

## **Convergent and Discriminant Validity of Clitoral Color Doppler Ultrasonography as a Measure of Female Sexual Arousal**

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*We examined the convergent and discriminant validity of clitoral ultrasonography as a measure of female sexual arousal by assessing the following: (a) its ability to discriminate between sexual and other forms of arousal; and (b) its correlation with subjective ratings of arousal. Results from 63 healthy premenopausal women indicate that ultrasonography was not successful in differentiating sexual arousal from a humor control condition. Furthermore, there were no significant correlations between clitoral blood-flow measures and subjective sexual arousal. Additional research is required to establish the specificity of ultrasonography as a measure of sexual arousal.*

Clitoral ultrasonography has recently been suggested as a possible replacement for standard vaginal photoplethysmography, used in most physiological studies of female sexual arousal. An early study of clitoral ultrasonography demonstrated that it is possible for two independent ultrasonographers to

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reliably assess clitoral blood flow in women who are not sexually aroused (Khalifé, Binik, Cohen, & Amsel, 2000). Subsequently, other studies have demonstrated differences in clitoral ultrasound measures in response to a variety of stimuli related to sexual functioning. Bechara and colleagues have reported significant differences in clitoral hemodynamics after the topical or sublingual introduction of vasoactive agents (Becher, Bechara, & Casabé, 2001; Bechara, Bertolino, Casabé, & Fredotovich, 2004). They also reported differential ultrasound readings in women with sexual dysfunction from healthy controls (Bechara et al., 2003). Munarriz, Maitland, Garcia, Talakoub, and Goldstein (2003) have shown increased blood flow in women through ultrasonography after EROS<sup>tm</sup> therapy; and, most recently, Garcia, Talakoub, Maitland, Dennis, Goldstein, and Munnariz (2005) have reported volumetric and hemodynamic changes in the clitoris following video and vibratory sexual stimulation for women with sexual dysfunctions.

In principle, clitoral ultrasonography is a more direct measure of the physiology underlying female sexual arousal than vaginal photoplethysmography; it also allows for direct comparison with men, in whom ultrasonography has become the gold standard for assessment of erectile difficulties (Connoly, Boriakchanyavat, & Sue, 1996; Wilkins, Sriprasad, & Sidhu, 2003). Further validation of clitoral ultrasonography would require at least two types of evaluation: (a) the discriminant validity, that is, determining if it differentiates sexual arousal from other forms of arousal; (b) convergent validity, that is, determining if it correlates with subjectively rated sexual arousal.

The following study compared clitoral blood flow across three conditions: sexual arousal, positive-emotion arousal (humor), and neutral. In addition, we examined the correlation between clitoral blood flow and subjective reports of sexual arousal. Despite the fact that previous research on female sexual arousal has controlled for general physiological arousal by inducing negative emotional states such as anger or fear, we used humor because recent research and theorizing has indicated that positive emotions such as humor may elicit a more similar psychophysiological reaction to sexual arousal than do negative emotions (Fry, 2002).

## MATERIALS AND METHODS

This Experiment was Reviewed and Approved by the McGill University Faculty of Medicine Institutional Review Board.

### Participants

Healthy premenopausal women between the ages of 18 and 45 years were eligible to participate. Exclusion criteria consisted of any medication use that interferes with sexual arousal, a history of any sexual arousal difficulties

or sexual dysfunction, menopause, major medical or psychiatric illness, or current pregnancy or breastfeeding.

## Experimental Manipulation

Volunteer participants were randomly assigned to one of three experimental conditions (sexual arousal, humor or neutral). We used four separate 7 min film segments as stimuli: (a) a neutral baseline video, consisting of a travelogue of the Amazon (Day, Cook, & Wolfe, 2001); (b) a sexually arousing video, consisting of an erotic film clip validated to induce sexual arousal in women at the Kinsey Institute (Janssen, Carpenter, & Graham, 2003); (c) a humorous video, consisting of two separate segments of *The Best Bits of Mr. Bean* (Vertue, Davies, Birkin, & Weiland, 1999); and (d) a neutral video, consisting of a travelogue of Madagascar (Day et al., 2001). We used Olympus Eyetrek FMD-250W goggles connected to a laptop computer to display the videos privately to each participant.

## Measures

### CLITORAL BLOOD FLOW

We used an Aloka 5000 ultrasound machine and a 13 mhz linear probe to measure clitoral blood flow. We recorded the following ultrasound parameters: peak systolic velocity (PSV), peak diastolic velocity (PDV), and resistance index (RI). A female ultrasound technician, one of the investigators, took all blood flow measurements at the junction of the crura and the body of the clitoris, following the procedure described by Khalifé et al. (2000).

### SUBJECTIVE AROUSAL

A female research assistant assessed subjective arousal with a series of Likert-style questions on sexual arousal, humor, and relaxation, with response options ranging from 0 (not at all) to 10 (the most ever).

## Procedure

After conducting a brief semistructured interview to collect sociodemographic, basic health, and sexual health information, we accompanied the women to the ultrasound room and showed them the equipment. Participants undressed from the waist down, assumed the lithotomy position on the examination table, and covered themselves with a disposable towel.

We measured clitoral blood flow before the experiment began. All participants then viewed the same neutral baseline video, followed by either the sexually arousing, humorous, or neutral video. We measured clitoral blood

flow and subjective arousal immediately after both the baseline and experimental videos.

### Data Analysis

We log transformed all ultrasound measures to normalize the variation in their distribution. Using univariate analysis of variance (ANOVAs) with post-hoc Tukey tests, we analyzed differences between groups. The baseline measures served as covariates for analysis of the experimental condition. We measured all correlations through Pearson's method.

## RESULTS

### Sample Characteristics

Sixty-three women participated in the study: 21 in the sexual arousal condition, 22 in the humor condition, and 20 in the neutral condition. There were no significant group differences with respect to age ( $M = 25.78$  years,  $SD = 5.99$ ), primary language, occupation, years of education, place of birth, relationship status, sexual orientation, birth-control method, or phase of menstrual cycle.

### Subjective Measures of Sexual Arousal

There were no significant group differences for subjective ratings of arousal during the baseline neutral film. During the experimental condition, however, subjective ratings clearly differentiated the groups, with women in the sexual arousal group rating their video as significantly more sexually arousing (sexual arousal  $M = 6.00$ ,  $SD = 2.55$ ; humor  $M = .77$ ,  $SD = 2.16$ ; neutral  $M = .40$ ,  $SD = 1.19$ ), and women in the humor group rating their video as significantly more humorous than those in the other two groups (humor  $M = 6.05$ ,  $SD = 3.08$ ; neutral  $M = 1.10$ ,  $SD = 1.74$ ; sexual arousal  $M = 2.48$ ,  $SD = 2.46$ ). Ratings of relaxation did not differ significantly across the three groups.

### Ultrasound Measures of Sexual Arousal

As with the subjective measures, there were no significant group differences in baseline ultrasound measures. In the experimental condition, there was a significant difference in mean PSV ( $F(2, 62) = 4.99$ ,  $p = 0.02$ ) between the sexual arousal and neutral groups, with women who viewed the sexually arousing video having a higher mean PSV ( $M = 10.36$ ,  $SD = 5.17$ ) than those who viewed the neutral video ( $M = 6.32$ ,  $SD = 2.36$ ). Women who viewed the humorous video did not differ significantly on PSV from either of the other two groups ( $M = 9.36$ ,  $SD = 8.05$ ). The other ultrasound

**TABLE 1.** Mean Clitoral Hemodynamics During Experimental Condition

	Experimental Condition		
	Neutral	Humor	Erotic
Peak systolic velocity	6.32 (2.86)	9.36 (8.05)	10.36 (5.17)*
Peak diastolic velocity	1.44 (.74)	3.28 (8.54)	2.18 (1.58)
Resistance index	.76 (.10)	.82 (9.89)	.80 (.11)

measures, PDV and RI, did not significantly differentiate the three groups (see Table 1).

### Correlation Between Subjective and Physiological Measures

There were no significant correlations between clitoral blood flow and subjective sexual arousal measures during the experimental condition (range  $r = .009$  to  $.179$ ,  $p > .05$ ).

## DISCUSSION

The two goals of this study were to establish whether increases in clitoral blood flow as measured by ultrasonography are specific to sexual arousal and whether they are correlated with subjective sexual arousal. Although ultrasonography clearly differentiated the sexual arousal condition from the neutral condition, it failed to discriminate between sexual arousal and another positive emotional state, humor. In addition, no measure of clitoral blood flow was significantly correlated with subjective sexual arousal.

There are several methodological considerations that may affect these conclusions. First, because clitoral ultrasonography depends on the free-hand placement and manipulation of an ultrasound probe on the clitoris, it is possible that ultrasonographer technique affected our results. Although two different ultrasonographers can reliably measure clitoral blood flow in healthy women who are not sexually aroused (Khalifé et al., 2000), it is less clear whether this reliability extends to experimental manipulations of sexual arousal. The pressure with which the probe is applied to the clitoris, in addition to the manipulation required to obtain an ultrasound reading, could inadvertently increase blood flow when coupled with a positive emotional state such as humor. The use of a remote-controlled ultrasound probe—which would standardize application pressure and angle of measurement, eliminate any effects of technician presence, and allow for continuous measurement—might reduce the clitoral blood flow increases that accompanied general physiological arousal in this study.

Second, because we did not use mechanical or pharmacological agents to obtain sexual arousal, our reported ultrasound measures were substantially

lower than those of other studies. It may be the ultrasonography is less sensitive than vaginal photoplethysmography in its ability to discriminate between different forms of arousal, which would limit its clinical application.

Third, although subjective ratings clearly differentiated the three groups, there were no significant correlations between the women's self-reported sexual arousal and measures of clitoral blood flow. This also occurs with vaginal photoplethysmography. A common explanation for this type of discordance has been that women are complex and that their physiological sexual arousal does not reliably translate into mental sexual arousal. In our study, the women clearly were sexually aroused mentally, and physiologically there were increases in PSV from baseline; however, the considerable variability in PSV among participants may have resulted in a lack of correlation with subjective ratings. In addition, the relatively modest overall PSV increase (a difference of 2.33 cm/s in mean PSV from baseline to erotic) may not be sufficient to obtain significant correlations with subjective ratings of sexual arousal. Because no other published studies of clitoral blood flow have correlated subjective with physiological measures, it is hard to determine whether or not our results are typical of clitoral ultrasonographic research in general. Future studies should certainly incorporate measures of subjective sexual arousal to further examine this phenomenon.

With some methodological modifications, clitoral ultrasound could be a promising measure of female sexual arousal. Before it can be advanced as a sound research and clinical instrument, however, its validity must be established.

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