Examining Penile Sensitivity in Neonatally Circumcised and Intact Men Using Quantitative Sensory Testing

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Purpose: Little is known about the long-term implications of neonatal circumcision on the penile sensitivity of adult men, despite recent public policy endorsing the procedure in the United States. In the current study we assessed penile sensitivity in adult men by comparing peripheral nerve function of the penis across circumcision status.

Materials and Methods: A total of 62 men (age 18 to 37 years, mean 24.1, SD 5.1) completed study procedures (30 circumcised, 32 intact). Quantitative sensory testing protocols were used to assess touch and pain thresholds (modified von Frey filaments) and warmth detection and heat pain thresholds (a thermal analyzer) at a control site (forearm) and 3 to 4 penile sites (glans penis, midline shaft, proximal to midline shaft and foreskin, if present).

Results: Penile sensitivity did not differ across circumcision status for any stimulus type or penile site. The foreskin of intact men was more sensitive to tactile stimulation than the other penile sites, but this finding did not extend to any other stimuli (where foreskin sensitivity was comparable to the other sites tested).

Conclusions: Findings suggest that minimal long-term implications for penile sensitivity exist as a result of the surgical excision of the foreskin during neonatal circumcision. Additionally, this study challenges past research suggesting that the foreskin is the most sensitive part of the adult penis. Future research should consider the direct link between penile sensitivity and the perception of pleasure/sensation. Results are relevant to policy makers, parents of male children and the general public.

Key Words: circumcision, male; infant, newborn; penis; sensation; sensory thresholds

Abbreviations and Acronyms

IIEF = International Index of Erectile Function

QST = quantitative sensory testing

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Recently the United States[1] and Canada[2] revised their policy statements on routine neonatal circumcision, which has reignited public interest in this long debated topic. These national policy statements are based on research that primarily focuses on the health outcomes of circumcision (eg protection against sexually transmitted infections) while little is known about the sexual correlates of neonatal circumcision and, in particular, penile sensitivity.[3] We address this gap by assessing objective measures of penile sensitivity across men who were vs were not neonatally circumcised.

A widely accepted but largely untested hypothesis holds that keratinization of the exposed glans penis epithelium occurs after circumcision, leading to reduced penile sensitivity.[4–6]

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A second hypothesis is that the removal of the highly innervated foreskin results in decreased penile sensitivity.[7] Whether reduction in sensitivity from neonatal circumcision leads to sexual dysfunction in adult men remains a largely untested hypothesis.

Few studies have explored the impact of circumcision on penile sensitivity by examining histological correlates or QST of penile sensation. One study reported no difference in keratinization of the glans penis in circumcised and intact cadavers.[8] Two studies have assessed penile sensitivity (ie fine-touch punctate pressure thresholds[7,9] and pain thresholds[9]) via QST across circumcision status in sexually healthy men. Results from these 2 studies were mixed, likely due to the different fibers assessed. Fine touch activates A-beta, large diameter, myelinated nerve fibers, whereas small, myelinated or unmyelinated C-fiber free nerve endings are activated by punctate pain[10] and thermal stimuli.[11] Interestingly, C-fibers are more likely to be implicated in sexual functioning or erotic sensation.[12,13] However, Payne et al found no differences in punctate pain thresholds across circumcised and intact men.[9]

In this study we assessed penile sensitivity in sexually healthy men who were circumcised as neonates, or were intact. We tested 3 hypotheses. 1) Circumcised men will have higher penile tactile and pain thresholds (ie lower sensitivity) compared to intact men. 2) Differences in penile sensitivity between the groups will be most pronounced at the glans penis, where keratinization is hypothesized to take place.[4–6] 3) Sensory thresholds obtained at the foreskin of intact men will be lower (ie more sensitive) than at the other sites tested.[7]

MATERIALS AND METHODS

Participants

Participants were recruited from Kingston, Ontario, Canada. Eligible participants were adult men 18 to 40 years old. Exclusion criteria were not fluent in English, active sexually transmitted infections, past/present sexual dysfunction, anatomical abnormalities of the genitals (congenital/acquired), cigarette smoking,[14] diagnosed cardiovascular condition(s), or medication(s) that may interfere with blood flow (eg antihypertensives) or sexual functioning (eg antidepressants, hormones).[15,16] Study procedures were approved by the Health Science Research Ethics Board at Queen's University.

Self-Reported Data

Information regarding sociodemographics and sexual function was collected. Sexual function was assessed via the IIEF, a 15-item measure of men's sexual functioning during the last 4 weeks across the 5 domains of erectile function, intercourse satisfaction, orgasmic function, sexual desire and overall satisfaction.[17]

Tactile Thresholds

Modified von Frey filaments were used to assess tactile and pain thresholds (as in Pukall et al).[18] Tactile thresholds (the lowest intensity of a stimulus required to perceive a touch sensation) were assessed using a 2 down 1 up staircase method.[18] Tactile thresholds were calculated by averaging gram values over the last 4 (of 6) reversals. Pain thresholds (the lowest intensity of a stimulus required to produce a sensation of pain) were assessed by applying consecutively higher filaments until pain was reported.

Thermal Thresholds

A thermal sensory analyzer (Medoc Advanced Medical Systems, Durham, North Carolina) with 5 mm × 5 mm thermode was used to assess warmth detection and heat pain thresholds.[19] The thermode was heated at 0.5C per second,[20] and participants were prompted to indicate a change in the probe temperature (warmth sensation, averaged over 3 trials) and perception of heat pain (averaged over 2 trials) by pressing a handheld button, which immediately returned the probe to its resting temperature.

Procedure

Eligible participants (assessed via a telephone interview) attended a single testing session at the Sexual Health Research Laboratory. Demographic and relationship information was collected during an interview, after which the IIEF was administered to assess sexual functioning. Next, QST protocols were used to test 4 locations including 1) a control site (volar surface of the forearm, 4 inches below the wrist); 2) middle of the glans penis, dorsal side (with foreskin retracted, if present); 3) anterior midline penile shaft, approximately equidistant from the coronal ridge and base of the shaft (below circumcision scar, if present); and 4) anterior proximal to midline penile shaft (along the midline). A testing site on the unretracted foreskin was included for intact men (fig. 1). [F1] Genital sites were randomized in a predetermined order that was matched within participant pairs.

Data Considerations

Demographics were assessed for group differences via t-tests or chi-squared analyses. An independent samples t-test was performed on total IIEF scores to compare sexual functioning across circumcised and intact men. Data from 12 men (6 circumcised, 6 intact) were excluded

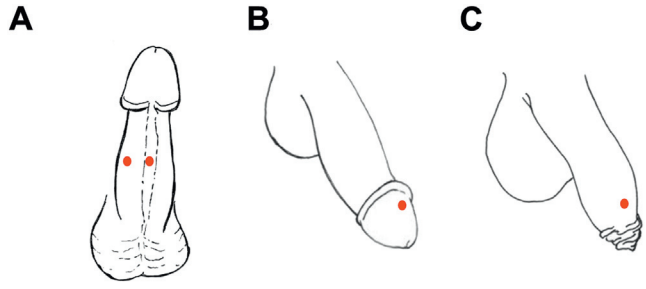

Figure 1. Penile testing sites on midline shaft and area proximal to midline shaft (*A*), glans penis (*B*) and foreskin (intact only, *C*).

from analysis because they had not engaged in sexual activity during the previous 4 weeks.

With respect to QST, for threshold trials in which the participant maximum stimulus intensity was reached, the highest value was assigned (11.75 gm in the case of punctate pain [in 84, 30% of trials]; 48C in the case of heat pain [in 50, 20% of trials]). No group differences were observed in the number of trials in which a maximum was reached.

Repeated measures ANOVA was used to assess between-group differences in QST thresholds across circumcision status. Positively skewed data (ie tactile thresholds) were log transformed and negatively skewed data (ie heat pain thresholds) were reflected log transformed to normalize the data.[21] The dependent variable was participant threshold (ie tactile or pain [grams], warmth detection or heat pain [degrees C]). The within-subjects variable was testing site (forearm, glans penis, midline shaft, proximal to midline shaft), and the between-subjects variable was circumcision status (circumcised, intact). A significant Mauchly's test of sphericity predicated interpretation of Greenhouse-Geisser corrected values. Participant age was covaried in corresponding ANCOVAs[22] but the results of these analyses did not differ and are not reported here.

Tests of foreskin sensitivity were conducted using independent sample t-tests to compare mean foreskin sensory thresholds (intact men only) to alternate testing sites (circumcised and intact men combined).

RESULTS

Sample Characteristics

Data from 62 men (30 circumcised, 32 intact; age range 18 to 37 years, mean 24.2, SD 5.1) are reported. The majority of the sample was Canadian born, religiously unaffiliated and educated. No significant group differences were observed across demographic variables (see table). [T1]

Participant demographic information

	Circumcised	Intact	Overall	p Value
Mean age (SD)	24.4 (5.23)	23.9 (4.99)	24.2 (5.07)	0.70
No. birthplace (%):				0.23
Canada	26 (86.7)	24 (75.0)	50 (80.6)	
United States	1 (3.3)	1 (3.1)	2 (3.2)	
Europe	1 (3.3)	3 (9.4)	4 (6.4)	
Other	2 (6.7)	4 (12.5)	6 (10.0)	
No. education (%):				0.66
Post-secondary ongoing	14 (46.7)	14 (45.2)	28 (45.9)	
Post-secondary complete	8 (26.7)	7 (22.6)	15 (24.6)	
Graduate/professional ongoing	6 (20.0)	5 (16.1)	11 (18.0)	
Graduate/professional complete	2 (6.7)	5 (16.1)	7 (11.5)	
No. occupation (%):				0.31
Employed full-time	8 (26.7)	12 (37.5)	20 (32.3)	
Employed part-time	2 (6.7)	1 (3.1)	3 (4.8)	
Student	20 (66.7)	17 (53.1)	37 (59.7)	
Unemployed	0 (0)	2 (6.3)	2 (3.2)	
No. current religious affiliation (%):				0.84
None/not applicable	22 (73.3)	28 (87.5)	50 (80.6)	
Catholic/Christian	2 (6.6)	3 (9.4)	5 (8.1)	
Jewish	3 (10.0)	0 (0)	3 (4.8)	
Other	3 (10.0)	1 (3.1)	4 (6.5)	
Mean IIEF total scores (SD)	66.8 (8.0)	61.4 (18.5)	63.6 (14.5)	0.26

As a result of participants declining to answer some questions, values may not add up to 100%.

Sexual Functioning

Sexual functioning, as indicated by IIEF total scores, did not differ significantly across circumcision status ($t(48)=1.15$, $p=0.26$).

Tactile Thresholds

Circumcised and intact men did not differ with respect to tactile thresholds. The forearm had the lowest tactile threshold (most sensitive to touch) compared to the glans and the area proximal to the midline shaft ($p \leq 0.01$) but not the midline shaft ($p=0.08$, fig. 2). [F2] Tactile thresholds at the midline shaft were significantly lower than at the area proximal to the midline shaft ($p=0.01$) and no other significant differences were observed across penile sites. A post hoc power analysis (power (1-β) set at 0.8, α set at 0.05, identical parameters used for all power calculations), indicated sufficient power to detect a small effect size. Tactile thresholds at the foreskin (intact men) were significantly lower (more sensitive) than all 3 genital testing sites but not the forearm (fig. 2).

Pain Thresholds

Circumcised and intact men did not differ with respect to pain thresholds. The forearm had higher pain thresholds (lower sensitivity) than the glans penis ($p<0.001$) and midline shaft ($p=0.02$), but not the area proximal to the midline shaft. The glans penis had lower pain thresholds (higher sensitivity) than the midline shaft ($p<0.01$) and the area proximal to the midline shaft ($p<0.001$). Thus, the site most sensitive to punctate pain was the glans penis, followed by the midline shaft, while the area proximal to the midline shaft and the forearm were less sensitive to pain. A power analysis revealed that a sample of 122 participants would be necessary to detect a small effect. Mean pain threshold of the foreskin did not differ from any other site tested (fig. 2).

Warmth Detection Thresholds

Sensitivity to warmth detection did not differ with respect to circumcision status or testing site. A power analysis indicated that 238 participants would be required to obtain a significant effect. The glans penis but no other site tested had higher warmth detection thresholds (lower sensitivity) compared to the foreskin ($p=0.02$, fig. 2).

Heat Pain Thresholds

Circumcised and intact men did not differ with respect to sensitivity to heat pain. The forearm had higher pain thresholds (lower sensitivity) compared

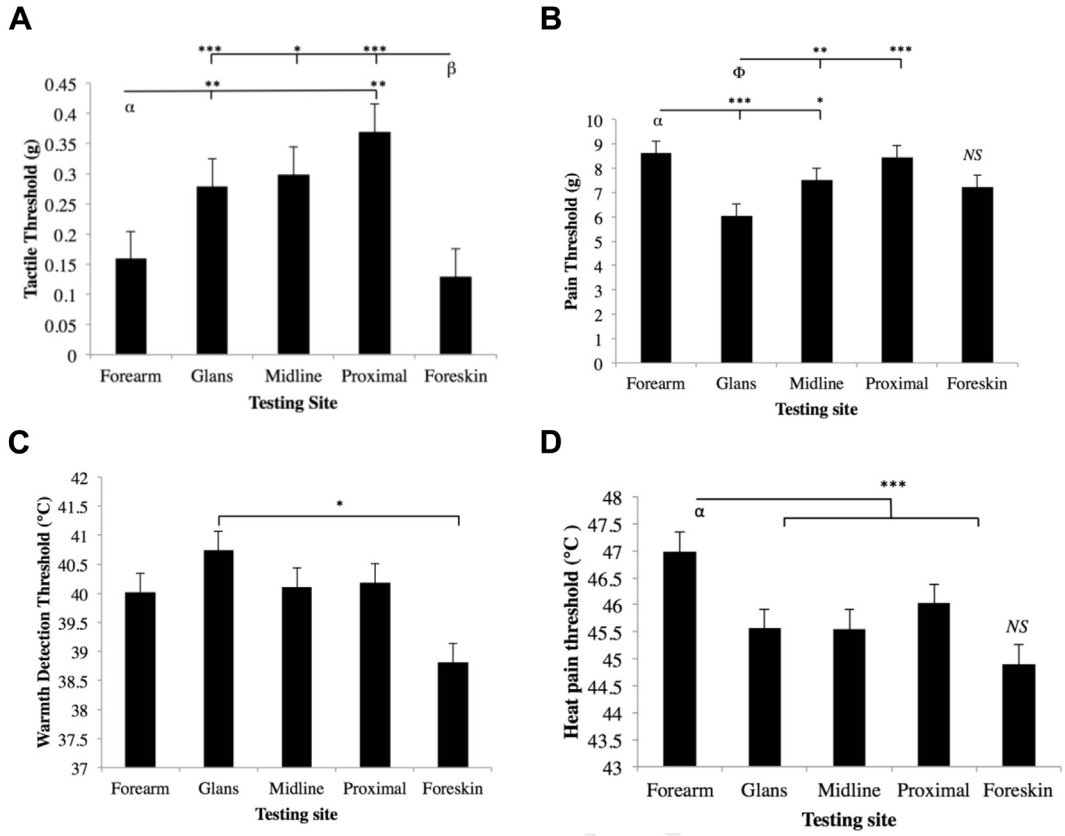

Figure 2. Tactile (*A*) and pain (*B*) thresholds for punctate stimuli and thermal stimuli (*C* and *D*) across testing sites (collapsed across circumcision status). Single asterisk indicates p <0.05. Double asterisk indicates p <0.01. Triple asterisk indicates p <0.001. Y-axis values are raw values (gm or degrees C). Analyses were performed on log transformed values (in *A* and *D*). Error bars represent standard error. Alpha indicates significant findings with forearm as comparison group. Beta indicates significant findings with foreskin as comparison group. Theta indicates significant findings with glans as comparison group. *NS,* not significant.

to all genital sites tested (p <0.001). Heat pain thresholds obtained at the midline shaft were lower (higher sensitivity) than the area proximal to the midline. A power analysis indicated sufficient power to detect a significant effect. The average heat pain threshold for the foreskin was not significantly different compared to any genital site tested (fig. 2).

DISCUSSION

Findings from the current sample of men indicate that neonatal circumcision is not associated with decreased penile sensitivity in adulthood compared to men who have never undergone the procedure. This study builds on previous research[7,9] by including QST measures that are likely more relevant to sexual pleasure (ie thermal detection, pain threshold) than fine-touch pressure thresholds alone.[12]

The keratinization hypothesis was not supported by this study.[3–6] No between-group difference in sensitivity of the glans penis (where keratinization is expected to occur) was observed in the current sample. This finding is counter to previous work which found lower tactile thresholds at the glans penis in circumcised vs intact men.[4–7] However, the lack of a significant between-group difference was repeated across 4 stimulation types in the current study, and is consistent with other findings.[9] However, it should be noted that research directly examining the tissue properties of the glans penis (eg via biopsy) is required to test this hypothesis directly.

It has been proposed that anatomical differences between the circumcised and intact penis (ie the presence/absence of the highly innervated foreskin) should be the focus of psychophysical studies comparing penile sensitivity across circumcision status, as opposed to anatomical similarities (eg sensitivity at the glans penis). Indeed, past studies examining penile sensitivity often exclude the foreskin as a testing site.[9,22,23] Sorrells et al concluded that the foreskin was the penile site most sensitive to fine-touch punctate pressure.[7] Results from the current study, examining 4 types of stimulation over multiple testing sites, indicate that foreskin removal is not associated with reductions in penile sensitivity or sexual dysfunction.

Similar to Sorrells et al,[7] we found that of all the genital sites tested, the foreskin was the most

sensitive to tactile sensation stimuli. However, given the high prevalence of fine-touch pressure receptors (Meissner corpuscles) in the preputial mucosa,[24] this finding was not unexpected. We extended the methods of Sorrells et al to include punctate pain, warmth sensation and heat pain, and failed to consistently replicate the findings by Sorrells et al across stimuli.[7] Pain thresholds (assessed via punctate and heat stimuli) at the foreskin did not significantly differ from any other genital site. With respect to warmth sensation, we observed that the foreskin was more sensitive than the glans penis but not the penile shaft (midline or proximal to the midline). Evidence that the epithelial tissue at the foreskin is structurally different from that of the glans penis (but not necessarily the shaft) has been demonstrated,[10] and the difference in warmth detection thresholds at the foreskin and glans penis indicates that the tissues may function differently as well. However, studies directly assessing the histology of different tissues in the penis in conjunction with men's sensory experiences need to be conducted to fully understand the implications of these potential functional differences.

The results of the current study concerning the sensitivity of the control site compared to the rest of the genital sites do not support the idea that foreskin removal is detrimental to penile sensitivity. Sensitivity at the foreskin did not significantly differ from the control site on the forearm for any stimulus modality tested. This finding is interesting given that other genital sites (eg the glans penis, the midline shaft) were more sensitive to pain stimuli than the forearm and, therefore, the foreskin. Thus, removing the highly innervated foreskin does not appear to remove the most sensitive part of the penis. However, these data are not sufficient to determine the extent to which the pattern of foreskin sensitivity observed is relevant to the experience of sexual response or sexual pleasure.

One limitation of the current study is the fact that we cannot draw conclusions about the implications of these findings for men's perceptions of sexual pleasure or sexual function, since the link between sensory testing and sexual arousal remains untested. Although sexual functioning as assessed via the IIEF did not differ across groups in this study, future research is required to examine associations among penile sensitivity, perceived sexual sensation and sexual functioning.

These analyses represent a lower bound estimate of punctate and heat pain thresholds due to participants reaching the upper limit of these stimuli and, thus, are a conservative estimate, in effect another potential limitation of the study. Researchers should consider including a wider range of stimulus modalities without negatively impacting participant comfort. Additionally, replication of this study is warranted with a larger sample size, as power analyses revealed that results for pain and warmth detection thresholds were underpowered and, thus, associated conclusions should be interpreted as preliminary.

CONCLUSIONS

We directly tested whether circumcision is associated with a reduction in penile sensitivity by testing tactile detection, pain, warmth detection and heat pain thresholds at multiple sites on the penis in groups of healthy (neonatally) circumcised vs intact men. This study indicates that neonatal circumcision is not associated with changes in penile sensitivity and provides preliminary evidence to suggest that the foreskin is not the most sensitive part of the penis. Methodology and results from this study build on previous research,[7,9] and imply that if sexual functioning is related to circumcision status, this relationship is not likely the result of decreased penile sensitivity stemming from neonatal circumcision.

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EDITORIAL COMMENT

The recent identification of the benefit of circumcision in the prevention of HIV led the American Academy of Pediatrics to revise its recommendations. Concerns continue to be raised about the potential impact in changing sensation of the penis after circumcision. Bossio et al address this concern with objective evaluation of penile sensation in men who underwent neonatal circumcision compared to uncircumcised men. They were unable to demonstrate differences in any of the tested parameters. In addition, they did not note any difference in sexual dysfunction in the tested cohorts.

Although these are positive findings, I suspect that they will not placate those opposed to newborn circumcision. The previous findings of the foreskin being a source of significant sensation (reference 7 in article) are also reason for concern. Men circumcised in infancy have never had this added source of sensation and, therefore, may not be able to determine that sensitivity was lost.

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REPLY BY AUTHORS

In this study we empirically tested 3 largely unverified hypotheses about the impact of neonatal circumcision on adult penile sensitivity, knowing that a single study will not resolve the circumcision debate. However, it is our hope that this research can begin to pave the way for additional work in the area of sexual correlates of circumcision. Specifically we hope to initiate a shift toward more empirically rigorous research exploring the impact of neonatal circumcision on the sexual lives of men. Further work is needed before we have answers about the long-term impact of circumcision. Indeed, perhaps definite conclusions will never be reached as personal beliefs about circumcision represent an important and virtually unstudied aspect of this discussion.

We must note that this study does not directly explore questions about the loss of the mobile properties of foreskin or the perception of dynamic stimuli over the penis—a challenge from a methodological standpoint. How does one compare differences in sensation when one group of men had the foreskin removed in infancy? These already contentious questions can be further complicated when navigating research protocols. Certainly these questions are important ones requiring further research.

It is possible that the findings in this report, suggesting that foreskin sensitivity may not be as important to sexual pleasure as other regions of the penis tested, may shed some light on these queries. However, these specific questions were not the focus of the current study. Our hope is that scientists will continue to use rigorous empirical methodology to explore these and other questions related to the sexual correlates of circumcision, while maintaining an objective stance.