Laser Doppler Imaging of Genital Blood Flow: A Direct Measure of Female Sexual Arousal

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ABSTRACT

Introduction. Female sexual arousal is a challenging construct to measure, partly because of the subtle nature of its indicators, vaginal lubrication and genital swelling. As a result, many instruments have been used in an attempt to accurately measure it; however, problems are associated with each. Furthermore, the relationship between subjective and physiological indicators of arousal appears to be influenced by the instrument used to measure physiological arousal. Specifically, instruments measuring physiological arousal internally yield lower correlations between measures of physiological and subjective arousal than instruments examining the external genitals. Laser Doppler imaging (LDI) is a direct measure of external genital blood flow.

Aim. The purpose of this study was to investigate the usefulness of LDI for measuring genital blood flow in women in response to erotic visual stimuli, and to explore the relationship between physiological and subjective sexual arousal.

Method. Sixty-five participants watched three 15-minute films during LDI scanning.

Main Outcome Measures. Two nature films (measuring acclimatization and baseline blood flow levels) and one randomly assigned experimental film (erotic, anxiety, humor, or neutral) were used. Participants rated their level of subjective arousal following the third film.

Results. Results indicated a significant effect of film condition on genital blood flow, $P < 0.001$, with the erotic condition differing significantly from the other three conditions. In terms of the relationship between physiological and subjective sexual arousal, physiological arousal was significantly predicted by subjective ratings of sexual arousal ($P < 0.001$).

Conclusions. LDI appears to be able to differentiate blood flow during erotic and nonerotic conditions. In addition, physiological sexual arousal was significantly predicted by women's reported subjective sexual arousal. These findings suggest that LDI is a useful instrument for measuring female sexual arousal, and that women may be more aware of their level of physiological arousal than previously assumed. **Waxman SE, and Pukall CF. Laser Doppler imaging of genital blood flow: A direct measure of female sexual arousal. J Sex Med 2009;6:2278–2285.**

Key Words. Genital Blood Flow; Female Sexual Arousal; Laser Doppler Imaging

Introduction

Female sexual arousal is an important aspect of female sexuality, yet it is a difficult phenomenon to investigate. The most common method by which to measure female sexual arousal is to examine changes in vaginal vasocongestion [1], as female sexual arousal involves increased blood flow in the circuitry of blood vessels located immediately under the vaginal epithelium. However, it has long been accepted that female sexual arousal is a much more difficult phenomenon to measure than male sexual arousal as vaginal lubrication and swelling of the female genitals are more subtle indicators of sexual arousal than penile tumescence [1]. As a result, a multitude of instruments have been developed in an attempt to measure female sexual arousal.

The vaginal photoplethysmograph is a device designed to measure changes in vasocongestion inside the vagina. Although the vaginal photoplethysmograph has been considered the gold standard for measuring female sexual arousal [2], there are inherent problems associated with its use. For

example, the device must be inserted into a woman's vagina prior to exposure to erotic stimuli, which is an intrusive process. In addition, insertion of such a device likely influences the experience of arousal for different women in numerous ways [2], for example, by applying pressure to the vaginal walls. Furthermore, this device provides only an indirect measure of blood flow via the recording of vaginal pulse amplitude (VPA) [3] that reflects changes in blood volume at each heartbeat with larger amplitudes suggesting higher levels of engorgement [4]. Finally, it is unclear whether increases in VPA reflect sexual arousal per se or perhaps an increase in physiological arousal, as some researchers have demonstrated increases in VPA in response to nonsexual, negatively perceived visual stimuli [5].

Most of the research to date has focused on the physiological component of female sexual arousal [2,6,7]. Those that have examined the relationship between physiological and subjective (or psychological) arousal often yield inconsistencies ranging from nonsignificant, to significantly positive, and to significantly negative correlations [4]. This lack of consistent findings may be a result of the instruments used to measure arousal. Specifically, the vagina is an internal structure, and thus lubrication in the internal genitalia may provide very little proprioceptive feedback to women. As such, instruments that assess female sexual arousal internally, such as the vaginal photoplethysmograph, may not capture important information that is provided by the external genitals.

External measures of female sexual arousal exist, although they are used much less frequently than the vaginal photoplethysmograph. These instruments have been developed to operate on the principle that temperature and increased blood flow as a result of arousal are related. For example, use of the labial thermistor clip has shown promising results for measuring physiological arousal in women, whereby temperature of the labia has been shown to consistently increase with exposure to erotic stimuli [7], and has also been shown to correlate strongly with subjective sexual arousal ratings [8]. Another example is thermal imaging, which detects infrared radiation from the skin using high-resolution, fast-scanning cameras and produces images of that radiation [2]. It is a noninvasive form of measurement; it does not require any insertion or genital contact. Like the labial thermistor clip, it also provides an absolute scale of measurement (i.e., temperature) that the photoplethysmograph lacks. Using thermal imaging, Kukkonen et al. [2] found that, during the erotic film condition, both men and women showed increased genital temperature as compared with baseline. In addition, genital temperature during the erotic film was found to be highly and significantly correlated with subjective ratings of sexual arousal for both men and women. This finding is in contrast to previous research reporting that levels of physiological arousal and subjective ratings of sexual arousal are discordant in women [9,10]. These, and other data, suggest that perhaps the low correlations between women's physiological and subjective sexual arousal reported with the vaginal photoplethysmograph may be an artifact of its internal placement and measurement. It is likely that women are more conscious of physiological changes in the labia as opposed to changes in blood flow in the vagina, leading to higher correlations between objective and subjective measures.

The external methods of measuring female sexual response are certainly useful and have yielded promising results; however, they indirectly measure sexual arousal via temperature changes. One way to solve this issue is to use a measure that directly measures blood flow. Laser Doppler imaging (LDI) is such a method for measuring female sexual response. It is a noninvasive procedure that directly measures superficial blood flow in the skin. Doppler imaging is based on the principle that there is a change in the frequency of light when it interacts with an object in motion (e.g., blood) [11]; therefore, when cells are moving, a small portion of light is shifted, detected, and converted into an electrical signal that will be processed further. To measure blood flow to the vulva, the imager is typically placed close to, but not touching, the vulva and can gather signals from a depth of up to 2–3 mm below the surface of the skin. The LDI has been used in one previous study to examine changes in vulvar blood flow as a measure of female sexual arousal. Styles et al. [12] found a significant increase in blood flow to the vulvar area after participants read a chapter of erotic fiction. The authors did not measure subjective sexual arousal; therefore, it is unknown whether physiological arousal (as measured by LDI) is correlated with subjective sexual arousal. The results suggest that LDI is a useful, novel procedure for measuring sexual arousal in women.

Aims

The aims of this study were to investigate the utility of LDI for measuring sexual arousal in sexu-