Fine-touch pressure thresholds in the adult penis

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OBJECTIVE

To map the fine-touch pressure thresholds of the adult penis in circumcised and uncircumcised men, and to compare the two populations.

SUBJECTS AND METHODS

Adult male volunteers with no history of penile pathology or diabetes were evaluated with a Semmes-Weinstein monofilament touch-test to map the fine-touch pressure thresholds of the penis. Circumcised and uncircumcised men were compared using mixed models for repeated data, controlling for age, type of underwear worn, time since last ejaculation, ethnicity, country of birth, and level of education.

RESULTS

The glans of the uncircumcised men had significantly lower mean (SEM) pressure thresholds than that of the circumcised men, at 0.161 (0.078) g ($P = 0.040$) when controlled for age, location of measurement, type of underwear worn, and ethnicity. There were significant differences in pressure thresholds by location on the penis ($P < 0.001$). The most sensitive location on the circumcised penis was the circumcision scar on the ventral surface. Five locations on the uncircumcised penis that are routinely removed at circumcision had lower pressure thresholds than the ventral scar of the circumcised penis.

CONCLUSIONS

The glans of the circumcised penis is less sensitive to fine touch than the glans of the uncircumcised penis. The transitional region from the external to the internal prepuce is the most sensitive region of the uncircumcised penis and more sensitive than the most sensitive region of the circumcised penis. Circumcision ablates the most sensitive parts of the penis.

KEYWORDS

circumcision, pressure sensitivity, penis

INTRODUCTION

Infant male circumcision, the most common medical procedure in the USA, might also be the most divisive. The long-term health impact of neonatal circumcision has received little study, while the consequences of circumcision on sexual function in the adult male have received even less attention.

A poorly documented study by Masters and Johnson, briefly mentioned only in their book [1] and never subjected to peer-review, claimed to find no difference in the fine-touch perception of the glans of circumcised and uncircumcised men. Several studies assessed the impact of circumcision on sexual function in adult men [2–6]. These studies had few subjects, a relatively short follow-up and a reliance on subjective self-reporting obtained from men with a history of penile and sexual dysfunction. Notable in these studies is the high percentage (27.3% [4] to 64.2% [6]) of subjects who were circumcised to correct a penile problem, and who reported no improvement after surgery, a decrease in penile sensitivity, or a reduction in erectile function.

Bleustein *et al.* [7], in a comparison study of men with and with no erectile dysfunction (ED), using quantitative somatosensory testing that included vibration, pressure, spatial perception, and warm and cold thermal thresholds, found that uncircumcised men had worse vibratory sensation and better fine-touch sensation. These differences disappeared when controlled for age, hypertension and diabetes.

Whether the penis is circumcised or not might also affect coitus. For women, having a male partner with a foreskin increased the duration and comfort of coitus and increased the likelihood of achieving single and multiple orgasms [8]. A recent multinational population survey using stopwatch assessment of the intravaginal ejaculation latency time (IELT) found that Turkish men, the vast majority of whom are circumcised, had the shortest IELT. When Turkish men were excluded from the analysis, there was no difference between circumcised and uncircumcised men [9]. Likewise, in a London population, men from Islamic countries were more likely to have premature ejaculation [10].

The type of nerve endings in the penis vary with location. The glans penis primarily has free nerve endings that can sense deep pressure and pain [11]. The transitional area from the external to the internal surface of the prepuce, or 'ridged band', has a pleated appearance that is continuous with the frenulum and has a high density of fine-touch neuroreceptors, such as Meissner's corpuscles [12–14]. Based on this histology, the transitional region and the ventral surface of the prepuce would be expected to have lower thresholds for light touch.

Controversy over the sensory consequences of infant male circumcision on adult sexual function has been fuelled by a lack of objective data. By objectively measuring penile sensitivity, the present study aimed to map the fine-touch pressure thresholds of the

FIG. 1. Locations on the dorsal penis evaluated for fine-touch pressure thresholds.

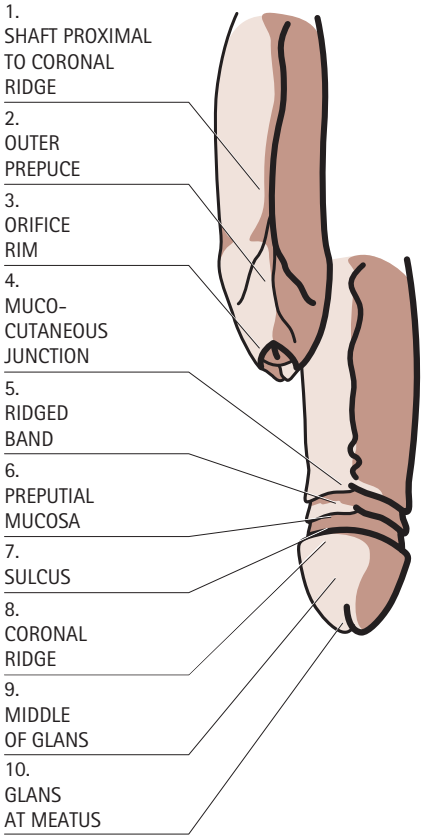
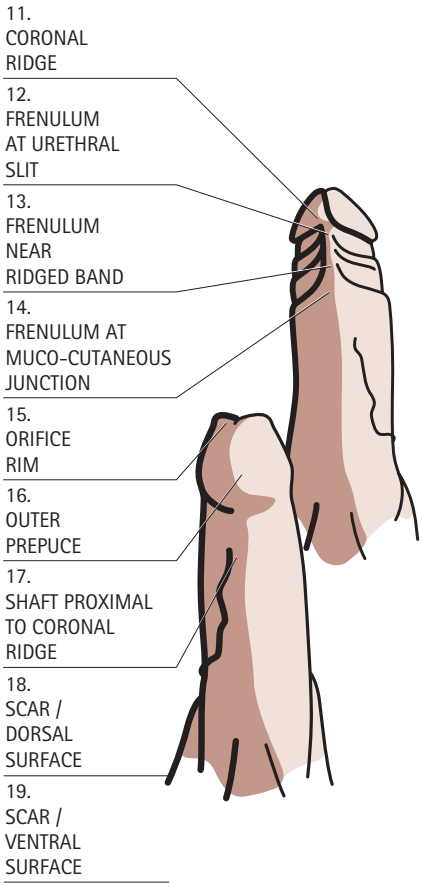


FIG. 2. Locations on the ventral penis evaluated for fine-touch pressure thresholds.



penis and quantify the differences in penile sensitivity between men with and without foreskins.

SUBJECTS AND METHODS

Subjects were recruited by posting 'fliers' at the San Francisco Bay Area medical school. Also, announcements were made on a medical radio programme, and advertisements were placed in local Bay Area general circulation newspapers.

Subjects were men aged >18 years in good health, with no genital alterations, except for circumcision, as determined by health-screening questions. A short questionnaire was completed to determine ethnicity, place of birth, highest education degree obtained, type of underwear worn, timing of last ejaculation, referral source, and health status. Circumcision status was determined by a physical examination.

Exclusion criteria were: transsexuals; intersex individuals; males born with abnormal genitals, e.g. hypospadias; a history of diseases or conditions known to affect sexual sensitivity and function, e.g. diabetes mellitus; a history of genital, prostate, or urinary tract disease of any kind, including but not limited to sexually transmitted diseases, open sores, or lesions at the time of screening; prostatitis; prostate cancer; BPH; spinal cord injury; peripheral nerve injury; peripheral neuropathy; sciatica; any penile piercing; penile enlargement surgery; any form of psychiatric condition; or a history of alcohol or substance abuse. Informed consent was obtained before testing.

The fine-touch sensitivity of 19 locations on the penis was measured using Semmes-Weinstein monofilament touch-test sensory evaluators (North Coast Medical Supply, Morgan Hill, CA, USA) [15–17] to create a penile sensitivity map (Figs 1 and 2)

On the dorsum of the penis, these locations were: (1) the shaft proximal to coronal ridge; (2) the outer prepuce; (3) the rim of the preputial orifice; (4) the muco-cutaneous junction; (5) the ridged band; (6) the preputial mucosa; (7) the coronal sulcus; (8) the coronal ridge; (9) the middle of dorsal aspect of the glans; (10) the glans at the meatus; on the ventral surface of the penis, the locations were (11) the coronal ridge; (12) the frenulum at the urethral slit; (13) the frenulum near the ridged band; (14) the frenulum at the muco-cutaneous junction; (15) the rim of the preputial orifice; (16) the outer prepuce; (17) the shaft proximal to the coronal ridge; and locations pertaining to circumcised men only (18) the circumcision scar on the dorsal surface and (19) the circumcision scar on the ventral surface. Locations 2–5 and 13–16 were measured only in uncircumcised men because these locations are ablated by circumcision.

Because of the method of data collection, it was impossible for the physician measuring the fine-touch thresholds to be unaware of the circumcision status of the subject. Likewise, because of the number of locations sampled, it was also impossible for the statistician to be unaware of the circumcision status of the subject.

Based on unpublished pilot data, it was determined that sampling 50 uncircumcised and 150 circumcised men would have 80% power to show a difference of 0.046 g with a type I error of 5%. Demographic information by circumcision status were compared using Mantel-Haenszel, Fisher's exact, chi-square and *t*-tests. Fine-touch pressure thresholds by location were compared using *t*-tests and linear regression. Mixed models for repeated data on single subjects stratified by location of measurement, which control for within-subject variability, were developed using locations present in both the circumcised and the complete penis. Models were assessed using forward, backwards and stepwise selection. Similar models were developed using only locations on the glans penis. This study protocol was approved by the Western Institutional Review Board.

RESULTS

In all, 163 subjects were enrolled; one uncircumcised man was excluded for diabetes, two uncircumcised men and one circumcised man were excluded for hypospadias. All of the men completed the

testing once it started. A comparison of the demographic information by circumcision status is shown in Table 1. Men born outside the USA were eight times more likely to be uncircumcised.

Fine-touch pressure thresholds for each of the penile positions is shown in Table 2 and Fig. 3. The region most sensitive to fine touch on the circumcised penis was the circumcision scar. The ventral scar was more sensitive than the dorsal scar (*t*-test and sign-test $P < 0.001$). In all but one position, fine-touch pressure thresholds were greater in the circumcised penis. The most sensitive regions in the uncircumcised penis are those removed by circumcision. There was no interaction between age and circumcision status.

When compared with the most sensitive area of the circumcised penis, several locations on the uncircumcised penis, which are missing from the circumcised penis, were significantly more sensitive (Table 2).

There was no association between fine-touch pressure threshold and the ambient room temperature at the time of the examination, the time since the reported last ejaculation ($P = 0.659$), or the country of birth.

TABLE 1 The demographics of the subjects by circumcision status

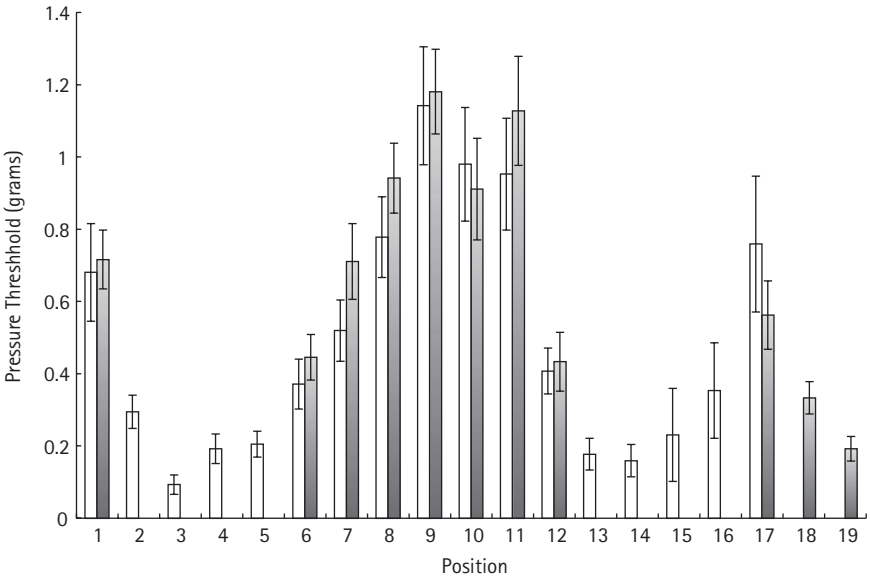
Measure	Not circumcised (68)	Circumcised (91)	Comparison
Mean (SD) age, years	51.0 (12.9)	48.3 (12.5)	0.180*
Born outside USA, n (%)	23 (34)	5 (5.5)	8.79 (3.13–24.68)†
Ethnicity			0.217‡
Caucasian, %	67	83	0.42 (0.20–0.90)†
Level of education, n(%)			0.278¶
High school	10 (15)	15 (16)	
Associate's degree	3 (4)	2 (2)	
Bachelor's degree	35 (51)	40 (44)	
Graduate school	9 (13)	8 (9)	
Master's degree	8 (12)	17 (19)	
PhD, JD, MD	3 (4)	9 (10)	
Underwear			0.625‡
Briefs	34 (50)	50 (55)	0.630§
Boxers	19 (28)	21 (23)	0.580§
None	12 (18)	15 (16)	1.00§
Both	3 (4)	5 (5)	1.00§
Referral source, n			
Newspaper	6	15	
Radio	6	16	
Friend	16	13	
Internet	4	6	
Flyer	1	4	
Study leader	5	13	
Mean (SD) days since last ejaculation	2.38 (2.47)	2.69 (3.46)	0.531

**P for t-test; †odds ratio (95% CI); ‡P for chi-square test; ¶P for trend analysis; §P for Fisher's exact test.*

TABLE 2 Mean fine-touch pressure threshold value (g) by position and circumcision status, and differences in fine-touch pressure threshold between the ventral scar (Position 19) and the position found only on the uncircumcised penis

Position	Not circumcised (SEM)	Circumcised (SEM)	Age-adjusted difference (% decrease)	Difference, g	P (t-test)	Difference adjusted for age	P
1	0.681 (0.135)	0.716 (0.081)	0.50 (7.0)				
2	0.2941 (0.046)			+0.104	0.0698	+0.086	0.1175
3	0.093 (0.027)			–0.095	0.0307	–0.111	0.0136
4	0.192 (0.041)			–0.003	0.9530	–0.017	0.7463
5	0.205 (0.036)			–0.083	0.7474	–0.002	0.9673
6	0.371 (0.069)	0.445 (0.063)	0.113 (25.3)				
7	0.519 (0.085)	0.7099 (0.105)	0.238 (33.6)				
8	0.778 (0.112)	0.941 (0.097)	0.228 (24.2)				
9	1.141 (0.163)	1.180 (0.117)	0.129 (10.9)				
10	0.979 (0.158)	0.911 (0.1406)	0.024 (2.6)				
11	0.952 (0.155)	1.1273 (0.151)	0.255 (22.6)				
12	0.407 (0.063)	0.433 (0.081)	0.057 (13.2)				
13	0.177 (0.044)			–0.012	0.8311	–0.027	0.6229
14	0.159 (0.045)			–0.029	0.5991	–0.045	0.4134
15	0.230 (0.129)			+0.041	0.7571	+0.014	0.9045
16	0.353 (0.132)			+0.1617	0.2328	+0.135	0.2614
17	0.759 (0.188)	0.562 (0.095)	–0.127 (–22.6)				
18		0.333 (0.045)					
19		0.192 (0.034)					

FIG. 3. Fine-touch pressure thresholds (g) by location on the adult penis, comparing uncircumcised men (red bars) and circumcised men (green bars), with a range of one SD shown with the error bars.



Variable	Estimate, g	SEM	t-value or F-value*	P
Penis				
Circumcision	−0.1554	0.0761	−2.04	0.0431
Hispanic	−0.214	0.133	−1.61	0.1104
Briefs	−0.203	0.075	−2.71	0.0075
Age (years)	0.011	0.003	3.66	0.0004
Location			13.69*	<0.0001
Glans Penis				
Circumcision	−0.161	0.078	−2.07	0.0398
Hispanic	−0.207	0.135	−1.53	0.1293
Briefs	−0.212	0.076	−2.77	0.0063
Age (years)	0.013	0.003	4.21	<0.0001
Location			17.64*	<0.0001

TABLE 3
The mixed model for repeated measures using locations found on both the circumcised and uncircumcised penis, and only on the glans penis

Using a mixed model to evaluate repeated measures, location of the measurement, age, wearing briefs, level of education, being Hispanic, and circumcision status were all statistically significant in the multivariate models (Table 3), e.g. with each year of age, the fine-touch pressure threshold increased by 0.011 or 0.013 g.

DISCUSSION

The glans in the circumcised male is less sensitive to fine-touch pressure than the glans of the uncircumcised male. The most sensitive location on the circumcised penis is the circumcision scar on the ventral surface. Five locations on the uncircumcised penis that are routinely removed at circumcision were more sensitive than the most sensitive location on the circumcised penis.

Despite the controversy over the long-term impact of male circumcision, no thorough, objective, quantitative studies measuring the long-term sensory consequences of infant circumcision have hitherto been reported. The present study provides the first extensive mapping of the fine-touch pressure thresholds of the adult penis. This information provides a baseline for future comparison studies and provides investigators with the testing locations that provide the most differentiation.

The Semmes-Weinstein monofilaments are individually calibrated to deliver a targeted force within a 5% SD. They have been used to test female genital sensitivity [17] and can be used to determine changes in sensitivity over time.

It is difficult to compare our data and results with those claimed by Masters and Johnson [1]; no method is documented, only their assertion of no difference in fine-touch reception on the glans. Nevertheless, their results, even if they were verifiable, are of little value to the question of the long-term sensory consequences of infant circumcision. First, the glans has virtually no fine-touch neuroreceptors [11–14]. Second, when determining the aggregate sensory impact of circumcision, the sensory effects of circumcision on the glans are of secondary significance, because the glans is not removed during circumcision. Instead of measuring changes in the glans after circumcision, it is more important to measure the sensory investment of the parts of the penis removed by circumcision.

In a subjective study with only a 44% response rate, Fink *et al.* [2] questioned men, using an unvalidated survey tool that they hoped would measure sexual function. Compared to before circumcision, men reported reduced erectile function ($P = 0.01$), decreased penile sensitivity ($P = 0.08$), no changes in sexual activity, and improved satisfaction after circumcision. The circumcisions were for 'medical reasons' in 88%. For a procedure that was expected to correct their problem, entirely favourable outcomes would be expected, but 38% reported a perceived problem or difficulty as a result of the procedure.

Collins *et al.* [3] studied 15 men who were circumcised as adults; all but one had a penile problem. The patients completed the Brief Male Sexual Function Inventory, an unvalidated measure of sexual function, before and at least 12 weeks after the procedure. Not surprisingly, this under-powered study failed to find any differences in sex drive, erection, ejaculation, problem assessment, or overall satisfaction. This is an intriguing finding because the men were circumcised expecting an improvement in sexual function and satisfaction.

In a study designed to measure the impact of anterior urethroplasty on erectile function, Coursey *et al.* [4] included a control group of men who were circumcised for 'phimosis or other benign indication'. Of the 48 men circumcised, only 22 (46%) completed the survey. Using an internally validated survey, 27% reported worsening satisfaction with their erectile function after a procedure.

In a Turkish population of 42 men in their third decade undergoing circumcision, 39 of whom sought circumcision for religious reasons, the Brief Male Sexual Function Inventory, measured before and at least 12 weeks after the procedure, showed no difference in any of the five areas assessed by the instrument. However, the mean IELT was significantly longer after circumcision ($P = 0.02$) [5]. As noted earlier, Turkish men had the shortest mean IELT of the countries assessed [9].

In a study of 95 men undergoing circumcision in China, erectile function was measured before and after surgery. Eighteen patients reported mild erectile dysfunction before circumcision, while 28 reported from mild to moderate erectile dysfunction after circumcision ($P = 0.001$). Also reported were increased problems with weakened erectile confidence ($P = 0.04$), difficult insertion during coitus ($P = 0.03$), prolonged intercourse in 31 cases ($P = 0.04$), and improved satisfaction in only 34 patients ($P = 0.04$) [6].

In a study of 125 men drawn from a urology clinic, Bleustein *et al.* [7] found that uncircumcised men, both with and with no erectile dysfunction, had lower thresholds for pressure using the same device as used in the present study. The differences they found were no longer statistically significant when adjusted for age, diabetes, and hypertension. Their age difference (7 years) was greater than in the present population. Their population consisted of patients referred to a urologist; the present subjects were drawn from the general population, and diabetics were excluded. We did not enquire about hypertension nor measure blood pressure. Bleustein *et al.* only sampled two locations, the meatus and the dorsal glans halfway between the meatus and the corona, in circumcised men, with an additional sample in uncircumcised men at the 'dorsal midline foreskin' with the prepuce in its natural position over the glans. In uncircumcised men, there were no significant differences between the measurements taken at the glans with the foreskin retracted and those taken at the level of the glans with the foreskin in its normal position. The positions used in that study correlate to positions 9, 10 and 16 in the present study. In our mixed model, controlling for location of the measurement, age, wearing briefs, being Hispanic, and circumcision status, position 10 had a lower threshold than position 9 (–0.243 g, SEM 0.079, $P < 0.002$). The present data indicated that the location on the uncircumcised penis measured by Bleustein *et al.* had one of the highest thresholds of the locations found only on the uncircumcised penis. We found that the age-adjusted thresholds were significantly lower in location 16 than either 9 or 10 (location 9, –0.75 g, SEM 0.184, $P < 0.001$; location 10, –0.56 g, 0.17, $P < 0.002$).

The studies detailed above share several important flaws: (i) a low response rate to opportunities to complete surveys (it is speculative as to how the half who did not complete these surveys would have responded); (ii) the lack of agreed upon, externally validated instruments to measure erectile function; (iii) small population sizes that limit the study power; (iv) the subjective nature of instruments used; (v) short follow-up times; and (vi) the patients in the studies were not genitally healthy.

The last three items deserve special comment. Self-reporting is notoriously unreliable, and all but one of the reported studies relied on patient testimony rather than objective measurements. Patients are highly susceptible to suggestions or inferences that surgery or treatments used to correct a problem will, in fact, correct that problem. Also, otherwise healthy men who seek circumcision for other than medical reasons are predisposed to reporting a favourable outcome. Furthermore, surveys with subjective measures are dependent on the respondent's state of health. When asked to rate quality of life of various impaired health states, healthy individuals will rate the quality lower than will a person in that particular health state. In these studies, it would be expected that the men rate their genital performance higher when in the genitally impaired condition than if they were not genitally impaired.

The short follow-up might have precluded changes in genital response and sensitivity that take longer to develop. Likewise, the acute changes from surgery and scar remodelling are known to take up to 12 months to resolve [18]. Finally, except for the Turkish study, the men in these studies had penile pathology. Consequently, improvements in this population would be expected regardless of the intervention, due to what is commonly referred to as the 'floor effect' (more room for improvement than deterioration). Consequently, the worsening in so many subjects is remarkable. It could be concluded that circumcision might be an invalid intervention for these medical conditions.

The present subjects, while drawn from the general population, were men who showed the initiative to participate. This might introduce a population and selection bias, but the objective nature of the measure should not have been affected. In the USA, uncircumcised men are demographically different from circumcised men. They tend to be younger and from certain ethnic backgrounds. They might also be from families with either higher or lower parental education levels, depending on the decade of their birth [19,20]. Younger men might have been less willing to participate in the study due to their increased modesty. As there are many more circumcised than uncircumcised men in the USA, recruiting equal numbers of subjects from each group was challenging.

The measurement of fine touch using pressure thresholds might be limited. Fine touch transmitted through Meissner's corpuscles might be dynamic, using a network of nerve endings. For example, the fingertips, which have a high density of Meissner's corpuscles, are able to interpret Braille when moving *over* raised dots, not merely by pressing *on* them. Consequently, a static measurement of pressure threshold can miss much of what the Meissner's corpuscles are capable of transmitting. An instrument that measures the sensitivity to light brushing or that can discriminate surface texture when rubbing might be needed to measure this dynamic sensation.

The differences in age, based on circumcision status, were expected. In their study, Bleustein *et al.* [7] found that uncircumcised men were a mean of 7 years older. Based on the fluctuations of circumcision rates over the past century, we expected genital integrity to be more prominent among older men and

among men in their twenties. Because the confidence, sufficient to volunteer for mapping of genitalia, might not come until the later twenties, this population might have been under-represented in our study.

Additional study with vibratory, hot and cold thresholds on a wider variety of positions on the penis is needed. Furthermore, development of a reliable method of measuring dynamic sensation is needed to identify, elucidate and quantify the sensory capacity of the various nerve endings in all parts of the penis, and to provide a greater understanding of the dynamic sensory interplay between the various parts of the uncircumcised penis during sexual activity. Finally, prospective real-time stopwatch assessments of the IELT at coitus in men, investigated in the laboratory by the Semmes-Weinstein touch test, would provide additional objective information of their sexual and particularly ejaculatory performance. Long-term monitoring of numerous factors of sexual pattern, including sexual pattern films, would provide additional information. Ideally, such investigations could be undertaken on adult subjects before and after elective circumcision, and in whom there is no preoperative pathology.

In conclusion, circumcision removes the most sensitive parts of the penis and decreases the fine-touch pressure sensitivity of glans penis. The most sensitive regions in the uncircumcised penis are those parts ablated by circumcision. When compared to the most sensitive area of the circumcised penis, several locations on the uncircumcised penis (the rim of the preputial orifice, dorsal and ventral, the frenulum near the ridged band, and the frenulum at the muco-cutaneous junction) that are missing from the circumcised penis were significantly more sensitive.

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CONFLICT OF INTEREST

None declared. Source of funding: National Organization of Circumcision Information Resource Centers. The director of National Organization of Circumcision Information Resources Centers (MFM) was involved in the design and conduct of the study; collection and interpretation of the data; and review, or approval of the manuscript.

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Abbreviations: **IELT**, intravaginal ejaculation latency time.