

## ORIGINAL RESEARCH—PHYSIOLOGY

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# The Labial Photoplethysmograph: A New Instrument for Assessing Genital Hemodynamic Changes in Women

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### ABSTRACT

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**Aim.** The labial photoplethysmograph (LP), a new measure for assessing genital responses in women, was compared to the vaginal photoplethysmograph (VP).

**Methods.** Fifteen women wore both devices simultaneously while viewing neutral, sexual, sexually-threatening, and threatening film clips.

**Results.** The LP and VP exhibited comparable specificity to sexual stimuli. Additionally, the LP demonstrated greater resistance to movement artifacts and a slightly higher correspondence with subjective measures of sexual arousal.

**Conclusion.** The LP, while somewhat more difficult to place and less comfortable than the VP, is a promising new measure of genital response in women that warrants further development.

**Key Words.** Female Central Nervous System Control; Female Psychophysiological Studies of Sexual Function; Female Vascular Physiological Studies of Genital Arousal

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### Introduction

The vaginal photoplethysmograph (VP) [1] is currently the most widely used, well-validated instrument to measure genital responses in women. This device, which is made of acrylic plastic and shaped like a menstrual tampon, measures vaginal wall blood flow using a light source and a photosensitive cell [2]. The output of the photoplethysmograph can be quantified, applying different filters, as vaginal pulse amplitude (VPA; the alternating current component) and/or vaginal blood volume (VBV; the direct current component). Although the device is easy to use and has been demonstrated to be both sensitive and specific to sexual arousal [3,4], it is associated with a number of problems that limit its use.

One problem with the VP is that it is unclear what and how changes in blood flow are reflected in its output [2]. The interpretation of the signal

is hindered by the lack of a satisfactory calibration method and our limited understanding of vaginal physiology. Furthermore, individual differences in anatomy and physiological response, such as resting levels of vaginal muscular tone and vaginal moistness, may affect the instrument's signal [5]. In addition, measurements collected with the VP during menses may be unreliable. Finally, participants' movements, including muscle contractions, easily affect the VP's output. Methods for processing artifacts vary greatly, although the method chosen may influence one's findings. The effects of artifacts can be transient, temporarily altering the signal amplitude, or more enduring, permanently shifting the output. Some have speculated that the lubricated epithelium enables the probe to slide easily to new vaginal tissue, which could cause these more enduring shifts in the signal [2]. Although a small plastic shield that helps stabilize the probe [6] is now used by most

researchers, artifacts are still common and problematic.

Other genital response measures exist that are less susceptible to some of these problems. For instance, the labial thermistor, a measure of labial temperature, provides absolute measurement units and is relatively insensitive to movement artifacts [7,8]. However, this instrument has other limitations. For instance, it is assumed to require more time than the VP to return to baseline, impeding the use of complex repeated measures designs. Also, researchers must control for ambient temperature [5]. Another instrument, developed by Levin and Wagner [9], detects changes in intravaginal oxygen pressure (pO<sub>2</sub>) and monitors tissue blood flow. This device consists of a heated oxygen electrode that is held on the vaginal wall by a partial vacuum generated by a suction cup. Although the device's output is hardly affected by participants' movements, the requirement of having the device placed by an investigator, and the potential vaginal mucosa damage that can result from the instrument's heat and suction, restrict its utility.

### Aims

Given the problems with the VP, the limitations of alternative measures, and the lack of a satisfactory approach to the improvement of their reliability and usability, the development of new female genital response measures is warranted. The present study evaluates the effectiveness of an instrument originally designed to measure blood flow in the ear lobe to measure blood flow in the labium minora. The labia were chosen as an alternate site for measurement, in part, because vasocongestion occurs in both the labia and the vagina during sexual arousal. As a result, measurements from the labia can be expected to result in similar response patterns as measurements from the vagina.

This instrument, the labial photoplethysmograph (LP), could overcome several problems with existing measures, while building on the strengths and advantages of vaginal photoplethysmography (e.g., its well-replicated specificity). Since it is worn externally, researchers can verify the placement of the device by visual inspection. Moreover, participants may find attaching an instrument to their labia minora more acceptable than inserting an instrument into their vagina. We compared the specificity of the LP and VP by asking a group of women to wear both devices simultaneously during the presentation of sexual, sexually threaten-

ing, and threatening stimuli [10]. Like the VP, the LP was expected to reflect changes in genital vasocongestion and to be specific to sexual stimuli. Therefore, correlations between each of the two instruments and subjective sexual arousal were expected to be comparable. Finally, we predicted that the LP would be less sensitive to artifacts caused by movement than the VP.

### Methods

#### Participants

Fifteen female participants between the ages of 18 and 21 (mean = 19.8, SD = 0.9) were recruited through undergraduate courses at a Midwestern university. The purpose of the study ("comparing two ways of measuring sexual arousal in women") was briefly described in undergraduate classes. Volunteers were contacted by phone or email, and they were offered the opportunity to come in to the lab to view the instruments first. Each woman received \$15 for participating. The study was approved by the University's Human Subjects Committee.

#### Film Stimuli

The participants were shown three 3-minute film excerpts. One film excerpt depicted a consensual, erotic, heterosexual encounter, edited to 1 minute of kissing/foreplay, 1 minute of oral sex being performed on the man and then the woman, and 1 minute of penile-vaginal intercourse [11]. The second film depicted a nonsexual, anxiety-inducing excerpt of a dog attacking a woman and child who try to escape [12]. The third film depicted a coercive heterosexual sexual interaction, with no explicit sexual activity being shown [13]. The order of the three film presentations was randomized. A documentary film about cats [14] was shown for 15 minutes to establish baseline levels. Parts of this film were also shown during the 10-minute return-to-baseline intervals between stimuli.

#### Movement and Muscle Contraction Instructions

To test the sensitivity of the two instruments to artifacts, participants were asked to perform several tasks, including scooting up in the testing chair, breathing fast and shallow, breathing slow and deep, and tensing abdominal and pelvic muscles.

#### Procedure

Upon arrival to the lab, participants, who were tested individually, entered a private, temperature-controlled testing room furnished with a recliner,

desk, and television monitor. A female experimenter explained the experimental procedure to the participants and assured them of confidentiality and the opportunity to withdraw at any time. After reading and signing an informed consent statement, the experimenter carefully instructed the participant how to place the genital response measures, provided a paper drape for the participant to cover herself, and left the testing room. When the participant signaled, via an intercom, that she was ready, the experimenter returned and visually checked placement of the devices. After assuring proper placement, the participant covered her lap again with the paper drape and a towel. The experimenter then put a cardiovascular recording device in place and explained the use of a continuous subjective lever to the participant. The experimenter then closed the testing room and retired to the adjoining room.

The experimental phase of the study started with a 15-minute adaptation phase, during which the participant was shown the sexually neutral film, to help the participant acclimate to the setting and instruments. The last minute of the adaptation period was used to establish physiological baselines. Participants then filled out discrete, subjective measures. This was followed by the presentation of the sexual, anxiety, and sexually threatening, films, in a random order, each followed by completion of the discrete subjective measures. Between the presentations of each film, the neutral film was shown for 10 minutes to permit participants to return to their baseline response levels. After the film presentations, the participant was asked to perform the different movements, and, at the end of the session, the postexperimental interview was completed.

### **Main Outcome Measures**

#### *Vaginal Photoplethysmograph*

The infrared VP was used to measure blood flow in the vaginal wall [3]. The depth of the probe and the orientation of the light-emitting diode was set using a small acrylic plate attached to the photoplethysmograph [6]. The VP was plugged in for 45 minutes prior to insertion. After testing, the VP and placement device were disinfected (high-level disinfection) using CidexPlus (glutaraldehyde 3.4%) with a 20-minute immersion time [5]. The alternating current (AC) signal was taken as a measure of VPA. The AC signal was band-pass filtered (0.5–30 Hz) and digitized (40 Hz) using a BIOPAC system (Model MP100).

#### *Labial Photoplethysmograph*

The LP is a small plastic clip housing a pulse plethysmograph (BIOPAC, Model TSD100) that can be placed on one of the labia minora. In between participants, this instrument also was disinfected using CidexPlus. The AC signal was taken as a measure of labial pulse amplitude (LPA). The AC signal of the LP was also band-pass filtered (0.5–30 Hz) and digitized (40 Hz). Subjects were instructed to place the instrument on the widest part of a labium minora.

#### *Cardiovascular Responses*

Systolic and diastolic blood pressure as well as heart rate were monitored using the arterial-volume clamp method (Biomedical Instrumentation TPD-TNO Portapres Model 2) from the middle phalanx of the middle and ring fingers of participant's nondominant hand. A hydrostatic reference was used to compensate for vertical movement with respect to heart level by attaching a height transducer to the participant's arm and finger [15]. The data were processed using the Modelflow method, which extrapolates several common cardiovascular signals from an arterial pressure waveform [16]. We extracted participants' heart rate, average blood pressure, systolic pressure, and diastolic pressure.

#### *Subjective Measures*

Participants were instructed to move a lever during the film presentations to indicate how sexually aroused they felt [17]. The calibrated lever produced a signal ranging from 1, indicating no sexual arousal, to 100, indicating maximum sexual arousal. Maximum sexual arousal was defined as the most sexually aroused the participant could recall ever having felt before. In addition, before and after the film presentations, participants were asked questions about their emotional state and sexual response, including their strongest feelings of sexual arousal as experienced during the films (ranging from 0, not at all, to 10, very strongly).

#### *Postexperimental Interview*

The experimenter interviewed each participant at the end of the experimental session. The participant was asked to respond from 0 (not at all) to 100 (very strongly) as to how difficult each instrument was to place, how much each instrument distracted them from the film, and how much discomfort each instrument caused them.

### Data Analysis

Data were reduced for the VP and LP using Acq-Knowledge Software (BIOPAC Systems, v.3.5.7). Genital response data were first smoothed with a window size of 10, then cut into 10-second, non-overlapping intervals. The first author checked for the presence of movement artifacts and scored them according to severity.<sup>1</sup> Artifacts were defined as small if they changed the average of the interval they appeared in by 25% or less compared to the nearest interval that did not contain artifacts. Medium-sized artifacts were defined as those that changed the interval's average by more than 25% but less than 50%, and large ones as those that changed the average by 50% or more. The average of an interval containing large artifacts was replaced with the mean of the two nearest unaffected intervals surrounding it, except when the affected interval was the first or last of a condition, in which case it was replaced with the mean of the closest, unaffected interval.

Physiological responses were quantified as the difference between the initial baseline and response levels recorded during experimental conditions. Statistical analyses were conducted using SPSS (v.11), MatLab (v.6.5.0.196271), and SuperANOVA (v.1.11). The Greenhouse–Geisser procedure was applied to all repeated measures ANOVAs to correct for violations of the sphericity assumption [18]. Correlations were transformed to Fisher's  $z$  prior to averaging [19].

## Results

### Subject Characteristics

Of the 15 participants, five were excluded from analysis due to unreliable LP data ( $N = 2$ ), unreliable VP data ( $N = 1$ ), unreliable VP and LP data ( $N = 1$ ), and experimenter error ( $N = 1$ ). Unreliable data were characterized by the presence of uncharacteristic, nonperiodic signals, which would not improve after asking participants to reposition or adjust placement of the device(s), or which occurred after the first experimental condition had been started. Of the remaining 10 participants (age: mean = 19.8,  $SD = 0.92$ ), eight were single

<sup>1</sup>Since the rater was aware of the instrument she was inspecting, a second rater, blind to instrument, also examined the signals for movement artifacts. Inter-rater agreement was assessed by correlating the number of artifacts identified by the two raters for the sexual film condition. Correlations were comparable for the two instruments ( $r = 0.81$  for the VP and  $r = 0.84$  for the LP).

(two were living with a sexual partner), eight were white (two were African American), and nine identified as heterosexual (one identified as bisexual). All 10 participants reported having had at least one sexual partner in the past year, although one had not had vaginal intercourse. Three women reported having no difficulty becoming and staying sexually aroused, six reported "occasional" difficulty, and one reported difficulty "less than 50% of the time."

### Subjective Sexual Arousal

The data of the subjective lever were subjected to a 3 (Film Condition: sexual, sexually threatening, threatening)  $\times$  18 (Interval) repeated measures analysis of variance (ANOVA). A significant effect of Film Condition was found ( $F_{2,18} = 7.63$ ,  $P < 0.02$ ,  $\eta_p^2 = 0.46$ ). Post hoc contrasts revealed that the sexual film (mean = 18.87,  $SD = 22.31$ ) resulted in higher levels of sexual arousal than the sexually threatening film (mean = 2.59,  $SD = 5.00$ ;  $F_{1,18} = 12.75$ ,  $P < 0.008$ ) and the threatening film (mean = 4.33,  $SD = 10.01$ ;  $F_{1,18} = 10.16$ ,  $P < 0.02$ ). The difference between the sexually threatening and threatening film conditions was not significant. No other main or interaction effects were significant. The same pattern of results was found for the question about participants' strongest feelings of sexual arousal (sexual film: mean = 4.85;  $SD = 0.83$ ; sexually threatening film: mean = 0.60;  $SD = 0.21$ ; threatening film: mean = 0.50;  $SD = 0.24$ ; main effect of Film Condition:  $F_{2,18} = 23.95$ ,  $P < 0.001$ ,  $\eta_p^2 = 0.73$ ).

### Genital Responses

**Baselines.** To evaluate the stability of baselines, we performed a 2 (Instrument)  $\times$  3 (Baseline: first, second, third)  $\times$  18 (Interval) mixed factor ANOVA, with instrument as the between-factor. The main effect of Instrument approached significance ( $F_{1,18} = 3.76$ ,  $P < 0.07$ ,  $\eta_p^2 = 0.173$ ). For one participant, the average output of the LP during the three baselines was approximately 10 times higher than that of the other subjects.<sup>2</sup> Exclusion of the data of this subject resulted in a significant main effect of Instrument (VP: mean = 3.80,  $SD = 2.66$ ; LP: mean = 117.73,  $SD = 148.22$ ;  $F_{1,16} = 4.98$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.237$ ). No other main or interac-

<sup>2</sup>Although the output units are relative, readers may notice that the mean and range of the LP output were larger than the mean and range of the VP output. The differences are attributable to different characteristics and amplification of the two instruments and are not expected to bias analyses.

tion effects were significant (with or without the data of this participant).

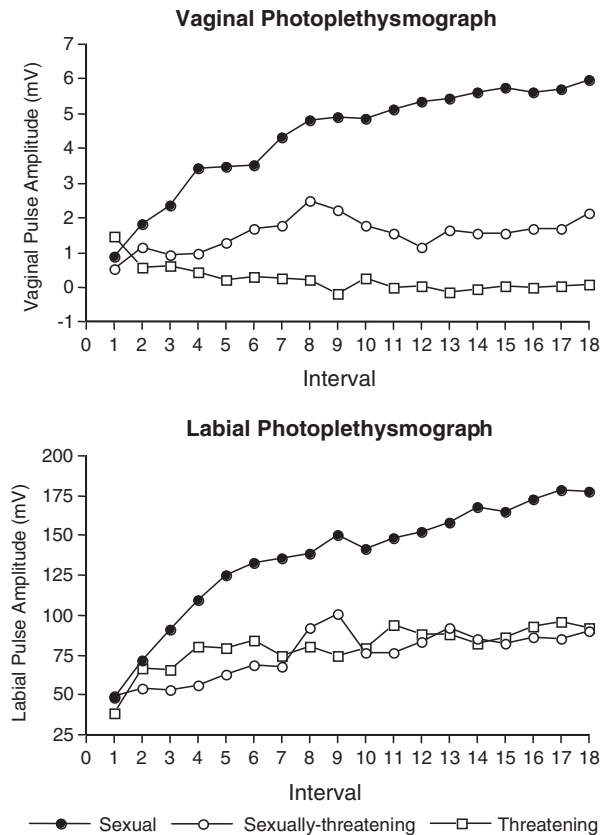
**Responses to Films.** A 2 (Instrument)  $\times$  3 (Film Condition)  $\times$  18 (Interval) mixed factor ANOVA, with instrument as the between-factor, was performed on the genital response data. The main effect of Instrument was significant ( $F_{1,18} = 17.04$ ,  $P < 0.002$ ,  $\eta_p^2 = 0.49$ ). Responses were smaller for the VP (mean = 1.89, SD = 3.38) than for the LP (mean = 122.13, SD = 173.51). Therefore, we conducted 3 (Film Condition)  $\times$  18 (Interval) ANOVAs separately for the two instruments. For both the VP and LP, a significant effect of Film Condition was found ( $F_{2,18} = 10.59$ ,  $P < 0.008$ ,  $\eta_p^2 = 0.54$  and  $F_{2,18} = 6.75$ ,  $P < 0.03$ ,  $\eta_p^2 = 0.73$ , respectively). Contrasts indicated that genital responses were larger during the sexual film (VP: mean = 4.40, SD = 4.38; LP: mean = 234.67, SD = 227.51) than for the sexually threatening film (VP: mean = 1.30, SD = 1.67;  $F_{1,18} = 9.91$ ,  $P < 0.006$ ; LP: mean = 95.07, SD = 109.07,  $F_{1,18} = 6.35$ ,  $P < 0.03$ , respectively) or the threatening film (VP: mean = -0.02, SD = 1.42;  $F_{1,18} = 20.09$ ; LP: mean = 36.66, SD = 77.69,  $F_{1,18} = 12.77$ ,  $P < 0.004$ ). Genital responses to the sexually threatening film were not significantly different from genital responses to the threatening film.

The main effect of Interval was also significant for both devices (VP:  $F_{17,153} = 7.77$ ,  $P < 0.02$ ,  $\eta_p^2 = 0.46$ ; LP:  $F_{17,153} = 4.90$ ,  $P < 0.02$ ,  $\eta_p^2 = 0.35$ ). However, this main effect was conditioned by an interaction between Film Condition and Interval, which was significant for the VP ( $F_{34,306} = 7.47$ ,  $P < 0.002$ ,  $\eta_p^2 = 0.45$ ) and a statistical trend for the LP ( $F_{34,306} = 3.68$ ,  $P < 0.08$ ,  $\eta_p^2 = 0.29$ ; see Figure 1).

Examination of Figure 1 suggests that average responses to the films varied most for the VP, and this seemed to be most pronounced in the first six intervals. To test the possibility that this was responsible for the significant interaction effect, we ran separate 3 (Film Condition)  $\times$  6 (Interval) repeated measures ANOVAs for intervals 1–6, intervals 7–12, and intervals 13–18. The interaction of Film Condition  $\times$  Interval was significant for intervals 1 through 6 ( $F_{10,90} = 7.98$ ,  $P < 0.003$ ,  $\eta_p^2 = 0.47$ ), and for intervals 7 through 12 ( $F_{10,90} = 2.79$ ,  $P < 0.05$ ,  $\eta_p^2 = 0.24$ ), but not for intervals 13 through 18.

### Cardiovascular Responses

One participant's cardiovascular data were lost due to excessive arm movement, as documented



**Figure 1** Genital response during the 3-minute testing period for each instrument for the sexual, sexually threatening, and threatening films.

by the hydrostatic reference on the PORTA-PRES, during the sexual film. However, this movement did not appear to affect the participant's VP or LP output. We conducted a 3 (Film Condition)  $\times$  18 (Interval) ANOVA for each cardiovascular measure (heart rate, systolic pressure, diastolic pressure, and mean blood pressure). There were no significant main or interaction effects for any of the cardiovascular measures. We conducted an additional repeated measure ANOVA, in which we included the baseline as a fourth testing level (Condition), using the raw data of all film conditions. Significant main effects of Condition were found for mean blood pressure ( $F_{3,24} = 6.94$ ,  $P < 0.02$ ), systolic blood pressure ( $F_{3,24} = 11.48$ ,  $P < 0.001$ ), and mean blood diastolic ( $F_{3,24} = 5.05$ ,  $P < 0.03$ ). The main effect of Condition was not significant for heart rate. Post hoc contrasts indicated that all film conditions were significantly higher than the initial baseline for the three blood pressure variables.

**Table 1** Number of intervals disturbed by artifacts by instrument and condition

	VP			LP		
	S film	ST film	T film	S film	ST film	T film
No artifacts	144	164	161	171	168	172
Small size artifacts*	21	7	10	9	9	4
Medium size artifacts <sup>†</sup>	7	5	4	0	1	0
Large size artifacts <sup>‡</sup>	8	4	5	0	2	4
Total artifacts	36	16	19	9	12	8

VP, vaginal photoplethysmograph; LP, labial photoplethysmograph; S, sexual; ST, sexual threat; T, threat.

\* Small size artifacts were defined as those artifacts that changed the average of the interval they appeared in by 25% or less compared to the nearest clean interval.

<sup>†</sup> Medium size artifacts were defined as those artifacts that changed the average of the interval they appeared in by greater than 25% but less than 50% compared to the nearest clean interval.

<sup>‡</sup> Large size artifacts were defined as those artifacts that changed the average of the interval they appeared in by 50% or greater compared to the nearest clean interval.

### Correlations among Measures

Within-subject correlations between the lever and each genital measure, and between the two genital measures, for the sexual film condition were *z*-transformed, averaged, and back-transformed [19]. The LP correlated somewhat more strongly than the VP with the lever during the sexual film (mean = 0.75; mean = 0.70, respectively). The average correlation between the two instruments was 0.61 (SD = 0.40). Cross-correlations between the two instruments centered around 0, indicating that neither instrument related to the other by 10-second lags.

### Presence and Duration of Artifacts

The LP was less affected by artifacts than the VP, particularly during the sexual film (see Table 1). The proportion of artifacts that changed an interval's average by more than 50% was smaller for the LP than for the VP interval. Consistent with these findings, instructions to move and tense muscles resulted in more artifacts for the VP than for the LP (see Table 2).

### Comfort and Ease of Placement

Women reported that the vaginal device was easier to place (VP: mean = 2.5, SD = 4.3; LP: mean = 16.5, SD = 21.4), caused less discomfort

**Table 2** Average artifact duration (standard deviation) in seconds by instrument and task

Task	VP	LP	<i>P</i> value
Scoot up in chair	17.0 (9.6)	8.6 (6.9)	0.01
Tense abdominal muscles	18.3 (11.9)	5.7 (10.6)	0.05
Tense pelvic muscles	25.5 (15.8)	5.3 (11.5)	0.02
Hold breath	5.9 (5.1)	1.5 (2.5)	0.03
Breath slow and deep	4.9 (8.4)	1.1 (2.1)	0.24
Pant	7.2 (6.3)	1.1 (3.3)	0.05

VP, vaginal photoplethysmograph; LP, labial photoplethysmograph.

(VP: mean = 19.0, SD = 25.7; LP: mean = 32.3, SD = 34.9), and interfered less with attending to the films (VP: mean = 15.0, SD = 16.50; LP: mean = 26.5, SD = 32.7) than the labial measure. However, none of these differences were statistically significant. For each instrument, discomfort levels were highly correlated with the level of interference with attending to the sexual films (VP:  $r = 0.83$ ,  $P < 0.01$ ; LP:  $r = 0.96$ ,  $P < 0.01$ ).

### Discussion

The purpose of this study was to evaluate a new instrument for the measurement of genital responses in women, the LP, by comparing it to the VP. Both the VP and the LP were specific to sexual stimuli: the instruments' output increased more to the sexual than to the sexually threatening and threatening films. Although the sexually threatening film evoked larger genital responses than the threatening film, this difference was not statistically significant.

Both instruments correlated strongly with participants' ratings of their own sexual arousal. Within-subjects correlations were higher for the LP, although the difference was small. Correlations between the two instruments were also moderately high. Correlations between subjective and physiological measures were higher than those found in many previous studies [10,20]. However, the majority of those studies have reported between-subjects correlations, the use of which is problematic due to the lack of an absolute scale or calibration method for pulse amplitude signals [21].

Although usually noted as a problem with the VP [5], both instruments returned to baseline levels between test films. A failure to return to baseline may have been missed due to insufficient

power, but inspection of the participants' individual records suggests that, in general, their responses indeed returned to baseline levels. One also might speculate that the sexual film did not induce sufficiently high levels of sexual arousal; however, not only did participants report feeling sexually aroused to this film, the same sexual film received the highest sexual arousal ratings from women in a study comparing 20 sexual film clips [22]. Future research should also explore the reliability of each instrument over multiple sessions to provide a clearer idea of each instrument's normal variability within individual participants.

The VP suffered from more, and larger, artifacts than the LP. While a similar number of artifacts were found in the LP signal for all three films, the number of artifacts for the VP almost doubled during the sexual film. The VP appeared particularly sensitive to artifacts caused by movement and muscle contractions (compared to changes in breathing), as demonstrated by the results of the movement task. This is consistent with findings from other studies showing that muscular activity in and around the vagina increases during sexual arousal, e.g. [23]. At the same time, these findings point at the possibility that changes in the output of the VP that are commonly assumed to reflect artifacts are in fact related to the arousal process, involving, more specifically, increases in vaginal or pelvic muscle tone or activity. It is unclear to what extent this may have influenced the findings of previous studies. However, the relatively large number of artifacts found, in particular for the VP, underscores the importance of developing a more standardized method for identifying and removing the effects of artifacts.

The physical changes that occur with vasocongestion may differentially affect the instruments. Feelings of pressure may rise more rapidly with the LP, because it is held in place by a spring hinge. Alternatively, some complex interaction could occur because increased vasocongestion in the vagina and labia may increase pressure for both instruments. Participants may not have been able to differentiate the two instruments sufficiently to rate them separately. To determine what level of discomfort would be attributable to which instrument, as well as how increased pressure with the LP may affect subjective sexual arousal, future researchers should ask participants to report on the instruments when they are worn separately, possibly in a between-subjects design.

Blood pressure levels, but not heart rate, were elevated during the sexual, sexually threatening, and threatening films; however, they were not significantly different. Although previous research has documented that cardiovascular responses are not specific to sexual arousal [6,24], researchers have expressed concern that the VP may reflect more general vascular events [2]. Our data suggest that genital blood flow, as measured by the VP and LP, is at least partly independent of systemic cardiovascular responses.

### Conclusion

The LP and VP exhibited similar levels of specificity to sexual stimuli and comparable correlations with subjective sexual arousal. The LP could benefit from design modifications that make it easier to place and more comfortable to wear. However, considering that the LP is more resistant to movement artifacts, it is a promising, cost-effective new measure of genital responses in women that warrants further development.

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### References

- 1 Sintchak G, Geer JH. A vaginal plethysmograph system. *Psychophysiology* 1975;12:113-15.
- 2 Levin RJ. Assessing human female sexual arousal by vaginal photoplethysmography—a critical examination. *Sexologies* 1998;6:26-31.
- 3 Geer JH, Morokoff P, Greenwood P. Sexual arousal in women: The development of a measurement device for vaginal blood volume. *Arch Sex Behav* 1974;3:559-64.
- 4 Laan E, Everaerd W, van Bellen G, Hanewald GJFP. Women's sexual and emotional responses to male- and female-produced erotica. *Arch Sex Behav* 1994;23:153-69.
- 5 Geer JH, Janssen E. The sexual response system. In: Cacioppo JT, Tassinari LG, Berntson G, editors. *Handbook of psychophysiology*. New York, NY: Cambridge University Press; 2000:315-41.
- 6 Laan E, Everaerd W, Evers A. Assessment of female sexual arousal: Response specificity and construct validity. *Psychophysiology* 1995;32:476-85.
- 7 Hoon PW, Coleman E, Amberson J, Ling F. A possible physiological marker of female sexual dysfunction. *Biol Psychiatry* 1981;16:1101-6.

- 8 Henson DE, Rubin HB. A comparison of two objective measures of sexual arousal of women. *Behav Res Ther* 1978;16:143–51.
- 9 Wagner G, Levin R. Oxygen tension of the vaginal surface during sexual stimulation in the human. *Fertil Steril* 1978;30:50–3.
- 10 Laan E, Everaerd W. Determinants of female sexual arousal: Psychophysiological theory and data. *Annu Rev Sex Res* 1995;6:32–76.
- 11 Pinowski N, editor. N Pinowski. *Outdoor Ecstasy. Ultimate Video*, Chatsworth, CA, 1994.
- 12 King S, Dunaway DC, Currier L, editors. L Teague. *Cujo*. Associated British Pathe, 1983.
- 13 Mastrosimone W, editor. RM Young. *Extremities*. Paramount Pictures Corp., Hollywood, CA, 1987.
- 14 Jampel B. *Cats: Caressing the tiger*. Columbia Tristar Home Video, Culver City CA, 1991.
- 15 Langewouters GJ. TNO-TPD Biomedical Instrumentation, Amsterdam, 1993, p. 66.
- 16 Wesseling KH, Jansen JR, Settels JJ, Schreuder JJ. Computation of aortic flow from pressure in humans using a nonlinear, three-element model. *J Appl Physiol* 1993;74:2566–73.
- 17 Wincze J, Hoon P, Hoon E. Sexual arousal in women: A comparison of cognitive and physiological responses by continuous measurement. *Arch Sex Behav* 1977;6:121–32.
- 18 Vasey MW, Thayer JF. The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. *Psychophysiology* 1987;24:479–86.
- 19 Silver NC, Dunlap WP. Averaging correlation coefficients: Should Fisher's z transformation be used? *J Appl Psychol* 1987;72:146–8.
- 20 Meston CM. The psychophysiological assessment of female sexual function. *J Sex Education Ther* 2000;25:6–16.
- 21 Janssen E. Psychophysiological measurement of sexual arousal. In: Wiederman MW, Whitley BE Jr, editors. *Handbook for conducting research on human sexuality*. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers; 2002:139–71.
- 22 Janssen E, Carpenter D, Graham CA. Selecting films for sex research: Gender differences in erotic film preference. *Arch Sexual Behav* 2003;32:243–51.
- 23 Bohlen JG, Held JP, Sanderson MO. Response of the circumvaginal musculature during masturbation. In: Graber B, editor. *Circumvaginal musculature and sexual function*. New York: Karger; 1982: 43–60.
- 24 Zuckerman M. Physiological measures of sexual arousal in the human. *Psychol Bull* 1971;75:297–329.