



Outcomes of variation in technique and variation in accuracy of measurement in penile length measurement

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Abstract

Accurate data regarding the size of the erect penis is of great importance to several disciplines working with male patients, but little data exists on the best technique to measure penile length. While some previous small studies have suggested good correlation between stretched penile length, others have shown significant variability. Penile girth has been less well studied, and little data exist on the possible errors induced by differing observers and different techniques. Much of the published data report penile length measured from the penopubic skin junction-to-glans tip (STT) rather than pubic bone-to-tip (BTT). We wished to assess the accuracy of different techniques of penile measurements with multiple observers. Men who achieved full erection using dynamic penile Doppler ultrasound for the diagnosis of sexual dysfunction or a desire for objective penile measurement were included in the study. Exclusion criteria were penile scarring, curvature, or congenital abnormality. In each case, the penis was measured by one of the seven andrology specialists in a private air-conditioned (21 °C) environment. Each patient had three parameters measured: circumference (girth) of the penile

shaft, length from suprapubic skin-to-distal glans (STT), and pubis-to-distal glans (BTT). The three measurements were recorded in the stretched flaccid state, and the same three measurements were then repeated in the fully erect state, following induction of full erection with intracavernosal injection. We analyzed the accuracy of each flaccid measurement using the erect measurements as a reference, for the overall patient population and for each observer. In total, 201 adult men (mean age 49.4 years) were included in this study. Assessing the penis in the stretched and flaccid state gave a mean underestimate of the erect measurement of ~20% (STT length 23.39%, BTT length 19.86%, and circumference 21.38%). In this large, multicenter, multi-observer study of penis size, flaccid measurements were only moderately accurate in predicting erect size. They were also significantly observer dependent. Measuring penile length from pubic bone to tip of glans is more accurate and reliable, the discrepancy being most notable in overweight patients.

Introduction

Concern and insecurity over penis size is ubiquitous among men in numerous cultures across the globe, though many are unaware of what actually represents “normal” size. Indeed, despite a reasonable body of research being carried out over the previous 50 years, the majority of studies have paid little attention to the methodological challenges in penile length assessment [1–3].

The majority of studies examining penile anthropometric data have relied on measurements in the flaccid state. The standard approach involves stretching of the flaccid penis and recording its length from suprapubic skin to the distal glans. This technique is inherently flawed by its use of

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Table 1 Previous studies published in penile size methodology and their errors

First author	Year	Number of participants	Measurement state	Age range	Marked limitations
Ponchietti [5]	2001	3300	Flaccid	17–19	Young population
Kinsey [6]	1948	2770	Both	20–59	Self-reported
Soylemez [7]	2012	2276	Flaccid	18–39	Narrow age range
Mehraban [8]	2007	1500	Flaccid	20–40	Narrow age range
Yilmaz [9]	2011	1132	Flaccid	19–30	Narrow age range
Kamel [10]	2009	1047	Flaccid	–	Flaccid only
Bondil [11]	1992	905	Flaccid	17–91	Flaccid only
Khan [12]	2011	609	Flaccid	16–90	Flaccid only
Ajmani [13]	1985	320	Flaccid	17–23	Young population
Promodu [14]	2007	301	Some erect	18–60	Mixed results
Awwad [15]	2005	271	Some erect	17–83	Mixed results
Sengezer [4]	2002	200	Erect	20–22	Young population
Smith [16]	1998	184	Erect	–	Self-reported
Da Ros [17]	1994	150	Erect	–	Unpublished—abstract only
Choi [18]	2011	144	Flaccid	21–89	Flaccid only
Son [19]	2003	123	Flaccid	19–27	Young population
Schneider [20]	2001	111	Erect	18–19	Young population
Shah [21]	2002	104	Flaccid	17–84	Flaccid only
Wessells [2]	1996	80	Erect	21–82	All patients have “sexual dysfunction”
Mondaini [22]	2002	67	Flaccid	16–55	Flaccid only
Chen [23]	2000	55	Erect	21–78	Unvalidated stretching-measuring device
Spyropolous [24]	2002	52	Flaccid	19–39	Narrow age range

stretching, as different investigators will vary the degree to which they stretch the penis. Some attempts have been made to standardize this aspect of measuring the flaccid penis, including development of an engineering model to approximate the optimal tensile force to be applied [4].

While previous studies have developed nomograms in a variety of areas, all published studies have some problems in methodology, as shown in the Table 1 below.

Most studies have used the length measured from the pubopenile skin junction to the tip of the glans (skin-to-tip, STT), while some have used the pubic bone-to-tip (BTT) of glans [25]. To date, there has not been a study that compared both STT and BTT measurements in the same cohort of patients.

We were concerned by the possible inaccuracy both in measuring penis length between flaccid and erect, and also the potential for observer bias in measuring and advising men.

Patients and methods

In total, 201 adult male patients who presented to a network of urology clinics across the Middle East were analyzed in

this cross-sectional observational study. All men either had erectile dysfunction (ED) or wished either to be advised on the size of the penis and whether they were “normal” or not. Some also actively expressed a desire to seek penile augmentation. Each patient was assessed by one of the seven experienced andrology specialists in a controlled environment: private, air-conditioned consulting rooms at a constant temperature (21 °C, 70 °F). The temperature in the examination rooms (and all the medical center) is automatically controlled with central air condition. Data were collected and recorded in centimeters to the nearest 5 mm. Each patient had three parameters measured: circumference (girth) of the penile shaft, length from suprapubic skin-to-distal glans (STT), and pubis-to-distal glans (BTT). The three measurements were recorded in the stretched flaccid state, and the same three measurements were then repeated in the fully erect state, following induction of full erection with intracavernosal injection (ICI). ICI is done for most of our ED patients as part of optional investigations for ED. Consecutive patients who underwent ICI and met the inclusion criteria were assessed.

Alprostadil 10 mcg was the injection agent utilized. For stretched flaccid length, the penis was extended to

Table 2 Overall results

	Erect skin-tip	Erect bone-tip	Erect girth	Stretched skin-tip	Stretched bone-tip	Flaccid girth
Mean	12.36	14.30	11.61	9.72	11.69	9.35
Std. Deviation	1.990	2.023	1.465	1.639	1.648	1.489
Range	5–17	8–19	8–16	6–15	8–17	5–14

maximum capacity at a 90-degree angle to the body with the patient in the upright standing position. For erect length measurement, a fully rigid erection was required for inclusion. Length was measured with a rigid plastic ruler, while girth was assessed using a disposable paper tape at the base of the penis.

Exclusion criteria were penile scarring, clinical evidence of Peyronie's disease, previous surgery (excluding circumcision—all patients were circumcised) and congenital curvature or hypospadias. Men who did not get a full erection were not included.

Data were collated and subsequently analyzed using the SPSS software package (IBM, SPSS Statistics 20). For each patient, the measurements in the erect state were considered the “real” values, and those in the stretched flaccid state were then compared to the corresponding “real” value, with absolute and percentage error recorded for each. All measurements were then placed into subgroups according to the examining andrologist. Variability in measurements was then assessed.

No extra tests were carried out beyond routine clinical care. Consent was collected from all participants and the study was approved by institutional ethics committee.

Results

The mean age of patients was 49.6 years (range 20–75; SD 12.9).

Overall results are shown in the Table 2.

A significant discrepancy was noted between erect measurements and flaccid state measurements, as seen in Table 3

Assessing the penis in the stretched and flaccid state gave a mean underestimate of the erect measurement of approximately 20% (STT length 23.39%, BTT length 19.86%, and circumference 21.38%).

All penile measurements correlated: STT and BTT lengths ($r = 0.910$, $p < 0.01$). Correlation existed between STT length and age ($r = -0.176$, $p < 0.01$), BTT length and age ($r = -0.100$, $p < 0.01$), and STT length and BMI ($r = -0.283$, $p < 0.01$). The other notable correlation was that between age and BMI—the older the patient, the higher the mean BMI ($r = 0.102$, $p < 0.01$). After controlling for age, correlation remained between STT length and BMI ($r =$

-0.270 , $p < 0.01$); this means effectively the penis “looks” shorter in overweight patients. After controlling for BMI, correlation remained between age and STT length ($r = -0.155$, $p < 0.01$), as well as between age and BTT length ($r = -0.094$, $p < 0.01$).

To assess variation in accuracy of measurement we analyzed variability in stretched and erect state measurements as shown in Table 4

Notable variation in the difference between stretched and erect state measurements is immediately apparent, as is the marked inter-observer variation. Assuming the erect size to be “accurate,” STT length measurements were inaccurate by between 16.44 and 26.82%. BTT length measurements were inaccurate by between 14.23 and 23.23%.

Discussion

Penile length is a concern for some men [26]. Penis size is a symbol of masculinity, and the perception of having a large penis has been linked to higher self-esteem and sexual identity [1, 27, 28]. From a psychological perspective, however, the crucial issue may not be actual penis size, but rather a man's perception of the size of his penis relative to other men's. However, penile length measurement is fraught with methodological challenges such as room temperature, stretched flaccid vs. erect length, pubic bone vs. penopubic skin junction, proximal point to glans tip, or coronal sulcus, and also the number of observers doing the measuring. We have shown here that the pubic BTT of glans measurement (BTT) is more accurate than the use of the penopubic skin junction as the proximal measurement point (STT). We have also shown that BMI is a major factor in limiting the accuracy of the STT measurement; furthermore, our data support the concept that aging reduces the length of the erect penis.

Variation in accuracy of measurement was most marked when comparing STT length. We hypothesized that this measurement generated the widest variation due to two principal factors, the first being the problem of how much axial traction the andrologist should apply. While it is possible to standardize the force, using a technique proposed by Chen et al. [23], this complicated methodology was neglected in our study in the interests of patient comfort. This concern for patient comfort is no doubt one of the

Table 3 Stretched and flaccid vs. erect measurements for the whole patient cohort

	Age	BMI	Erect skin-tip	Erect bone-tip	Erect girth	Stretched skin-tip	Stretched bone-tip	Stretched girth	Skin-tip difference	As %	Bone-tip difference	As %	Girth difference	As %
Mean	49.64	28.77	12.51	14.43	11.74	9.58	11.57	9.23	2.93	23.39	2.87	19.86	2.51	21.38
MRRange	20–75	16–51	7–17	9–19	8–16	5–15	8–17	5–13	2	12–29	1–2	10.5–11.1	3	18.75–37.5

main problems associated with measuring the stretched flaccid penis. The second problem that we associated with the wide interobserver variation in measuring the STT length is that of the somewhat variable proximal end point for measuring at the suprapubic skin. Different andrologists are likely to employ slightly different techniques, such as whether the patient should remain in full expiration for the duration of the measurement, or, indeed, the posture the patient should adopt.

Nonetheless, a significant degree of variation in accuracy of measurement remained when comparing BTT length measurements, even though this parameter in theory negates perhaps the most marked source of error inherent in the STT measurement noted above (i.e., that there is a definitive proximal end point in the bony pubis, as opposed to the somewhat labile end point of the suprapubic skin).

Although there is no standard technique for measuring penile length, numerous researchers measure penile length along the dorsum of the penis beginning from the penopubic skin junction to the tip of the glans (STT) [25]. This measurement has been used to measure the flaccid, stretched flaccid, and erect states. Other authorities advocate for the use of pubic BTT of glans (BTT). A meta-analysis of 17 studies required the use of BTT measurement for inclusion, all used SFL and 3 used both SFL and erect length [3].

Wessells et al. measured flaccid and erect penile dimensions in 80 physically normal men before and after pharmacological erection. They found that the mean flaccid length was 8.8 cm, stretched length was 12.4 cm, and erect length was 12.9 cm. There was no significant difference between both stretched and erect measurements; stretched length most closely correlated with erect length [2]. Promodu et al. had different results when they studied penile dimensions in 93 healthy men: the mean flaccid length was found to be 8.21 cm, mean stretched length was 10.88 cm, and circumference was 9.14 cm. Mean erect length was found to be 13.01 cm and erect circumference 11.46 cm. These results, like ours, show significant variation in penile dimensions between both stretched and erect state [14].

Our data support the Promodu study findings, with larger numbers, and demonstrates the potential for misdiagnosis introduced by observer error. What is interesting is that few “penile augmentation” techniques claim to give lengthening of more than a centimeter or so—such measurements are well within the realm of observer variability for flaccid measurements.

The fact that we have demonstrated that BTT is longer than STT measurements and that STT correlated with BMI is intuitive. While the differences may be intuitive, this paper establishes the magnitude of the difference. The greater the BMI, the thicker the pre-pubic fat pad will be and thus the shorter the STT penile length measurement. However, we believe that we are the first to demonstrate a clear correlation

Table 4 Inter-observer variability in assessing stretched vs. erect size

Andrologist Identifier	Number of patients	Skin–tip difference	As %	Range	SD	Bone–tip difference	As %	Range	SD	Girth difference	As %	Range	SD
1	28	3.29	25.56	1–6	1.06	3.29	22.30	1–6	1.09	2.17	19.20	1–3	0.55
2	27	2.30	19.31	0–5	1.18	2.26	15.97	0–5	1.20	2.67	22.09	1–4	1.00
3	34	3.47	26.82	0–6	1.63	3.47	23.23	0–6	1.63	3.06	26.53	0–6	1.678
4	59	3.27	25.73	1–5	1.09	3.16	21.93	1–5	1.13	2.50	21.50	0–4	0.92
5	17	2.12	16.44	1–4	0.76	2.12	14.23	1–4	0.76	1.71	14.87	0–4	1.02
6	24	2.38	19.93	–4–6	2.69	2.42	17.01	–3–8	2.90	2.79	23.02	–2–7	2.22
7	12	2.50	21.74	–4–6.5	2.30	2.00	15.89	–4–4	2.01	2.00	15.89	–3–5	1.77
Total	201	2.93	23.39	–4–6.5	1.63	2.87	19.86	–4–8	1.66	2.51	21.38	–3–7	1.38

between patient age and erectile BTT penile length. It thus appears that erect length decreases as men age.

Our study could be improved by using the same group of patients and having each patient assessed by each andrologist in turn, thus negating any artifact from using different patients. Unfortunately most men are reluctant to undergo physical examination of their genitalia and dislike ICI induction of erection. Therefore, practical constraints and respect for patient wishes preclude this methodology.

This is a sample of men all of whom are circumcised, and from a culture where objective confirmation of a “normal” penis is often requested prior to marriage (which often happens late in life). It is possible that different results would be obtained in a more heterogeneous or circumcised cohort, although there is no obvious reason to expect this.

Also, we may be criticized for assuming that measurement of the erect penis is the reference value. Ideally a number of specialists would have measured the same erect penises on a number of occasions to determine inter-observer variability when measuring the erect penis, but due to geographic, logistical, and ethical issues this was again not possible. It does, however, seem logical to assume that a fully erect penis, not requiring stretching or support, should be the easiest to measure. It is also the case that most men are concerned with their erect penile dimensions more than flaccid, although a minority does focus on flaccid size, as do nearly all intervention studies so far reported.

The difference in penile circumference between the stretched flaccid state and the erect state may predominantly be due to the actual morphological changes that occur with engorgement, rather than operator error. Our comparison of circumference in this study was more for completeness and should be considered as a separate piece of information generated, rather than a measure to reflect on inter-observer variability.

All our men were given ICIs as part of ED investigations or for counseling about penile size. This is our standard practice in the Middle East for men concerned by penile size or ED unresponsive to oral medication. In other

cultures, video sex stimulation may well be a less-invasive substitute, but there remain countries where the use of erotic images, even for medical reasons, is unacceptable.

Conclusion

This large multicenter, multi-observer study of penile length measurement, demonstrates that flaccid measurements are unreliable and erect measurements are superior. Based on our data, measuring penile length from pubic bone to glans tip is the method of choice. Furthermore, variation in accuracy of measurement (inter-observer variability) is such that a single evaluator is encouraged in such studies.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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