ORIGINAL RESEARCH—ANATOMY/PHYSIOLOGY

The Sensitivity of Continuous Laboratory Measures of Physiological and Subjective Sexual Arousal for Diagnosing Women with Sexual Arousal Disorder

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ABSTRACT

Introduction. Past findings on the diagnostic sensitivity of vaginal photoplethysmography are limited by testing among women with heterogeneous sexual dysfunctions and by the use of statistical techniques that are unable to assess how changes in subjective arousal are associated with changes in physiological arousal.

Aims. The aims of this study were to: (i) test the sensitivity of vaginal photoplethysmography and continuous measures of subjective sexual arousal in differentiating between women with and without sexual arousal or orgasm dysfunction; and (ii) examine the diagnostic utility of measuring the synchrony between genital and subjective sexual responses.

Methods. Sexual arousal was assessed in sexually healthy women (n = 12), women with orgasm disorder (OD; n = 12), and 38 women who met the criteria for the three subcategories of sexual arousal dysfunction described by Basson et al. (i.e., genital sexual arousal disorder [GAD; n = 9], subjective sexual arousal disorder [SAD; n = 13], and combined genital and subjective arousal disorder [CAD; n = 16]).

Main Outcome Measures. Physiological sexual arousal was assessed using vaginal photoplethysmography, and subjective sexual arousal was measured continuously and using a Likert-scale in response to sexual videos.

Results. Women with GAD showed the lowest and women with CAD showed the highest levels of vaginal pulse amplitude response to erotic stimuli. Women with sexual arousal disorder showed significantly lower levels of subjective sexual arousal to erotic stimuli than did sexually healthy women. Relations between subjective and physiological measures of sexual arousal were significantly weaker among women with sexual arousal disorder than sexually healthy women or women with OD.

Conclusion. Preliminary support was provided for the diagnostic utility of measuring the synchrony between subjective and genital arousal in women with sexual arousal disorder. Findings do not support the sensitivity of using vaginal photoplethysmography, or continuous or Likert-scale measures of subjective arousal for differentiating between subtypes of women with sexual arousal disorder. **Meston CM, Rellini AH, and McCall K. The sensitivity of continuous laboratory measures of physiological and subjective sexual arousal for diagnosing women with sexual arousal disorder. J Sex Med 2010;7:938–950.**

Key Words. Vaginal Photoplethysmography; Female Sexual Dysfunction; Female Sexual Arousal Disorder; Female Sexual Function Index; Female Orgasmic Disorder; Assessment of Female Sexual Arousal

Introduction

To date, clinicians have relied almost exclusively upon self-report measures for the diagnostic assessment of sexual dysfunction in women, namely clinician-administered interviews, validated questionnaires, patient diaries, and sexual event logs. Physiological assessment techniques have focused primarily on detecting changes in vaginal blood flow using indirect measures of heat dissipation or thermography [1], Doppler ultrasonography [2], or, most commonly, vaginal

photoplethysmography. The degree to which such physiological measures may be used as an indicator of sexual dysfunction in women has been debated in the literature since Sintchak and Geer first introduced the vaginal photoplethysmograph in 1975 [3]. Two issues remain unresolved. First, findings to date have not consistently supported the diagnostic sensitivity of vaginal photoplethysmography. Wincze et al. [4], and Palace and Gorzalka [5,6] found lower levels of vaginal blood volume (VBV) responses to an erotic film among women with arousal and orgasm difficulties compared with control women. Morokoff and Heiman [7], however, failed to find differences in vaginal pulse amplitude (VPA) between women with and without sexual difficulties, and Wincze et al. found no significant differences in VBV sexual responses in women who were assessed prior to and following sex therapy [8]. The methodology of some of these earlier studies has been criticized for combining women with a variety of sexual difficulties into one heterogeneous experimental group.

Later sexual psychophysiological studies that have more carefully classified women according to specific *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR) [9] criteria have been only slightly more successful at differentiating between women with and without sexual dysfunction. One study found vaginal photoplethysmography differentiated between women with and without dyspareunia when the women viewed film scenes depicting coitus, but not other erotic scenes [10]. However, more recent studies have failed to find significant differences in VPA responses between women with dyspareunia and control women [11–13]. Meston and Gorzalka noted differences in VPA between women with and without orgasm difficulties, but only when exposed to 20 minutes of acute exercise designed to activate the sympathetic nervous system [14]. In the absence of nervous system activation, there were no substantial differences between sexually functional women, anorgasmic women, or women with low sexual desire in their levels of vaginal response to an erotic film.

Given the vaginal photoplethysmograph specifically measures the arousal, or vasocongestive, phase of a woman's sexual response, one might expect it to be most effective in differentiating between women with and without an arousal disorder. Findings to this regard have been mixed. Basson and Brotto found that VPA responses predicted which of a group of estrogenized postmenopausal women with acquired female sexual arousal disorder (FSAD) and orgasmic impairment benefited from treatment with sildenafil [15], and Brotto et al. noted VPA differences between women with sexual arousal disorder and controls under conditions of laboratory-induced hyperventilation known to increase sympathetic nervous system activation [16]. Other recent studies, however, failed to find significant differences in VPA responses between women with and without sexual arousal dysfunction [17,18].

Basson et al. [19], based on the recommendations of the 2nd International Consensus Panel—a meeting of experts that was sponsored by the American Foundation of Urologic Disease for the redefinition of sexual dysfunction in women, proposed that a distinction be made between women with sexual arousal concerns that are psychological or subjective in nature, those that are genital, and those that include complaints of both decreased subjective and genital arousal. Using this proposed classification system, two recent studies have noted differences in VPA responses between specific subgroups of women with an arousal disorder. One study found that VPA responses to erotic stimuli significantly increased among subgroups of women with absent or diminished subjective sexual arousal, control women, and women with a combination of genital and subjective sexual arousal concerns, but not among women with arousal concerns pertaining specifically to genital arousal [20]. A second study found VPA differences to laboratory-induced hyperventilation between women with genital or combined genital and subjective arousal concerns from women with subjective arousal concerns or control women [16]. Together, the findings from these two studies suggest the vaginal photoplethysmograph may be sensitive at discriminating between women with and without specific genital, but not subjective, arousal disturbances.

A second issue in the debate as to whether physiological measures may be used as an indicator of sexual dysfunction in women centers around the concordance, or lack thereof, between subjective and physiological measures of sexual arousal in women. In contrast to findings in the male sexual psychophysiology literature which generally indicates high correlations between erectile and self-reported arousal, studies that have employed both subjective and physiological indices of sexual arousal in women have reported correlations that are generally very low. Explanations proposed to account for the low concordance rates in women include: an inability for women to detect subtle

changes in vaginal blood flow [21], negative affect induced by using traditionally male-produced erotica [22], demand characteristics associated with women's reluctance to report being aroused [23], and lack of importance or inattention to genital cues [24]. The findings from studies that have tested these hypotheses can only partially explain the desynchrony noted between responses in women [25]. Some theorists have proposed the desynchrony may be the result of genital responses occurring automatically and independent of conscious thought processing [26].

Recently, Rellini et al. tested the hypothesis that the lack of concordance between measures of women's sexual arousal relates to the data handling and statistical analyses used in past studies to assess the association between physiological and subjective sexual arousal [27]. The authors noted that past studies of this nature have sampled numerous VPA data points and correlated an average of these points with a single Likert-scale subjective arousal data point [7,28] or a mean composite of several Likert-scale questions [29]. In doing so, the richness of the data is reduced, and how changes in one measure may be associated with changes in the other measure cannot be assessed. Rellini et al. proposed that a more appropriate way to analyze the relationship between VPA and subjective sexual arousal is to continuously and simultaneously measure the two variables throughout exposure to sexual and nonsexual films, and to use hierarchical linear modeling (HLM) for the statistical analysis [27]. (For a full explanation of the advantages of using HLM analyses, see Rellini et al. [27]). Using HLM to assess the relation between VPA and continuous measures of sexual arousal, Rellini et al. reported significant relations between VPA and subjective sexual arousal in sexually healthy women.

The primary goal of the present study was to test the sensitivity of vaginal photoplethysmography and continuous measures of subjective sexual arousal in differentiating between sexually healthy women and women with specific subtypes of sexual arousal disorder proposed by Basson et al. [19]. To this regard, the findings from this study will help determine whether laboratory measures of subjective and physiological sexual arousal in women may be useful in the classification and diagnosis of sexual arousal dysfunction in women. A secondary goal of this study was to examine the relation between subjective and physiological sexual arousal in women with orgasm dysfunction (OD). Given that orgasm is believed to be both a mental and physiological experience [30], it may be that women with OD, particularly those without complaints of decreased genital arousal, have difficulty attaining orgasm because they are unable to maintain a focus on physiological sexual sensations. If this is the case, we would expect there to be significantly greater desynchrony between subjective and genital measures of sexual arousal among women with orgasm difficulties compared to sexually healthy women. To this regard, findings from this study may provide insight into the etiology of OD in women.

Method

Participants

Participants were 62 women recruited via local community and university advertisements. The respondents were informed that the purpose of the experiment was to investigate the effects of brief visual stimuli which included erotic content on emotional and physiological responses. Exclusion criteria assessed during initial phone interviews included: (i) under the age of 18; (ii) postmenopausal; (iii) currently pregnant; (iv) current and/or previous reported diagnoses of DSM-IV-TR [9] axis I disorders including: organic mental syndromes and disorders, schizophrenia, delusional disorder or psychotic disorders not classified elsewhere, bipolar disorder, eating disorders (such as anorexia nervosa and bulimia), depression, and panic disorder; (v) currently receiving medications known to affect vascular or sexual functioning (including antidepressants, antihypertensives); (vi) a history of diabetes, thyroid disorder, cardiovascular disease, neurological disease, or stroke; (vii) homosexual orientation; and (viii) no sexual activity in the past 4 weeks.

Women who qualified for inclusion in the study were evaluated for current sexual functioning during a second telephone screening using a structured clinical interview designed to assess both DSM-IV-TR criteria for sexual dysfunction and subtypes of sexual arousal disorder as outlined by Basson et al. [19]. The interviews were conducted by a clinical doctoral student with over 300 hours experience in clinical assessment. The interviews were extensive and allowed for appropriate clarification of answers required for accurate diagnoses. Based on the information obtained during interviews, the participants were categorized into one of five groups. These groups were identified as: (i) women with no current sexual concerns or problems (controls); (ii) women with generalized OD;

Table 1 Mean (±SDs) Female Sexual Function Index (FSFI) scores by participant group

	Controls N = 12	OD N = 12	SAD N = 13	GAD N = 9	CAD N = 16
Desire	5.1 (0.87)	4.20 (1.09)*,‡,¶	2.18 (1.12)*,†,§	3.45 (1.27)*,‡	2.59 (1.04)*,†
Arousal	5.7 (0.27)	4.48 (0.94)*,‡,¶	2.92 (1.17)*,†	3.75 (1.16)*,¶	2.49 (0.85)*,†,§
Lubrication	5.7 (0.31)	5.23 (0.66)*,§,¶	4.61 (0.88)*,‡	3.83 (1.55)*,†	3.36 (0.95)*,†,‡
Orgasm	5.30 (0.78)	1.87 (0.94)*	2.95 (1.58)*	2.75 (1.55)*	2.23 (1.05)*
Satisfaction	5.20 (0.74)	4.70 (0.62)‡,§,¶	3.49 (1.20)*,†	3.55 (0.81)*,†,¶	2.65 (0.97)*,†,§
Pain	5.0 (1.82)	5.47 (0.62)§	5.60 (0.76)§	4.25 (1.72)†,‡,¶	5.33 (0.77)§
FSFI—Total	32.14 (3.31)	25.93 (2.95)*,‡,§,¶	21.75 (5.38)*,†	21.58 (5.15)*,†	18.64 (3.60)*,†

*Significant difference from controls.
†Significant difference from OD.
‡Significant difference from SAD.
§Significant difference from GAD.
¶Significant difference from CAD.
Superscripts indicate significant differences ($P < 0.05$) between groups, within FSFI domains, based on follow-up independent sample *t*-tests.
OD = orgasm dysfunction; SAD = subjective sexual arousal disorder; GAD = genital sexual arousal disorder; CAD = combined genital and subjective arousal disorder.

(iii) women with subjective sexual arousal disorder (SAD); (iv) women with genital arousal disorder (GAD); and (v) women with combined subjective and genital arousal disorder (CAD). The subgroups of sexual arousal dysfunction were categorized according to the recommendations published by the 2nd International Consensus Panel [19].

Twelve women were included in the control group based on the criteria of no self-report of any current sexual concerns or distress during the clinical interview. Twelve women were included in the OD group based on meeting DSM-IV-TR criteria for female orgasmic disorder, generalized subtype (i.e., orgasm problems occurred in all situations and all contexts with or without a partner) as self-reported during the clinical interview, and reporting "no" to the question, "Do you think you have an arousal problem?" during the telephone screening interview. Thirteen women were included in the SAD group based on meeting the following consensus panel criteria for SAD [19]: "Absence of or markedly diminished feelings of sexual arousal (sexual excitement and sexual pleasure) from any type of sexual stimulation. Vaginal lubrication or other signs of physical response still occur." Nine women were included in the GAD group based on meeting the following consensus panel criteria for GAD [19]: "Absent or impaired genital sexual arousal. Self-report may include minimal vulval swelling or vaginal lubrication from any type of sexual stimulation and reduced sexual sensations from caressing genitalia. Subjective sexual excitement still occurs from non-genital sexual stimuli." These women also met DSM-IV-TR criteria for FSAD. Sixteen women were included in the CAD group based on meeting the following consensus panel criteria for CAD [19]: "Absence of or markedly diminished feelings of sexual arousal (sexual excitement and sexual pleasure), from any type of sexual stimulation as well as complaints of absent or impaired genital sexual arousal (vulval swelling, lubrication)."

Female Sexual Function Index (FSFI) [31] scores on the arousal and lubrication domains were used as a validity check on our subgroup classification of sexual arousal disorder. Women in the control group scored within the range of sexually healthy women on both the arousal and lubrication domains of the FSFI; women with SAD scored within the range of women with FSAD on the FSFI arousal domain; women with GAD scored with the range of women with FSAD on the FSFI lubrication domain; women with CAD scored with the range of women with FSAD on both the FSFI lubrication and arousal domains [31]. For FSFI means (±SD) by group, see Table 1.

Consistent with literature that indicates a high comorbidity of arousal and orgasm problems in women [32], many of the women in the three arousal disorder groups indicated difficulties with orgasm during the clinical interviews. Specifically, 14 women in the CAD group reported difficulties with orgasm (10 generalized, 4 situational), eight women in the GAD group reported difficulties with orgasm (five generalized, three situational), and 11 women in the SAD group reported difficulties with orgasm (six generalized, five situational). Situational orgasm disorder in this study referred to women whose orgasm difficulties were limited to certain types of stimulation, situations/circumstances, and/or partners. Women who complained only of difficulty attaining orgasm with vaginal versus clitoral stimulation were not considered to have situational orgasm disorder.

Measures

Sexual Functioning

The FSFI was used to assess current levels of sexual function [31]. The FSFI is composed of 19 items divided into factor-analytically derived subscales: desire (two items), arousal (four items), lubrication (four items), orgasm (three items), satisfaction (three items), and pain (three items). The reliability and validity of the FSFI have been well established [31–33].

Physiological Sexual Arousal

Physiological responses to audiovisual films were measured using a vaginal photoplethysmograph to detect changes in VPA [3]. VPA is a measure of short-term changes in vaginal wall engorgement [34] and has been found to be a sensitive measure of sexual arousal in women [35]. VPA was sampled 80 times per second during the entire film sequence, and the amplitude of each vaginal pulse wave was recorded in millivolts (mV). Using the same procedures as previous studies of this nature [14,29,36], psychophysiological artifacts related to movement or contractions of the pelvic muscles were deleted using a computer software program following visual inspection of the data.

Continuous Subjective Sexual Arousal

In order to measure subjective sexual arousal both continuously and simultaneously during exposure to erotic films, the Sexual Psychophysiology Laboratory at the University of Texas at Austin developed a device termed the "arousometer" which consists of a computer optic mouse which is mounted on a wooden track divided into eight intervals, from "0" to "7" which reflect increasingly higher levels of feeling sexually aroused. (For full discussion of the arousometer, see Rellini et al. [27]).

Likert Scale Subjective Response to the Erotic Films

In order to compare subjective responses to previous studies of this nature, the following three subscales of an adapted version of the film scale by Heiman and Rowland [37] were administered: mental sexual arousal (two items), negative affect (five items), and positive affect (four items).

Stimuli Material

Films

Film stimuli consisted of a 14-minute audiovisual film which included: (i) 1 minute display of the word "relax;" (ii) 3 minutes of a neutral stimuli (travel film); and (iii) 10 minutes of an erotic film. The erotic segment depicted a heterosexual couple engaging in foreplay (i.e., kissing, petting, manual stimulation), oral sex, and sexual intercourse, and has previously been shown to induce sexual arousal in women in our laboratory [27].

Procedure

After completing phone screening interviews, the participants were scheduled for a single experimental session in the Sexual Psychophysiology Laboratory at the University of Texas at Austin. Upon arrival, the participants signed consent forms, were given a chance to ask questions, and then completed the FSFI [31] and a demographics questionnaire. The participant inserted the vaginal photoplethysmograph alone in the internally locked testing room, and notified the experimenter via an intercom system when she was ready. At this time, she relaxed on a recliner chair for a 10-minute habituation period before exposure to the 14-minute film sequence. During the film, continuous levels of physiological and subjective sexual arousal were recorded using the vaginal photoplethysmograph and the arousometer. Following the film sequence, the participant completed the film scale and got dressed. The participants were debriefed and compensated $50.00 for their time. All procedures were approved by the University of Texas at Austin Internal Review Board.

Data Reduction

Using the AcqKnowlegdge (BioPack, Santa Barbara, CA, USA) software program, the researcher recorded the peak-to-trough value (in mV) for each pulse throughout the film presentations. Data were then averaged across 10-second intervals which produced 18 data points during the neutral film, and 60 data points during the erotic film for each participant. For correlational analyses with Likert scale scores, VPA difference scores were computed by separately averaging VPA responses across the entire neutral and erotic film segments, and subtracting the mean of the neutral film from the mean of the erotic film.

The subjective data collected from the arousometer were sampled every 0.5 second and averaged across every 10 seconds throughout the film presentations. Corresponding to the VPA data, this provided 18 data points during the neutral film, and 60 data points during the erotic film. Each data point was expressed as the movement of the pointer on a range from 0 to 100 potential points (i.e., the value "0" and "7" on the arousometer

moved by the participants corresponded to point "0" and "100" on the computer screen).

Data Analysis

As per the analyses described in Rellini et al. [27], three sets of analyses were conducted in this study to assess group differences, including: (i) increases in VPA; (ii) increases in both continuous and Likert scale subjective sexual arousal; and (iii) relationships between continuous physiological and subjective sexual arousal. The HLM analyses in this study were conceptualized as two-level models. The rate of change in VPA, subjective sexual arousal, and increase in VPA predicted by subjective sexual arousal were computed using OLS-based procedures used in HLM methodology. This type of analysis looks at changes in the outcome variable within an individual, and then compares the rate of change between individuals. An important advantage of this methodology over repeated measures analyses of variance (ANOVAS) or multivariate analyses of variance (MANOVAS) is the ability to look at changes relative to the individual without the error introduced by between participant differences in baseline levels of VPA. HLM allows one to simultaneously assess within and between-participant differences in the rate of change during the nonsexual and the sexual videos.

In the first HLM analysis, we regressed physiological sexual arousal (VPA) on time, the within-participant covariate (level 1). In this model, level 2 variables (between-participant predictors) were the groups (i.e., controls, OD, SAD, GAD, CAD). Women in the control group were used as the reference group, meaning that responses from each group were compared to controls. No comparisons were computed between the different sexual disorders. A second HLM model, similar to the first, was computed, but subjective sexual arousal was regressed on time (within participant) while level 2 remained the same. These two HLM models allowed us to compare the groups on rate of change (slope coefficients) for VPA, taking into consideration the wide discrepancies in baseline VPA levels. The slope of the regression lines computed within participants allows comparison of rates of change between participants. The groups were compared to each other on intercept and slope estimates with slope coefficients indicating the number of units in the outcome variable that changed for each unit of increase in the within-person predictor (HLM beta coefficients are not standardized). This means that for the HLM analyses where VPA was the outcome and time was the within-person predictor (level 1), the beta coefficients indicated the number of millivolts VPA increased for each 10 seconds of the erotic video (units for time were 10-second bins). A third HLM analysis was computed for VPA as predicted by subjective sexual arousal to assess the association between the two variables. For this model, level 2 (between participants) included the dummy-coded groups as in the other two HLM analyses. The intercept of the regression lines was centered, which means that the intercept indicated VPA given the participants' average subjective sexual arousal. The women were compared on estimated VPA levels when subjective sexual arousal was the average subjective sexual arousal computed on the entire sample of women. In this model, the slope coefficients indicated the unit of increase in VPA (millivolts) when there was an increase in a unit in subjective sexual arousal (range for subjective sexual arousal: 1–100).

Results

Participants

A one-way ANOVA revealed that women in the five groups did not significantly differ on age, $F(4, 57) = 0.69$, $P = 0.60$. Likelihood ratio analyses indicated that women in the five groups did not significantly differ on ethnicity, LR = 18.32, $P = 0.31$, or educational background, LR = 14.85, $P = 0.25$. Kendall's tau-b analyses indicated that women in the five groups did not differ significantly in length of current relationship, $T = 1.68$, $P = 0.09$. For demographic breakdowns by group, see Table 2.

To determine the overall group differences on the FSFI, MANOVAS were conducted using group as the between-subject variables, and FSFI domain and full-scale scores as the dependent variables. Results indicated significant differences between groups on the desire domain, $F\ (4,\ 58) = 15.12$, $P < 0.001$; the arousal domain, $F\ (4,\ 58) = 26.19$, $P < 0.001$; the lubrication domain, $F\ (4,\ 58) = 15.26$, $P < 0.001$; the orgasm domain, $F\ (4,\ 58) = 16.04$, $P < 0.001$; the satisfaction domain, $F\ (4,\ 58) = 17.34$, $P < 0.001$; and the FSFI full-scale score, $F\ (4, 58) = 21.37$, $P < 0.001$. The groups did not significantly differ on the pain domain of the FSFI, $F\ (4,\ 58) = 1.82$, $P = 0.14$. Follow-up t-tests between each group on each domain score and full-scale score of the FSFI are indicated in Table 1.

Physiological Sexual Arousal

Women in all five groups showed a significant increase in VPA associated with exposure to the

Table 2 Participant characteristics by group

	Controls N = 12	OD N = 12	SAD N = 13	GAD N = 9	CAD N = 16
Age					
Mean (SD)	28.08 (8.40)	24.67 (6.11)	28.38 (8.68)	28.44 (9.06)	29.75 (8.48)
Range	20–45	19–41	19–50	19–45	18–51
Race n (%)					
African American	0 (0.00)	1 (8.30)	0 (0.00)	0 (0.00)	1 (6.30)
Caucasian	10 (83.30)	10 (83.30)	9 (69.20)	5 (55.60)	10 (62.50)
Hispanic	1 (8.30)	0 (0.00)	1 (7.70)	3 (33.30)	3 (18.80)
Native American	1 (8.30)	0 (0.00)	1 (7.70)	1 (11.10)	0 (0.00)
Asian	0 (0.00)	1 (8.30)	2 (15.40)	0 (0.00)	2 (12.50)
Education					
High school graduate	2 (16.70)	0 (0.00)	0 (0.00)	1 (11.10)	3 (18.80)
College	10 (83.30)	12 (100)	11 (84.60)	7 (77.80)	10 (62.50)
Advanced degree	0 (0.00)	0 (0.00)	2 (15.40)	1 (11.10)	3 (18.80)
Length of current relationship					
<1 year	7 (58.3)	4 (33.3)	2 (15.4)	2 (22.2)	2 (12.6)
1–5 years	3 (25.0)	4 (33.4)	5 (38.5)	4 (44.4)	8 (50.1)
>5 years	0 (00.0)	3 (25.0)	5 (38.5)	3 (33.3)	6 (37.5)
Not currently involved	2 (16.70)	1 (8.30)	1 (7.70)	0 (0.00)	0 (0.00)

Data in parentheses reflect percentages of the four separate groups, not the database as a whole.
OD = orgasm dysfunction; SAD = subjective sexual arousal disorder; GAD = genital sexual arousal disorder; CAD = combined genital and subjective arousal disorder.

sexual videos ($\beta = 2.43$, $t = 4.60$, $P < 0.001$), suggesting the films were effective in eliciting genital sexual arousal among all groups of women.

When women with the three subtypes of arousal disorder were grouped together and compared with the control women, it appeared that the control group showed an increased physiological response from the neutral to the erotic film ($\beta = 2.64$, $t = 2.54$, $P < 0.001$), but no significant differences were observed between women with an arousal disorder and sexually healthy women ($\beta = 0.12$, $t = 1.31$, $P = 0.929$). The level 1 variance remaining unexplained in this model was 45.37 (χ^2 [58] = 22,725.28, $P < 0.001$). When women in the three subgroups of arousal disorder were separated during the analysis, women in the SAD, GAD, and OD groups showed a significantly weaker increase in VPA as compared to women in the control group. Follow-up analyses that used seconds as predictors of the changes in VPA revealed that as the movie changed from neutral to exponentially more erotic content (i.e., foreplay, oral sex, and vaginal intercourse), the increase in VPA was significantly lower in women with GAD than in women with SAD, ($\beta = -0.0026$, $t = -4.84$, $P < 0.001$). This coefficient means that over the course of the 840 seconds of the video sequence, the VPA of women with GAD was 2.18 mV less compared to women with SAD. By contrast, women in the CAD group showed a significantly greater VPA increase from neutral to erotic films as compared to women in the control group. A total of 88.8% of the variance explained by this model is between-participant variance, suggesting that this model was successful at predicting the between-participant variance. The variance component of level 1 (σ^2) was 47.7 (χ^2 [58] = 35,635.65, $P < 0.001$), suggesting that while a portion of the within-participant variance was explained by the model, a significant portion still remained unexplained. Table 3 illustrates the β coefficients, and *t* and *P* values for the analyses conducted on this

Table 3 Summary of hierarchical linear modeling results

Groups	β	*t*	*P*
VPA changes from neutral to erotic films (mV)			
Controls	2.64	13.87	0.000
OD	–1.17	–4.51	0.000
SAD	–0.67	–2.55	0.011
GAD	–1.18	–3.90	0.000
CAD	1.41	5.58	0.000
Continuous subjective sexual arousal changes from neutral to erotic films (0–100)			
Controls	31.75	21.60	0.000
OD	–4.63	–2.23	0.026
SAD	–4.81	–2.36	0.018
GAD	–8.17	–3.52	0.001
CAD	–4.85	–2.50	0.013
Continuous subjective sexual arousal in relation to VPA			
Controls	3.19	10.67	0.000
OD	–0.37	–0.73	0.466
SAD	–1.86	–4.97	0.000
GAD	–1.19	–2.03	0.042
CAD	–1.71	–5.06	0.000

Subjective sexual arousal was measured with the arousometer. The control group is the reference group, meaning that the other β coefficients are the sum between the control β and the β coefficient of interest. All coefficients are not standardized.
OD = orgasm dysfunction; SAD = subjective sexual arousal disorder; GAD = genital sexual arousal disorder; CAD = combined genital and subjective arousal disorder; VPA = vaginal pulse amplitude.

Table 4 Mean (±SDs) vaginal pulse amplitude (VPA) and continuous subjective sexual arousal by participant group

	Neutral Film		Erotic Film	
	Mean	*SD*	Mean	*SD*
VPA (mV)				
Controls	3.98	1.93	7.62	6.68
OD	3.49	3.91	5.40	5.88
SAD	4.49	5.17	7.26	9.79
GAD	3.40	4.25	5.04	6.75
CAD	3.20	3.48	6.49	8.47
Subjective sexual arousal (0–100)				
Controls	0	0	43.78	26.88
OD	0	0	33.08	15.87
SAD	0	0	24.76	21.45
GAD	0	0	23.45	17.12
CAD	0	0	29.07	20.89

OD = orgasm dysfunction; SAD = subjective sexual arousal disorder; GAD = genital sexual arousal disorder; CAD = combined genital and subjective arousal disorder.

model. Table 4 provides the means and standard deviations (SDs) of the VPA scores by film and group. Figure 1 illustrates the HLM slopes for VPA for each of the participant groups.

Subjective Sexual Arousal

Analyses conducted among all women using continuous subjective sexual arousal data (i.e., arousometer) showed a significant increase in subjective sexual arousal from neutral to erotic films ($\beta = 31.75$, $t = 22.10$, $P < 0.001$). This can be interpreted as an increase of approximately 32% from neutral to erotic films, and indicates the erotic films were effective in eliciting subjective perceptions of sexual arousal among all groups of women.

When women in the arousal disorder subtypes were grouped in a single group and compared to controls, they showed a significantly lower increase in subjective sexual arousal ($\beta = -5.56$, $t = 1.65$, $P < 0.001$). When these women were divided into the three different subgroups and compared to women in the control and OD groups, women in the OD group and women in each of the arousal disorder subgroups showed a significantly lower increase in subjective sexual arousal from neutral to erotic films as compared to controls. The β coefficients for OD, SAD, and CAD were all significant at level $P < 0.05$, and ranged between –4.85 and –4.62, while the coefficient for GAD was –8.17 ($t = -3.52$, $P < 0.001$). In the model comparing the control group to OD, GAD, SAD, and CAD, 16.1% of the variance at level 1 remained unexplained (χ^2 [58] = 3,092.94, $P < 0.001$). The between-participant variance explained by this model was 42%. Follow-up analyses revealed the increase in continuous subjective sexual arousal did not significantly differ between subgroups of women with GAD and SAD, ($\beta = -3.42$, $t = -0.42$, $P = 0.68$). Table 3 illustrates all the coefficients for this model. Table 4 provides the means and SDs of the continuous subjective arousal scores by film and group. Figure 2 illustrates the HLM slopes for continuous subjective sexual arousal for each of the participant groups.

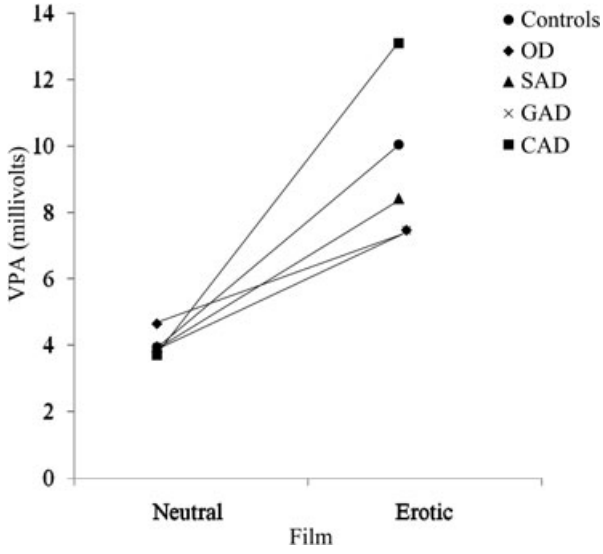

Figure 1 Illustration of HLM coefficients computed for VPA during neutral and erotic videos for women in the CONTROL, OD, SAD, GAD, and CAD groups.

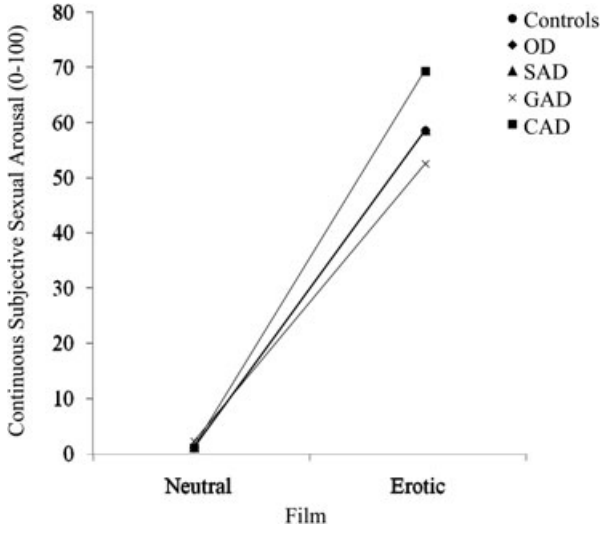

Figure 2 Illustration of HLM coefficients computed for continuous subjective sexual arousal measured with the arousometer during neutral and erotic videos for women in the CONTROL, OD, SAD, GAD, and CAD groups.

Table 5 Group differences on Likert scale measures

Film scale	Controls	OD	SAD	GAD	CAD
Mental sexual arousal	5.43 (1.36)[a]	4.55 (1.35)	3.67 (0.93)[b]	3.78 (1.03)[b]	4.57 (0.90)
Positive affect	3.79 (1.39)[a]	3.03 (1.27)[a]	2.33 (1.00)[b]	2.25 (0.88)[ba]	2.75 (1.30)
Negative affect	1.70 (0.61)	1.54 (0.50)[a]	1.63 (0.56)	1.85 (0.64)[a]	1.39 (0.35)

Different superscripts indicate a significant difference between groups, within domains, $P < 0.05$.
OD = orgasm dysfunction; SAD = subjective sexual arousal disorder; GAD = genital sexual arousal disorder; CAD = combined genital and subjective arousal disorder.

ANOVAs were conducted on self-report measures of affect and mental sexual arousal in order to compare results with previous studies that have used Likert scale measures of subjective responses. When scores were combined from the women in the three arousal disorder groups, levels of mental sexual arousal (t [44] = 3.49, $P = 0.001$) and positive affect (t [44] = 2.99, $P = 0.005$) after the erotic video were significantly lower as compared to the control group. No significant differences were observed between women in the control and the three combined arousal disorder groups on measures of negative affect. Tukey's post hoc tests showed that the differences in levels of mental sexual arousal and positive affect were caused by a significant difference between the control and the SAD groups (mental sexual arousal M difference = 1.77, $P < 0.05$; positive affect M difference = 1.46, $P < 0.05$), and between the control and the GAD groups (mental sexual arousal M difference = 1.66, $P < 0.05$; positive affect M difference = 1.54, $P < 0.05$). No significant differences were observed between the OD and control groups on any of the film scale subscales. Table 5 provides a summary of the means and SDs observed between groups for each of the film scale subscales.

Relationship between Physiological and Continuous Subjective Sexual Arousal

Changes in continuous subjective sexual arousal significantly predicted changes in VPA for women in the control group. Estimates based on beta coefficients suggested an increase in 1 mV corresponded to an increase of 31.9 units in continuous subjective sexual arousal (range 0–100). Women in the OD group did not show a significant difference from control women in the relationship between VPA and subjective sexual arousal. Women in each of the arousal disorder subcategories showed a significantly weaker relationship between VPA and subjective sexual arousal as compared to controls, with women in the SAD and CAD groups showing the greatest variance from controls. Although this model significantly explained between-participant differences, a significant portion of between-participant variance in the overall strength of the relationship between VPA and subjective sexual arousal remained unexplained in this model (χ^2 [56] = 5,435.44, $P < 0.001$). The 42.8% of the variance explained by the model is within-participant variance, meaning that the model explains between- and within-participant variance comparatively. Figure 3 illustrates the HLM slopes for the relationships between continuous subjective sexual arousal and VPA for each of the participant groups.

In order to compare findings with past research of this nature, a series of correlations were conducted between VPA difference scores and Likert scale ratings of mental sexual arousal within each of the control, OD, and arousal disorder subgroups. None of the correlations were significant (all P values > 0.1).

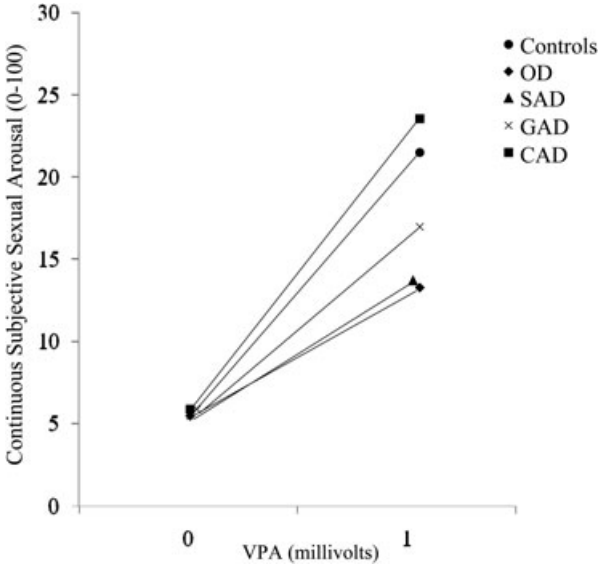

Figure 3 Illustration of HLM slope coefficients for the relationship between VPA and continuous subjective sexual arousal for women in the CONTROL, OD, SAD, GAD, and CAD groups.

Discussion

This study was the first to compare continuous laboratory measures of physiological and subjective sexual arousal, and relations between these measures, among sexually functional women; women with orgasm difficulties; and women diagnosed with one of three subtypes of sexual arousal disorder: genital, subjective, and combined. Women with both the GAD and SAD subtypes of arousal disorder experienced significantly lower levels of VPA response to erotic films compared with control women. As can be seen in Figure 1, women with GAD evidenced the smallest increase in VPA among the sexual arousal subgroups. Follow-up analyses confirmed that women with GAD had significantly smaller increases in VPA than did women with SAD. Brotto et al. [20] also reported that women with GAD showed lower levels of VPA to erotic films, compared to control women and women with other subtypes of arousal disorder.

Unexpectedly, women with CAD showed the highest level of VPA response to erotic films, a level that was significantly higher than that of sexually healthy women. Brotto et al. [20] also unexpectedly found that women with CAD did not show significantly lower levels of VPA compared with sexually healthy women. This means that, despite reporting impairment in genital responding (i.e., vulval swelling, lubrication) during the clinical interviews, and despite reporting substantially lower levels on the lubrication subscale of the FSFI compared with controls (see Table 1), they showed no detectable impairment in genital arousal as measured by the vaginal photoplethysmograph. One possibility is that these women experience impairment in genital arousal only in real-life situations where myriad performance, body image, and contextual factors may be at play, and such impairment does not generalize to a laboratory setting. Another possibility is that these women actually do show a genital response in sexual situations, but they, for whatever reason, are not detecting the response. Based primarily on clinical observations, Basson described these women as possibly "missing" their genital vasocongestion [38]. Whether women with CAD are not responding genitally in real-life sexual situations, or whether they are simply not detecting their physiological response, is a theoretically interesting question with important treatment implications. If the former is true, like women with GAD, these women may benefit from agents such as sildenafil [39] or yohimbine plus L-arginine glutamate [40] that act on peripheral mechanisms to enhance genital engorgement. However, if the latter is true, as the VPA data presented here suggest, these women are not likely to benefit from vasoactive agents, but may benefit from treatment that includes training them to attend to genital cues and to interpret the cues in a positive and sexually enhancing manner. The fact that women with CAD showed the highest level of VPA response—even higher than sexually healthy women, argues against the diagnostic utility for using VPA alone to diagnose subtypes of sexual arousal disorder in women.

As expected, continuous measures of subjective sexual arousal to an erotic film were significantly lower among women with an arousal disorder compared with sexually healthy women. However, although the follow-up results did not reach significance, women with GAD reported the lowest levels of subjective arousal, as opposed to women with SAD as would be expected. As with the continuous measures of subjective arousal, Likert scale measures of mental sexual arousal, assessed following the erotic films, differentiated between women with SAD and sexually healthy women, and between women with GAD and control women. Unlike the continuous measures of subjective arousal, Likert scale measures of mental arousal did not differentiate between women with CAD and control women. Taken together, the findings suggest that laboratory indices of subjective sexual arousal, whether measured continuously during the presentation of sexual stimuli or using a Likert scale following the erotic stimuli are effective for differentiating between women with an arousal disorder and sexually healthy women, but not between women with subtypes of sexual arousal disorder.

Using the same methodology and statistical analyses as that used here, Rellini et al. [27] reported an increase of approximately 37% in continuous subjective arousal with an increase of 1 mV in VPA among sexually healthy women. In the present study, control women reported a comparable increase of approximately 32% in continuous subjective arousal with an increase of 1 mV of VPA. Of note, relations between VPA and continuous subjective arousal were significantly weaker than those seen among sexually healthy women or women with OD for each of the subgroups of women with an arousal disorder. This is a novel and noteworthy finding that has potentially important clinical implications. Of the subgroups of women with an arousal disorder, women with GAD showed

the closest relation between genital and subjective arousal, SAD the weakest relation, and CAD in between. It is tempting to speculate that the greater the genital arousal, the more likely genital sensations will be detected by the woman, thus increasing her subjective arousal and synchrony between responses. However, the degree to which these measures correspond may be wholly unrelated to objective levels of subjective or physiological sexual responding. For example, a woman may experience a substantial increase in genital arousal with a sexual stimulus, but if she does not notice or attend to the change, or if she attends to the change but does not interpret it as being a "sexual" change per se, it is likely to have minimal, if any, impact on her subjective experience of arousal. Conversely, a woman may experience only minute increases in genital arousal to a sexual stimulus, but if she is practiced at detecting such changes and interprets them as being a "turn on," the genital changes, small as they may be, could substantially impact her mental experience of arousal. Knowing the extent to which a woman who suffers from an arousal disorder is impacted psychologically by changes in genital response has clear relevance for cognitive–behavioral interventions.

Correlations between VPA and Likert scale measures of subjective sexual arousal were not significant for any of the groups of women. This is not surprising given the small sample size, the limited number of data points analyzed (i.e., one per dimension), and the fact that past studies using Likert scale measures of subjective sexual arousal have frequently failed to find substantial relations between these measures. We strongly suggest that researchers interested in examining relations between psychological and physiological aspects of sexual arousal consider using methodological techniques that allow for the examination of relations throughout the erotic exposure. Given the wide variability between women in what they find sexually arousing, and evidence that suggests the genital response may be a more primed, automatic response than the mental experience of arousal [26,41], one would expect relations between cognitive and physiological measures to vary widely according to the specific erotic scenes presented during the film stimuli. Such variability would not likely be detected using a Likert scale questionnaire that asks for retrospective recall of arousal.

With regard to women with orgasm difficulties, a number of noteworthy findings emerged. First, women with OD showed significantly smaller increases in VPA compared with sexually healthy women. Meston and Gorzalka [14] found that women with OD did not differ from controls in VPA responses under testing conditions similar to those used in the present study. Differences in participant classification could feasibly account for the differences between studies. In the present study, all women with OD met the criteria for generalized subtype, meaning they were unable to attain orgasm in all situations and all contexts. In the Meston and Gorzalka study, the sample was comprised of both women with generalized anorgasmia and women who were anorgasmic only in certain situations or contexts (situational subtype). To the extent that generalized anorgasmia represents a greater impairment in sexual function than situational anorgasmia, perhaps, unlike the women in Meston and Gorzalka's study, women with OD in the present study experienced a level of disruption in their sexual function that was substantial enough to be detected using vaginal photoplethysmography. When women in the Meston and Gorzalka study were tested under conditions of increased autonomic arousal that possibly put them above an optimal level for sexual responding, differences between women with and without orgasm problems emerged in the same direction as that reported here [14].

A second noteworthy finding is that women with OD versus controls experienced lower levels of mental arousal to the erotic films despite having answered "no" when asked if they had an arousal problem during the screening interview. The fact that they did experience lower levels of subjective arousal is not surprising, however, given they scored significantly lower than controls on both the arousal and lubrication domains of the FSFI when assessed during the study. This finding of a disconnect between self-labeling oneself as having an arousal problem, and falling within the clinical range of having an arousal problem using a validated questionnaire, highlights the importance of using careful diagnostic criteria when classifying women with sexual disorders.

A secondary purpose of this study was to test the hypothesis that, given orgasm is believed to be both a mental and physiological experience, women with OD may have difficulty attaining orgasm because they are unable to maintain focus on physiological sexual sensations. Findings from this study do not support this speculation. Contrary to this hypothesis, and despite having lower levels of VPA and subjective arousal than control women, women with OD showed synchrony between subjective and genital sexual arousal

comparable to sexually healthy women and significantly greater than women with an arousal disorder. While speculative, the fact that relations between subjective and genital arousal differed significantly between control women and women with an arousal disorder, but not between control women and women with an orgasm disorder lends support to the possibility that desynchrony between subjective and genital arousal may be a specific marker of arousal disorder in women.

Conclusions

The findings from the present investigation do not support the sensitivity of using vaginal photoplethysmography alone for diagnosing subgroups of women with sexual arousal disorder. The findings also indicate that both continuous and Likert scale measures of laboratory-induced sexual arousal are effective for diagnosing women with an arousal disorder, but not for differentiating between subtypes of arousal disorder. Perhaps most noteworthy, the findings from this study point to the potential diagnostic relevance of examining the synchrony between subjective and physiological measures of sexual arousal when assessing women with an arousal disorder.

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Conflicts of Interest: None.

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