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Effects of Sexual Arousal on Genital and Non-Genital Sensation: A Comparison of Women with Vulvar Vestibulitis Syndrome and Healthy Controls

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Abstract The relationship between sexual arousal and sensory perception has been a topic largely neglected within the realm of human sexuality research. The present study assessed the influence of sexual arousal on genital and non-genital sensation in women. It also examined the theory that painful intercourse is associated with insufficient sexual arousal. A total of 20 healthy women and 20 women with Vulvar Vestibulitis Syndrome (VVS) underwent genital and non-genital sensory testing at baseline and in response to erotic and neutral stimulus films. Touch and pain thresholds were assessed at the vulvar vestibule, inside the labia minora, and on the volar surface of the forearm. Sexual arousal was assessed via the measurement of surface skin temperature changes of the labia minora using a labial thermistor clip. Participants also completed questionnaires pertaining to mood, pain, and sexual functioning. In response to the erotic stimulus, both groups evidenced a significant increase in physiological sexual arousal and vulvar sensitivity. Women with VVS reported a significantly lower desire to engage in intercourse after having viewed the erotic film and reported lower levels of desire and arousal on questionnaire measures. Women with VVS also exhibited significantly more genital and non-genital pain sensitivity than healthy women across all conditions, in addition to more catastrophizing, hypervigilance, and fear of pain. Contrary to some theories, these data suggest that women with VVS are not lacking in physiological sexual arousal, and that physiological sexual arousal may actually increase vulvar sensation. Lack of subjective sexual arousal, however, may yet be implicated in vulvar pain during intercourse.

Keywords Sensation · Sexual arousal · Dyspareunia · Vulvar vestibulitis syndrome · Labial thermistor clip

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Introduction

The line between pain and pleasure has never been a clear one, particularly when it comes to sexuality. This is illustrated by sadomasochistic behavior during which some individuals experience noxious stimuli as sexually pleasurable or incorporate mildly painful stimuli, such as spanking or scratching, into their sexual repertoires. Similarly, sexual arousal has long been believed to influence sensory touch and pain perception, though very little data exist regarding this. In media, literary, and historical depictions of sexual activity, we see both expressions of intense delight with the slightest touch and, paradoxically, increased tolerance of and expressions of pleasure in response to noxious stimuli. In

addition, contradictory sources have suggested that sexually aroused individuals are both more and less sensitive to stimuli (Kinsey, Pomeroy, Martin, & Gebhard, 1953; Masters & Johnson, 1966). These seemingly contradictory reports may, in part, be the result of a lack of distinction between touch and pain, where the influence of sexual arousal may be different.

Supporting a link between sexual arousal and sensation, lack of sexual arousal has commonly been hypothesized to play an etiological role in dyspareunia (Bancroft, 1989; Hawton, 1985; Lazarus, 1989). During the female sexual response cycle, many physiological changes accompany sexual excitement. These include lubrication, separation of the labia minora, distension of the vaginal canal, and elevation of the cervix and uterus (Masters & Johnson, 1966). Presumably, if a woman were to attempt vaginal penetration in the absence of physiological sexual arousal, this would result in pain due to increased friction and collision. Beyond anatomical considerations, however, it remains uncertain what effect, if any, sexual arousal has on sensory perception.

We have been unable to find published data examining the influence of sexual arousal on genital sensation in women. Some research has been conducted, however, on the influence of vaginal stimulation and sexual arousal on peripheral sensation. Most notably, Whipple and Komisaruk (1985) demonstrated a decrease in finger pain sensitivity in response to vaginal self-stimulation (pressure applied to the anterior vaginal wall) in healthy women, but found no changes in sensitivity to touch. This effect was even more pronounced when the stimulation was perceived as pleasurable or produced orgasm (Whipple & Komisaruk, 1988). Paradoxically, increases in pain sensitivity of the hand have been shown in response to auditory sexual stimuli in women (King & Alexander, 2000). The difference in findings between these two studies may be attributable to the nature of the different stimuli used; however, it would seem unlikely that the influence of vaginal stimulation and arousal would be opposing.

With respect to sexual dysfunction, King and Alexander (2000) demonstrated lower pain sensitivity to be associated with weaker sexual motivation, lower sexual enjoyment, and increased sexual inhibition. Reduced finger sensitivity to touch has also been associated with a decrease in desire in healthy women and those undergoing fluoxetine treatment (Frohlich & Meston, 2005a). In women undergoing fluoxetine treatment, lower finger touch sensitivity was associated with lower levels of sexual arousal. These findings, however, could be attributable to a general drug blunting effect. In another investigation by Frohlich and Meston (2005b), women suffering from Sexual Arousal Disorder exhibited lower finger touch sensitivity, and this was significantly associated with the severity of the condition. Reduced genital sensation has also been found in sexually dysfunctional women (Byun, Yoon, & Hong, 2004; Romanzi, Groutz, Feroz, & Blaivas, 2001). Taken together, these data suggest a link between sexual dysfunction and reduced touch and pain peripheral sensitivity. Dyspareunia, however, represents a state of heightened pain sensitivity associated with sexual dysfunction.

Supporting the theory that dyspareunia is associated with low sexual arousal, affected women commonly report a lack of sexual arousal, along with lower frequencies of intercourse and self-stimulation, lower levels of desire and pleasure, less success at achieving orgasm through intercourse and oral stimulation, and more negative attitudes towards sexuality than matched controls (Meana, Binik, Khalifé, & Cohen, 1997a; Reissing, Binik, Khalifé, Cohen, & Amsel, 2003). Lack of sexual arousal, however, may not be the only factor associated with pain perception during coitus as women suffering from dyspareunia share many commonalities with other chronic pain sufferers. These include elevated levels of anxiety (Gates & Galask, 2001; Nunns & Mandal, 1997; Payne, Binik, Amsel, & Khalifé, 2005), depression (Dunn, Croft, & Hackett, 1999; Jantos & White, 1997; Nylanderlundqvist & Bergdahl, 2003), somatization (van Lankveld, Weijenborg, & Ter Kuile, 1996; Wylie, Hallam-Jones, & Harrington, 2004), catastrophization (Pukall, Binik, Khalifé, Amsel, & Abbott, 2002), and hypervigilance for pain-related stimuli (Payne et al., 2005). Hypervigilance to threat in particular has been hypothesized to distract sexually dysfunctional patients away from erotic stimuli resulting in dysfunctional sexual arousal (Barlow, 1986; Dove & Wiederman, 2000; van den Hout & Barlow, 2000), which itself has been hypothesized to exacerbate the pain experience in women with dyspareunia (Payne et al., 2005).

Wouda et al. (1998) compared sexual arousal in women suffering from dyspareunia and healthy controls in response to visual sexual stimuli using vaginal pulse amplitude (VPA). While watching scenes depicting oral sex, both groups exhibited similar increases in physiological sexual arousal. However, while watching segments showing coitus, a further increase in vasocongestion in control women and a decrease in women with dyspareunia was found. Women suffering from dyspareunia did not report this same decrease on measures of subjective sexual arousal, suggesting that they did not subjectively experience these scenes as less sexually arousing. Subjective arousal, however, was assessed only after presentation of both stimulus films in the same order (oral followed by coitus). This may have made it difficult for participants to distinguish or remember differential subjective responses to the two stimuli. In a subsequent investigation by Brauer, Laan, and ter Kuile (2006), physiological and subjective sexual arousal were compared among women suffering from dyspareunia and healthy controls in response to stimuli depicting oral sex and coitus. Subjective sexual arousal was assessed immediately following each stimulus film. Contrary to Wouda et al.'s findings, women with dyspareunia obtained higher genital responses to the coital stimulus and

lower responses to the stimuli depicting oral sex. Women with dyspareunia also reported less positive feelings in response to the erotic films.

The contradictory findings obtained from these two studies fail to clarify the role of sexual arousal in dyspareunia. Furthermore, neither study explicitly examined the link between sexual arousal and genital sensation. Part of the difficulty may result from the use of the vaginal photoplethysmograph and its corresponding VPA signal. Most notably, VPA is a relative unit of measurement unsuitable for between-subjects comparisons (Janssen, 2002), in the absence of a large sample size. Also, the photoplethysmograph requires insertion into the vaginal canal, which can be experienced as quite painful for women suffering from dyspareunia. An alternative measure of female physiological sexual arousal which does not suffer these limitations is the labial thermistor clip. This device measures sexual arousal via surface temperature recording of the labia minora (Henson, Rubin, Henson, & Williams, 1977) and has significant advantages over the more commonly used vaginal photoplethysmograph. These include objective units of measurement, fewer data artifacts, less subjectivity in data treatment, and a higher concordance with measures of subjective sexual arousal (Janssen, 2002; Payne & Binik, 2006).

The present study sought to experimentally investigate the relationship between sexual arousal as measured via the labial thermistor clip, and both genital and non-genital sensation in healthy women and women suffering from dyspareunia. The main objectives were to address whether sexual arousal influenced sensation and also whether dyspareunia resulting from Vulvar Vestibulitis Syndrome (VVS) was associated with an impairment in sexual arousal. VVS is believed to be the most common form of dyspareunia in premenopausal women (Harlow & Stewart, 2003; Laumann, Paik, & Rosen, 1999; Meana, Binik, Khalifé, & Cohen, 1997b) and thus was chosen as the dyspareunia subtype to be investigated in this study. This condition is characterized by severe pain upon vestibular touch or attempted vaginal entry, tenderness to pressure localized within the vulvar vestibule, and physical findings limited to vulvar erythema (Friedrich, 1987). Though multiple factors have been hypothesized to play a role in VVS, a clear etiology has yet to be established (Pukall, Payne, Kao, Khalifé, & Binik, 2005).

It was hypothesized that sexual arousal would result in an increase in genital and non-genital sensitivity to touch and a decrease in genital and non-genital sensitivity to pain. These predictions would account for the apparent inconsistencies between reports of both increased and decreased sensitivity. It would also allow for a functionally wider range of potentially pleasurable stimuli during sexual activity by increasing the range between stimuli which are undetectable and stimuli which are painful. It was also hypothesized that women with VVS would evidence impaired physiological and subjective sexual arousal associated with an increase in genital pain sensitivity as compared with the healthy group. Factors associated with altered pain perception, such as catastrophizing, hypervigilance, and fear, were also assessed and compared between groups in an effort to investigate their impact on pain perception. It was hypothesized that women with VVS would obtain higher ratings on all of these pain-related measures, consistent with previous research (Payne et al., 2005; Pukall et al., 2002).

Method

Participants

Participants were recruited via media advertisements and screened during a semi-structured telephone interview. All subjects were required to be between 18 and 45 years of age, native English or French speakers, and in good general health. Women were included in the healthy group if they reported pain-free intercourse. Inclusion criteria for women suffering from VVS were: (1) pain during intercourse occurring on more than 50% of occasions for a minimum of six months and (2) pain limited to intercourse and other activities involving vestibular pressure and/or vaginal insertion. Exclusion criteria for both groups were: (1) pelvic and/or vaginal pain due to another cause (e.g., vaginal atrophy); (2) major medical and/or psychiatric illness; (3) active vaginal infection; (4) past surgery in the vulvar area; (5) current pregnancy; and/or; (6) vaginal delivery.

Of the women who were screened via telephone and attended their first testing session, one healthy participant was excluded due to the presence of a hymeneal band, and five women suffering from vulvar pain were excluded for not meeting criteria for VVS. Three participants were also excluded for failing to achieve a stable baseline labial temperature during testing (2 healthy, 1 VVS) and one due to technical error (VVS). Two additional women failed to appear for sessions 2 or 3 (1 healthy, 1 VVS). The final sample consisted of 20 healthy women (*M* age, 22.20 yrs, $SD = 3.29$) and 20 age-matched participants suffering from VVS (*M* age, 23.85 yrs, $SD = 3.54$).

Measures

Touch thresholds were determined using graded disposable filaments that varied in length and diameter and were calibrated using a digital balance (Eliav & Gracely, 1998). The filaments were clamped at the appropriate length with hemostatic forceps and applied incrementally to the three locations at 5 sec inter-stimulus intervals until the participant reported detecting a sensation. These same filaments were also used

to determine pain thresholds at the labia and forearm. Additional filaments (Touch-Test Sensory Evaluator, North Coast Medical Inc.) exerting higher pressures were used solely on the forearm if the disposable ones could not exert enough pressure to elicit pain. Pain thresholds at the vulvar vestibule were assessed using a vulvalgesiometer (Pukall, Binik, & Khalifé, 2004), a manual, spring-base device that applied pre-calibrated pressures with a cotton-swab tip. The vulvalgesiometer exerts a range of forces from 3 g to 1 kg, and is better able to mimic the quality of pain women with VVS experience during intercourse than the filaments. The wider contact surface of the cotton swab tip produces a burning sensation, while the small filaments produce more of a pricking pain.

Reliability for the disposable von Frey filaments used in a stepwise fashion at the vulvar vestibule ranges from .47 to .60 between two separate testing sessions (Pukall et al., 2002). However, a simplified incremental approach was used here in order to minimize the testing time, and the influence of testing on sexual arousal. No such reliability data are yet available for the vulvalgesiometer.

A labial thermistor clip was used as a measure of physiological sexual arousal. It was composed of a highly sensitive surface thermistor (Yellow Springs Instruments model 427 probe) glued to one end of a metal clip. A silicone pad was fashioned on the other side of the clip directly perpendicular to the thermistor disk. A sliding ring encircling both ends of the clip served to open and close the device. A female researcher placed the thermistor clip on the widest part of the left labium minus so that the thermistor was located on the distal side. The left labium was chosen so as not to confound results from labial sensory testing which took place on the right labium. The clip was fastened as securely as required to be comfortable, yet remain attached when given a gentle tug. The thermistors were gas sterilized after each use with the STERRAD System which uses low-temperature hydrogen peroxide gas plasma. A second thermistor was secured to the wall in the experimental room to monitor ambient temperature. While participants privately viewed stimulus materials, labial and room temperature were monitored remotely in the adjacent equipment room.

Participants completed a total of eight questionnaires (see Appendix), including both the State and Trait subscales of the State-Trait Anxiety Inventory-Form Y (STAI; Speilberger, 1983) and the Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996). Question 21 of the BDI-II was omitted because it inquires about loss of interest in sexual activity, a common symptom associated with VVS. Participants also completed the short version of the Health Anxiety Inventory (HAI; Salkovskis, Rimes, Warwick, & Clark, 2002) and the Female Sexual Function Index (FSFI; Rosen et al., 2000). The HAI is a reliable and valid measure of health anxiety composed of a main section and negative consequences subscale (Salkovskis et al., 2002). The FSFI is a brief self-report measure of female sexual function composed of six subscales; desire, subjective arousal, lubrication, orgasm, satisfaction, and pain.

The Pain Catastrophizing Scale (PCS; Sullivan, Bishop, & Pivik, 1995) was administered as a measure of catastrophizing to pain. This scale is a reliable and valid measure of pain magnification, rumination, and helplessness. The Pain Vigilance Awareness Questionnaire (PVAQ; McCracken, 1997) was administered as a measure of hypervigilance to pain. This scale assesses awareness, vigilance, preoccupation, and observation of pain. It displays good internal consistency, test-retest reliability, and has been validated for use in both chronic pain patients and non-clinical samples (McWilliams & Asmundson, 2001). The Pain Anxiety Symptoms Scale-20 (PASS-20; McCracken & Dhingra, 2002) was also administered as a measure of fear of pain. This questionnaire is composed of four subscales; cognitive anxiety; escape/avoidance; fearful appraisal; and physiological anxiety. The PASS-20 subscales demonstrate good internal consistency, and are designed to measure fear of pain across cognitive, behavioral, and physiological domains.

The PCS, the PASS-20, and the PVAQ were administered once to healthy participants with reference to their non-intercourse pain identified during the semi-structured interview, and twice to VVS participants; once with reference to their intercourse pain and a second time with reference to their non-intercourse pain. VVS participants also completed the short form of the McGill Pain Questionnaire (MPQ; Melzack, 1987) with reference to their coital pain. The MPQ has become one of the most widely used tests for pain measurement. Much like the original, the short form provides an abridged checklist of adjectives that describe pain quality and intensity, and provides a global multidimensional measure of pain.

Following exposure to both erotic and neutral-control stimulus films, participants completed a questionnaire assessing subjective sexual arousal designed for the purposes of this study. This consisted largely of a questionnaire used in a previous study (see Kukkonen et al., 2006) in addition to specific items designed to assess the influence of sensory testing used in this study. The questionnaire contained items designed to assess relaxation, enjoyment, and general sexual arousal (3 items), mental sexual arousal (2 items), behavioral/motivational aspects of sexual arousal (2 items), and physiological sexual arousal (2 items). Participants answered the questions on 7-point Likert scales (1 = not at all to 7 = very much). Two additional questions assessed the influence of sensory testing on attention and sexual arousal. With respect to attention, participants were asked to indicate on a bipolar scale from 1 to 7 where their attention was focussed during sensory testing (1 = completely on the testing, 7 = completely on the film). Regarding sexual arousal,

participants were first asked if sensory testing influenced their sexual arousal and in what direction (increased or decreased). They were then asked to rate on a 7-point Likert scale the degree to which their sexual arousal was influenced (1 = very little, 7 = a lot).

Procedure

After eligibility for the study was determined during the telephone screening interview, participants were scheduled for three one-hour testing sessions to take place on different days. Session 1 was conducted at the participating gynecologist's office. After arriving at the office, the study was explained to participants in greater detail and informed consent was obtained. They then completed a semi-structured interview including questions pertaining to demographic, gynecological health, and relationship history. During this interview, both groups were read a list of body locations and asked if they experienced pain at least once a month or more in any of these locations. For every recurrent pain identified, participants were asked to rate the seriousness and interference of this pain on an 11-point Likert scale (0 = not serious/no interference at all, 10 = most serious/complete interference). They were then asked to identify their worst recurrent, non-intercourse related pain, and to report its intensity and unpleasantness (0 = least intense/unpleasant, 10 = most intense/unpleasant). This was termed their non-intercourse pain and was used as a reference in some of the pain-related questionnaires. Women suffering from VVS were also asked additional information regarding their intercourse pain (e.g., location, duration, intensity). Following the interview, a gynecological examination was performed during which a diagnosis of VVS was either confirmed or excluded according to Friedrich's (1987) criteria. The gynaecologist also preformed a cotton-swab palpation of 3 randomly ordered, control-matched, vestibular sites (3, 6, and 9 o'clock). During this procedure, a female researcher recorded pain ratings as reported at each location on a Likert scale ranging from 0 (no pain) to 10 (worst pain imaginable). These ratings were averaged across locations to create a Vestibular Pain Index. A standard bimanual palpation of the vagina, uterus, and adnexae was also performed. At the end of this session, participants were given a questionnaire package, including detailed instructions to complete at home and return at the next session.

Session 2 was conducted at the sexual psychophysiological laboratory. Participants were familiarized with the testing setting and equipment, and the experimental procedure was explained. Participants were then asked to complete the STAI (State). Following this, the experimenter left the room and participants undressed from the waist down. They were instructed to lie down in a supine position on the gynecological table and to cover themselves from the waist down with a disposable sheet. The experimenter then re-entered the room and performed baseline sensory testing assessing both touch and pain thresholds at the following locations in the following order; 9 o'clock position in the vulvar vestibule, inside portion of the right labium minus, and the volar surface of the forearm. Touch stimuli were applied incrementally at 5 second inter-stimulus intervals, and participants were asked to indicate the point at which they began to feel a sensation. Pain-threshold stimuli were applied incrementally at 10 second inter-stimulus intervals until the participants reported that the sensation was beginning to become painful.

After baseline touch and pain thresholds had been established, the researcher attached a labial thermistor clip to the left labium minus. Most participants felt a gentle tugging sensation during the placement of the clip, but remained largely unaware of the device thereafter. Participants were then given DVD goggles and the experimenter left the room. The DVD goggles were equipped with ear phones and connected to a DVD player in the adjacent testing room. Participants first listened to jazz music until their labial temperature stabilized (achieved maximum variability of 0.05°C or less within a 2 min period), which took approximately 5–10 min. Once a stable baseline was reached, either a neutral or erotic film was viewed (counterbalanced between sessions 2 and 3). The neutral film consisted of a Canadian Film Board travelogue with no sexual content, while the erotic film depicted two consenting adults engaged in a range of heterosexual sexual activity along the following timeline from stimulus onset; 0:56 female nudity, 3:02 cunnilingus, 5:31 male nudity and fellatio, 7:16 vaginal penetration. Participants watched the film for 10 minutes, after which point the experimenter returned to repeat sensory testing while participants continued to watch the film. Following these procedures, participants dressed and completed a questionnaire pertaining to subjective sexual arousal.

Session 3 followed the same procedure as Session 2, but participants viewed the film they had not yet seen, and baseline sensory testing was not repeated. At the end of this session, participants were debriefed and compensated $75.00.

This study was reviewed and approved by the McGill University Faculty of Medicine Institutional Review Board.

Results

Sample characteristics

The means and SDs for a subset of the sample characteristics are shown in Table 1. There were no significant differences between groups with respect to age, education, income, place

Table 1 Means and SDs on subject characteristics by group

	Healthy ($n = 20$)		VVS ($n = 20$)	
	M	*SD*	*M*	*SD*
% Painful intercourse	1.95	4.01	92.62***	11.22
Vestibular pain index	1.23	1.55	7.68***	1.27
Number of non-intercourse pains	3.35	1.56	3.75	1.83
Interference of non-intercourse pains	2.74	1.84	4.07*	1.59
Intensity of worst non-intercourse pain	5.10	2.29	6.75*	2.47
Pain intensity on first intercourse	4.10	2.33	6.80**	3.00
Intercourse frequency per month	9.30	6.69	4.77*	4.48
% Orgasm with intercourse	35.17	39.15	15.00*	20.39

Note. All participants abstaining from intercourse were not included in these analyses (Healthy = 3, VVS = 6).
*$p < .05$; **$p < .01$; ***$p < .001$.

of birth, religion, type of contraception used, age at first intercourse, total number of intercourse partners, body mass index, or total number of gynecological problems. Women with VVS reported experiencing vulvar pain for a mean duration of 4.52 years ($SD = 3.41$). On a series of Likert scales ranging from 0 to 10, (0 = not at all, 10 = worst possible), women with VVS rated the mean intensity of their vulvar pain as 7.35 ($SD = 1.61$), and the associated mean unpleasantness of their vulvar pain as 8.00 ($SD = 1.59$). On the McGill Pain Questionnaire, women with VVS rated their vulvar pain as being similar in severity to that of lower back or cancer pain. They also reported experiencing pain on a significantly greater percentage of intercourse occasions than healthy women, $t(38) = 34.03$, $p < .001$, and obtained a significantly higher Vestibular Pain Index rating during the gynaecological examination, $t(38) = 14.40$, $p < .001$.

The groups did not differ with regard to the number of recurrent non-genital pains they experienced, though women with VVS rated the degree of interference of these pains as significantly more severe, $t(38) = 2.45$, $p < .05$, and reported significantly higher pain intensity ratings for their worst non-intercourse pain than healthy participants, $t(38) = 2.19$, $p < .05$. Women with VVS were also significantly more likely to have been diagnosed with a chronic pain condition, $\chi^2 = 5.71$, $p < .05$.

Women suffering from VVS reported experiencing significantly more pain on their first intercourse attempt than healthy women, $t(38) = 3.18$, $p < .01$. Healthy women engaged in sexual intercourse significantly more often per month than women with VVS, $t(38) = 2.52$, $p < .05$, and also experienced a significantly higher percentage of orgasms with intercourse, $t(29) = 2.04$, $p < .05$. On the Female Sexual Function Index (see Table 2), a significant multivariate effect for group was obtained, $F(6,24) = 25.69$, $p < .001$. Women with VVS reported experiencing significantly more difficulty with desire, $F(1,29) = 5.27$, $p < .05$, arousal, $F(1,29) = 6.84$, $p < .05$, lubrication, $F(1,29) = 7.99$, $p < .01$, and pain, $F(1,29) = 168.58$, $p < .001$.

Mood, health, and pain-related questionnaire measures

Means and SDs on measures of mood, health, and pain-related coping are shown in Table 3. No significant group differences were found on the BDI-II or the STAI. Women with VVS obtained higher scores on the main section of the HAI, $F(1,38) = 10.33$, $p < .01$, but not on the negative consequences subscale.

All pain-related measures were compared between genital and non-genital pains within women with VVS, between both groups with respect to non-genital pain, and between VVS genital pain and healthy participant's non-genital pain. These three comparisons were used in an attempt to examine whether the experience of genital pain is qualitatively distinct from the experience of non-genital pain regardless of group, or if any significant differences could be attributed to the group. As healthy participants were recruited only if they experienced pain-free intercourse, it was impossible to compare responses to genital pain between both groups given the current design, therefore limiting the conclusions which can be draw from these comparisons.

On the PCS, women with VVS reported higher pain catastrophizing for intercourse pain, $F(1,38) = 39.90$, $p < .001$, and non-intercourse pain, $F(1,38) = 11.41$, $p < .01$, as compared with healthy participant ratings for non-intercourse pain. Tests of within-group differences for VVS participants

Table 2 Means and SDs on the Female Sexual Function Index by group

	Healthy ($n = 20$)		VVS ($n = 20$)	
	M	*SD*	*M*	*SD*
Desire	4.59	0.95	3.68*	1.24
Arousal	5.06	0.89	4.14*	1.09
Lubrication	5.28	1.03	4.07**	1.34
Orgasm	4.37	1.37	3.80	1.82
Satisfaction	4.52	1.38	3.83	1.38
Pain	5.79	0.38	2.42***	0.98

*$p < .05$; **$p < .01$; ***$p < .001$.

Table 3 Means and SDs on mood, health, and pain-related measures by group

Variable	Healthy non-intercourse pain ($n = 20$)		VVS intercourse pain ($n = 20$)		VVS non-intercourse pain ($n = 20$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
BDI-II	8.15	7.38	11.25	10.63		
STAI	39.45	10.20	40.10	10.25		
HAI						
Main section	11.70	6.95	19.45**	8.24		
Negative consequences	3.70	3.96	4.70	2.88		
PCS	12.45	5.61	25.90***	7.68	21.40**	10.43
PVAQ	31.80	13.38	55.70***	10.62	49.10***	8.64
PASS						
Cognitive anxiety	8.30	5.22	16.10***	4.02	15.05***	5.74
Escape/avoidance	9.90	5.18	13.65*	3.80	14.60**	4.28
Fearful appraisal	3.95	4.27	8.50**	5.49	7.20	5.99
Physiologic anxiety	3.30	3.57	8.10**	5.56	7.75**	5.67

*$p < .05$; **$p < .01$; ***$p < .001$.

(intercourse vs. non-intercourse pain) revealed no significant differences. An identical pattern of results was obtained on the PVAQ on which women with VVS reported higher vigilance for both intercourse, $F(1,38) = 39.02$, $p < .001$, and non-intercourse pain, $F(1,38) = 23.58$, $p < .001$, as compared with the healthy participant ratings for non-intercourse pain.

Women with VVS also obtained higher scores on all four subscales of the PASS-20 with respect to intercourse pain as compared with healthy participant ratings for non-intercourse pain: cognitive anxiety, $F(1,38) = 27.99$, $p < .001$; escape/avoidance, $F(1,38) = 6.81$, $p < .05$; fearful appraisal, $F(1,38) = 8.55$, $p < .01$; and physiological anxiety, $F(1,38) = 10.55$, $p < .01$. With respect to non-intercourse pain, women with VVS also obtained higher ratings on cognitive anxiety, $F(1,38) = 15.15$, $p < .001$, escape/avoidance, $F(1,38) = 9.77$, $p < .01$, and physiological anxiety, $F(1,38) = 8.81$, $p < .01$, whereas only a trend was observed on the fearful appraisal subscale, $F(1,38) = 3.90$, $p = .055$. When comparing intercourse to recurrent pain ratings on the PASS-20 within the VVS group, no significant differences were found.

Physiological sexual arousal

Figure 1 illustrates mean labial temperature in response to both erotic and neutral stimuli by group. Baseline room temperature and fluctuations in room temperature did not differ significantly between groups or conditions. For labial temperature, Greenhouse-Geisser conservative degrees of freedom were used to test significance. Labial temperature data were subjected to a 2 (Group: Healthy vs. VVS) × 2 (Film Order: Neutral vs. Erotic Film first) × 2 (Time: Baseline vs. Baseline + Peak Delta after film onset) × 2 (Film: Neutral vs. Erotic) ANOVA. A significant Film x Time interaction was found, $F(1,36) = 87.69$, $p < .001$. Post-hoc Tukey HSD tests revealed that mean temperature was significantly higher after exposure to the erotic film as compared to before presentation of either neutral, $Q(4,36) = 17.04$, $p < .01$, or erotic films, $Q(4,36) = 16.96$, $p < .01$, and after presentation of the neutral film, $Q(4,36) = 18.90$, $p < .01$.

A significant Film × Film Order interaction was also found, $F(1,36) = 4.54$, $p < .05$. Post-hoc Tukeys revealed that labial temperature was higher during the erotic film if the neutral film was presented first ($M = 34.16$, $SD = 0.02$) versus when the erotic film was presented first ($M = 33.39$, $SD = 0.02$), $Q(4,36) = 4.26$, $p < .05$. These data indicate that physiological sexual response was maximized when participants were exposed to the neutral stimulus first, perhaps due to an increased level of comfort and familiarity with the setting and testing procedure, or the lack of baseline sensory testing prior to viewing the erotic film. For women in the VVS group, the more anxious they were before the erotic film (as indicated on the subjective arousal questionnaire), the less physiological arousal they experienced $r(18) = -.49$, $p < .05$.

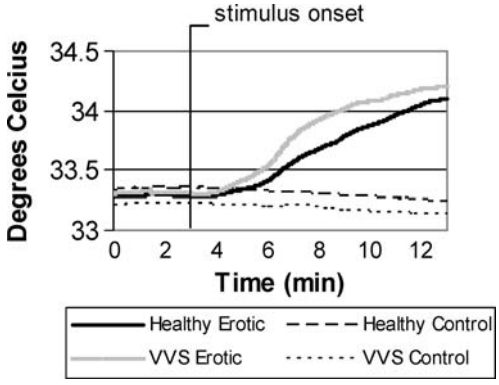

Fig. 1 Physiological sexual arousal as measured by labial temperature in response to both erotic and neutral stimuli by group

Subjective sexual arousal

A 2 (Group: Healthy vs. VVS) × 2 (Film: Neutral vs. Erotic) × 2 (Film Order: Neutral vs. Erotic Film first) ANOVA was computed on total subjective arousal scores calculated based on the 7 questionnaire items relating specifically to sexual arousal. A significant main effect of Film was found, $F(1,36) = 208.94$, $p < .001$, with participants reporting the erotic film as more sexually arousing ($M = 27.84$, $SD = 0.18$) than the neutral film ($M = 8.75$, $SD = 0.09$).

Means and SDs for individual items of the subjective sexual arousal questionnaire are shown in Table 4. A 2 (Group: Healthy vs. VVS) × 2 (Film Order: Neutral vs. Erotic Film first) MANOVA was computed separately for the 7 items relating to sexual arousal completed after exposure to the erotic film. A significant multivariate effect for group was obtained, $F(7,30) = 7.73$, $p < .01$. Women with VVS reported less desire to engage in intercourse than healthy women, $F(1,36) = 7.73$, $p < .01$, and an almost significantly reduced level of mental sexual arousal, $F(1,36) = 3.96$, $p = .054$.

Healthy women reported feeling more relaxed during the neutral film ($M = 6.65$, $SD = 0.59$) than women with VVS ($M = 6.10$, $SD = 0.85$), $t(38) = 2.38$, $p < .05$. However, women with VVS reported paying more attention to the neutral film ($M = 4.65$, $SD = 0.99$) versus the sensory testing than healthy women ($M = 3.75$, $SD = 1.48$), $t(38) = 2.26$, $p < .05$. The more anxious healthy women felt before the erotic film, the less they enjoyed the film $r(18) = -.46$, $p < .05$.

During the erotic film, 12 healthy women reported that the sensory testing decreased their sexual arousal for a mean of 3.67, and four experienced an increase for a mean of 2.50. Eleven women with VVS also reported a decrease in sexual arousal for a mean of 2.73, while five experienced an increase for a mean of 3.80.

Between-subject correlations of labial temperature and total subjective arousal scores across both neutral and erotic film conditions were $r(38) = 0.74$, $p < .01$ for healthy women and $r(38) = 0.67$, $p < .01$ for women with VVS.

Touch thresholds

Due to significant skewness, all threshold data were log transformed prior to analysis. Figure 2 illustrates the thresholds for touch obtained by location and condition tested. Greenhouse-Geisser conservative degrees of freedom were used to test significance. Touch thresholds were entered in a 2 (Group: Healthy vs. VVS) × 3 (Time: Baseline vs. Neutral Film vs. Erotic Film) × 3 (Location: Vulvar Vestibule vs. Labium Minus vs. Volar Forearm) ANOVA. A significant Time × Location interaction was found, $F(3, 129) = 2.82$, $p < .05$. Post-hoc Tukey tests revealed that the forearm was more sensitive to touch than both the labia, $Q(3,76) = 9.89$, $p < .01$, and the vulvar vestibule, $Q(3, 76) = 6.14$, $p < .01$. The vestibule in turn was more sensitive to touch than the labia, $Q(3,76) = 3.75$, $p < .05$. For both groups, the vulvar vestibule was more sensitive to touch with exposure to the erotic film as compared with the neutral film, $Q(9,152) = 4.88$, $p < .05$.

Pain thresholds

Figure 3 illustrates the thresholds for pain obtained by location and condition tested. Greenhouse-Geisser conservative degrees of freedom were used to test significance. Pain thresholds of the labium minus and forearm tested with the filaments and vulvar vestibule pain thresholds tested with the vulvalgesiometer were analyzed separately. Labium and forearm were analyzed together in a 2 (Group: Healthy vs. VVS) × 2 (Location: Labium Minus vs. Forearm) × 3 (Time: Baseline vs. Neutral Film vs. Erotic Film) ANOVA. Significant main effects were found for Location, $F(1,38) = 13.11$, $p < .001$, and Time, $F(2, 75) = 4.89$, $p < .05$. The labia was more sensitive to pain than the forearm, and post-hoc Tukey tests revealed that both locations were less sensitive to pain during the neutral, $Q(3,76) = 3.66$, $p < .05$, and erotic film, $Q(3,76) = 3.94$, $p < .05$, as compared with baseline. No significant differences were found in labial or forearm pain thresholds between neutral and erotic film

Table 4 Means and SDs on items assessing subjective sexual arousal after exposure to the erotic film

	Healthy ($n = 20$)		VVS ($n = 20$)	
	M	*SD*	*M*	*SD*
Relaxation	5.55	1.00	5.25	1.25
Enjoyment	4.42	0.82	4.25	1.29
General sexual arousal	4.60	1.23	4.70	1.34
Mental sexual arousal	4.95	1.39	4.00*	1.56
Desire to engage in intercourse	6.05	1.05	4.75**	1.77
Desire to masturbate	4.45	1.90	3.60	2.19
Physical sexual arousal	4.60	1.35	4.80	1.51
Perceived genital change	4.10	1.52	4.75	1.58
Level of sexual arousal compared with partner	2.80	1.40	2.95	1.28

*$p = .054$; **$p < .01$.

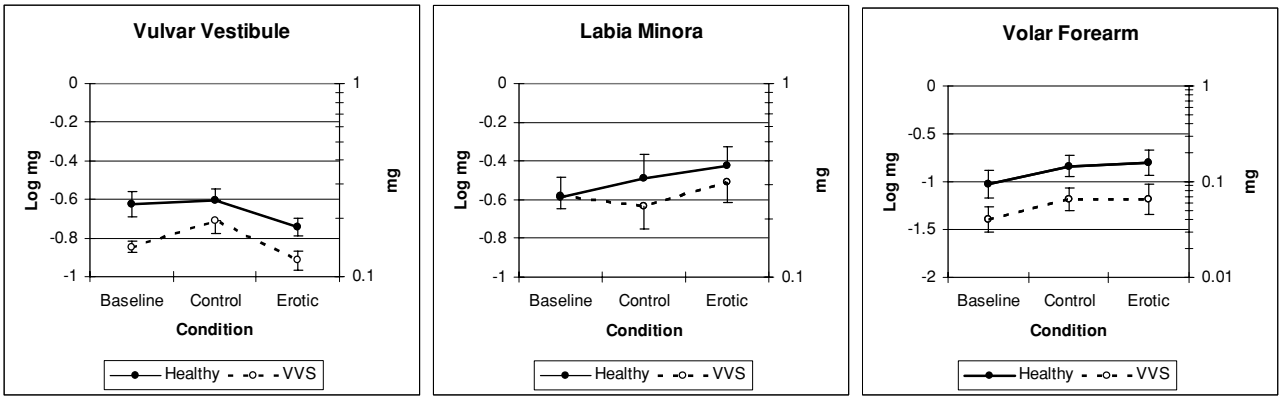

Fig. 2 Touch thresholds by location and condition tested

conditions. A between-subjects effect for Group was found, $F(1, 38) = 9.68$, $p < .01$, indicating that women with VVS experienced more pain at both the labia and forearm.

Vestibular pain thresholds were analysed using a 2 (Group: Healthy vs. VVS) × 3 (Time: Baseline vs. Neutral Film vs. Erotic Film) ANOVA. A Time × Group interaction was found, $F(2, 62) = 3.35$, $p = .05$. Post-hoc Tukey tests revealed that vulvar pain thresholds were higher in healthy women during baseline, $Q(6, 76) = 11.42$, $p < .001$, neutral $Q(6, 76) = 6.75$, $p < .001$, and erotic conditions $Q(6, 76) = 8.77$, $p < .001$. Planned comparisons also revealed that within the healthy group, vulvar pain thresholds were significantly higher at baseline versus the erotic condition, $t(76) = 2.41$, $p < .01$, while within the VVS group, vulvar pain thresholds were significantly higher during the neutral versus the erotic condition, $t(76) = 2.15$, $p < .05$.

Discussion

This study sought to determine whether sexual arousal influenced genital and non-genital sensation to see if dyspareunia resulting from VVS was associated with a relative lack of sexual arousal. Exposure to the erotic film resulted in an increased sensitivity to touch and pain in the vulvar vestibule. This increase in sensitivity may be the result of vasocongestion to the area. Similarly, other physiological changes that accompany sexual arousal may also contribute to heightened sensation, including myotonia, engorgement of the clitoris, and formation of the orgasmic platform (Masters & Johnson, 1966). Much like King and Alexander's (2000) data, the direction of the sensory change would seem to be different than that found by Whipple and Komisaruk (1985), though neither of these studies examined genital sensation. In addition, no impact was found for the influence of sexual arousal on peripheral sensation. This is potentially due to an order of testing effect, whereby peripheral sites were tested after the vestibule. Though this minimized testing time, sexual arousal may have decreased. Consistent with Whipple and Komisaruk (1985), an effect was not obtained for touch at either non-vulvar locations tested though both the labia and forearm evidenced a decrease in sensitivity to pain with exposure to the erotic film; however, this last effect was also observed with exposure to the neutral film, pointing to the role of distraction rather than sexual arousal per se.

For touch thresholds, the vulvar vestibule was more sensitive in both groups during the erotic condition as compared

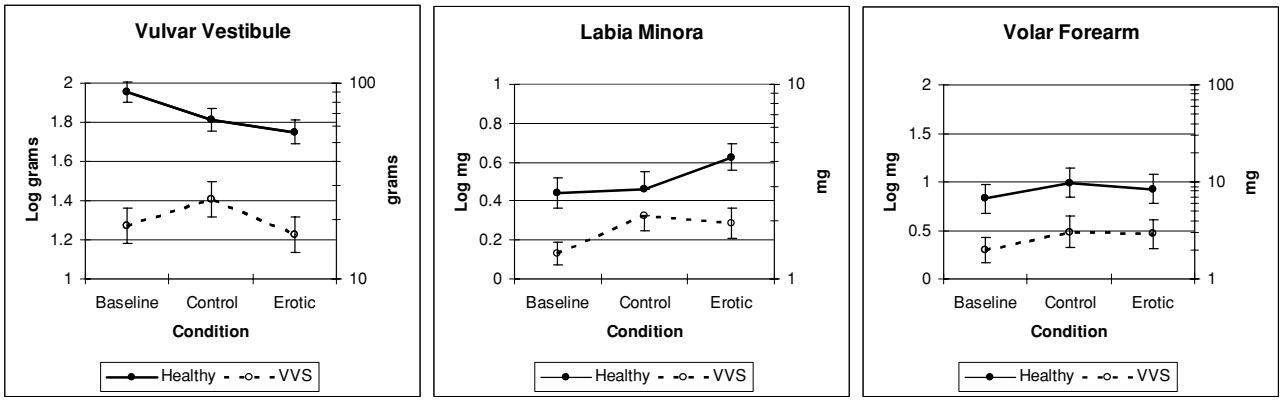

Fig. 3 Pain thresholds by location and condition tested

with the neutral condition, but not when compared with the baseline condition. This is perhaps due to the distracting nature of the stimuli which was controlled for in the neutral condition. As for pain, within the healthy group the vulvar vestibule was more sensitive to pain during the erotic condition only in contrast with the baseline condition. As pain demands more attention than touch, the distracting nature of the stimuli may not have been as large an issue here. In Women with VVS, however, the vulvar vestibule was again more sensitive to pain during the erotic condition in contrast with the neutral film. This is possibly due to the combination of a ceiling effect and the finding that women with VVS reported paying more attention to the neutral film than healthy women.

Results also support the separation of touch from pain. The forearm, though more sensitive to touch, was less sensitive to pain than the labia. The labia were also less sensitive to touch than the vulvar vestibule, possibly explaining why this genital structure did not evidence a similar pattern in response to sexual arousal. These results further suggest that the genital/non-genital distinction may not be the appropriate one based on sensory evidence. The vulvar vestibule may be a particularly unique genital area with sensory properties as different from other genital locations as other more distant peripheral locations, such as the forearm. The general insensitivity of the labia to touch was supported by the fact that, according to the participants in the current study, the thermistor clip, when attached to the labium minus, was barely detectable. That being said, if vasocongestion is responsible for the effect obtained at the vestibule, one would expect a similar effect at the labia minora where an increase in temperature was recorded with exposure to the erotic film. However, if vasocongestion results in an increase in sensitivity, this may result from an interaction between blood flow and the innervation characteristics of the affected area.

Women with VVS also experienced more pain than healthy participants at all locations tested. These data replicate the generalized sensory abnormality found in other studies (Giesecke et al., 2004; Granot, 2005; Granot, Yarnitsky, Friedman, & Zimmer, 2002; Pukall et al., 2002; Rosenman, 2002). This is also consistent with evidence suggesting that women with VVS possess a vulnerability associated with chronic inflammatory conditions (Gerber, Bongiovanni, Ledger, & Witkin, 2002; Gerber & Witkin, 2003; Jeremias, Ledger, & Witkin, 2000; Witkin, Gerber, & Ledger, 2002). Similarly, women with VVS commonly have a history of repeated yeast infections (Mann, Kaufman, Brown, & Adam, 1992) and, in this study, were more likely to have been diagnosed with another chronic pain condition. A physiological vulnerability for the repeated experience of pain could also explain findings on pain-related measures, whereby women with VVS reported more health anxiety, in addition to more catastrophizing, hypervigilance, and fear of both intercourse and non-intercourse pain. These factors, in turn, could further exacerbate pain perception. More specifically, women with dyspareunia resulting from VVS may be at risk for interpreting ambiguous stimuli in an unpleasant way. Similarly, many descriptors used to describe the quality of pain experienced by VVS sufferers (e.g., burning, aching, throbbing; Payne et al., 2005) are also commonly used to describe pleasurable sexual activity, speaking to the possibility of an interpretation bias.

Both groups showed a greater increase in labial temperature with exposure to the erotic film versus the neutral film, and reported the erotic film to be more arousing than the neutral film. No group difference with reference to physiological sexual arousal was obtained. Thus, our data contradict the notion that dyspareunia resulting from VVS is associated with a lack of physiological sexual arousal. Regarding subjective arousal, however, women with VVS reported a significant trend for lower levels of mental sexual arousal and less desire to engage in intercourse with a partner following exposure to the erotic film. They also reported engaging in sexual intercourse less frequently and experiencing significantly less arousal and desire on the FSFI than healthy women.

Correlations between physiological and subjective sexual arousal were high as compared with that commonly achieved with VPA measurement. These results are consistent with previous research reporting higher concordance between ratings of subjective and physiological sexual arousal using the labial thermistor clip (Henson, Rubin, & Henson, 1979). However, current calculations of concordance are often performed between VPA and a continuous subjective measure of sexual arousal. The latter was not used in the present study so as not to distract the participants any further from the stimulus film than the sensory testing already did. As such, these data are not appropriate for comparison with VPA concordance ratings obtained with continuous measurement of subjective sexual arousal.

There are some limitations to this study that are worth noting. The results presented were based on a relatively small sample size and, as such, are only preliminary. The experimenter was also not masked to the stimulus film condition or the diagnostic status of the participants. In an effort to reduce testing time, baseline sensory testing was not repeated. Therefore, valuable reliability data are lacking. Additionally, the present investigation asked participants to identify when a stimulus became painful, and not whether it was experienced as subjectively pleasurable or not. This instruction may have artificially created a hypervigilance for pain influencing the enjoyment of the stimuli. To tease apart these issues, future investigations of the influence of sexual arousal on sensation should investigate sensation intensity separately from valence. Alternatively, pain tolerance could be assessed in addition to threshold. Finally, despite a significant Time

x Group interaction for vestibular pain, significant post-hoc effects were only obtained through planned comparisons, rather than the more conservative Tukey HSD approach. This suggests that the effect of sexual arousal on vulvar pain sensitivity was not as strong as that found for touch.

These data have implications for the treatment of women suffering from dyspareunia. One common technique in sex therapy is to encourage the woman to increase her level of sexual arousal based on the assumption that this will decrease her pain. While these data do not completely refute this approach, they do suggest that this could potentially result in an increase in sensitivity. Furthermore, interventions aimed at reducing muscle tension, such as pelvic floor physiotherapy, are typically conducted in an unaroused state. These exercises will then be incorporated into the sexual situation where women suffering from dyspareunia may be experiencing an increase in vulvar sensitivity due to sexual arousal. Therefore, incorporating a graded exposure of these techniques with sexual arousal may facilitate the generalization of treatment benefits to the sexual context. Finally, sex therapists need to address issues related to fear, catastrophizing, and hypervigilance for pain in respect to both intercourse and non-intercourse pain by incorporating pain-management therapy techniques into their interventions. This is supported by the success of group cognitive-behavior therapy in the treatment of VVS (Bergeron et al., 2001), which comprises techniques aimed at reducing fear of pain during intercourse and other maladaptive affective and cognitive responses.

Appendix

List of questionnaire measures and their abbreviations

Abbreviation	Questionnaires
STAI	State-Trait Anxiety Inventory
BDI	Beck Depression Inventory
HAI	Health Anxiety Inventory
FSFI	Female Sexual Function Index
PCS	Pain Catastrophizing Scale
PVAQ	Pain Vigilance Awareness Questionnaire
PASS-20	Pain Anxiety Symptoms Scale
MPQ	McGill Pain Questionnaire

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