–3]. The rationale for treating GSI with electrical stimulation is that the current will cause a pelvic floor muscle (PFM) contraction similar to a voluntary contraction, thus strengthening the PFM [1,4,5].

Several studies have demonstrated a significant strength increase after PFM exercise alone [6–9]. However, there are only few studies evaluating PFM strength increase after electrostimulation alone [10,11]. Sand et al. [11] demonstrated a significant strength increase after electrical stimulation in a placebo-controlled randomized study using a specially designed electrode. On the other hand, Hahn et al. [12] could not demonstrate any effect on PFM strength after 6 months of electrical stimulation. The results of Hahn et al. [12] correspond with those of Haig et al. [13] and Laycock et al. [14], where no additional significant benefit was found by adding electrical stimulation to a PFM strength training program.

There are few studies analyzing the effect of electrical stimulation on urethral pressure, and the mechanism of action is unclear [15]. Erlandson et al. [16] reported a huge variation in urethral pressure rise during electrical stimulation, from 2% to 118% (mean 25%). On the other hand, Bump et al. [17] demonstrated that when performing an effective voluntary PFM contraction (defined as ≥120% of the passive maximum and mean urethral closure pressure), the mean urethral closure pressure increased from 18.7 ± 2.0 to 28.1 ± 2.4 cmH_2O. We have been unable to find any published study comparing urethral pressure rise during electrical stimulation and PFM contraction in the same women.

In Norway home-based electrical stimulation is often offered as first choice of treatment for GSI, using Conmax or Medicon MS 105 [2]. In a pilot study, Bø and Maanum [18] found that electrical stimulation with these two stimulators only induced observable and perceived PFM contraction in 1 of 9 subjects, and

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caused pain and discomfort in most women. The one participant reporting that the contraction during electrical stimulation was perceived in the same way voluntary PFM contraction claimed that the contraction was much weaker than a voluntary contraction. However, the study did not involve any urodynamic assessment simultaneously with voluntary PFM contraction, or during electrical stimulation.

The aim of the present study was to evaluate whether electrical stimulation using Conmax and Medicon MS 105 increases urethral pressure, and to compare a possible change in urethral pressure during electrical stimulation with that of a voluntary PFM contraction.

Patients and Methods

Twelve women with GSI, mean age 49.9 years (range 33–66), gave their written consent to participate in the study. Mean parity was 2.3 (range 1–4). They were all participating in a PFM exercise program, training the PFM with 8–12 contractions, three sets per day, in addition to participating in a 45-minute weekly PFM exercise class according to Bø et al. [7].

The inclusion criterion was the ability to perform a correct PFM contraction. This was assessed by vaginal palpation (one finger in the distal part of the vagina) and observation of inward movement of the perineum during attempts to contract [19,20].

Two electrical stimulators, Conmax and Medicon MS 105, preset at 50 Hz, were used in random order. The amplitude of Conmax ranges from 0 to 90 mA, graded from 1 to 6 at the apparatus, and the pulse width is 0.75 ms. Medicon MS 105 has an amplitude of 0–100 mA, graded from 1 to 10 at the apparatus, and pulse width of 0.5 ms. In both stimulators the current is intermittent: Conmax 4 s on and 4 s off; Medicon MS 105 1.5 s on and 3 s off.

Procedure

Before beginning the investigation the bladder was emptied in all participants. With the patient in the lithotomy position, the urethral and bladder pressures were recorded simultaneously through a double-lumen 8 Ch catheter. The catheter was fluid perfused with 3 ml/h and connected to external transducers. The urethral pressure was recorded with the catheter lumen in the 3 o'clock position. After determining the resting urethral pressure, the catheter was taped at the site of maximal urethral pressure.

After insertion of the catheter the participants first performed three voluntary attempts at maximum PFM contraction. After a short break and randomization to stimulator number 1 or 2, the electrode from either Conmax or Medicon MS 105 was inserted into the vagina. With the current switched off, resting maximum urethral pressure was registered and the participants were again asked to perform three maximum voluntary PFM contractions. The emphasis was to contract as hard as possible and to perform a fast contraction. The intervals between the three voluntary contractions were approximately equal to the contraction time.

After a short break the patients themselves increased the current step by step to tolerance level. Maximum urethral pressure was registered, together with current intensity. The participants were asked to describe any pain and how they perceived the stimulation [18]. A visual analog scale (VAS) 0 = no pain to 10 = intolerable pain was used to quantify the degree of pain during stimulation. The current was then switched off, and the same procedure was followed with the second stimulator.

The results are given as mean + SEM. Paired differences between each stimulator and the corresponding voluntary contraction are given with means and 95% confidence intervals (CI). Differences between urethral pressure during voluntary PFM and during electrical stimulation were estimated using Wilcoxon's matched-pairs signed rank test. Differences were considered statistically significant when $P<0.05$.

Results

Voluntary PFM contraction was easy to observe in all women. The mean tolerance level with Conmax was 5.05, SEM 0.28, range 2.5–6. In 6 of 12 patients no PFM contraction could be observed during electrical stimulation. The patients who perceived a contraction described the sensation as different from a voluntary contraction. Measured with VAS, pain at the tolerance level was mean 6.8 with SEM 0.64 and range 0.7–9.9.

The mean tolerance level with Medicon MS 105 was 7.27, SEM 0.7, range 4–10. In 6 of 12 patients a contraction during electrical stimulation could not be observed, and the patients reported that the sensation was not equal to a voluntary PFM contraction. Measured with VAS, pain at the tolerance level was mean 6.1, SEM 0.81, range 0–9.1.

In 4 patients involuntary contractions of the external hip rotators or the hip adductors were observed during electrical stimulation.

The changes in urethral pressure during voluntary PFM contraction and vaginal electrical stimulation are shown in Table 1. The urethral pressure increase was significantly higher during voluntary PFM contraction than during electrical stimulation. In 4 patients there was no increase in urethral pressure: in 3 this corresponded with no observable or perceived contraction. In 2 of the subjects in whom no contraction was observed, there was a contraction of the external hip rotators.

Discussion

The main results of the study was that the urethral pressure was found to increase significantly more during voluntary PFM contraction than during vaginal electri-

Table 1. Change in maximum urethral pressure (cmH_2O) during voluntary PFM contraction and vaginal electrical stimulation ($n=12$)

	Mean	SD	SEM	95% CI	*P* value
Conmax					
Voluntary PFM	23.2	8.4	2.5		
Elec. stim.	15.2	11.5	3.3		
Paired diff.	−8.0	6.7	1.9	−12.3; −3.7	0.0067*
Medicon MS-105					
Voluntary PFM	22.6	8.8	2.6		
Elec. stim.	10.4	6.2	1.8		
Paired diff.	−12.2	5.9	1.7	−15.9; −8.4	0.0022*

* Wilcoxon matched-pairs signed rank test, two-tailed

cal stimulation. As there are several electrical stimulators available today, all with different technical parameters, these results cannot be generalized to other stimulators. However, the two stimulators tested in the present study have been used by more than 3000 women in Norway during recent years [2].

The efficacy and strength of voluntary muscle contraction is dependent upon the total number of recruited and activated motor units, the frequency of excitation and the muscle volume (cross-sectional area of the muscle) [21]. The pelvic floor muscles are difficult to contract correctly [22], therefore only women participating in a PFM exercise program, capable of conducting correct contractions, were included in this study. However, most of the patients had recently started their training period and therefore cannot be considered to be very skilled or having strong PFMs.

A voluntary contraction was easily observable in all participants as an inward lift of the perineum and squeeze around the urethra and vagina [19,20]. The urethral pressure increased during every voluntary contraction. However, there was a variation in degree of urethral pressure rise. This is in correspondence with Bump et al. [17], who demonstrated a great variation in whether a voluntary PFM contraction influenced the urethral pressure or not. One effect of regular PFM exercise may be that the contraction becomes more and more effective towards the urethra.

As electrical stimulation aims to cause a contraction of the PFM, one would expect that such a contraction would be observable from the outside in the same way as a voluntary contraction. However, in correspondence with previous reported results [18], in some women a similar contraction was not observable from the outside or perceived by the women as a voluntary contraction during electrical stimulation. In some subjects there was correspondence with no or low pressure rise in the urethra, and no observed or perceived contraction. However, although there was no visible contraction, the urethral pressure increased in most cases.

One factor that may explain why a contraction cannot be observed from the outside during electrical stimulation is that the elicited contraction is very weak. This may be due to only one of the many PFM being activated, or that only a few motor units within a single muscle have been recruited. Impedance, pulse width, current intensity, pain, technical flaws in the apparatus and placement of the electrode may explain why only part of the total muscle fibers or few of the muscles are activated [23]. On the other hand, pain itself may cause muscle contraction, and a possible contraction may therefore be a secondary effect of electrical stimulation.

Since the thickness of the PFM has been measured by ultrasound to only a mean of 9.4 mm ± 0.8 [24], correct location of the electrode inside the vagina is difficult. Erlandson et al. [16] have shown that a change in probe position of more than 5–10 mm caused a decrease in urethral response. The authors concluded that the best responses were obtained with the electrodes 'in close proximity to the PFM and probably also the pudendal nerves'.

Instructions for placement of the probe within the vagina and placement of the electrode on the probe from Medicon are based on these results. In the present study the instructions for placement of the probe in the vagina were followed and controlled by the investigator. However, individual differences in vagina anatomy and individual differences in location and volume of the PFM may explain why some women are less affected than others. In addition, long-standing peripheral nerve damage may explain a weak contraction in some women [25,26]. EMG was not used in this study, and a possible correspondence between weak contraction and peripheral nerve damage needs to be investigated in a future study.

Current intensity is an important factor for creating a muscle contraction during electrical stimulation [23,27]. During electrical stimulation an adaptation to the current occurs [23]. In the present study the participants were given time to adapt to the current and were encouraged by the investigators to increase the current as much as possible. The tolerance level achieved can be considered high and satisfactory. Most likely current intensity cannot explain why electrical stimulation caused less urethral pressure increase than voluntary PFM contractions in the present study.

Vaginal electrical stimulation caused pain in most women. However, there was a great variation in the degree of pain at the same current intensities. Pain itself may cause muscle contraction [27], thereby increasing the urethral pressure. Fall and Lindstrøm [1] state that many humans do not tolerate current intensities high enough to create contractions. Pain can be considered an undesired side effect to electrical stimulation, and has been reported in other studies [1,27]. One important factor influencing the stimulation of sensory fibers, and thereby pain, is pulse width. The pulse widths of 0.5 and 0.75 ms of the two stimulators used in the present study may be considered too high [23]. However, pain has also been reported in a study using an electrical stimulator with a pulse width within the given recommendation of 0.2 ms [11]. There seems to be a need to develop electrical stimulators that cause less pain.

The results of the present study indicate that voluntary contractions are more effective in increasing urethral pressure than vaginal electrical stimulation. There are few studies comparing the effect of electrical stimulation and voluntary PFM exercise before and after a treatment period [12–14]. Hahn et al. [12] found no effect on PFM strength after electrical stimulation (8 hours at night) or PFM exercise. Haig et al. [13] and Laycock et al. [14] were unable to detect significant differences in muscle strength by adding interferential therapy to PFM exercise.

Conclusion

Voluntary PFM contraction increased urethral pressure significantly more than did vaginal electrical stimulation. The participants demonstrated high levels of current tolerance. Electrical stimulation caused pain in most subjects. There is a need for randomized controlled trials using reproducible and valid outcome measures to compare the effects of electrical stimulation and PFM exercise to treat GSI.

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EDITORIAL COMMENT: Are pelvic floor exercises and electrical stimulation equivalent forms of therapy for genuine stress incontinence? Do they both utilize the same mechanism of action? Bø and Talseth delve deeper into this area of research by comparing the effect of electrical stimulation and voluntary pelvic floor muscle contraction on maximum urethral pressure, finding that voluntary contraction produces a significantly higher rise in maximum pressure than does electrical stimulation. These results suggest that electrical stimulation and voluntary pelvic floor exercises are not one and the same. However, many points should be made. Although the participants in the study carried a clinical diagnosis of genuine stress incontinence and could generate an appropriate pelvic floor contraction, one wonders whether a control group (continent, able to generate pelvic floor contraction) should have been included. Also lacking from the study design is a recording of

EMG activity from the pelvic floor, which might assist in identifying patients with poor placement of the vaginal probe. It is interesting that patients reported different perceived sensations in conjunction with a voluntary versus an elicited contraction. It is equally interesting that hip muscle group contraction resulted from electrical stimulation in some patients. Obviously vaginal probe placement for electrical stimulation needs to be standardized to maximize its effects.