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The simultaneous and independent measurement of penile circumference and length

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It has been recently shown that in the early stages of erection, the human penis undergoes a substantial length change that is not detected using circumferential measurement devices. The present report introduces a relatively simple device that can assess changes in both length and circumference. The device promises to provide a low-cost alternative to the precision and sensitivity associated with plethysmography.

At present, the physiological assessment of human penile tumescence can be divided into two major and distinct measurement technologies: plethysmographic (Freund, Sedlacek, & Knob, 1965) and circumferential (Bancroft, Jones, & Pullen, 1966; Barlow, Becker, Leitenburg, & Agras, 1970). While there is limited empirical evidence comparing the two methods (see Freund, Langevin, & Barlow, 1974; McConaghy, 1974), most investigators acknowledge the superior precision of the volumetric device (Rosen & Keefe, 1978; Zuckerman, 1971). Penile circumferential responses below 10% full erection are usually ascribed to random variation (Abel, Barlow, Blanchard, & Mavissakalian, 1974; Abel & Blanchard, 1976). However, Earls and Marshall (in press) report that penile responses below 10% are quite meaningful. Specifically, these investigators found that the penis undergoes a substantial length change (mean = 34.5%, range = 16.0%-54.1%, n = 6) before any circumferential increases are evident. In fact, initial length increases are accompanied by a circumferential decrease. These data prompted the construction of a new device to measure both penile circumference and length changes.

DESIGN CONSIDERATIONS

The anatomical construction of the penis poses two major problems to the measurement of length changes during tumescence: the selection of a suitable transducer and the attachment of the transducer to the penile shaft. To illustrate, the transducer reported here is an open mercury-in-rubber strain gauge. The advantages of this choice are that mercury strain gauges are inexpensive, readily accessible, and have well defined operating characteristics (Davidson, Malcolm, Lanthier, Barbaree, & Ho, 1981; Earls & Jackson, 1981; Parks Electronics Laboratories). Logically, one end of a length assessment device should be attached to the penile glans or coronal ridge, with the opposite end secured to the base of the penis. However, the dorsal side of a flaccid penis is generally curvilinear in shape, which, according to pilot studies, introduces two problems for the interpretation of the results. First, the distance between the coronal ridge and the base of a curved, flaccid penis tends to be approximately equal to the distance between the same two points when the penis straightens and attains roughly 50% erection. The resulting polygraphic function of a "length" erection is a sigmoidal curve with two levels of arousal (baseline and 50% tumescence) represented by the same plethysmographic voltage output. Second, due to subject movement or blood flow, a flaccid penis often shifts position during baseline measures. While there are no appreciable diameter or length changes accompanying these shifts, a coronal ridge to penile base measure, along a curvilinear surface, records the movements as dramatic and spurious length changes.

The manner in which the mercury gauge (or any other device) is secured to the penis is also problematic. A flaccid penile shaft is generally short (7-12 cm; Masters & Johnson, 1966), requiring a short length of mercury gauge. However, these strain gauges are limited in the degree to which they can be stretched. Furthermore, the force required to stretch a gauge increases in some direct function with the amount of existing stretch. Therefore, if a gauge is required to double in length, the force required to stretch the gauge the first 50% of the doubling will be much less than the force necessary to stretch the gauge the final 50%. This characteristic of mercury strain gauges means that during an erection a considerable amount of tension is exerted on the penile skin when a short-length gauge is used. The problem is further exacerbated by the fact that flaccid penises that are initially short tend to manifest more of a relative

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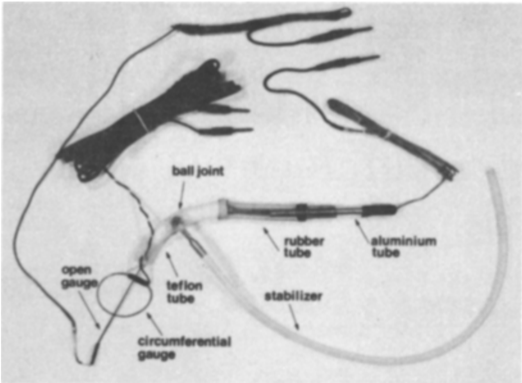

Figure 1. A photograph of a transducer designed to measure penile circumference and length simultaneously and independently.

length change than penises that were initially longer in the flaccid state (Masters & Johnson, 1966).

One way to take advantage of the known operating characteristics of mercury-in-rubber strain gauges and avoid the above problems is to assess length changes at only one point on the penile shaft. That is, one end of the strain gauge can be attached to the penis, close to midshaft, and the opposite end can be anchored at some arbitrary "off-penis" location. The midshaft location avoids the area of penile curvature. In addition, the distance covered by the strain gauge along the penile shaft is reduced; therefore, the measure is less susceptible to penile movement artifacts. Finally, since the strain gauge is secured at an arbitrary "off-penis" location, the size of the strain gauge can be kept constant (one size for all subjects) and long, thus circumventing the stretch limitations of short strain gauges.

With these considerations in mind, two mercury strain gauge types were combined in a relatively simple configuration, shown in Figure 1. As indicated, penile circumference changes are assessed with a digital mercury-in-rubber strain gauge. Penile length changes are monitored with an open mercury-in-rubber strain gauge that resides in a plastic (Teflon), rubber, and aluminum cartridge.

With this device, penile length and circumference are measured by having a subject place the digital gauge at the base of his penis. The length cartridge is turned away from the body and secured to the thigh. The length gauge is pulled out approximately 1.5 cm from the end of the Teflon tube and taped to the midshaft of the penis with 1.0-in. Blendoderm surgical tape. This tape was designed to be used on skin surfaces, has a high degree of elasticity, and does not interfere with erection.

This arrangement of the two gauge types has a number of advantages. The chief advantage is that the device employs mercury-in-rubber strain gauges. Since these gauges have been used extensively over the past 10 or 15 years, most of their operating characteristics have been well defined. In addition, the combination of gauges yields an overall device that is inexpensive, lightweight, and easy to construct and that offers experimenters the ability to measure penile circumference and length independently and simultaneously. The assessment of these two penile dimensions should, in principle, closely approximate or even surpass the precision and sensitivity of true plethysmography. What follows, then, is a brief description of an experiment in which penile responses to erotic stimuli were assessed using the device shown in Figure 1.

METHOD

A total of six subjects were employed. Their penile responses to an erotic stimulus (photographic slide) were monitored using two Parks plethysmographs (Model 270). These devices translated the conductance changes in the mercury gauges to a dc voltage. The voltage was, in turn, translated by two digital voltmeters (reading in units of .001 V) and a Beckman Type R dynagraph. A Sony camera, videotape recorder, and television monitor were focused on the digital voltmeters, which tracked circumferential and length changes. The resulting video recording allowed the data to be accurately recorded for a second-by-second analysis. To facilitate this analysis, the camera was also focused on a real-time counter reading in units of .001 sec and a 6-W lamp that indicated the onset and offset of a stimulus.

RESULTS AND DISCUSSION

The polygraphic data obtained for one subject is presented in Figure 2, and the correlations between circumference and length changes are presented in Table 1 (all subjects). As shown in Figure 2, when the complete length change (Channel 1) is visually compared with the complete circumferential change (Channel 4), it appears that the measurement of length does not add

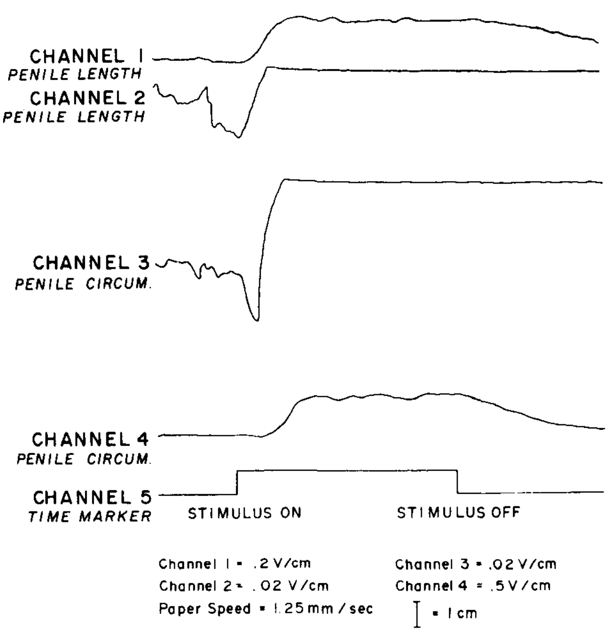

Figure 2. A section of a polygraphic record during the simultaneous measurement of penile length and circumferential changes.

Table 1
Correlations Between Penile Circumference and Length

Subject	1 r	1 df	2 r	2 df	3 r	3 df	Overall r	Overall df
1	−.852†	11	−.092	18	.969*	5	.945*	31
2	−.933*	5	−.471†	7	1.000	0	.997*	18
3	−.907*	11	−.031†	23	.997*	10	.859*	36
4	−.958*	7	−.296†	11	.970†	2	.935*	25
5	−.988*	12	−.729*	16	.980†	2	.892*	31
6	−.985*	8	−.512†	13	.988*	3	.654*	36
$\bar{X}$	−.937		−.355		.981		.880	

Note–*1 = beginning of downward deflection to minimum voltage; 2 = beginning of downward deflection to return to baseline; 3 = minimum voltage to return to baseline.*
$*p < .01$. †Nonsignificant.

a substantial amount of additional information. In fact, the overall correlations between length and circumference were extremely high (mean r = .88). However, a comparison of Channels 2 (length) and 3 (circumference) indicate that when the voltage output arising from changes in these two penile dimensions is magnified, the initial changes in both are not at all congruent (see also a discussion by McConaghy, 1974). The introduction of the stimulus results in a short latency followed by a decrease in penile circumference. The decrease in circumference is accompanied by a rapid monotonic increase in penile length. This pattern of responding was characteristic of all subjects tested.

As mentioned above, the overall correlation between circumference and length is quite high. However, the data of particular interest here are those pertaining to the initial stages of erection (i.e., during the circumferential decrease). It is apparent from an inspection of Table 1 that the early stages of erection are characterized by a strong inverse relationship between the two penile dimensions: During erection, length increases continually; circumference decreases slightly before increasing.

To further illustrate this, the magnitude of penile length changes during the initial stages of erection have been summarized for all subjects in Figure 3. The bar histogram shows the percentage of length change at various intervals during the circumferential decrease and at 10% of the total circumferential change during erection. As indicated, the average circumferential change at minimum voltage is approximately 2.5%. The average penile length at the same point in time is 18.8% of the total length change during erection (SD = 8.6, range = 10.3%-34.9%). By the time penile circumference has reattained its baseline value, length has further increased to 34.5% of the total change (SD = 12.4, range = 25.6%-58.9%). When penile circumference is 10% of its maximal value, length has changed 55.7% (SD = 12.8, range = 36.7%-75.0%).

The most reasonable interpretation of these results is that the early stages of erection are characterized by an initial influx of arterial blood into the penile cavernosa. The blood flow forces the penis longitudinally until the cavernosa become saturated, at which time circumferential expansion begins (cf. McConaghy, 1974). In any case, it is clear that traditional circumferential transducers are limited in that they represent blood flow (and, therefore, erectile changes) only after the cavernosa reach some degree of engorgement. The devices described in the present paper allow researchers to evaluate both length and circumference changes during the whole erectile cycle, thereby more accurately and completely describing this cycle.

It is important to note that the transducer does not offer a convenient alternative to current measurement technology. That it works is indisputable; but the device shown in Figure 1 is cumbersome and demands that subjects arrange the two mercury gauges in such a position that neither interferes with the other. In the experiment reported here, it required 10-30 min for each subject to fit and adjust the gauge to his penis. The transducer can by no means be thought of as a "finished product"; rather, it provides a means to demonstrate that length changes do offer additional information in penile assessments and, more important, that these changes can be measured. It is our hope that researchers will recognize the potential value of penile length changes and direct some efforts to addressing the problems inherent in length measurement.

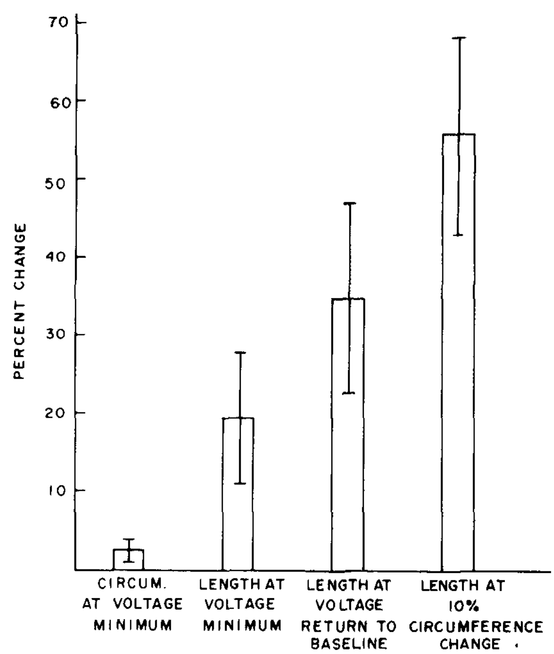

Figure 3. A bar histogram showing the average circumferential and length changes immediately following stimulus introduction and at 10% of full erection (circumference).

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NOTE

1. The precise details pertaining to the construction of this device are available upon request. However, any reasonably equipped workshop should be able to construct a similar transducer with little difficulty.

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