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Tactile Sensitivity in Women with Sexual Arousal Disorder

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Evidence suggests that tactile sensitivity may differ between women with sexual arousal difficulties and women with normal sexual functioning. Tactile sensitivity was examined on the distal portion of the dominant hand index finger and on the lower lip in women with female sexual arousal disorder (FSAD) ($n = 17$) and in normally functioning women ($n = 17$). The two groups did not differ significantly in age, length of current relationship or on measures of sexual experience and sexual desire. Hierarchical binary logistic regression indicated that finger threshold was significantly associated with FSAD women versus control women, and hierarchical linear regression indicated that finger threshold was associated with severity of arousal dysfunction. Logistic regression showed that 76.5% of participants were correctly classified and 23.5% were incorrectly classified using tactile sensation as a predictor variable. Possible underlying mechanisms and clinical implications are discussed.

KEY WORDS: cutaneous sensation; sexual dysfunction; female sexuality; tactile receptors; sexual arousal dysfunction.

INTRODUCTION

Convergent evidence suggests that tactile sensitivity may be associated with sexual arousal and that alterations in tactile sensitivity may impact sexual function. Firstly, the female genitalia contain rich sensory innervation. The inner two-thirds of the vagina is innervated by only pain receptors, but the outer third, in particular, between the vaginal wall and the bladder, is innervated by touch receptors known as Merkel tactile discs (Krantz, 1958), which respond to steady pressure (Vallbo & Hagbarth, 1968). The external genitalia are more richly innervated. The mons veneris, labia majora, labia minora, and the clitoris are innervated by Meissner corpuscles, Merkel tactile discs, Pacinian corpuscles, Ruffinian corpuscles, and pain receptors (Krantz, 1958; Yamada, 1951). Mechanical stimulation to the genital region suggests that different areas of the genitalia respond to different types of stimulation; the external genitals contain high and low threshold slowly adapting (SA) receptors and low threshold rapidly adapting (RA) receptors. The vagina contains primarily RA receptors, although some SA receptors respond to deep pressure. The cervix contains SA receptors that respond to pressure and velocity (Cueva-Rolon, Munoz-Martinez, Delgado-Lezama, & Raya, 1994).

Secondly, factors that affect sexual arousal in women have also been shown to affect tactile sensitivity. Normal estrogen levels are required to produce adequate vaginal lubrication (Bachmann, 1995), and estrogen treatment has been found to affect tactile sensitivity in rats and canaries (Bereiter & Barker, 1975; Bereiter, Stanford, & Barker, 1980; Hinde & Steele, 1964; Kow & Pfaff, 1973). Findings from animal studies suggest that stimulation of the sympathetic nerves supplying the genitalia causes contractions of both non-vascular and vascular smooth muscle, which may in turn limit blood flow to the uterus, vagina, and other tissues (for review, see Meston & Bradford, 2003). However, several studies in women have shown that sympathetic activation induced using exercise (Meston & Gorzalka, 1995, 1996) or ephedrine (Meston & Heiman, 1998) facilitates genital arousal in women. Tactile sensitivity may also be affected indirectly through modulation of the sympathetic nervous system (SNS), and contradictions also exist in this literature,

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with some studies finding that sympathetic activation increases tactile sensitivity (Loewenstein, 1956) and others suggesting that it decreases tactile sensitivity (Kissin, McDanal, Brown, Xavier, & Bradley, 1987). Individuals with hypertension often report sexual difficulties (Bansal, 1988; Leiblum, Baume, & Croog, 1994), and studies suggest that tactile thresholds increase as blood pressure increases in non-medicated subjects (Rosa, Ghione, Panattoni, Mezzasalma, & Giuliano, 1986; Zamir & Shuber, 1980). Men with erectile problems have reduced tactile sensitivity compared to men with no erection difficulties (Morrissette, Goldstein, Raskin, & Rowland, 1999; Rowland, 1998; Rowland, Haensel, Blom, & Slob, 1993; Rowland, Leentvaar, Blom, & Slob, 1991).

The present study represents the first empirical examination of tactile sensitivity in women with Female Sexual Arousal Disorder (FSAD) compared to women reporting no sexual difficulties. The purpose of this study was to increase understanding of the underlying physiological mechanisms associated with FSAD. It is predicted that impairment in sexual arousal functioning will be associated with reduced tactile sensitivity.

METHOD

Participants

Participants were 17 female college students with FSAD (M age = 18.7 yrs, SD = 1.1) and 17 female college students who were functioning normally sexually (M age = 18.7 yrs, SD = 1.0). Participants were recruited from Introduction to Psychology courses. Prospective participants were initially screened using an Internet based questionnaire aimed at identifying women who were 18 years or older, involved in a sexually active relationship (prospective participants indicated "yes" to the question, "Are you in a sexually active relationship?"), and not taking antidepressant medication.

Approximately 1300 women met the Internet screening criteria and, of these, a total of 372 agreed to attend a screening session at the Female Sexual Psychophysiology Laboratory. After providing written consent, participants were asked to complete a series of questionnaires aimed at identifying women who were experiencing problems with vaginal dryness and women who were not experiencing sexual problems.

Inclusion criteria were lack of vaginal lubrication 50–100% of the time, present over the past six months (FSAD group), or no problems with vaginal lubrication during the past six months (control group) (Sexuality Inventory [SI]; questionnaire adapted, for the purposes of this study, from the Sexual Functioning Index [Taylor, Rosen, & Leiblum, 1994]). Control participants were included if they indicated that they were orgasmic at least 50% of the time in any one sexual activity. Sexual activities included "masturbation," "manual stimulation by partner," "oral stimulation by partner," "intercourse," and "intercourse and manual stimulation by self or partner" (Orgasmic Functioning Questionnaire [OFQ]; [Meston, Jung, Hanson, & Gorzalka, 1993]). For example, if a participant was able to achieve orgasm 50% of the time during masturbation but was never able to achieve orgasm in any other situation, the participant was considered 50% orgasmic and was included. Conversely, a participant who was able to reach orgasm only 40% of the time in all the listed activities was not included. Thus, orgasmic ability was defined as the participant's ability to achieve orgasm given optimal (for each individual participant) conditions. This scoring procedure has been used in previous research of this nature (Meston & Gorzalka, 1996; Meston, Gorzalka, & Wright, 1997). Control participants were also required to fall within one SD of the mean of the Female Sexual Functioning Index (FSFI) normative sample (Rosen et al., 2000) on the FSFI domain (desire, arousal, lubrication, orgasm, pain, satisfaction) and full scale scores.

Exclusion criteria were (1) lack of sexual activity (the participant reported that she was not currently in a sexual relationship), (2) mild to severe score on the Beck Depression Inventory (BDI; Beck & Beamesderfer, 1974), (3) use of any antidepressant or other medication known to affect sexual functioning, (4) diabetes or thyroid disease, and (5) limited sexual experience (defined as one standard deviation below the mean on the Derogatis Sexual Functioning Inventory Experience subtest—see below for more details) (Derogatis, 1978).

A total of 63 women met the on site screening criteria and, of these, 44 agreed to participate in an interview conducted by a clinical psychology doctoral student with a master's degree in clinical psychology. The clinical interview was aimed at determining whether the participants met DSM-IV-TR (American Psychiatric Association, 2000) criteria for Hypoactive Sexual Desire Disorder, Sexual Aversion Disorder, FSAD, Female Orgasmic Disorder, Dyspareunia, or Vaginismus.

A total of 26 women met the questionnaire screening criteria for FSAD, and of those, 14 met DSM-IV-TR criteria for FSAD and three met DSM-IV-TR criteria for both FSAD and Female Orgasmic Disorder, lifelong generalized type. Four participants were excluded as their arousal difficulties were subthreshold, i.e., the arousal symptoms were not persistent or recurrent enough to qualify as FSAD. One participant was excluded as her

primary diagnosis was hypoactive sexual desire disorder (HSDD), with some secondary arousal difficulties. One participant was excluded as her primary diagnosis was dyspareunia, with some secondary arousal difficulties. Three participants were excluded as their primary diagnosis was Female Orgasmic Disorder (specific, acquired), with some secondary subthreshold arousal difficulties. Of the final 17 FSAD participants, 9 (53%) reported that they were using oral contraceptives.

A total of 18 women met the questionnaire screening criteria for the control group and the clinical interview confirmed that they did not meet DSM-IV-TR criteria for any sexual disorders. All 18 control women fell within one SD of the mean on all domains of the FSFI (Rosen et al., 2000). One control participant was later excluded, however, as she obtained a finger sensation threshold score of 72.3 mg, which was over three SD above the mean finger sensation threshold score for the overall sample (overall sample $M = 26.37$, $SD = 12.34$). Of the final 17 control participants, 10 (58%) reported that they were using oral contraceptives.

Measures

Participants completed eight self-report measures. The measures were used to identify women who met DSM-IV-TR criteria for FSAD and to identify a group of normally functioning control participants.

Derogatis Sexual Functioning Inventory (DSFI)

All participants were administered the DSFI Experience subtest and the DSFI Body Image subtest. The DSFI Experience subtest contains 24 items regarding petting, oral sex, intercourse, and masturbation. Participants indicated (yes/no) whether they have ever engaged in that activity. Retest coefficients and internal consistency coefficients for the DSFI Experience subtest are .90 (Derogatis & Melisaratos, 1979). Content analysis of the DSFI Experience subtest indicates that a wider range of sexual behaviors is sampled by this subtest than comparable measures and that this subtest is both a reliable and valid measure of sexual behavior (Andersen & Broffitt, 1988). The Experience subtest of the DSFI was used to ensure that all participants were sexually experienced. Any prospective participant who indicated a level of sexual experience one SD below the mean was not included in the study. The DSFI Body Image Scale contains 22 items; 10 items pertain to general body image issues, six items to female body image issues, and six items to male body image issues (Derogatis, 1978).

Orgasmic Functioning Questionnaire (OFQ)

As described above, participants completed selected portions of the OFQ designed to assess the participant's ability to achieve orgasm. Data collected from 246 women indicate that the OFQ has an internal consistency alpha = .78 (Meston et al., 1993).

Female Sexual Function Index (FSFI)

The FSFI is a 19-item measure of female sexual functioning. It provides a total score as well as domain scores for desire, arousal, lubrication, orgasm, satisfaction, and pain. The FSFI has been validated on a population of normally functioning and FSAD women (Rosen et al., 2000). The FSFI demonstrated high test-retest reliability ($r = .79$ to .86), internal consistency (Cronbach's alpha, .82 and higher), and good divergent validity (as compared to the Locke-Wallace Marital Adjustment Test) (Rosen et al., 2000). The FSFI has been shown to discriminate between sexually functional women and women with FSAD (Rosen et al., 2000) and women with Female Orgasmic Disorder (Meston, 2003).

Sexual Satisfaction Scale for Women (SSS-W)

The Contentment, Communication, and Compatibility Domains of the SSS-W (Meston & Trapnell, 2004) were used to evaluate the sexual satisfaction of the participants. Participants were asked questions such as, "I often feel my partner isn't sensitive or aware enough about my sexual likes and desires." Response scale ranges from 1 ("strongly disagree") to 5 ("strongly agree"). The measure demonstrated moderately high test-retest reliability for both sexually functional ($r = .58 - .76$) and dysfunctional women ($r = 0.65 - 0.74$) and discriminated between sexually functional and dysfunctional women ($p < .001$) (Meston & Trapnell, 2004). The Contentment, Communication, and Compatibility domains of the SSS-W were assessed to use as potential covariates in statistical analysis.

Sexual Functioning Index (SFI)

The Sexual Functioning Index (Taylor et al., 1994) was adapted for the purposes of this study such that participants were asked to report how frequently they have experienced "lack of vaginal lubrication" over the past month as well as over the past six months. This adaptation was done in order to increase the likelihood that

participants who had a persistent and recurrent problem with vaginal lubrication would be identified. Response scale ranged from 0 ("not at all") to 4 ("always").

Beck Depression Inventory (BDI)

The BDI is a 21-item measure of depressive symptomotology. Meta-analysis indicated a mean coefficient alpha of 0.81 for nonpsychiatric patients and 0.86 for psychiatric patients. Correlations between the BDI, clinical ratings, and the Hamilton Psychiatric Rating Scale for Depression for nonpsychiatric and psychiatric patients ranged from .60 to .74. The BDI discriminates depression from anxiety and between subtypes of depression (Beck, Steer, & Carbin, 1988)

Beck Anxiety Inventory (BAI)

The BAI is a 21-item measure of anxiety symptomotology. The measure has high internal consistency (alpha = .92) and 1-week test-retest reliability $r = .75$. The measure discriminated between anxious and nonanxious groups, and moderately correlated with the Hamilton Anxiety Rating Scale, $r = .51$ (Beck, Epstein, Brown, & Steer, 1988).

Medical Background Questionnaire

This measure was developed for the present study. It included items such as age, antidepressant use, number of alcoholic beverages consumed per week, and number of cigarettes smoked per week.

Tactile Sensitivity

Tactile sensitivity was measured using Von Frey monofilaments on the distal portion of the index finger of the participant's dominant hand and on the lower lip on the side corresponding to the finger measurement (e.g., right index finger, right side of lower lip). The fingers were chosen to measure tactile sensitivity to be consistent with the previous literature (e.g., Pukall, Binik, Khalife, Amsel, & Abbott, 2002). The lips were chosen because they are a primary erogenous zone, and testing on the lips does not require an invasive physical examination. A Von Frey monofilament is a hair-like fiber that, when pressed against the skin until the hair bends, reliably applies a specific force; the amount of applied force depends upon the diameter and length of the hair (Bell-Krotoski &Tomancik, 1987). A pilot study indicated that commercially available monofilaments were not sufficiently sensitive to measure tactile sensation on the mouth and, for some participants, on the fingers, and thus monofilaments were made and calibrated in the laboratory. Monofilaments were made by gluing polypropylene suture thread (Ethicon Prolene Sutures, Med-Vet International, Illinois) to a commercially produced plastic monofilament casing (a pen-like instrument; North Coast Medical, San Jose, CA) and calibrated using an analytical balance (Eliav & Gracely, 1998). Based on pilot testing, monofilaments applying 6, 8, 10, 20, 30, 40, and 80 mg of force were used on the fingers, and monofilaments applying 2, 4, 6, 8, 10, 20, and 40 mg of force were used on the lower lip.

Blood Pressure

Systolic and diastolic blood pressure were assessed using a digital blood pressure cuff (Smith & Nephew, Inc.).

Procedure

Participants who met the criteria for the study were scheduled for physiological testing and additional questionnaire testing. All examiners were female and were masked to the sexual functioning of the participants. When participants arrived at the laboratory, they were taken into the testing room and instructed to read a consent form (all provided consent). Participants then were invited to sit in a comfortable recliner for the testing.

Tactile Sensitivity

Prior to testing, the experimenter demonstrated that the monofilaments were neither dangerous nor painful. To ensure placement accuracy of repeated tests, a water-soluble circular ink mark 1cm diameter was placed on the center of the distal portion of the dominant index finger. The monofilament tip was placed inside the circular ink mark. On the lips, the monofilament was placed in the middle of the selected half of the lower lip. During testing the participants were asked to close their eyes and place their hand palm up with the fingers in a relaxed, curled position (for testing on lips, participants were asked to close their eyes and sit back and relax with their head tilted toward the experimenter).

The monofilaments were presented using a forced choice paradigm and the method of constant stimuli, procedures previously demonstrated to provide an accurate estimate of threshold (e.g., Bell-Krotoski, 1990, Maaser

& Farley, 1980). Specifically, the experimenter cued the participant to attend to her tactile sensations by saying "okay," and on either the count of "one" (1.5 sec) or "two" (1.5 sec), the monofilament was pressed against the participant's skin until it bent, and was held for 1.5 sec. The experimenter paused 1.5 sec between each count, such that each trial lasted 4.5 sec. The participants indicated on which count she felt the stimulus and was instructed to guess if she were not sure (chance levels of performance over many trials with a given stimulus suggested that the participant was unable to detect the stimulus).

A broad range of monofilament sizes was used initially, and then, based on each participant's performance, a smaller set of monofilament sizes were selected that best reflected the participant's range of sensation. Specifically, seven different monofilament sizes were applied, in semirandom order, 10 times for a total of 70 trials. If the participant demonstrated a gradual shift in accuracy of sensation, the monofilaments were narrowed to five sizes (e.g., little to no sensation on the smallest monofilaments [5/10 correct], sporadic sensation on mid-sized monofilaments [7 or 8/10 correct], accurate sensation on the largest monofilaments [10/10 correct]). If the participant demonstrated a rapid shift in accuracy of sensation, the monofilaments were narrowed to four sizes, as the use of five sizes in such cases would be unnecessarily redundant (e.g., little to no sensation with smaller monofilaments, accurate sensation on larger monofilaments). The selected monofilaments were then applied, in semirandom order, 20 times for a total of 80 to 100 trials. Thus, combining the data from the two stages, the selected monofilaments were applied a total of 30 trials each. Between stages, the participants filled out questionnaires.

Blood Pressure

Blood pressure was measured after the participant had been seated at least 30 min to ensure that measurements reflected resting blood pressure.

Debriefing

When the participant completed the experiment, she was given credit toward her Introduction to Psychology course requirement and debriefed regarding the purpose of the experiment. All participants, regardless of diagnosis, were provided a handout containing information about local psychotherapy opportunities, as required by the IRB.

Data Reduction

Raw scores for each monofilament size were converted to percent correct scores, such that 100% correct indicated that full tactile sensation was experienced and 50% correct indicated that no tactile sensation was experienced (chance levels of perception). Perceptual sensitivity to different monofilament sizes was plotted by fitting the data to a cumulative normal distribution. Specifically, the true cumulative normal psychometric function of each participant was estimated by employing the least-squares method to calculate the curve that best fit the percent correct scores of the four or five monofilament sizes. Threshold was defined as the interpolated monofilament size at which the participant was 84% correct, because this is the point at which the threshold estimate variability is most likely to be least (Green, 1990).

RESULTS

Analyses of Potential Covariates

Factors thought to affect sexual functioning were assessed for potential use as covariates in statistical analysis. These included physical characteristics, such as blood pressure (systolic and diastolic) (Bansal, 1988; Leiblum et al., 1994), pulse (Meston & Gorzalka, 1996), cigarette and alcohol use (Crenshaw & Goldberg, 1996), psychological factors such as depression (Frohlich & Meston, 2002), anxiety (Barlow, 1986), and body image (Jagstaidt, Golay, & Pasini, 1996), and sexual factors, such as comfort, contentment, compatibility, and satisfaction with sexual partner.

Covariates and finger and lip threshold were tested for multicollinearity using logistic regression analysis to examine the variance inflation factor (VIF). Covariates were considered multicollinear if they had a VIF score >2.5 (Allison, 1999). Covariates that demonstrated significant multicollinearity were combined with other covariates with which they were highly correlated. If highly correlated variables could not be combined, they were dropped from the analyses. Systolic blood pressure (VIF = 4.37), diastolic blood pressure (VIF = 3.81), BDI score (VIF = 2.73), SSS-W Contentment (VIF = 3.82), SSS-W Communication (VIF = 3.84), and SSS-W Compatibility (VIF = 4.11) all demonstrated multicollinearity. Systolic and diastolic blood pressures were significantly correlated ($r = .81$, $p < .001$), and thus systolic blood pressure was dropped from the analysis. BDI scores were significantly correlated with several variables (BAI score $r = .57$,

Table I. Summary of Covariates

Covariate	FSAD ($n = 17$)		Control ($n = 17$)				
	M	*SD*	*M*	*SD*	β	$\chi^2(2)$	*p*
Systolic BP	112.7	14.2	115.4	15.5	−.01	.29	ns
Diastolic BP	72.2	10.6	73.5	10.1	−.01	.14	ns
Pulse	68.1	10.2	72.2	8.2	−.05	1.74	ns
Cigarette Use (per/wk)	11.4	33.9	.1	.5	.14	3.90	.05
Alcohol Use (per/wk)	3.6	3.6	2.8	3.0	.07	.51	ns
Anxiety (BAI)	10.7	6.8	11.2	7.3	−.01	.05	ns
Depression (BDI)	7.3	6.4	5.2	3.8	.08	1.43	ns
Body Image (DSFI)	3.6	.6	3.8	.6	−.71	1.46	ns
SSS-W Contentment	19.6	4.7	23.7	2.0	−.33	9.90	.002
SSS-W Communication	25.0	4.3	27.8	3.8	−.18	4.08	.04
SSS-W Compatibility	24.4	5.1	27.8	2.8	−.22	5.91	.02
SSS-W Combined	23.0	4.7	26.4	2.9	−.31	8.10	.004

$p < .001$; body image $r = -.64$, $p < .001$; SSS-W Contentment scale $r = -.35$, $p = .04$; SSS-W Compatibility scale $r = -.47$, $p = .01$). Depression is a factor that is highly likely to be associated with sexual problems, and therefore it would be inappropriate to drop it from the model. Thus, BDI and BAI scores were combined to produce a single mood score. The SSS-W Contentment, SSS-W Communication, and SSS-W Compatibility scales were significantly correlated and thus were combined into a full-scale SSS-W variable. Re-examination of VIF using the above-described modifications indicated that issues of multicollinearity were resolved.

A series of binary logistic regressions was performed to determine whether any of the potential covariates should be included for statistical analysis. Diagnostic category was entered as the dependent variable and each potential covariate was entered. As illustrated in Table I, cigarette use ($\beta = .14$, $SE = .18$, Exp (B) = 1.15, $\chi^2(1) = 3.90$, $p = .05$) and SSS-W ($\beta = -.31$, $SE = .13$, Exp (B) = .74, $\chi^2(1) = 8.10$, $p = .004$) significantly predicted sexual functioning and thus were used in later analyses. In all later analyses, SSS-W was converted to tercile scores in order to account for possible nonlinearity.

Analysis of Group Differences in Sexual Functioning

A series of independent *t*-tests was used to compare the FSAD and control groups. Because of the increased likelihood of Type I errors when multiple statistical tests are performed, we considered only mean differences of $p < .005$ ($p < .05/10$) statistically significant. As illustrated in Table II, the FSAD group did not significantly differ from the control group in age, length of relationship, or sexual experience. In addition, they did not differ on the

Table II. Group Differences in Sexual Functioning

Measure	FSAD ($n = 17$)		Control ($n = 17$)			
	M	*SD*	*M*	*SD*	$t(33)$	*p*
Age	18.7	1.1	18.7	1.0	<1	ns
Length of Relationship (months)	13.9	9.4	12.5	12.8	<1	ns
Sexual Experience	20.3	2.2	20.7	2.0	<1	ns
FSFI						
Sexual Desire	7.4	1.8	8.2	1.3	1.38	ns
Arousal	14.5	3.2	18.3	1.6	4.39	<.001
Lubrication	14.9	3.3	19.7	0.8	5.78	<.001
Orgasm	9.6	4.0	13.8	1.4	4.13	<.001
Satisfaction	10.9	3.5	14.1	1.2	3.52	<.001
Pain	10.7	4.0	14.3	0.9	3.69	<.001
Total Score	25.5	5.3	33.2	1.9	5.58	<.001

Note. Sexual Experience scores were raw scores, on a 24 point scale (from the DSFI Experience subtest). FSFI scores range: Sexual Desire, 2–10; Arousal, 0–20; Lubrication, 0–20; Orgasm, 0–15; Satisfaction, 2–15; Pain, 0–15; Total Score, 2–36.

FSFI Desire Domain. The groups differed significantly on the FSFI Arousal, Lubrication, Orgasm, Satisfaction, and Pain Domains, and on the Total FSFI Score.

Analysis of Tactile Sensitivity and Sexual Functioning

Analyses were conducted to determine if tactile sensitivity scores differed between FSAD and control women. That is, hierarchical binary logistic regression was performed to determine whether a participant's tactile sensitivity score correctly predicted her diagnosis of FSAD versus no sexual problems. Sexual functioning (FSAD, control) was entered as the dependent variable; covariates were entered in the first block, lip in the second block, and finger threshold in the third block. As illustrated in Table III, after cigarette use and SSS-W were entered, the likelihood ratio test indicated that the two variables significantly predicted the occurrence of FSAD versus control. After lip threshold was entered, the likelihood ratio test indicated that the block did not significantly predict the occurrence of FSAD. After finger threshold was entered, the likelihood ratio test indicated that the block significantly predicted the occurrence of FSAD versus control. In this sample, 76.5% of FSAD participants were correctly classified as FSAD, and 76.5% of control participants were correctly classified as control. Group differences in tactile sensation are illustrated in Table IV.

Additional analyses were conducted to determine if women who reported more severe problems with sexual arousal also exhibited more severe deficits in tactile sensation. That is, hierarchical linear regression was performed to determine the relationship between the severity of sexual dysfunction and tactile sensation thresholds. The Lubrication Domain of the FSFI was used as a quantitative measure of FSAD severity (dependent variable) and finger and lip thresholds were used as the independent variables. Using the same procedure described above, the covariates were re-examined to determine whether a significant relationship existed between each covariate and the Lubrication Domain of the FSFI. Linear regression was performed entering each potential covariate as an independent variable, but only cigarette use ($\beta = -.07$, $SE = .02$, $t = -3.27$, $p = .003$, $R^2 = .25$) and SSS-W ($\beta = .36$, $SE = .14$, $t = 2.56$, $p = .02$, $R^2 = .17$) were significantly associated with the FSFI Lubrication domain.

Table III. Likelihood Ratio Test: FSAD versus Control

Variables entered	β	SE	Exp(B)	χ^2	*df*	*p*
Cigarette, SSS-W	—	—	—	8.77	3	.03
Lip Threshold	.06	.05	1.06	1.23	1	ns
Finger Threshold	.09	.05	1.10	4.05	1	.04

Table IV. Group Differences in Tactile Sensation

	FSAD ($n = 17$)		Control ($n = 17$)			
Measure	*M*	*SD*	*M*	*SD*	*d*	*t*
Finger threshold (mg)	29.1	*9.7*	20.8	*7.8*	1.10	2.82*
Lip threshold (mg)	14.7	*7.6*	10.9	*8.0*	0.47	1.42

*$p < .025$

To examine the relationship between severity of arousal dysfunction and tactile sensation, hierarchical linear regression was performed by entering cigarette-use and SSS-W into the first block, lip threshold into the second block, and finger threshold into the third block. Cigarette use ($\beta = -.07$, $SE = .02$, $t = -3.55$, $p = .001$) and SSS-W ($\beta = .36$, $SE = .12$, $t = 2.94$, $p = .01$) were significantly associated with lubrication functioning ($R^2 = .41$). Controlling for cigarette use and SSS-W, lip threshold ($\beta = -.05$, $SE = .06$, $t = -.81$, $p = .42$, $R^2\Delta = .01$) was not significantly associated with lubrication functioning. Controlling for cigarette use, SSS-W, and lip threshold, finger threshold ($\beta = -.06$, $SE = .05$, $t = -1.06$, $p = .30$, $R^2\Delta = .02$) was not significantly associated with lubrication functioning.

To determine whether any outliers in the data could be significantly affecting the model, studentized residuals were computed. Studentized residuals above 2.0 were considered as indicative of outliers. Two of the FSAD participants met these criteria, and the model was re-examined after these participants were removed. Cigarette use ($\beta = -.07, SE = .01, t = -5.18, p < .001$) and SSS-W ($\beta = .26$, $SE = .09$, $t = 2.80$, $p = .01$) were significantly associated with lubrication functioning ($R^2 = .55$). Controlling for cigarette use and SSS-W, lip threshold was not significantly associated with lubrication functioning ($\beta = -.03$, $SE = .05$, $t = -.54$, $p = .59$, $R^2\Delta = .01$). Controlling for cigarette use, SSS-W, and lip threshold, finger threshold was significantly associated with lubrication functioning ($\beta = -.10$, $SE = .04$, $t = -2.37$, $p = .03$, $R^2\Delta = .08$).

DISCUSSION

Finger threshold was significantly associated with presence or absence of FSAD and with severity of FSAD.

These findings were consistent with a pilot study in which as few as 25% of women reported vaginal dryness; in those women tactile sensitivity on the finger was significantly decreased as compared to normally functioning college-aged women (Frohlich & Meston, 1999).

Tactile sensitivity may be associated with FSAD because of individual differences in tactile sensation mechanisms. Women with arousal problems may simply have fewer tactile receptors than sexually functional women (Krantz, 1958). Alternatively, the central nervous system processing of tactile receptor signals may differ between women with and without FSAD. The amount of stimulation that produces afferent unit impulses does not vary, while the amount of stimulation needed for conscious perception of tactile stimulation does vary (Johansson & Vallbo, 1979), and this process may differ between women with and without FSAD.

The association between tactile sensation and FSAD may result from abnormalities in vascular mechanisms. Previous studies have found that men with erectile dysfunction have lower tactile sensitivity compared to men with normal erectile capacity (Rowland et al., 1993), and both erectile functioning and vaginal lubrication are dependent upon adequate blood flow to the genital tissue. When genital tissue becomes engorged with blood, such as with erection, tactile thresholds increase and this increase is more substantial in men with erectile problems (Rowland, 1998). Cigarette use was significantly associated with lubrication problems in the present study, which is consistent with studies in men that have noted that long-term cigarette use is associated with deterioration of the penile vasculature, resulting in erectile dysfunction (DePalma et al., 1987). Finally, hypertension decreases blood flow to the genitals (Okabe, Hale, Kumon, Heaton, & Adams, 1999), which decreases local temperature, which in turn has been shown to decrease tactile sensation in the penis of dogs (Johnson & Kitchell, 1987).

It is also feasible that anxiety and/or cognitive distraction may explain the association between tactile sensitivity and FSAD. Previous studies have noted an association between anxiety, cognitive distraction and sexual arousal dysfunction (Beck, Barlow, Sakheim, & Abrahamson, 1987; Geer & Fuhr, 1976). If women with FSAD are more anxious and distracted, they may be less likely to attend to physical sensations such as those experienced during sexual activity and those experienced during a tactile sensation examination. Future studies could evaluate the effects of distraction on tactile sensation and sexual functioning among sexually functional and dysfunctional populations by using a dichotic listening task (Geer & Fuhr, 1976), a sentence completion task (Beck et al., 1987), and/or electric shock (Beck et al., 1987).

It is of interest that FSAD was significantly associated with decreased sensitivity of the finger, which is not a primary erogenous zone. This suggests that the underlying mechanism may be a physiological process that is systemic, such as a vascular dysfunction, or a psychological process that may affect measurement of tactile sensation all over the body, such as anxiety or distraction. If so, tactile sensation on the index finger may serve as a biological marker for sexual arousal dysfunction.

It is unclear why tactile sensation of the index finger, but not the lower lip, was associated with severity of arousal functioning. It is possible that lip sensation is associated with severity of arousal functioning but was not detected in this study. Alternative measures of cutaneous sensation, such as vibrotactile sensation, temperature sensation, pain sensation, or sensory nerve conduction velocity, may be more sensitive at detecting individual differences in lip sensation. It is also possible that declines in skin sensation may be more readily noted on the more distal portions of the body (i.e., the extremities) than on the more proximal portions of the body, as is found in diabetic patients (Cavanagh, Simoneau, & Ulbrecht, 1993). Lip sensation may not have distinguished between sexually functional and dysfunctional women due to greater variation in lip sensation across the menstrual cycle. The facial tissue contains a higher density of estrogen receptors than the fingers (Hasselquist, Goldberg, & Schreter, 1980), and studies suggest that exogenous and endogenous estrogen levels affect tactile sensitivity (Bereiter & Barker, 1980; Herren, 1933; Komisaruk, Adler, & Hutchison, 1972). To our knowledge, no studies have examined the effects of oral contraceptive use on tactile sensation. In the present study, approximately half of the participants in each group reported oral contraceptive use, suggesting that if oral contraceptive use affects tactile sensation, it would have affected both groups equally.

It is important to note that severity of arousal functioning was significantly associated with finger threshold, but only after two outliers were removed from the model. The two outliers were women with FSAD who indicated fairly severe problems with vaginal dryness, but who also exhibited tactile sensation thresholds similar to women in the normally functioning group. In addition, logistic regression indicated that approximately a quarter (23.5%) of the FSAD women were incorrectly classified as control participants using finger and lip threshold as predictor variables. This suggests that tactile sensation is associated with FSAD for some women but not others. This is consistent with a recently proposed model of FSAD

suggesting that the broad diagnostic category of FSAD may comprise several subtypes (Basson, 2002). Given that this model has not been empirically validated yet, this interpretation must be considered highly speculative. Future research is needed to determine why some women with FSAD exhibit diminished tactile sensation while others do not.

This study had several limitations. Previous studies indicate that several aspects of tactile sensation are associated with sexual functioning, but in the present study, only non-genital regions were examined and only punctate sensation was measured. That is, studies in men with premature ejaculation (Xin et al., 1996) and in women with vulvar vestibulitis (Pukall et al., 2002) suggest an association between genital tactile sensation and sexual functioning, while the association between non-genital tactile sensation and sexually functioning is less clear. A study in men with premature ejaculation noted differences in vibrotactile sensation (Rowland et al., 1993; Xin et al., 1996), and a study in women with vulvar vestibulitis noted differences in punctate tactile and pain sensation (Pukall et al., 2002). Future studies will need to include a more comprehensive cutaneous sensation examination.

Future studies are needed to examine whether tactile sensitivity measures are useful in differentiating women with different types of sexual problems. This study found an association between arousal functioning and tactile sensation in FSAD women. It is possible that tactile sensitivity may also be associated with clinically diagnosed desire disorders, such as Hypoactive Sexual Desire Disorder or Sexual Aversion Disorder, as well as other DSM-IV-TR sexual disorders, such as situational type Female Orgasmic Disorder, Dyspareunia, and Vaginismus. To our knowledge, only one other study has examined cutaneous sensation in women with other types of sexual dysfunction. Pukall et al. (2002) noted that women with a specific form of dyspareunia (sexual pain), known as vulvar vestibulitis, have significantly more sensitive tactile and pain thresholds than normally functioning women. Taken together, this indicates that overly sensitive cutaneous sensation may lead to sexual pain, while inadequate cutaneous sensation may lead to impaired desire and/or arousal functioning, suggesting an optimal U curve of tactile sensitivity. A better understanding of the relationship between tactile sensation and sexual dysfunction may help elucidate the etiology of sexual dysfunction and may facilitate diagnostic accuracy and treatment effectiveness. For example, if some types of sexual dysfunction arise from impaired or highly acute tactile sensitivity, medications that may increase or decrease sensation thresholds, such as alprostadil or dinoprostone (Neal, 2002) and/or fluoxetine (Yilmaz, Tatlisen, Turan, Arman, & Ekmenkcioglu, 1999), could prove beneficial.

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