# The Genito-Pelvic Pain/Penetration Disorder Paradigm and Beyond

Spoelstra, Symen Kornelis

# CHAPTER 6

## Dynamic Clinical Measurements of Voluntary Vaginal Contractions and Autonomic Vaginal Reflexes

Paul M.A. Broens
Symen K. Spoelstra
Willibrord C.M. Weijmar Schultz

Paul M.A. Broens and Symen K. Spoelstra are both first author.

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## ABSTRACT

**Introduction.** The vaginal canal is an active and responsive canal. It has pressure variations along its length and shows reflex activity. At present, the prevailing idea is that the vaginal canal does not have a sphincter mechanism. It is hypothesized that an active vaginal muscular mechanism exists and might be involved in the pathophysiology of genito-pelvic pain/penetration disorder.

**Aim.** The aim of this study was to detect the presence of a canalicular vaginal "sphincter mechanism" by measuring intravaginal pressure at different levels of the vaginal canal during voluntary pelvic floor contractions and during induced reflexive contractions.

**Methods.** Sixteen nulliparous women, without sexual dysfunction and pelvic floor trauma, were included in the study. High-resolution solid-state circumferential catheters were used to measure intravaginal pressures and vaginal contractions at different levels in the vaginal canal. Voluntary intravaginal pressure measurements were performed in the left lateral recumbent position only, while reflexive intravaginal pressure measurements during slow inflation of a vaginal balloon were performed in the left lateral recumbent position and in the sitting position.

**Main Outcome Measures.** Intravaginal pressures and vaginal contractions were the main outcome measures. In addition, a general demographic and medical history questionnaire was administered to gain insight into the characteristics of the study population.

**Results.** Fifteen out of the sixteen women had deep and superficial vaginal high-pressure zones. In one woman, no superficial high-pressure zone was found. The basal and maximum pressures, as well as the duration of the autonomic reflexive contractions significantly exceeded the pressures and the duration of the voluntary contractions. There were no significant differences between the reflexive measurements obtained in the left lateral recumbent and the sitting position.

**Conclusion.** The two high-pressure zones found in this study, as a result of voluntary contractions and, even more pronounced, as a result of reflexive contractions on intravaginal stimulation, support the hypothesis that the vaginal canal has an active and passive canalicular sphincter mechanism. Further investigation of this sphincter mechanism is required to identify its role in the sexual response and genito-pelvic pain/penetration disorder.

## INTRODUCTION

The vagina does not simply act as a passive conduit for the passage of the penis, fetus, semen, and menses, but it is also a responsive, active canal with pressure variations along its length and contractile muscular activity [1]. The anal canal and the urethra both have sphincter mechanisms [2]. Shafik presented anatomical evidence on the existence of a vaginal sphincter; however, he could not provide physiological evidence because the vaginal sphincter was inaccessible and too thin to place electrodes in for testing [3]. The vaginal wall consists of outer longitudinal and inner circular smooth muscles. Contraction of the longitudinal smooth muscles shortens and widens the vagina, whereas contraction of the circular smooth muscles constricts the vagina [4]. Vaginal smooth muscle motility is under the influence of the autonomic nervous system and is known to increase around menstruation, in order to evacuate the contents of the uterus and vagina. However, most women do not consciously feel these spontaneous contractions [5]. At present, it is not clear whether the vaginal wall itself is composed of striated muscles.



The vaginal canal is anchored within a bed of powerful striated muscles, which can be divided into four groups. From superior to inferior, these layers are (i) the endopelvic fascia attached to the superior fascia of the levator ani muscle; (ii) the pelvic diaphragm/the levator ani muscles, suspended from the fascia of the internal obturator muscle: the puborectalis muscle and the pubovisceral muscles (= the pubococcygeal muscle and the iliococcygeal muscle); (iii) the urogenital diaphragm/perineal diaphragm: the deep transverse perineal muscle (perineal membrane) and external urethral sphincters; and (iv) the superficial transverse perianal muscles and the muscles of the cavernous bodies: the bulbospongiosus muscles and ischiocavernosus muscles and the external anal sphincter [6]. There is wide interindividual variation in the size, power, and voluntary control of these striated muscles [7].

Intravaginal pressure variations occur along the length of the vaginal canal. The intravaginal pressure is a key parameter in the strength of the pelvic floor muscles in women [8]. Kegel was the first to measure this intravaginal pressure. In the 1950s, he introduced the “perineometer” to improve the strength of the pelvic floor muscles for the treatment of urinary stress incontinence in postpartum women. He observed that after the patients had completed his pelvic floor physiotherapy exercises, they not only reported relief from urinary incontinence but also improvement in sexual satisfaction [9]. Over the next 30 to 40 years, the perineometer was the gold standard to measure intravaginal pressure and hence pelvic floor strength. Although several different new devices were introduced to measure intravaginal pressure [10–12], these techniques did not correct for the pressure created by the device itself. In the late 1960s and early 1970s, it became clear that infusion manometry, after correction for the balloon, was the only technique that could measure absolute pressure [8,13,14].

In 1992, Bø was the first to attempt to distinguish variations in pressure along the vaginal canal. She found the highest intravaginal pressure 3.5 cm from the vaginal introitus, using a vaginal balloon. However, this balloon measured an average pressure at only one level. Therefore, it was not possible to provide a pressure profile along the vaginal canal [15]. In 2005, Guaderrama et al. used infusion manometry to obtain vaginal pressure profiles in 14 asymptomatic women. They concluded that the intravaginal pressure was highest in the mid-zone over a length of 3–4 cm. Peak pressure occurred in the vaginal canal approximately 2 cm cranial to the hymen. In this vaginal high-pressure zone, the maximum pressure during voluntary contraction was significantly higher than the maximum pressure at rest. Guaderrama et al. suggested that the vaginal high-pressure zone is related to the contraction of the pelvic floor musculature, but they did not indicate which particular muscles were involved [16]. In 2007, Jung et al. assessed the shape and characteristics of the vaginal high-pressure zone described by Guaderrama et al. In nine asymptomatic women, they performed ultrasound imaging of a compliant fluid-filled bag that had been placed in the vaginal high-pressure zone. When the bag volume was increased, the vaginal high-pressure zone opened with lateral vaginal wall extension first, followed by anteroposterior vaginal wall extension. Based on these observations, Jung et al. concluded that the puborectalis muscle was responsible for the vaginal high-pressure zone [2]. In 2010, Raizada et al. performed a study on 16 asymptomatic women, using a side-hole infusion manometry technique to measure contact pressure at point locations. Ultrasound and magnetic resonance imaging revealed a vaginal high-pressure zone in the distal part of the vagina [8].

The anal canal, vaginal canal, and urethra have a common embryological origin. During the fourth to seventh week of embryological development, the cloaca becomes separated by the urorectal septum into the urogenital sinus ventrally (which develops into the urethra and vaginal canal) and into the anorectal canal dorsally [17,18]. Based on this knowledge, we hypothesized that the vaginal canal has a canalicular sphincter mechanism, analogous to the anal canal and urethra. This active mechanism in the vaginal canal could contribute to the sexual response and might explain why, in genito-pelvic pain/penetration disorder, vaginal penetration is difficult or even impossible. The purpose of this study was to detect the presence of a canalicular vaginal sphincter mechanism by measuring intra-vaginal pressure at different levels of the vaginal canal during voluntary pelvic floor contractions and during induced reflexive contractions.

## METHODS

### Participants

The study was conducted on 16 asymptomatic nulliparous women at the Department of Obstetrics and Gynaecology and Sexology and the Department of Surgery, Anorectal Physiology Laboratory of the University Medical Center in Groningen, the Netherlands. In the period from June 2012 to January 2013, 21 women without pelvic floor trauma and sexual dysfunction were recruited by an advertisement sent by e-mail to the medical students at the medical school at the University of Groningen. Interested candidates received a written letter with information about the study.



Prior to participation, all the subjects signed an informed consent form and completed a general demographic and medical questionnaire to provide insight into their characteristics and to confirm the absence of sexual dysfunction and pelvic floor trauma. Participants received a small financial compensation for their participation.

Inclusion criteria were (i) asymptomatic; (ii) nulliparous; (iii) aged between 18 and 45 years; (iv) able to read and understand the Dutch language; and (v) prepared to give signed informed consent. Exclusion criteria were (i) (current and past) pregnancy; (ii) a history of pelvic floor trauma and/or surgery; and (iii) sexual dysfunction.

### Manometry Catheter, Data Recording, and Data Analysis

To measure intravaginal pressure and vaginal contractions at different levels in the vaginal canal, a high-resolution solid-state (Boston-type) circumferential catheter (Unisensor K12981, Attikon, Switzerland) was used with an outer diameter of 12F (= 4 mm). Boston-type sensors do have small balloons around the catheter with one microtip transducer inside. Therefore, they measure the mean surrounding pressure at their location. These are absolute pressures. This catheter measured the mean pressure at intervals of 8 mm over a total length of 6.8 cm into the vaginal canal. The sample frequency of the measuring equipment is 50 Hz. The color scheme as used in Figure 1 is a simple transformation of the measured pressures in mm Hg. The lowest pressures (0 mm Hg) is dark blue, while the highest pressure 180 mm Hg is presented as purple as can be seen on the left side of the figure (Figure 1).

Another catheter (Unisensor K14204) with an outer diameter of 14F (= 4.7 mm), equipped with two microtip sensors alone, was connected to a vaginal balloon that was inflated with water at 37°C during the vaginal filling test while recording the pressure inside the balloon. This catheter was placed anteriorly to the earlier mentioned Boston-type catheter. The pressures measured inside this vaginal balloon were corrected for the resistance of the balloon itself as every balloon does not have a linear resistance [19]. Therefore, real absolute vaginal pressures were obtained. The data were recorded and analyzed with the high-resolution manometry equipment version 8.23 (Medical Measurement Systems, Enschede, The Netherlands).

## Test Procedure

Two tests were performed by a female nurse-practitioner, under the supervision of a surgeon with extensive experience with intracorporal pressure measurements and a gynecologist/sexologist, under nonerotic circumstances. The method of instruction was standardized.

First, the "voluntary vaginal contraction test" was conducted in the left lateral recumbent position. During this test, the circumferential catheter, carefully fixed to the buttocks of the participant, was placed into the vaginal canal. Then the basal vaginal pressure was measured, followed by the maximum pressure during maximal voluntary pelvic floor contraction. This contraction pressure was recorded three times; the highest value was used for analysis.

Second, the "vaginal filling test" was performed in the left lateral recumbent position and in the sitting position, to evaluate whether the outcomes were position dependent. With the circumferential catheter still in situ, a collapsed balloon connected to a second catheter was placed into the vaginal canal. When the patient was completely relaxed, the balloon was inflated very slowly (0.5 mL/second) with water at 37°C. During inflation, the pressure in the vaginal balloon (corrected for the pressure of the balloon itself), the pressure on different levels in the vagina canal, and the volume of water inflated into the balloon were recorded. The women were instructed to retain the balloon for as long as possible. The test was stopped when the patient had reached the limit of tolerance. Then the balloon was emptied completely. Subsequently, the test was repeated in sitting position.

The study was approved by the Medical Ethical Board of the University Medical Centre in Groningen.

### Statistical Analysis

The data were analyzed with SPSS for Windows, version 20.0 (IBM SPSS Statistics, IBM Corporation, Armonk, NY, USA). Nonparametric tests were used, because the distribution of (some of) the data was not symmetrical. Consequently, median and range (minimum and maximum) values are given. The Wilcoxon paired data rank test was used to compare differences between the parameters in the study group. A P value of $<0.05$ was considered to be statistically significant.

## RESULTS



### Study Population

Originally, 21 women were recruited for the study. Five subject measurements were excluded because of technical problems with pressure recording. Ultimately, 16 nulliparous subjects completed the study and had evaluable data. They did not report any adverse side effects.

Mean age of the subjects was 23 years (standard deviation [SD] 3.5; range 20–32). Mean weight was 68 kg (SD 4.7; range 61–76) and mean height was 172 cm (SD 5.2 range; 163–180). All the participants had a high education level: 87.5% university and 12.5% higher education. The majority of the women in the study population were students (87.5%) (Table 1).

One woman had attention deficit hyperactivity disorder for which she was receiving methylphenidate; none of the other women were using medication. Fifty percent of the women had a heterosexual relationship. None of the women reported homosexual orientation.

Ten women were sexually active (62.5%), whereas six women were not sexually active (37.5%). The majority of the women (56%) were using an oral contraceptive; three women (19%) had an intrauterine device and one woman was using condoms for contraception (6%). Three women (19%) were not using any contraceptives at all. Two out of the 16 participants had contracted a sexually transmitted disease in the past (chlamydia and human papillomavirus, respectively). None of the women in the study reported sexual abuse. None of the women had pelvic floor trauma or surgery and none reported sexual dysfunction.

**TABLE 1 |** Demographic and medical characteristics of the study population

| | | Study population (N = 16) | |
|---|---|---|---|
| | | Mean (SD) or n | % |
| Age (years) | | 23 (SD 3.5) | |
| Weight (kg) | | 68 (SD 4.7) | |
| Height (cm) | | 172 (SD 5.2) | |
| Highest education | University | 14 | 87.5 |
| | Higher education | 2 | 12.5 |
| Student | Yes | 14 | 87.5 |
| | No | 2 | 12.5 |
| Diseases | ADHD | 1 | 6 |
| | No diseases | 15 | 94 |
| Use of medication | Methylphenidate | 1 | 6 |
| | No | 15 | 94 |
| Relationship | Heterosexual | 8 | 50 |
| | Homosexual | 0 | 0 |
| | No relationship | 8 | 50 |
| Sexually active | Yes | 10 | 62.5 |
| | No | 6 | 37.5 |
| Use of contraceptive | Condoms | 1 | 6 |
| | Oral contraceptive | 9 | 56 |
| | Intrauterine device | 3 | 19 |
| | No | 3 | 19 |
| Sexual transmitted infections in the past | Yes | 2 | 12.5 |
| | No | 14 | 87.5 |
| Sexual abuse | Yes | 0 | 0 |
| | No | 16 | 100 |
| Pelvic floor trauma/operations | Yes | 0 | 0 |
| | No | 16 | 100 |
| Dyspareunia and sexual dysfunction | Yes | 0 | 0 |
| | No | 16 | 100 |

ADHD = attention deficit hyperactivity disorder; SD = standard deviation

## Voluntary Vaginal Contraction Measurements in the Left Lateral Recumbent Position

### *Deep and Superficial*

Median deep vaginal basal pressure was 5 mm Hg (range 0–30); median deep vaginal maximum squeeze pressure was 45 mm Hg (range 10–110). Median superficial vaginal basal pressure was 15 mm Hg (range 5–35); median superficial vaginal maximum squeeze pressure was 65 mm Hg (range 15–115) (Table 2).

**TABLE 2 |** Voluntary and reflexive contractions in the left lateral recumbent position

| | | Voluntary vaginal contraction in left lateral recumbent position (n = 16) | | | Reflexive vaginal contraction in left lateral recumbent position (n = 12) | |
|---|---|---|---|---|---|---|
| | | median | range | Wilcoxon rank test | median | range |
| Deep | Basal vaginal pressure (mmHg) | 5 | 0-30 | 0.006 | 15 | 0-30 |
| Deep | Maximum vaginal pressure (mmHg) | 45 | 10-110 | 0.006 | 173 | 90-225 |
| | | median | range | Wilcoxon rank test | median | range |
| Superficial | Basal vaginal pressure (mmHg) | 15 | 5-35 | 0.032 | 25 | 0-105 |
| Superficial | Maximum vaginal pressure (mmHg) | 65 | 15-115 | 0.015 | 145 | 30-225 |

P < 0.05 = significant



## Reflexive Vaginal Contraction Measurements in the Left Lateral Recumbent Position

### *Deep*

Median vaginal basal pressure was 15 mm Hg (range 0–30). Median starting point of reflexive contraction after balloon filling was 53 mL (range 20–95), with a local vaginal pressure of 25 mm Hg (range 10–40). Median maximum reflexive contraction after balloon filling was 175 mL (range 90–340), with a local vaginal pressure of 173 mm Hg (range 90–225). Median local vaginal contraction duration was 307 seconds (range 172–555). Median maximum vaginal balloon pressure was 50 mm Hg (range 5–90), and the maximum length of the local vaginal high-pressure zone was 3 cm (range 2–4) (Tables 2 and 3).

**TABLE 3 |** Reflexive contractions in the left lateral recumbent position and in sitting position

| | | Reflexive vaginal contraction in left lateral recumbent position (n = 12) | | | Reflexive vaginal contraction in sitting position (n = 16) | |
|---|---|---|---|---|---|---|
| | | median | range | Wilcoxon rank test | median | range |
| Deep | Basal vaginal pressure (mmHg) | 15 | 0-30 | NS | 18 | 5-60 |
| | Starting point reflexive contraction: after balloon filling (ml) | 53 | 20-95 | NS | 68 | 10-135 |
| | Starting point reflexive contraction: local vaginal pressure (mmHg) | 25 | 10-40 | NS | 30 | 10-85 |
| | Maximum reflexive contraction: after balloon filling (ml) | 175 | 90-340 | NS | 160 | 75-315 |
| | Maximum reflexive contraction: local vaginal pressure (mmHg) | 173 | 90-225 | NS | 165 | 60-460 |
| | Maximum local vaginal contraction duration (s) | 307 | 172-555 | NS | 305 | 100-525 |
| | Maximum vaginal balloon pressure (mmHg) | 50 | 5-90 | NS | 45 | 5-100 |
| | Maximum length of local vaginal high pressure zone (cm) | 3 | 2-4 | NS | 2.6 | 2-4 |
| | | median | range | Wilcoxon rank test | median | range |
| Superficial | Basal vaginal pressure (mmHg) | 25 | 0-105 | NS | 30 | 5-115 |
| | Starting point reflexive contraction: after balloon filling (ml) | 90 | 30-225 | NS | 78 | 5-150 |
| | Starting point reflexive contraction: local vaginal pressure (mmHg) | 35 | 15-55 | NS | 38 | 15-91 |
| | Maximum reflexive contraction: after balloon filling (ml) | 153 | 30-275 | NS | 135 | 75-310 |
| | Maximum reflexive contraction: local vaginal pressure (mmHg) | 145 | 30-225 | NS | 160 | 25-455 |
| | Maximum local vaginal contraction duration (s) | 155 | 70-640 | NS | 240 | 70-420 |
| | Maximum length of local vaginal high pressure zone (cm) | 1.5 | 2-3 | NS | 2.2 | 2-3 |

P < 0.05 = significant
NS = not significant

***Superficial***

Median vaginal basal pressure was 25 mm Hg (range 0–105). Median starting point of reflexive contraction after balloon filling was 90 mL (range 30–225), with a local vaginal pressure of 35 mm Hg (range 15–55). Median maximum reflexive contraction after balloon filling was 153 mL (range 30–275), with a local vaginal pressure of 145 mm Hg (range 30–225). Median local vaginal contraction duration was 155 seconds (range 70–640), and the maximum length of the local vaginal high-pressure zone was 1.5 cm (range 2–3) (Tables 2 and 3).

## Reflexive Vaginal Contraction Measurements in the Sitting Position



***Deep***

Median vaginal basal pressure was 18 mm Hg (range 5–60). Median starting point of reflexive contraction after balloon filling was 68 mL (range 10–135), with a local vaginal pressure of 30 mm Hg (range 10–85). Median maximum reflexive contraction after balloon filling was 160 mL (range 75–315), with a local vaginal pressure of 165 mm Hg (range 60–460). Median local vaginal contraction duration was 305 seconds (range 100–525). Median maximum vaginal balloon pressure was 45 mm Hg (range 5–100), and the maximum length of the local vaginal high-pressure zone was 2.6 cm (range 2–4) (Table 3; Figure 1).

***Superficial***

Median vaginal basal pressure was 30 mm Hg (range 5–115). Median starting point of reflexive contraction after balloon filling was 78 mL (range 5–150), with a local vaginal pressure of 38 mm Hg (range 15–91). Median maximum reflexive contraction after balloon filling was 135 mL (range 75–310), with a local vaginal pressure of 160 mm Hg (range 25–455). Median local vaginal contraction duration was 240 seconds (range 70–420), and the maximum length of the local vaginal high-pressure zone was 2.2 cm (range 2–3) (Table 3; Figure 1).

There were no significant differences between the measurements obtained in the left lateral recumbent position and the sitting position (Table 3).

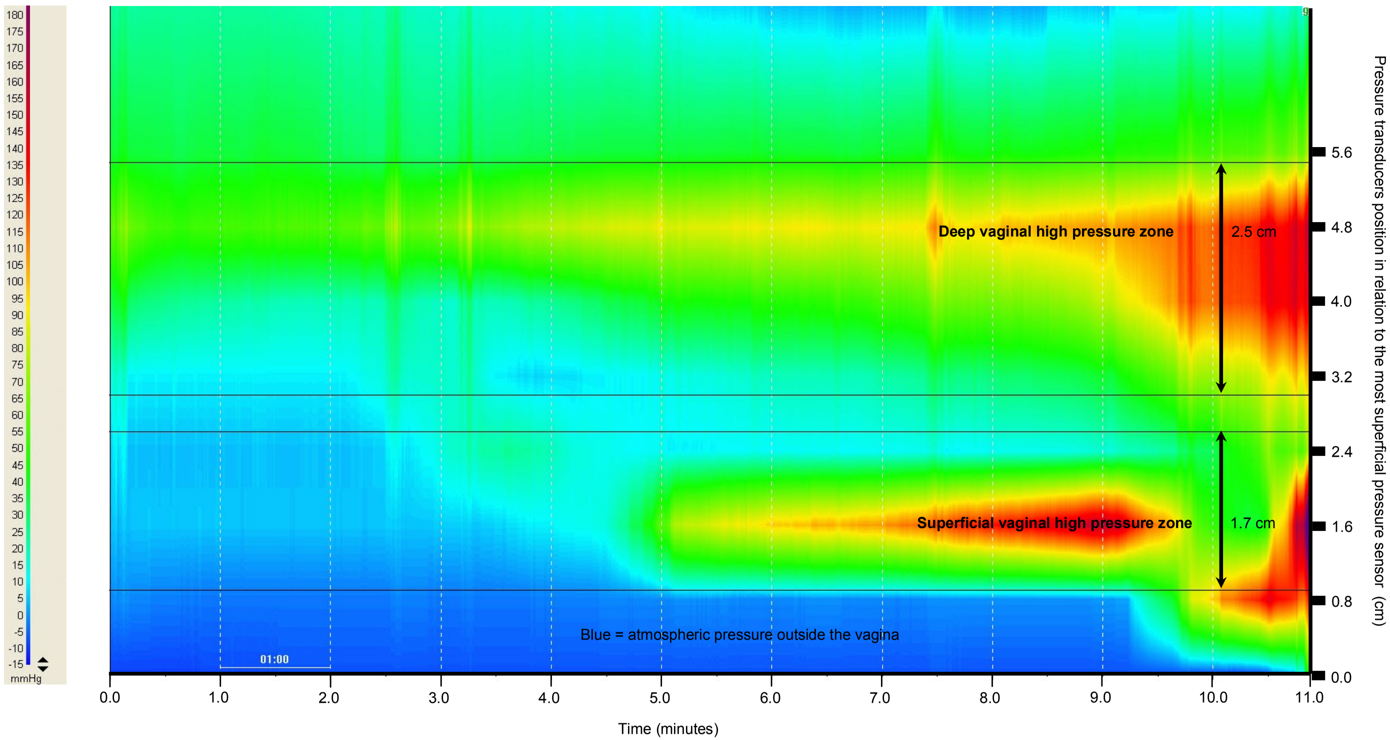


**Figure 1 | Deep and superficial vaginal high-pressure zones during filling of the vaginal balloon.** Dynamic pressure profile during slow filling of the vaginal balloon in the sitting position of one asymptomatic, nulliparous woman. On the left side, color translation can be seen of the measured local vaginal pressures. Blue means atmospheric pressure (outside the vagina); red means high-pressure recording. On the horizontal axis, the duration of contraction can been seen. The right vertical axis shows the position of the pressure transducers (black stripes) in relation to the most superficial pressure sensor. The position in the vaginal canal can be calculated from the location of the atmospheric pressure recording. The deep and superficial high-pressure zones are indicated in the figure. Borders of the high-pressure zones are marked with black horizontal lines (deep and superficial). During balloon filling, the local pressure recording catheter moved a little bit up inside the vaginal canal. This explains why the superficial high-pressure zone was partly displaced outside the vaginal canal.

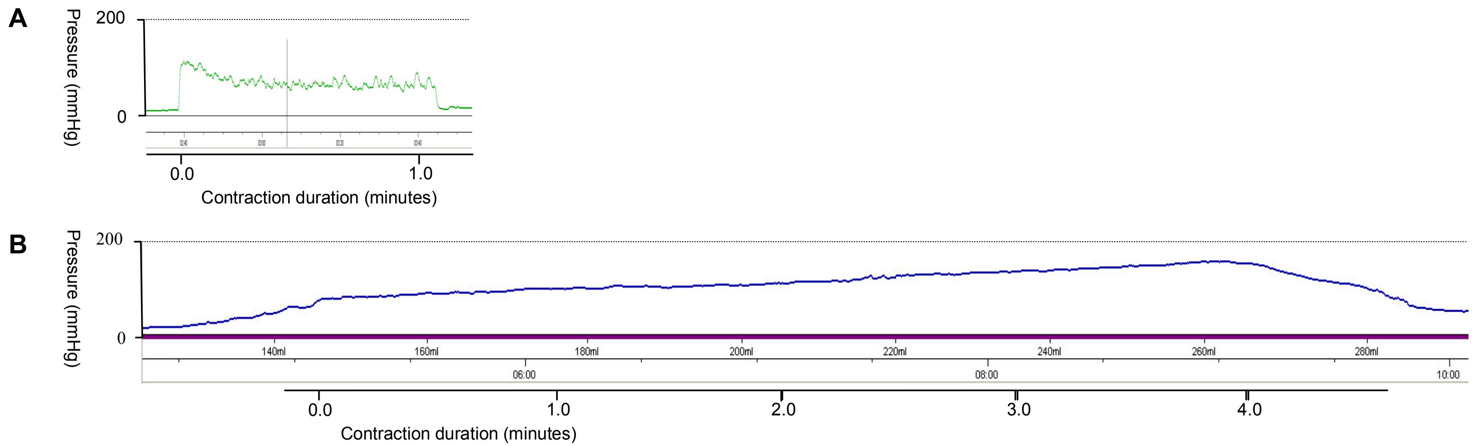


**Figure 2 | Example of voluntary vs. reflexive contractions of the vagina of one asymptomatic, nulliparous woman.** (A) Voluntary contraction in the left lateral recumbent position: low, gradually decreasing and fluctuating pressures with a relatively short duration (less than 1.5 minutes). (B) Reflexive contractions in the sitting position: much higher, gradually increasing pressures of much longer duration (up to 6+ minutes).

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## DISCUSSION

Voluntary contractions and reflexive contractions were measured with the voluntary vaginal contraction test and the vaginal filling test, respectively. Voluntary contractions were characterized by low (decreasing) and fluctuating pressures ("cogwheel phenomenon") of short duration (less than 1.5 minutes). In contrast, reflexive contractions were characterized by much higher (increasing) pressures of much longer duration (even longer than 6 minutes) (Figure 2). Strikingly, the basal pressure, maximum pressure, and duration of the reflexive contractions significantly exceeded the pressures and duration of the voluntary contractions. These high vaginal pressures were registered with low pressures in the vaginal balloon (Table 3). Obviously, low intravaginal pressure provokes contractions of the vagina and/or surrounding muscles. This implies a (autonomic) reflexive process. There were no significant differences between the reflexive measurements obtained in left lateral recumbent position and those obtained in the sitting position. Apparently, the reflexive contractions were not position dependent.

This study revealed that 15 out of the 16 women had two separate vaginal high-pressure zones: a deep high-pressure zone (median length 2.6 cm) and a superficial high-pressure zone (median length 2.2 cm). Even a very low pressure in the balloon resulted in powerful reflexive contractions in these two areas of the vaginal canal. In one woman, no superficial vaginal high-pressure zone was measured and this could not be attributed to technical failure. Her medical history did not account for this observation. A possible explanation is anatomical variation, for example, absent or defective receptors/reflex in this area.

Based on our findings, we hypothesize that the deep high-pressure zone represents the "deep vaginal sphincter," i.e., puborectalis muscle contraction, mediated by the vagino-puborectalis reflex [20]. We further postulate that the superficial vaginal high-pressure zone represents the "superficial vaginal sphincter," i.e., bulbocavernosus muscle contraction, mediated by the superficial vagino-bulbocavernosus reflex. In a study of Shafik, both the vagino-puborectalis reflex and vagino-bulbocavernosus reflex were absent upon distension of the anesthetized vagina, which implies that afferent receptors are located somewhere deep and superficial in the vaginal canal [21].

At present, the pathophysiology of female sexual pain disorders, renamed in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition as genito-pelvic pain/penetration disorder, is not fully understood [22]. We theorize that the canalicular vaginal sphincter mechanism identified in this study could play a substantial role in female sexual (dys)functioning. In 1995, Shafik suggested that during vigorous penile thrusting, the vagina distends and two genito-pelvic reflexes might be triggered: the vagino-bulbocavernosus reflex and the vagino-puborectalis reflex [20]. It has also been suggested that during orgasmic arousal or because of penile thrusting, simultaneous contraction of the puborectalis muscle and the bulbocavernosus muscle narrows the vaginal tube and the vaginal introitus. At the same time, the contractions of the pubococcygeus muscle and iliococcygeus muscle (owing to their lateral pull directions) contribute to the tenting effect [20,23]. Masters and Johnson have assumed that orgasms come about by stimulation of various genital areas that have the same feeling quality [24]. Others distinguish two or even three different types of orgasmic feelings: clitoral/vulvar, vaginal (vaginal wall), and uterine/cervical [25]. More frequent vaginal orgasm is associated with experiencing greater excitement from deep vaginal stimulation [26]. Brody et al. found that current sensitivity and responsiveness of the cervix are associated with greater vaginal orgasm consistency, which might be due to (at least in part) the different neurophysiological projections of those regions in comparison with other genital areas. Whether these "specific neurophysiological projections" also might be involved in our voluntary and reflexive contractions, as response to intra-vaginal stimulation, is obvious, but needs confirmation by research focusing on these voluntary contractions and autonomic reflexes under erotic conditions.



When we apply our results to genito-pelvic pain/penetration disorders, our hypothesis is that in lifelong vaginismus, autonomic reflexive contractions in the bulbocavernosus muscles occur. We also postulate that in the initial stages of dyspareunia, voluntary contractions in the puborectalis muscle and bulbocavernosus muscle occur (as a defense mechanism) [27]. It is reported that the pelvic floor is indirectly innervated by the limbic system [28]. Therefore, it is reasonable that the pelvic floor muscles respond to emotional stimuli and/or states, such as anxiety [29]. In a study of Broens et al., they proved that a comparable anal-external sphincter continence reflex is started by stimulation of anal submucosal receptors [30]. Most likely this superficial vaginal reflex will be triggered on the same way. Long-lasting contractions of the vagina may induce mucosal injury followed by an overreaction of the autonomic reflexive contractions of these muscles, which makes it impossible to differentiate vaginismus from dyspareunia on the basis of clinical examination.

Our study has a number of limitations. Prior to the tests, no manual examination of the pelvic floor muscles on the asymptomatic women was performed. Although all participants reported no sexually or pelvic floor complaints, theoretically it might have been possible that some women were not able to contract and relax their pelvic floor muscles adequately. However, the median basal pressures measured in these women were 25 mm Hg. This makes it unlikely that these women had an overactive pelvic floor. Moreover, this would not have affected the outcome of the study because voluntary contractions were compared with reflexive contractions within the same woman. In 1 woman out of 16 women, no superficially high pressure zone could be detected. Because of a low number of participants, we cannot predict the prevalence of this anatomical/physiological variant.

A significant next step would be to investigate intravaginal pressures and the vaginal reflex profile in women with lifelong vaginismus and dyspareunia. Detailed knowledge of the intravaginal pressures and vaginal contractions in these two patient groups may help to identify the specific pathogenesis of these severely distressing conditions. In addition, it would also be interesting to investigate the role of different emotional stimuli (e.g., disgust) on pelvic floor muscle contractions in healthy subjects and women with genito-pelvic pain/penetration disorder

## CONCLUSION

The two high-pressure zones found in this study, as a result of voluntary contractions and, even more pronounced, as a result of reflexive contractions on intravaginal stimulation, support the hypothesis that the vaginal canal has an active and passive canalicular sphincter mechanism. Further investigation of this sphincter mechanism is required to identify its role in the sexual response and the genito-pelvic pain/penetration disorder.

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