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8-13 Hz Fluctuations in Rectal Pressure Are an Objective Marker of Clitorally-Induced Orgasm in Women

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RUNNING HEAD: Rectal Pressure and Orgasm

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ABSTRACT

Orgasm is a subjective experience accompanied by involuntary muscle contractions. We hypothesized that orgasm in women would be distinguishable by frequency analysis of a perineal muscle-derived signal. Rectal pressure, an index of perineal muscle activity, was measured continuously in 23 healthy women during different sexual tasks: receiving clitoral stimulation, imitation of orgasm, and attempt to reach orgasm, in which case the women were asked to report whether orgasm had been reached ("orgasm") or not ("failed orgasm attempt"). We performed spectral analysis on the rectal pressure data and calculated the spectral power in the frequency bands delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-13 Hz), and beta (13-25 Hz). The most significant and most important difference in spectral power between orgasm and both control motor tasks (imitation of orgasm and failed orgasm attempt) was found in the alpha band. An objective rule based on spectral power in the alpha band recognized 94% (29/31) of orgasms and correctly labeled 69% (44/64) of all orgasm attempts as either successful or failed. Because outbursts of alpha fluctuations in rectal pressure only occurred during orgasm and not during voluntary imitation of orgasm or failed attempts, we propose that they represent involuntary contractions of muscles in the rectal vicinity. This is the first objective and quantitative measure that has a strong correspondence with the subjective experience of orgasm.

KEY WORDS: orgasm in women; rectal pressure; spectral analysis; fast fluctuations.

INTRODUCTION

Orgasm in women is a subjective experience and although it has been studied quite extensively (Mah & Binik, 2001), there is no objective marker. Most physiological research has focused on contractions of striated perineal muscles (Mah & Binik, 2001), because the occurrence of involuntary (reflexive) muscular contractions is an important feature of orgasm in women (Carmichael, Warburton, Dixen, & Davidson, 1994; Masters & Johnson, 1966; Reubens, 1982). The activity of these muscles has been studied directly through EMG (Carmichael et al., 1994) and indirectly through pressure measurements in viscera that penetrate the pelvic floor (Bohlen, Held, Sanderson, & Ahlgren, 1982; Graber & Kline-Graber, 1979). Based on this, muscles presumed to contract during orgasm are the levator ani muscle (Bohlen et al., 1982; Graber & Kline-Graber, 1979) and anal sphincter (Carmichael et al., 1994; Masters & Johnson, 1966). Uterine contractions are assumed to occur during orgasm (Bohlen et al., 1982; Chayen, Tejani, Verma, & Gordon, 1979; Masters & Johnson, 1966) because oxytocin, a powerful stimulant of uterine smooth muscle, is released into the blood during orgasm (Carmichael et al., 1987; Carmichael et al., 1994).

In a search for an objective orgasm marker, three types of orgasm in women have been described based on rectal and/or vaginal pressure patterns (Bohlen et al., 1982; Carmichael et al., 1994): one type is characterized by regular contractions, another by regular and irregular contractions, and a third type by the lack of regular contractions. However, this method is neither objective nor quantitative.

Furthermore, the correspondence between these contractions and the subjective orgasmic experience (received through self-report of the women) differed between studies. While Carmichael and colleagues (1994) described that subjective markers correspond to measured pelvic contractions, such an objective-subjective agreement was not found by others

(Bohlen et al., 1982; Masters & Johnson, 1966). For example, the three patterns described by Bohlen and colleagues (Bohlen et al., 1982) do not correspond with three discernible subjective experiences.

In their review, Mah and Binik (2001) have proposed that the frequency content of muscle contractions during orgasm may be a good marker for the subjective orgasmic experience. Therefore, we aimed to distinguish orgasm-specific muscle contractions by their frequency characteristics. We measured rectal pressure as an index of perineal muscle activity while women attempted to reach orgasm through clitoral stimulation. Spectral analysis was used to fractionate the signal into different frequency bands.

METHOD

Participants

A total of 23 healthy heterosexual female participants (M age, 33.5 years; range, 21 to 51) participated in the study together with their partner after giving written informed consent according to the Declaration of Helsinki. Participants were recruited via an online casting bureau. The enrollment period was three years, but over this period the procedure and equipment remained unchanged. The procedures were approved by the Medical Ethics Committee of the University Medical Center Groningen. Thirteen participants were nulliparrous. Ten participants had one or more children, four of which were born by caesarian delivery. Twenty-one participants were Caucasian and two were from African descent. Educational level of the participants was variable. None of the participants used recreational drugs or had a history of physical, psychiatric or sexual disorders.

Procedure

Rectal pressure was measured during in a positron emission tomography (PET) study on brain activation during sexual stimulation and orgasm. This meant that women lay supine in a brain scanner while being measured. The partner stood next to the participant and manually stimulated her clitoris. This type of stimulation was chosen because it induces no artifacts in rectal pressure and is the most effective means of inducing orgasm in women (Lloyd, 2005). During the debriefing, the participants did not report important differences between their “laboratory orgasms” and those reached under normal circumstances.

Measures

Rectal pressure measurements (in cm H_2O) were made with a rectal probe (B. Braun Melsungen AG ©, type 501002/7; Melsungen, Germany) containing a microtip transducer. The signal was sampled via the MMS system (Medical Measurements Systems B.V.; Enschede, The Netherlands) and 50 Hz data were stored for analysis.

Measurements were performed for two minutes in the following sequence (see also Table I). At first, rectal pressure during non-sexual rest was measured as a reference task to make inter-individual comparison possible. For measurements 2 and 3, women were asked to imitate orgasm, i.e., to voluntarily contract muscles in the rectal vicinity (abdominal, hip, thigh, and perineal muscles) in a rhythmic fashion, while their clitoris was being stimulated by their partner. This task served as a control for the motor output during orgasm, because we expected the same muscles to contract, but with discernible frequency characteristics. During measurements 4 and 5, the partner provided clitoral stimulation but the women were asked not to make any movements and not to have an orgasm. At measurements 6, 7, and 8, the partner provided clitoral stimulation with the aim of inducing an orgasm. After each of these measurements, women either reported that they had not reached orgasm (“failed orgasm attempt") or that they had ("orgasm"). Failed orgasm attempts were also used as a control for the motor output during orgasm.

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insert Table I about here

Orgasm attempts with ambiguous subjective reports were excluded from the analysis. Stimulation of the clitoris started before the beginning of the measurements to create an existing sexually salient context from the start of each experiment. Because of technical requirements for the PET measurements, participants were asked to attempt to reach orgasm in a specified 40-second interval. For all measurements, only data of this interval were analyzed.

Data Analysis

Rectal pressure data (50 Hz) were analyzed with Matlab, version 5.3 (The MathWorks, Inc.; Massachusetts). The power spectrum was calculated by Fourier analysis. Total spectral power in the delta (0.5-4 Hz), theta (4-8 Hz), alpha (8-13 Hz) and beta (13-25 Hz) band was calculated by discrete integration of the power spectrum over frequency. The spectral power in each frequency band was divided by that during non-sexual rest (intra-individual normalization). These normalized integrals did not have a normal distribution over tasks and participants, so analysis of variance was done with a Kruskal-Wallis test for task effects, and a post-hoc Wilcoxon rank sum test was performed for between-task comparison in each frequency band, using a Bonferroni correction for multiple comparisons ($\alpha_{crit} = .0083$, because of six comparisons in every frequency band).

We developed an orgasm detecting algorithm that labeled orgasm attempts as either "failed orgasm attempt" or "orgasm". It was based on spectral analysis of rectal pressure during orgasm attempts and used the frequency band that was most characteristic for orgasm as input. This was done by introducing a cut-off value for spectral power that sorted orgasm attempts into one of these two categories, i.e., all orgasm attempts with spectral power above a specific cut-off value were classified as "orgasm", and those with spectral power under the cut-off value were classified as "failed orgasm attempt". The participant's statement was used as gold standard. The optimal cut-off value was defined as the one that reached the highest classification accuracy, i.e., the maximum overlap between objective and subjective measures. Specificity, sensitivity, positive predictive value, and negative predictive value were also calculated.

RESULTS

Of the 23 participants, 17 achieved one or more orgasms. A total of 31 orgasms and 33 failed orgasm attempts were included for analysis. Visual inspection of the pressure vs. time graphs showed that patterns of rectal pressure during orgasm were very variable between participants. Further examination suggested that, in many cases, the orgasm measurement contained more high frequency components than measurements of the other tasks. Spectral analysis confirmed this. Typical examples are given in Fig. 1. In this figure, raw data (left panels) and power spectral density (right panels) of rectal pressure are shown. The lines at 0.5, 4, 8, 13 and 25 Hz indicate the different frequency bands. Note the difference in alpha and beta power between "orgasm" and "failed orgasm attempt".

A Kruskal-Wallis test was performed on the normalized spectral power and showed a significant task effect in all four bands (see Table II). Post hoc analysis showed that normalized spectral power in all bands was significantly lower during clitoral stimulation than in all other tasks (see Fig. 2). The bars indicate the median; upper and lower quartiles are indicated by the whiskers.

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insert Table II about here

No significant difference was found between both control tasks, voluntary imitation of an orgasm and failed orgasm attempt, in any of the investigated bands. However, normalized spectral power during orgasm was significantly greater in the alpha (8-13 Hz) and beta (13-25 Hz) bands than during both control tasks. This was not the case for the delta (0.5-4 Hz) and theta (4-8 Hz) bands (table III and figure 2). The most significant difference in spectral power between orgasm and both control tasks was in the alpha band, a measure of rectal pressure fluctuations between 8 and 13 Hz ("alpha power": Table III and Fig. 2).

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insert Table III about here

Based on this, the orgasm detection algorithm applied alpha power to classify orgasm attempts as successful or failed. When the cut off value was chosen at 3.0, i.e., all orgasm attempts with alpha power more than three times higher than non-sexual rest, were classified as "orgasm", those with less were classified as "failed attempt", total accuracy (overlap between objective and subjective measures) was maximal: 69% (44/64) of orgasm attempts were identified correctly as either failed or successful. For this cut off value of alpha power, the specificity was 45% (15/33), the sensitivity 94% (29/31), the negative predictive value was 88% (15/17), and the positive predictive value 62% (29/47). The dependency of accuracy, specificity and sensitivity on alpha power, is depicted in Fig. 3.

DISCUSSION

The aim of this study was to identify an objective physiological correlate of orgasm in women. In particular, we hypothesized that the involuntary perineal muscular contractions that accompany orgasm could be distinguished by their frequency characteristics. Indeed, the spectral power in both the alpha and beta bands, representing the strength of muscular contractions in the 8-13 and the 13-25 Hz frequency bands respectively, was significantly greater during successful orgasm attempts than during all other tasks. This was not the case for the slower frequency bands delta (0.5-4 Hz) and theta (4-8 Hz) (see Table III and Fig. 2). Especially, 8-13 Hz fluctuations in rectal pressure were a hallmark of orgasm.

Imitation of orgasm and failed orgasm attempts also involved, often forceful, contraction of striated perineal musculature. Nevertheless, spectral power in the alpha and beta bands was significantly lower during these control motor tasks than during orgasm. Taken together, these results suggest that frequency characteristics can be used to distinguish the involuntary muscular contractions during orgasm, because faster fluctuations occurred predominantly during orgasm and not during voluntary imitation of orgasm or failed attempts.

The origin of these fast fluctuations in rectal pressure is likely to be muscular contractions in the vicinity of the rectum. From the present data, we were unable to determine which muscles contributed to the signal but, according to the literature, the following muscles contract during orgasm and hence could be responsible for the fast fluctuations in rectal pressure: (parts of the) levator ani muscle (Bohlen et al., 1982; Graber & Kline-Graber, 1979), the anal sphincter (Carmichael et al., 1994; Masters & Johnson, 1966), and the uterus (Bohlen et al., 1982; Chayen et al., 1979; Masters & Johnson, 1966).

A limitation of this study was the fact that participants lay in a scanner and were asked to reach orgasm in a specified 40-second interval. Despite this, they did not report important differences between their “laboratory orgasms” and their normal orgasms. A benefit of this requirement was that approximately half of all orgasm attempts failed, thus creating an additional control task for the motor output of orgasm. These failed orgasm attempts were similar in their delta and theta content of rectal pressure (contractions between 0.5 and 8 Hz), but, like voluntary imitation of orgasm, lacked the faster contractions (esp. 8-13 Hz) that accompanied orgasm.

Orgasms in our study were all clitorally-induced. This method was chosen because it induced no artifacts in rectal pressure and is the most effective means of inducing orgasm (Lloyd, 2005). Because of the first reason, rectal pressure fluctuations can not be measured during orgasms achieved through intra-vaginal stimulation. Studying the question whether orgasms achieved via that way will give the same result is therefore not possible. However, we think that there will be no difference in rectal pressure fluctuations during orgasm when the orgasm is achieved via a different way. The assumption that there is a different typology of clitoral versus vaginal orgasms can not be supported in the literature, because there is a striking lack of reliable physiological data for this typology (Mah & Binik, 2001).

Orgasm-associated rectal pressure patterns are highly variable between individuals (Carmichael et al., 1994) and we could qualitatively confirm this for our participants. We deliberately ignored this fact and included all reported orgasms in the spectral analysis. Also, we always analyzed a fixed 40-second interval containing the orgasm, regardless of orgasm duration. Despite this indiscriminate approach, we found that significantly higher spectral power in the alpha and beta band (contraction frequencies between 8 and 25 Hz) was characteristic of orgasm (see Fig. 2C and 2D). This clearly demonstrates the robustness of this approach.

We also developed an algorithm to recognize orgasms on the basis of rectal pressure. It used the alpha band, the frequency band most specific for orgasm, and classified an orgasm attempt as successful when spectral power in the alpha band (alpha power) was at least three times higher than during rest. When alpha power was less than three times higher than during rest, the attempt was classified as failed. This algorithm could recognize 94% (29/31) of all orgasms and correctly labeled 69% (44/64) of all orgasm attempts as successful or failed. This means that our algorithm displayed a 69% overlap with the elusive subjective orgasmic experience.

Frequency characteristics of rectal pressure might also be of clinical use. Orgasmic disorders are the second sexual problem in women by prevalence (Laumann, Gagnon, Michael, & Michaels, 1994). One evident orgasmic disorder is anorgasmia, the inability to achieve orgasm. Rectal pressure frequency characteristics might help to diagnose or treat anorgasmic women. One might think of a biofeedback method that informs a patient of the alpha power in rectal pressure, in order to increase awareness of a women and her partner. This, however, requires further research, e.g. in women with sexual disorders.

The observation that fluctuations in rectal pressure are orgasm-specific is in accordance with the literature, where has been described that muscular contractions start at the onset of orgasm (Bohlen et al., 1982; Carmichael et al., 1994). This means that these muscular contractions do not correspond with sexual arousal, which is a sexual phase before the orgasm. In our study, this can be seen in fluctuations in rectal pressure during both control tasks. During personal debriefing after the experiment, the participants mentioned that there was a big difference in sexual arousal between both tasks, being highly sexually aroused during the failed attempts. But no differences in rectal pressure fluctuations were found between the imitation task and the failed orgasm attempts. Therefore, the presented method, which is orgasm-specific, could become a meaningful addition to photoplethysmography, which correlates mainly with physiological arousal.

Taken together, our findings indicate that 8-13 Hz fluctuations in rectal pressure constitute an objective and quantitative marker of orgasm in women that is sensitive and yet robust to interindividual variability and temporal dilution.

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Table I: Experimental Tasks

Time (minutes)	**Measure-ment**	**Instruction**
0–2	1	Passive non-sexual resting state
2–10		No measurements
10–12	2	Imitating an orgasm while the clitoris was stimulated
12–20		No measurements
20–22	3	Imitating an orgasm while the clitoris was stimulated
22–30		No measurements
30–32	4	Stimulation of the clitoris
32–40		No measurements
40–42	5	Stimulation of the clitoris
42–50		No measurements
50–52	6	Stimulation of the clitoris, trying to reach orgasm
52–60		No measurements
60–62	7	Stimulation of the clitoris, trying to reach orgasm
62–70		No measurements
70–72	8	Stimulation of the clitoris, trying to reach orgasm

Table II: Results of Kruskal-Wallis Analysis

Frequency band	χ^2	**df**	***p***
Delta (0.5-4 Hz)	43.03	3, 84	< 0.001
Theta (4-8 Hz)	55.82	3, 84	< 0.001
Alpha (8-13 Hz)	49.47	3, 84	< 0.001
Beta (13-25 Hz)	35.31	3, 84	< 0.001

Note: degrees of freedom (df) = (independent groups -1) , (n – independent groups).

Table III: Post hoc Comparisons Between Orgasm and Imitation of Orgasm or Orgasm and Failed Orgasm in Different Bands

Frequency band	**Tasks**	**z**	**df**	***p***	**ES (*d*)**
Delta (0.5-4 Hz)	Orgasm vs. Imitation of orgasm	0.82	73	ns	0.05
	Orgasm vs. Failed orgasm attempt	1.69	62	< .05	0.27
Theta (4-8 Hz)	Orgasm vs. Imitation of orgasm	3.90	73	< .001*	0.66
	Orgasm vs. Failed orgasm attempt	2.61	62	< .01	0.51
Alpha (8-13 Hz)	Orgasm vs. Imitation of orgasm	3.73	73	< .001*	0.62
	Orgasm vs. Failed orgasm attempt	2.98	62	< .01*	0.17
Beta (13-25 Hz)	Orgasm vs. Imitation of orgasm	2.90	73	< .01*	0.52
	Orgasm vs. Failed orgasm attempt	2.68	62	< .01*	0.27

Note: * $p < \alpha_{crit}$. Comparison is only significant when $p < \alpha_{crit}$. $\alpha_{crit} = 0.0083$ because of post hoc Bonferroni correction for six comparisons in every frequency band; only two of these comparisons are shown. Degrees of freedom (df) = n -2. Effect Size (ES) is calculated using Cohen's *d*.

Figure Captions:

Figure 1: Example of a rectal pressure pattern (subject 15) during five different tasks.

Figure 2: Task effects on normalized spectral power in four frequency-bands.

Figure 3: Performance of orgasm detecting algorithm.