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New device for penile vibrotactile stimulation: description and preliminary results

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Summary. A small, lightweight mini-vibrator for measuring penile sensitivity is described. Data on subjective thresholds to vibrotactile stimulation were collected from sexually functional and dysfunctional men during both flaccid and tumescent penile states. Two sites, the dorsal and ventral surfaces of the glans penis, were stimulated. Results indicated a significant correlation between thresholds obtained with the mini-vibrator and those obtained with another stimulating device. In addition, the patterns of sensitivity in the flaccid and in the tumescent penis were similar to those found in previously studied samples of sexually functional and dysfunctional men. This device has advantages over other vibrators in that it can be attached directly to the penis and does not lose contact with the penile surface during tumescence.

Key words: Penile sensitivity – Vibrotactile – Papaverine – Erectile dysfunction – Vibrator – Erection

Recent investigations suggest that vibrotactile stimulation applied to the penis may be an effective tool for studying potential sexual function and response in men. Specifically, penile vibrotactile stimulation has been used to enhance erectile response during exposure to visual erotica [5], to elicit ejaculation [1, 10] and to relate penile thresholds to various aspects of erectile and gonadal function [2–4, 6]. The use of this measure as a research and diagnostic tool has been limited by the instrumentation currently available for applying the vibrotactile stimulation. Commercial stimulation devices are either handheld (e.g. Biothesiometer, Biomedical Instruments, Newbury, Ohio, USA), thereby preventing controlled application and measurement of sensitivity, or, as is the case with stimulators intended for personal use, lack the means for precise control over stimulus characteristics such as intensity and duration. Even instruments designed specifically for dermal or penile stimulation are limited in their application. Several commercially available devices (e.g. Vibration II, Sensortek, NJ, USA; ViriCare, Polystan Benelux, The Netherlands) allow only for stimulation of the underside of the penis; their weight and lack of mobility during tumescence or erection of the penis may produce pressure variation during testing or result in a loss of contact with the penis.

A new vibrotactile stimulation device is described; a mini-vibrator sufficiently small, lightweight, and versatile to attach directly onto the penis. Stimulation of any surface of the penis is possible, with fairly constant surface pressure and precise control over stimulus duration and intensity. Preliminary data are presented to demonstrate the efficacy of this device for determining penile sensory thresholds in the flaccid and tumescent penis, and these data are compared with thresholds obtained with a more conventional vibrotactile stimulation set-up as previously described [6].

Materials and methods

Subjects

Fifteen men participated. Five of these (controls) were healthy, sexually functional men recruited through word of mouth ($\bar{x}$ age = 47.0 years). The remaining ten (dysfunctional) were patients referred through the urology outpatient clinic of a teaching hospital ($\bar{x}$ age = 46.1 years). All patients reported erectile dysfunction and were unable to achieve or hold an erection sufficient for intercourse. These patients underwent routine differential diagnosis, which included a complete physical examination, neurological examination, Doppler investigation of cavernous arteries, penile brachial index measurement, and papaverine injection. Informed consent, as approved by the University Medical Ethics Committee, was obtained from all subjects.

Apparatus

The major components of this device are the mini-vibrator itself, the control panel (battery- or wall-powered), and the erectiometer, which makes attachment of the vibrator to the penis possible (Fig. 1). Detailed drawings are provided in Figs. 2, 3. The stimulating surface of the vibrator has a vibroactive, circular area of

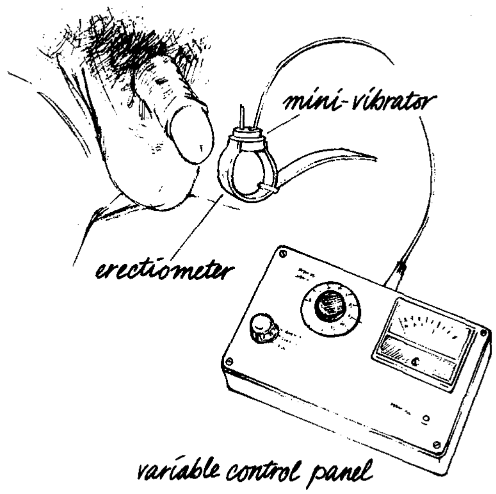

Fig. 1. Components of the mini-vibrator, showing method of attachment to penis

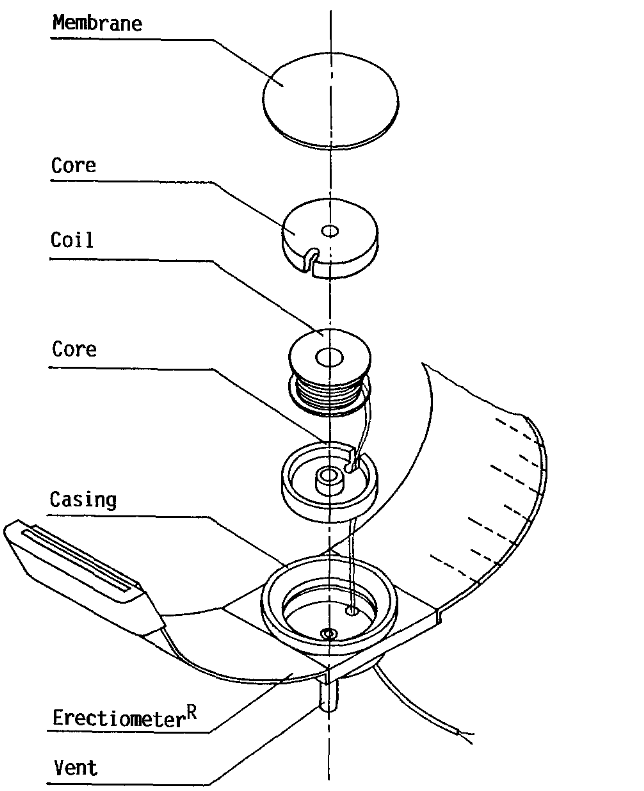

Fig. 2. Exploded view of the mini-vibrator. Components are made of the following materials: membrane, silicone rubber; core, ferroxcube; coil, makrolon polycarbonate spool with 125 windings of copper thread (0.15 mm diameter); casing, celoron; vent, stainless steel (external diameter 2.0 mm; internal diameter 1.6 mm)

approximately 250–315 mm^2, and produces vertical vibration up to 125 µm. Output frequency is 100 Hz. Variable control allows a preset stimulation level from 0.0 µm to the maximum. Attachment of the control panel to a simple timer used for photographic development enables precise control over stimulus duration from 0.1 to 60 s, or stimuli may be presented manually at variable durations.

The mini-vibrator is secured to the penis with a modified erectiometer. The erectiometer (Eska, Walter Koss OHG, Geissenheim, FRG) consists of a 2-cm-wide felt band, 19 cm long, with a sliding collar fastened to one end. The band, calibrated in millimeters, may expand with tumescence, although a force of about 250 g is required for expansion [8].

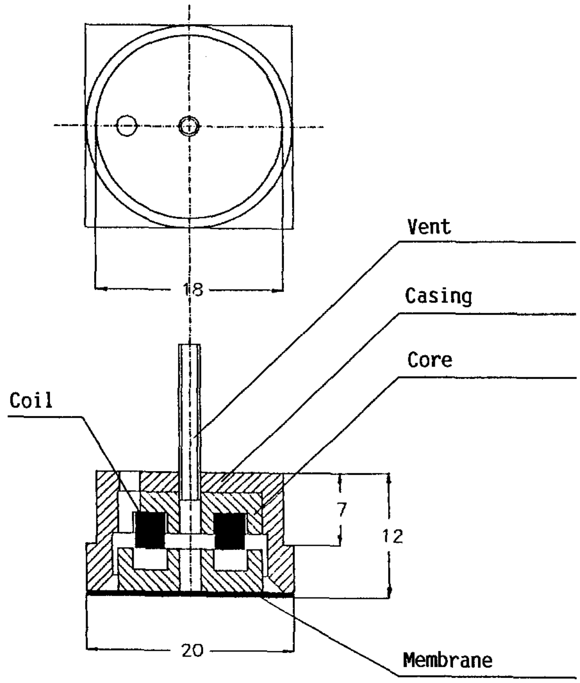

Fig. 3. Cross-sectional view with dimensions (in mm) of the mini-vibrator

Procedure

Subjective threshold to vibrotactile stimulation was determined using the psychophysical method of limits, in which stimuli (duration 1 s) of increasing or decreasing magnitude are presented successively. The mean of at least five threshold crossings was used to establish the threshold. A threshold crossing was defined as a change in response (from detection to non-detection, or vice versa) followed by at least two consecutive similar responses.

Penile thresholds were determined in the flaccid state and during tumescence, induced through a single intracavernosal injection of 40 to 100 mg papaverine sulphate (Centrafarm, Belgium). For all control subjects and for seven dysfunctional subjects who were undergoing a differential diagnosis, a dose of 50 mg was administered. One dysfunctional subject was given a higher dose (80 mg) as part of a differential diagnosis, as there was no response to 50 mg. Two dysfunctional men who self-administered papaverine for intercourse were given the amount regularly injected to achieve erection (40 and 100 mg).

The average increase in penile circumference during tumescence was 14.8 mm, and the average self-reported amount of tumescence was 72.5 mm on a 100-mm analog scale, indicating that full erection was not achieved in all subjects.

After retracting the foreskin of the penis, the experimenter attached the vibrator to the underside of the tip of the flaccid penis such that stimulation was applied to the frenular area of the glans. The erectiometer was sufficiently tight so that the vibrator would not move, but loose enough so there was minimal or no skin indentation. Penile circumference, as indicated by the erectiometer, was noted and the threshold was determined. Upon completion, the vibrator was attached to the dorsal surface of the flaccid penis with stimulation applied to the glans (opposite to the frenular area). The erectiometer was adjusted to approximately the same circumference

Table 1. Penile thresholds (µm: mean ± SEM) in sexually functional and dysfunctional men during flaccidity and tumescence

	n	Flaccid[a]			Tumescent		
		V	D	V+D	V	D	V+D
Control	5	10.2 (2.1)	9.3 (2.5)	9.7[b] (5.1)	15.4 (2.4)	12.5 (2.7)	13.9 (5.4)
Dysfunctional	10	15.8 (1.0)	15.4 (1.3)	15.6[b] (2.9)	31.6 (2.5)	36.7 (3.4)	35.6 (7.7)

V = ventral; D = dorsal

[a] $P < 0.001$ for overall comparison between flaccid and tumescent states

[b] $P < 0.05$ for comparison between flaccid and tumescent states in each group of subjects

as that noted during ventral stimulation, so contact pressure between the penis and the stimulator remained about the same.

After thresholds has been determined in the flaccid penis, the vibrator was removed, papaverine was administered, and the vibrator was reattached in the manner described above after maximum tumescence was achieved.

Results

Data were obtained from four similarly constructed mini-vibrators. The output from each vibrator was calibrated and standardized to microns of vertical movement.

Correlation with data using another vibrator

Of the 15 subjects tested with the new mini-vibrator, 14 had also undergone testing on the ventral surface of the penis with a modified biothesiometer (Biomedical Instruments, Newbury, Ohio, USA). Threshold values from the two vibrators were significantly correlated for both the flaccid (Pearson $r = 0.62$; $P = 0.02$) and the tumescent penis ($r = 0.73$; $P = 0.005$).

Patterns of responding in sexually functional and disfunctional men

A three-way ANOVA was performed on thresholds, with one between-group factor (control vs dysfunctional groups) and two within-subject factors (flaccid vs tumesecent penis; ventral vs dorsal surface). Thresholds were higher (though not significantly) in men with erectile dysfunction than in controls ($P = 0.11$), and thresholds during tumescence were higher than during flaccidity ($P < 0.001$) (Table 1). These findings were similar to those found in a larger sample of subjects using a modified biothesiometer [6]. One difference was that thresholds using the mini-vibrator were higher than those using the biothesiometer (mini-vibrator $\bar{x} = 21.7$ µm versus biothesiometer $\bar{x} = 2.6$ µm).

Several previously unreported findings were obtained with the mini-vibrator. Thresholds on the dorsal surface of the glans penis were not different from those of the ventral surface ($P = 0.99$); and thresholds at these two sites were significantly correlated during the flaccid state ($r = 0.54$; $P = 0.04$) and during tumescence ($r = 0.81$; $P < 0.001$). In addition, dysfunctional subjects showed a higher increase in threshold (from 15.6 to 35.6 µm) from flaccid to tumescente states than control subjects (9.7 to 13.9 µm) ($P = 0.07$). Finally, thresholds on the dorsal surface of the penis followed a pattern similar to those on the ventral surface. That is, there were elevated thresholds during tumescence, and in both penile states dysfunctional men had higher thresholds than controls.

Discussion

These data on penile thresholds using the mini-vibrator were comparable to those obtained from another, commercially available vibrator. The overall correlation between the two vibrators was moderately high ($r = 0.68$) and in our view, more than adequate, given that consecutive testing with the same device (biothesiometer) yields a correlation not much higher ($r = 0.82$) [4]. Furthermore, patterns of sensitivity using the mini-vibrator during flaccid and tumescent states of the penis, and in sexually functional and dysfunctional men, were consistent with those found using the biothesiometer [6], thus verifying the validity of this new measuring device. The difference in absolute thresholds between the two vibrators compared here may be related to the type of vibration produced and to the method of calibrating each of the devices. For example, the mini-vibrator produces only vertical vibration, and therefore is calibrated only for vertical movement. In contrast, the biothesiometer is calibrated for lateral movement [2]. Therefore, the importance of including data from a comparison group of healthy, sexually functional men, in research of this type, should be reiterated. Other factors, including the use of a less precise methodology for determining thresholds with the mini-vibrator (method of ascending/descending limits with the mini-vibrator vs method of random stimuli for the biothesiometer), different frequencies of stimulation (100 vs 120 Hz), and slightly different stimulation loci, may also have contributed to these differences.

The primary advantage of the mini-vibrator lies in its light weight and compact size, which allow finely controlled stimulation to be applied to any surface of the penis (or any other appendage with a circumference of 170mm or less) over extended periods of time. Given that the dorsal and ventral surfaces of the penis are served by different branches of the pudendal nerve [7, 11], this capability may be useful both for research investigation and for the detection of sensory/neural deficits in the genital region.

Although it remains to be demonstrated, the mini-vibrator might also be used to stimulate erection (or ejaculation). Unlike other devices, the mini-vibrator remains in contact with the penis as tumescence occurs, because the device is attached directly onto the penis with the erectiometer. The device may also be attached to the glans penis, frequently the most responsive area of the penis for producing erection (and ejaculation). Finally, because the device is fixed in place during stimulation, there is no need for the experimenter's presence during the procedure, thereby enabling more privacy for the patient or subject. The above capabilities may be especially important in the differential diagnosis of men with erectile difficulties. Simple non-invasive methods that increase the likelihood of erections in these men reduce the probability that they might have to undergo more invasive procedures [9].

Some limitations of the mini-vibrator have also been noted. Firstly, maximal stimulation has been limited to 125 μm. This level is considerably less than that of other vibrators, which may reach 200 μm or more, and therefore the mini-vibrator may not be sufficient to stimulate erection or ejaculation for some men. Some difficulty was also encountered with attachment of the vibrator onto the dorsal glans penis in several of the uncircumcised men. The retracted foreskin tended to push the vibrator off the tip of the penis. Finally, although not a procedural problem in the present investigation, in situations where the vibrator is attached to the penis while in the process of tumescence (e.g. vibrotactile stimulation used to produce erection), the force of the expanding penis against the erectiometer (which requires force of about 250 g before it begins to expand) may dampen the intensity of the stimulation and reduce the effectiveness of the vibrator. Despite the limitations, we have found the mini-vibrator superior to other available stimulators for determining penile sensitivity; it allows sensitivity to be determined on any penile surface, it eliminates cumbersome gadgetry associated with larger systems, and it provides the potential for stimulating erection or ejaculation in patients at a variety of penile locations without the presence of the experimenter or clinician.

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