A Psychophysiological Investigation of the Pelvic Floor. The Mechanism of Vaginism
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Voluntary control over pelvic floor muscles in women with and without vaginistic reactions

The ability to voluntarily contract and relax the pelvic floor muscles may differentiate women with and without vaginistic reactions. This was investigated using intravaginal surface electromyographic (EMG) recordings of the pelvic floor muscles and EMG measurements of the surrounding muscle groups, during muscle exercises. Sixty-seven physician- or self-referred women with vaginismus and 43 control subjects participated. They performed six short flick contractions and three 10-second holding contractions. No difference in baseline was found between groups, indicating a comparable level of relaxation. There was no difference between groups in performance of the exercises. As the women with vaginistic reactions do not have less voluntary control, treatment should not be based solely on an increase in control.
Introduction

Vaginismus is defined as an involuntary contraction of the muscles of the outer third of the vagina. The contraction interferes with coitus and occurs during attempts at penetration with for example a penis, finger, speculum or menstrual tampon (American Psychiatric Association, 1994). The muscles involved in these contractions - the pelvic floor muscles - surround the urethra, vagina and anus. They are under voluntary control and, among others, play a role in holding urine and feces when there is an urge to void or defecate. However, the pelvic floor muscles can also contract involuntarily, as is shown during orgasm (Perry & Whipple, 1981) or during vaginistic reactions. These latter contractions are spastic, as opposed to the rhythmic contractions during orgasm (Fertel, 1977).

Despite the growing interest in the pelvic floor muscles and their function, little is known about the characteristics of pelvic floor muscle activity in women with vaginistic reactions. In the literature, lack of control over these muscles is often suggested as one of the explanatory factors of vaginismus (e.g. Fordney, 1978). For example, Barnes, Bowman and Cullen (1984) suggested that patients with vaginismus have a faulty perception of vaginal muscle tone. According to the authors, these women fail to distinguish between a relaxed state and spasm and are unaware that tone can be altered voluntarily. Since the early 1940s an increase in voluntary control over the pelvic floor muscles is seen as one of the important parts of therapy (Malleson, 1942; Hall, 1952). So-called ‘Kegel-exercises’ - exercises to contract and relax pelvic floor muscles - are often advised (Colgan & Beaureais, 1977; Fertel, 1977; Barnes et al., 1984), but controlled studies on the effect of voluntary pelvic floor muscle control on vaginistic reactions have not so far appeared.

The aim of this study was to investigate voluntary control over pelvic floor muscles in women with and without vaginistic reactions. Voluntary control is defined as the ability to contract and relax the muscles when asked to do so. The exercises in this experiment consisted of short flick contractions, 10-second holding contractions and gradual contractions. As the activity of surrounding muscle groups may contribute to pelvic floor activity (Bo & Stien, 1994; Shortle & Jewelewicz, 1986), gluteal, adductor and abdominal muscle activity was also investigated.

If lack of voluntary control is an important contributing factor to vaginistic reactions, we expect women with such reactions to have less voluntary control over the pelvic floor muscles than women without them.

Patients and Methods

The subjects were 67 physician- or self-referred patients with vaginismus and 43 control subjects with no sexual or pelvic floor complaints. The mean age was 25 (SD = 6), ranging from 18 to 45 years. Almost all subjects (N = 107) had a heterosexual orientation, 2 considered themselves to be homosexual and 1 reported being bisexual. Forty-six women had a steady relationship with a mean duration of 3.4 years (SD = 3.7). All the women were nulliparous and premenopausal.

The women with vaginismus met the criteria of the Diagnostic and Statistical Manual of Mental disorders (DSM-IV)(American Psychiatric Association, 1994). These are (1) a recurrent or persistent involuntary contraction of the perineal muscles
surrounding the outer third of the vagina on an attempt at penetration with a penis, finger, tampon or speculum; and (2) marked distress or interpersonal difficulty due to the vaginistic reactions. The control subjects had no history of sexual and pelvic floor problems; they were able to insert menstrual tampons without difficulty. Forty women of the control group (93%) were experienced with vaginal intercourse. The inclusion and exclusion criteria were checked in a questionnaire assessing both pelvic floor and sexual function. For this paper this questionnaire was used to assess micturition and defecation behavior.

Fifty-five of the women in the vaginismus group (82%) had been diagnosed earlier by a general practitioner or a gynecologist, including a physical examination. Of the control women, 21 (49%) had had a gynecological examination, all without abnormal findings.

Setting and apparatus
Pelvic floor muscle activity was measured using an intravaginal surface EMG device (Perry, 1987) consisting of an acrylic plug with three electrodes lengthwise embedded in its surface. The electrodes were 3 cm in length and placed at 3, 6 and 9 o'clock. The device is 5 cm long. It was sterilized in a solution of Cidex-activated glutaraldehyde before use (Geer, 1980). Bipolar surface EMG recordings of surrounding muscle groups were made by means of Ag-AgCl pellet electrodes (1cm² contact area).

All EMG signals were recorded continuously during baselines and muscle exercises. EMG signals were recorded using a preamplifier with a frequency range of 1Hz - 1000Hz, and a gain of 1000. The output of this amplifier was led to a variable-gain contour follower with the time constant set at 25 msec, and the gain set at 60 for the pelvic floor and 30 for the surrounding muscle groups, resulting in an overall-gain of respectively 60,000 and 30,000. The output of the contour follower (commonly referred to as 'integrated EMG') was sampled at a rate of 10 samples per second using a personal computer (IBM compatible 80486/33) and a Keithley System 570 for 12-bit analogue/digital conversion, with an input range of +/- 5 volt. All physiological measures were recorded on a WEKAGRAPHER OEM 821060 thermo writer (paper speed 100mm/min.). To verify the accuracy of the measurements, the raw EMG of the pelvic floor was sampled at 100 Hz. Offline integration of this signal showed no significant difference from the output of the contour follower sampled at 10 samples per second. Therefore, the contour follower output was used for analysis.

Procedure
Subjects either responded to an advertisement in a women's magazine or newspaper or were referred by their therapist. They received written information about the procedure and were invited for an interview. During the interview the experiment was explained and questions were answered. Subjects were assured privacy, anonymity and confidentiality, and it was stressed that they could withdraw from the experiment at any time. They were asked to fill out questionnaires about their sexual and pelvic floor history and function. Women who were willing to participate signed a written informed consent form. Subjects were tested individually, but not during menstruation. At the beginning of the experimental session, the subject was asked to empty her bladder. Surface electrodes were then placed on the abdominal and adductor muscle groups. When the experimenter had left the room, the subject inserted the vaginal device, attached the electrodes to the gluteal muscles and redressed. Depth and placement of the
vaginal device were controlled by its shape, the end of the device consisting of a circular plate. Subjects were instructed to insert the probe with the cable at the 12 o'clock position such that the plate would touch the labia. All electrodes were placed according to the instructions of Fridlund and Cacioppo (1986), Basmajian (1989), and Zipp (1982). When she was ready she was asked to take a supine position and the correct attachment of the electrodes was tested by contractions of the different muscle groups.

After a relaxation period (5 min) and a first baseline measurement (30 sec) of all recorded muscle groups, the subject was asked to perform six flick contractions with her pelvic floor muscles, and then to perform 10-second holding contractions. Following these exercises there was a second baseline measurement, followed by a resting period. During this first group of exercises the subject was instructed to use the pelvic floor muscles only. The same exercises were repeated with the subject allowed to use other muscle groups that may also support the pelvic floor muscles. The third and fourth sets of exercises focused on the adductor muscle group and abdominal muscle groups respectively, and the subject was asked not to contract other related muscle groups. An exit interview inquired upon subjective experiences and feelings about the experiment.

An appointment for a second experimental session was made, during which the four sets of exercises were repeated. The results of the first experimental session were not analyzed but used to adjust the situation to make the subjects feel more comfortable and relaxed.

Data reduction, Scoring and Data analysis
All EMG data were entered into a computer program developed at our laboratory that enabled off-line graphical inspection of the raw data. For each baseline recording responses were averaged over the entire 30 second period, resulting in one baseline score (mean baseline in \( \mu \)Volts) per baseline recording. Muscle activity was calculated as a computer-detected change from the preceding baseline.

The BMDP 4V program (BMDP Statistical Software, 1990) was used for the analysis of variance. The Greenhouse-Geisser epsilon procedure was applied to the repeated measures ANOVAs to correct for the violation of the sphericity assumption in repeated measures designs.

Statistical power was computed (Cohen, 1977). Expecting a medium effect size (\( \delta = .50 \)) with \( \alpha = 0.05 \), the power was 0.83.

Results

Subjective report
The women with vaginistic reactions, as well as those in the control group, reported that they felt comfortable during the experiment, with no pain or discomfort due to insertion of the vaginal probe. Compared to the women in the control group, those with vaginistic reactions expected the experiment to be worse; in particular they expected more discomfort from inserting the vaginal device. Subjects indicated that the instructions for the exercises were clear, and most of them found it easy to perform them as instructed. Although the subjects felt they were able to contract their pelvic floor muscles, almost half indicated that it was difficult to do so without significant contraction of the surrounding muscle groups.
Voluntary control over pelvic floor muscles

Baseline
A 2 x 4 (group x trial) repeated measures ANOVA was computed to investigate differences in baseline levels of the pelvic floor muscles. There was no difference in baseline between groups ($F(1,108) = 0.47, p = 0.49$). The mean baseline was 1.36 µVolt (SD = 0.82).

Figure 1 shows a main effect for baseline, indicating a decrease in baseline over time ($F(5.19,560.96) = 13.52, p < 0.0001$).

Figure 1. Decrease in baseline, measured before the four different groups of exercises.

Figure 2. EMG registration of pelvic floor activity during the exercises.
Exercises
To investigate the flick contractions of the pelvic floor muscles, a 2 x 6 (group x trial) repeated measures ANOVA was computed using change from baseline in μVolt. No significant differences were found, indicating that the short flick contractions were equal in amplitude (mean control group = 4.48 μVolt, SD = 2.4 μVolt, mean patient group = 3.7 μVolt, SD = 2.6 μVolt). An effect for trial ($F(3.05,329.42) = 3.83$, $p < 0.01$) was significant, indicating a decrease in contraction amplitudes over time. The mean pelvic floor activity decreased from 4.04 μVolt for the first contraction to 3.85 μVolt for the sixth.

A 2 x 3 (group x trials) repeated measures ANOVA was computed for the 10-second holding contractions, and no difference was found in amplitude between the two groups. As before, the contraction amplitudes decreased over time ($F(1.87,201.62) = 4.9$, $p < 0.001$).

An example of the pelvic floor EMG recording of the exercises is given in Figure 2.

![Graphs showing EMG recordings of gluteal, abdominal, adductor muscles, and pelvic floor (integrated) and raw-EMG signals.](image)

Figure 3a. Illustration of the effect of surrounding muscle groups on pelvic floor muscle activity. Activity during the exercises for pelvic floor muscles only.
**Voluntary control over pelvic floor muscles**

**Surrounding muscle groups**

When pelvic floor exercises were performed while other supporting muscle groups were used as well, the mean amplitude of the contraction increased. However, there were no differences between groups in amplitude of the short or long contractions. The amplitude of the abdominal and adductor muscle groups during the exercises for pelvic floor muscles did not differ between groups. The effect of the surrounding muscle groups is illustrated in Figure 3.

**Relaxation**

As indicated by the main effect for baseline (see Figure 1), the instruction to relax as much as possible did not result in the lowest activity possible. Just as a high baseline level interfered with the ability to perform the exercises, as is shown in Figure 4, performance of the exercises also affected the baseline. Some women, for example, could not relax between two contractions (Figure 5). Others showed an increase in relaxation after some contractions. These different relaxation patterns were found in both groups of women.
Figure 4. Registration of the exercises of a woman with a high baseline level.

Additional analyses
The difference in activity of the surrounding muscle groups between the exercises for the pelvic floor muscles only and the second set of exercises, where surrounding muscle activity was allowed, indicated that the women tried to reduce the activity of the surrounding muscle groups during the exercises for the pelvic floor muscles only. However, in most women some minor activity of other muscles was seen. To check for the possible influence of this muscle activity, we selected a subsample of women with absolutely no activity in surrounding muscle groups during the first set of exercises. Twenty-three women could be selected, 5 in the control group and 18 in the patient group. The performances of these women on the exercises did not differ from the performances of the other women.
Hyperactivity of the pelvic floor may be a factor in vaginistic reactions, and may also cause complaints related to the other openings in the pelvic floor. Clinical evidence suggests that it may lead to hesitant micturition, bladder outlet obstruction and eventually urinary retention, constipation, irritable bowel syndrome (IBS) and obstructed defecation. Thirteen questions of the pelvic floor questionnaire were scored by two people to decide whether micturition and defecation behavior was abnormal. The inter-rater reliability was $\kappa = 0.79$, indicating the proportion of judgments in which there was agreement after chance agreement was excluded (Cohen, 1960). Results from the pelvic floor questionnaire showed that 55% ($N = 37$) of the women included in the patient group also reported abnormal micturition or defecation behavior.

The patient group ($N = 67$) was split in those with vaginistic complaints only ($N = 30$) and those with pelvic floor complaints, including women with vaginismus and micturition and/or defecation problems ($N = 37$). These two groups were compared to the control group.

The three groups differed in frequency of micturition ($F (2, 106) = 19.63, p < 0.0001$) with the pelvic floor group reporting a mean of 8.84 micturition per 24 hours ($SD = 3.13$). The pelvic floor group had a more disturbed micturition and defecation pattern than the other groups ($F (2, 106) = 15.28, p < 0.0001$).

With regard to the pelvic floor exercises, there was no difference in baseline between groups. However, there was a difference in the flick contractions between the control group and the group with pelvic floor complaints ($F (1, 78) = 7.11, p < 0.01$). This effect was not found for the three 10-second holding contractions ($F (1, 78) = 2.31, p = 0.13$). These results are shown in Figure 6.
Discussion

Although the ability to control the pelvic floor muscles is mentioned as one of the explanatory factors in vaginismus (Barnes et al., 1984; Malleson, 1942; Hall, 1952), this is not confirmed by our results. Voluntary control over pelvic floor muscles was defined as the ability to contract and relax these muscles when instructed to do so. The results indicated no difference between the women with and without vaginistic reactions. Although there is a remarkable difference between women in pelvic floor muscle activity and the ability to contract and relax the pelvic floor muscles, most women were able to perform the pelvic floor muscle exercises without difficulty. The additional analyses indicated that the amount of control may be influenced by the severity of the pelvic floor complaints. Women with complaints related to more than one opening in the pelvic floor had less activity during the short contractions than did the control women.

Most subjects indicated that their pelvic floor muscles reached maximum relaxation during the initial relaxation period. However, this subjective experience was not consistent with the recorded pelvic floor muscle activity. Although subjects were asked to relax their pelvic floor muscles as much as possible, the results indicated that during the initial baseline measurement the muscles were not in the most relaxed state, as is shown by the decrease in baseline over time. This discrepancy between subjective and physiological reports can be explained by either a limited level of muscle awareness, or by changes in muscle activity below a detectable threshold.

When investigating pelvic floor activity, both slow-twitch and fast-twitch muscle fiber activity is important. By performing flick contractions as well as 10-second holding contractions, the activity of both types of muscle fibers is taken into account (Norton, 1996). There were no differences between groups in resting tone or ability to voluntarily control the pelvic floor muscles. Thus, it is unlikely that therapy focusing exclusively on relaxation and increase of control will be successful.