ORIGINAL RESEARCH—PHYSIOLOGY

Sensation and Sexual Arousal in Circumcised and Uncircumcised Men

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ABSTRACT

Introduction. Research, theory, and popular belief all suggest that penile sensation is greater in the uncircumcised as compared with the circumcised man. However, research involving direct measurement of penile sensation has been undertaken only in sexually functional and dysfunctional groups, and as a correlate of sexual behavior. There are no reports of penile sensation in sexually aroused subjects, and it is not known how arousal affects sensation. In principle, this should be more closely related to actual sexual function.

Aim. This study therefore compared genital and nongenital sensation as a function of sexual arousal in circumcised and uncircumcised men.

Methods. Twenty uncircumcised men and an equal number of age-matched circumcised participants underwent genital and nongenital sensory testing at baseline and in response to erotic and control stimulus films. Touch and pain thresholds were assessed on the penile shaft, the glans penis, and the volar surface of the forearm. Sexual arousal was assessed via thermal imaging of the penis.

Results. In response to the erotic stimulus, both groups evidenced a significant increase in penile temperature, which correlated highly with subjective reports of sexual arousal. Uncircumcised men had significantly lower penile temperature than circumcised men, and evidenced a larger increase in penile temperature with sexual arousal. No differences in genital sensitivity were found between the uncircumcised and circumcised groups. Uncircumcised men were less sensitive to touch on the forearm than circumcised men. A decrease in overall touch sensitivity was observed in both groups with exposure to the erotic film as compared with either baseline or control stimulus film conditions. No significant effect was found for pain sensitivity.

Conclusion. These results do not support the hypothesized penile sensory differences associated with circumcision. However, group differences in penile temperature and sexual response were found. **Payne K, Thaler L, Kukkonen T, Carrier S, and Binik Y. Sensation and sexual arousal in circumcised and uncircumcised men. J Sex Med 2007;4:667–674.**

Key Words. Circumcision; Sensation; Sexual Arousal; Thermography

Introduction

There has been much controversy concerning the sexual effects of male circumcision. Theoretical arguments propose that the circumcised penis is less sexually sensitive than the uncircumcised penis due to the loss of thousands of nerve endings and the permanent exposure of the glans penis [1,2]. Similarly, in a survey of 162 men, circumcised participants reported less penile sensation than their uncircumcised counterparts, and complained more of a progressive decline in

genital sensitivity throughout adulthood [3]. Individuals having undergone circumcision as adults, have also reported a loss in penile sensation following the procedure [4]. Finally, circumcision has also been suggested to alter central nervous system development through a reduction in sensory feedback to the brain, resulting in a subject who is less sexually excitable through penile stimulation [5].

With one exception, quantitative penile sensory measurement comparing sexually functional uncircumcised and circumcised men appears to be lacking. Masters and Johnson reported no differences in tactile discrimination between uncircumcised and circumcised men on the ventral or dorsal surfaces of the glans penis [6]. Instead, research to date has focused on the relationship between penile sensory thresholds and sexual functioning by comparing groups of sexually functional and dysfunctional men. According to this research, men suffering from erectile dysfunction have been shown to exhibit lower penile sensitivity to vibration [7–10], heat [7,10], pressure, touch, and cold [7], than sexually functional men. Men suffering from premature ejaculation have been demonstrated to have heightened penile vibrotactile sensitivity [11]. Age-related decline in penile sensitivity has been demonstrated with respect to vibrotactile [12] and electrical penile sensitivity [13]. Although multiple sensory modalities have been investigated, the measurement of these has been largely limited to the assessment of detection thresholds. Sensory pain thresholds are also of interest, particularly with respect to sexuality, where potentially aversive stimulation may be experienced as pleasurable.

Penile sensation has also been investigated as a correlate of other aspects of sexual functioning. Increased penile sensitivity has been found to correlate positively with frequency of sexual activity and the ability to achieve and maintain an erection, in addition to shorter latencies to maximum erection, and maximum penile tumescence [14].

No data exist, however, examining genital sensitivity during sexual arousal in men, which is more relevant to sexual functioning [15]. One such study was recently completed examining the influence of sexual arousal on genital and nongenital sensation in women with and without vulvar vestibulitis syndrome [16]. Results from this investigation showed that sexual arousal was accompanied with an increase in vulvar sensitivity. Rowland et al. [8] examined changes in penile vibrotactile thresholds following papaverine-induced erection, and found that penile sensitivity decreased. This is directly contrary to what has been found in women. However, Rowland et al.'s study was limited by a small sample size and the use of a papaverine injection, which it could be argued, may elicit a physiological response in the absence of subjective sexual arousal. In addition, the injection itself may have produced a painful or distracting stimulus for the sensory stimulus of interest.

One reason why genital sensitivity has not been examined in sexually aroused men, may be due to technical limitations. Namely, the monitoring of physiological sexual arousal in men has traditionally relied on the direct contact of a device with the genital area, whether it be by penile plethysmography, rigiscan monitoring, or penile ultrasonography. However, any obstruction or contact with the skin will influence and hinder genital sensory testing. More recently, thermal imaging has been validated for use as a measure of physiological sexual arousal in both men and women, and possesses several advantages over other methods [17]. Namely, thermal imaging does not require any direct contact with the genital area, rendering the concomitant measurement of physiological sexual arousal and genital sensitivity possible.

Aims

This study was therefore designed to compare penile touch and pain sensation, between uncircumcised and circumcised men, in both the sexually unaroused and aroused state. It was predicted that increases in penile temperature and subjective sexual arousal would be associated with increased penile sensitivity in both groups. It was also predicted that circumcised men would exhibit lower sensitivity of the glans penis across all conditions.

Methods

This study was reviewed and approved by the McGill University Faculty of Medicine Institutional Review Board.

Participants

Participants were recruited via media advertisements and screened during a semistructured telephone interview. All subjects were required to be between 18 and 45 years of age, native English or French speakers, and in good general health. Participants were excluded from the study if they suffered from any major medical and/or psychiatric illness, took medications affecting erectile func-

tioning, had a phimosis, were currently experiencing a sexual dysfunction, had undergone any genital surgery with the exception of circumcision, or reported that they did not find erotic material sexually arousing. The final sample consisted of 20 uncircumcised men and 20 age-matched (±3 years) circumcised men.

Main Outcome Measures

A semistructured interview was administered with respect to demographics, in addition to medical and sexual history. Participants completed the International Index of Erectile Function (IIEF) [18], a brief measure of erectile functioning that is cross-culturally valid. The IIEF has high internal consistency and good construct validity across five domains of sexual functioning, including erectile function, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction. Participants also completed the State subscale of the State-Trait Anxiety Inventory–Form Y (STAI) [19], as a measure of anxiety experienced prior to viewing of the stimulus films.

A questionnaire assessing subjective sexual arousal was designed for the purposes of this study. The questionnaire contains items designed to assess relaxation, enjoyment, general sexual arousal (4 items), mental sexual arousal (1 item), behavioral/motivational aspects of sexual arousal (2 items), and physiological sexual arousal (4 items). Participants answered the questions on 7-point Likert scales (1 = not at all, to 7 = very much). Three additional questions assessed the influence of thermal imaging and sensory testing on attention and sexual arousal. Regarding sexual arousal, participants were asked to rate on a 7-point Likert scale the degree to which their sexual arousal was influenced (1 = very little, 7 = a lot) by the processes of filming their genitals and sensory testing, respectively. With respect to attention, participants were asked to indicate on a bipolar scale from 1 to 7 where their attention was focused during sensory testing (1 = completely on the testing, 7 = completely on the film).

Genital temperature was measured using a TSA ImagIR thermal imaging camera provided by Seahorse Bioscience (North Billerica, MA) [17]. The sensitivity of this camera is 0.07°C, and the sampling interval was set at 16 frames per second. Surface skin temperature recording was taken from a region of interest located just below the glans penis, adjacent to the coronal ridge on the lateral right surface of the penile shaft.

Touch and pain thresholds were tested on the penile shaft, the glans penis, and the volar surface of the forearm. Touch thresholds were determined using graded disposable filaments that varied in length and diameter, and were calibrated using a digital balance [20]. The filaments were clamped at the appropriate length with hemostatic forceps and applied incrementally to the three locations at 5-second interstimulus intervals until the participant reported detecting a sensation. These same filaments were applied at 10-second interstimulus intervals in order to determine pain thresholds. Additional filaments (Touch-Test Sensory Evaluator, North Coast Medical Inc., Morgan Hill, CA, USA) exerting higher pressures were used solely on the forearm, should the disposable ones not exert enough pressure to elicit pain.

Stimulus Materials

Participants viewed two 10-minute film segments: a control film consisting of a Canadian Film Board travelogue with no sexual content, and a sexually arousing film depicting consenting adults engaged in mutual oral and coital sexual activity. The order of film presentation was randomized and counterbalanced between both groups. Participants viewed the stimulus films on Olympus Eyetrek FMD-250W goggles (Centre Valley, PA, USA) connected to a DVD player.

Procedures

Participants were given information about the study, and screened during a semistructured telephone interview in order to assess for possible inclusion in the study. Suitable participants were scheduled for two separate testing sessions. Session 1 was approximately 1 hour in duration. Upon arrival, the study procedure was explained in greater detail to participants and they were shown the testing equipment and facility, during which they had the opportunity to ask any questions. Following this, informed consent was obtained. Participants then completed the semistructured demographic interview in addition to the STAI and the IIEF. The researcher then left the room and asked the men to disrobe from the waist down. Once the participant was ready, the researcher returned to the room in order to assess baseline touch and pain thresholds. After this was completed, the thermal imaging camera was focused on the genital area. Participants then listened to soothing jazz music for a period of 10 minutes in order to allow for skin temperature to stabilize.

Following this, video presentation commenced. Participants were shown either the sexually arousing or the control film, during which penile temperature was continuously monitored. After 10 minutes elapsed, temperature monitoring was stopped, and the researcher re-entered the room and assessed tactile and pain thresholds while the participants continued to view the stimulus film. Participants were required to say "touch" or "pain" aloud when that threshold had been reached. Once the thresholds had been established, stimulus presentation was terminated, and participants were asked to complete a questionnaire pertaining to subjective sexual arousal. Session 2 proceeded exactly as session 1, only without the semistructured interview, administration of the IIEF, and baseline sensory testing. During this session, subjects were presented the video clip they had not yet seen. After the session was completed, participants were debriefed.

Results

Data Analysis

Subject characteristics were compared between groups using chi-square and *T*-tests. Group differences on questionnaire measures were analyzed using *T*-tests and MANOVA where appropriate in order to minimize Type I error [21]. Due to significant skewness, threshold data were log transformed prior to analysis. Temperature and threshold data were analyzed using repeated-measures ANOVAS. Where it is appropriate (with repeated measures that have >2 levels), Greenhouse-Geisser conservative degrees of freedom were used to test significance as an adjustment for violations of sphericity. Tukey honest significant difference post-hoc analyses were also computed on threshold and temperature data.

Sample Characteristics

There were no significant differences between groups with respect to age (M = 23.67, SD = 4.00), education, income, culture, language, place of birth, or religion χ^2 (all $P > 0.05$). The groups also did not differ with respect to age at first intercourse or relationship status. Smoking and drinking habits were not significantly different between groups; however, the circumcised group reported more recreational-drug use ($\chi^2 = 5.01$, $P < 0.05$), the majority of which consisted of marijuana. With the exception of four participants suffering from asthma in the uncircumcised group, none of the participants reported having a chronic illness. The five domain scores obtained on the IIEF for all sexually active participants (19 uncircumcised, 18 circumcised) were entered into a multivariate analysis of variance. No differences were obtained between groups on any of the domains.

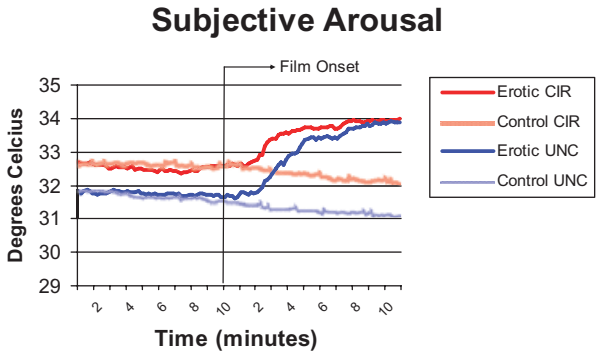

Figure 1 Penile temperature in circumcised (CIR) and uncircumcised (UNC) men with exposure to erotic and control stimulus films.

Physiological Sexual Arousal

A 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic first) × 2 (film: control vs. erotic) × 2 (time: baseline vs. postfilm) ANOVA was computed on penile temperature. Baseline values correspond to the last temperature recording obtained after baseline stability had been reached. Postfilm values correspond to the last temperature recorded after the 10-minute film-viewing period had elapsed (just prior to sensory testing). A film × time effect was found ($F_{1,36} = 118.20$, $P = 0.01$). As compared with baseline readings, penile temperature was lower after exposure to the control film ($Q_{4,\ 36} = 4.45$, $P < 0.05$), and higher after exposure to the erotic film ($Q_{4,\ 36} = 17.29$, $P < 0.01$) (Figure 1). Postfilm penile temperature was also much higher after the erotic film than after the control film ($Q_{4,\ 36} = 22.41$, $P < 0.01$). A time × group interaction was found ($F_{1,36} = 7.85$, $P < 0.01$). Uncircumcised men had significantly lower penile temperature than circumcised men, regardless of film, at baseline ($Q_{4,\ 36} = 10.27$, $P < 0.01$), and to a somewhat lesser extent, at postfilm readings ($Q_{4,\ 36} = 4.66$, $P < 0.05$). In circumcised men, postfilm penile temperature was higher than baseline penile temperature in uncircumcised men ($Q_{4,\ 36} = 14.11$, $P < 0.01$); however, there was no significant difference in penile temperature between baseline readings in circumcised men as compared with postfilm temperature in uncircumcised men. A time × film

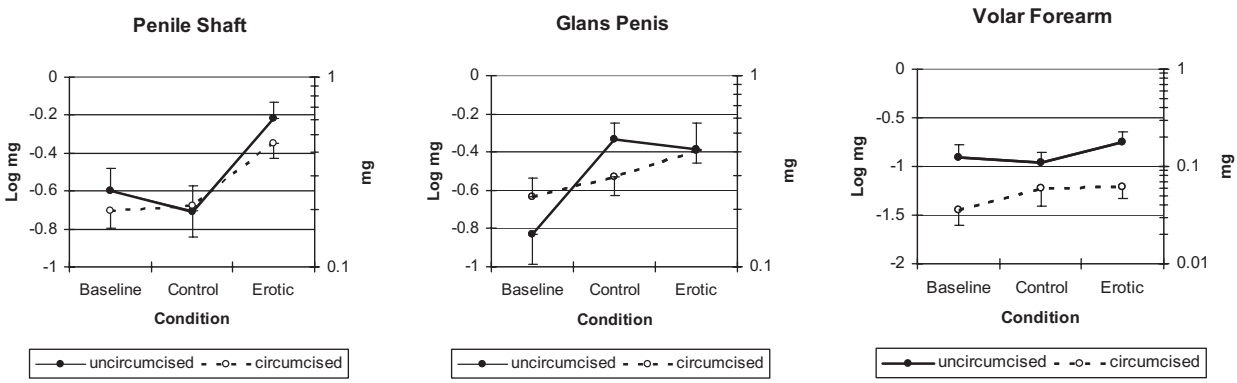

Figure 2 Penile touch thresholds as measured by location and condition.

order effect was also found ($F_{1,36} = 4.48$, $P < 0.05$). Baseline penile temperature was higher, regardless of condition, if the control film was presented first ($Q_{4,\ 36} = 5.76$, $P < 0.01$).

In order to further elucidate these findings, a 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic first) × 2 (film: control vs. erotic) ANOVA was computed on change in temperature values between pre- and postfilm measurements. A significant group effect was found ($F_{1,36} = 7.48$, $P = 0.01$), indicating that uncircumcised men experienced a higher change in penile temperature with exposure to the erotic film than circumcised men. A significant effect was also obtained for film order ($F_{1,36} = 5.39$, $P < 0.05$), indicating that penile temperature increased more in response to the erotic film if it was the first film presented.

Subjective Sexual Arousal

A 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic first) × 2 (film: control vs. erotic) × 2 (time: baseline vs. postfilm) ANOVA was computed on total subjective arousal scores calculated based on the seven questionnaire items relating specifically to sexual arousal. A significant effect was found for film ($F_{1,36} = 166.31$, $P < 0.01$), whereby both groups reported the erotic film to be more arousing than the control film. The groups did not differ with how relaxed they felt during the films, how much they enjoyed the films, or where their attention was oriented during sensory testing. There was also no significant difference between stimulus films with respect to attentional allocation during sensory testing.

A 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic film first) × 2 (film: control vs. erotic) ANOVA was computed on measures of state anxiety administered just prior to viewing of the films. A significant film × film order interaction was found ($F_{1,36} = 11.32$, $P < 0.01$). Participants were more anxious before the erotic film if this was the second film presented ($Q_{4,\ 36} = 4.05$, $P < 0.05$).

The effect of sensory testing on subjective sexual arousal was also assessed. During the control film, a total of 11 participants reported that the process of sensory testing influenced their level of sexual arousal, with nine participants reporting an increase, and four reporting a decrease. More circumcised participants reported an increase in their level of arousal, while more uncircumcised men reported being unaffected ($\chi^2 = 6.47$, $P < 0.05$). During the erotic film, 23 of 40 participants reported that the testing process affected their level of sexual arousal, seven of whom reported an increase, and 19 reported a decrease. No significant group differences were found χ^2 ($P > 0.05$).

Between-subject correlations of penile temperature and total subjective arousal scores across both control and erotic film conditions were $r^2(38) = 0.77$, $P < 0.001$ for the uncircumcised group, and $r^2(38) = 0.82$, $P < 0.001$ for the circumcised group.

Touch Thresholds

Due to significant skewness, all threshold data were log transformed prior to analysis. Greenhouse-Geisser corrected degrees of freedom were also used to test significance. Means and standard errors for touch thresholds are displayed in Figure 2. Touch thresholds were entered in a 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic first) × 3 (time: baseline vs. control film vs. erotic film) × 3 (location: penile glans vs. penile shaft vs. volar forearm)

ANOVA. A significant main effect was found for time ($F_{2,72} = 12.68$, $P < 0.01$). Overall, all locations tested were less sensitive to touch during exposure to the erotic film as compared with baseline ($Q_{3,72} = 6.91$, $P < 0.01$) and control film conditions ($Q_{3,69} = 4.28$, $P < 0.01$).

A significant group × location main effect was found ($F_{2,62} = 4.85$, $P < 0.05$). Uncircumcised men were more sensitive to touch on their forearm as compared with either the glans penis ($Q_{6,62} = 4.80$, $P < 0.05$) or penile shaft ($Q_{6,62} = 4.67$, $P < 0.05$). Circumcised men were also more sensitive to touch on their forearm as compared with either the glans penis ($Q_{6,62} = 10.07$, $P < 0.01$) or penile shaft ($Q_{6,62} = 9.32$, $P < 0.01$). Additionally, circumcised men were more sensitive to touch on the forearm than uncircumcised men ($Q_{6,62} = 5.56$, $P < 0.01$).

A significant main effect for film order was obtained, indicating that those who viewed the control film first were less sensitive to touch ($F_{1,36} = 5.68$, $P < 0.05$).

Pain Thresholds

As with touch thresholds, pain thresholds were entered in a 2 (group: circumcised vs. uncircumcised) × 2 (film order: control first vs. erotic first) × 3 (time: baseline vs. control film vs. erotic film) × 3 (location: penile glans vs. penile shaft vs. volar forearm) ANOVA. A significant main effect for location was found ($F_{2,45} = 7.11$, $P < 0.01$), indicating that the forearm was less sensitive to pain than the penile shaft ($Q_{3,45} = 4.23$, $P < 0.05$). No other significant main effects were found.

Discussion

Contrary to popular theory and existing data, uncircumcised men did not exhibit more penile sensitivity than circumcised men. This is consistent with Masters and Johnson's earlier findings [6], and yet, is surprising given widespread assumptions to the contrary. It is possible that the uncircumcised penis is more sensitive due to the presence of additional sensory receptors on the prepuce and frenulum, but this cannot be compared with the absence of such structures in the circumcised penis. This notwithstanding, the present data do cast doubt on the notion that the glans penis is more sensitive in the uncircumcised man due to the protective function of the prepuce. Possible explanations for the origin of such a belief may date back to historical traditions, whereby circumcision was performed in order to reduce sexual gratification [22], or to prevent masturbation [23]. This may have led to the general notion that circumcised men were somehow "less sexual" and therefore less "sexually sensitive" than uncircumcised men.

Regarding the influence of sexual arousal on sensation, both circumcised and uncircumcised participants were less sensitive to touch overall with exposure to the erotic film. This is consistent with Rowland et al.'s findings [8], and also suggests that the effect is not limited to genital sites. While this finding may be attributable to a general distraction effect, the difference in sensitivity found during the erotic and control film (designed to control for distraction) would suggest otherwise. It is, however, possible that the erotic film was experienced as more distracting than the control film. However, attentional focus was reported similar for both films. Nevertheless, a word of caution is warranted: the present protocol required participants to be engaged in multiple tasks simultaneously (i.e., watching films while interpreting genital stimuli), and as such, no data exist regarding the reliability of genital sensory testing during stimulus film presentation.

Findings from this study can be compared with those obtained from a similar study examining the influence of sexual arousal on genital sensation in women [16]. Results indicated that, for women, sexual arousal was accompanied with an increase in vulvar sensitivity. This is opposite to the decrease in sensitivity observed in men. Speculation as to why such a gender difference may exist must await further replication of these results with a larger sample size.

Regarding peripheral sensitivity, circumcised participants were more sensitive to touch on the forearm as compared with uncircumcised participants. This is consistent with research which found that circumcised boys exhibited heightened pain responses to vaccinations 4 to 6 months after circumcision [24]. This cannot account, however, for why a between-group difference was not found in either genital area. Furthermore, pain thresholds did not differ between groups or conditions. This last result may represent a limitation of the stimulus being used. The monofilament sutures may not have been strong enough in order to elicit a (truly) painful experience. Similarly, many of the participants described the stimulus as a small pricking sensation.

Physiological measurement via thermal imaging indicated that both groups experienced an increase in penile temperature with exposure to

the erotic film, as compared with a decrease in penile temperature with exposure to the control film. However, participants in the uncircumcised group had lower overall penile temperature and a greater increase in penile temperature in the arousal condition. This result was unexpected, and we do not have an adequate explanation. While this could be attributed to the presence of the prepuce, temperature recording was taken just below the glans penis with the prepuce unretracted. Whether this temperature differential translates into any functional differences remains to be investigated.

A number of significant findings were also obtained for film order. For both groups, baseline penile temperature was higher and touch sensitivity lower if participants were presented the control film first. This may be due to the fact that these participants could predict when the erotic film was to be viewed, although the effect was not specific to the erotic condition. Similarly, participants were also more anxious before the erotic film if the control film had been presented first.

Conclusions

In sum, the present study found no difference in genital sensation between uncircumcised and circumcised men. In light of these findings, the examination of penile sensory differences between uncircumcised and circumcised men warrants further study via a replication with a larger sample size including the measurement of multiple sensory modalities over multiple penile locations (comprising those believed to be directly affected by circumcision). The finding of a difference in physiological sexual arousal pattern as measured by surface skin temperature also requires further investigation. Namely, the relationship between penile surface skin temperature and penile circumference, volume, and/or rigidity needs to be established. This would help clarify whether the observed difference can be attributed to functional or anatomical differences between uncircumcised and circumcised men.

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