Adult Male’s Penile Size Measurement and Its Affecting Factors

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Abstract

Background: In the general population, it is estimated that 91% of adult males perceive their penile size to be smaller than average. Concern about penile size can affect one’s self-esteem, which then affects its sexual function, satisfaction, as well as physical and mental health. Therefore, accurate penile measurements are needed for clinical and academic purposes.

Reviews: Measurement of penile size can be performed in an erect, stretched, even flaccid condition. However, from various researches, there is no standardization of such a measurement method. Various researches have carried out average penile measurement but many factors can affect these results such as race, genital conditions, systemic diseases, surgical procedures, and aging.

Summary: There is no internationally agreed way of measuring an adult male’s penis and many other factors can make the results of penile measurements vary. Proper measurement and finding out the right average of penile size in adult male with regard to other affecting factors, will be indispensable for both clinical and academic purposes.
1. Introduction

As ancient as the humankind existence, we learned that men have assumed that a symbol of masculinity, sexual satisfaction, and better reproductive abilities is to have a large penile size.\(^1\)\(^,\)\(^2\) Likewise we also learned that the stigma of having small penile size is a shame.\(^3\) In the general population, it is estimated that 91% of adult males perceive their penile size to be smaller than average.\(^4\) This dissatisfaction is also affected by men’s expectations of the larger penile size, which are favored by women.\(^5\) The concern about penile size can affect one’s self-esteem, sexual function and satisfaction, and also physical and mental health.\(^6\),\(^7\) Accurate penile measurements are needed for clinical and academic purposes such as for diagnosing micropenis, genital anatomic malformations, determining situations that require penile enlargement surgery, evaluating the results of medical and surgical interventions, experimental research, education on normal penile measurement, and making condoms that are suitable for the right size.\(^8\),\(^9\)

The aim of writing this literature review article is to find out how to measure penile size, the average measurement of adult male penile from recent researches, and various conditions that can affect adult male’s penis size.

2. Review

Penile Growth

After the first trimester of pregnancy, the production of gonadotropins from the fetal hypothalamic-pituitary axis is required for penile enlargement.\(^9\) Penile growth requires hormones and androgen receptors that function properly.\(^10\) At the end of gestation, the average penile length is 2cm.\(^9\) After the infant was born, penile growth does not require a surge of hormones but is the result of normal growth.\(^9\) Various researches have shown that in pre-puberty, the average penile measurement is 6cm.\(^11\),\(^12\)

Penile growth from puberty to adulthood is affected by activation of the hypothalamic-pituitary-gonadal axis that stimulates testosterone production in the testes.\(^9\),\(^13\) Rapid penile enlargement occurs at the beginning and during the puberty.\(^14\)–\(^16\) From a research in Brazil, we found out that the average penile length at 12 years old is at 8.6 cm, 13 years old is at 10.1 cm, and 14 years old is at 11.5 cm.\(^16\) On another research done by Marshall and Tanner, the penile length measured at the age of 12.5 years is at 12.5-14.5 cm and at the age of 14.5 years, it is measured at 12.5-16.5 cm.\(^16\) On another research conducted by Schonfeld and Beebe and a research in Japan found the average penile length at the age of 14 was 9.8 cm and 8.3 cm respectively.\(^16\) In 2012, Soydan, et al. found the average length of the penis at the age of 13 years is at 10.56 cm, age of 14 years is at 11.26 cm, and age of 15 years is at 11.82 cm.\(^16\)

In the adult male’s penis, androgen receptors are no longer expressed, thus, the reduction in penile size in the event of androgen deficiency after puberty is minimal.\(^17\) It is also not possible to increase the size of the penis by giving testosterone to men.\(^17\)

Measuring The Penile Size

A rigid straight ruler is usually used to measure the length of the penis, especially for erect penile length (EPL) and stretched penile length (SPL).\(^18\)–\(^20\) Study from Omer, et al. found that the most commonly used tool for measuring the penile is using a semi-rigid ruler.\(^21\) The difficulty of following the curvature of the penis has led other researchers to recommend the use of a flexible tape measure that does not stretch to measure the flaccid penile length (FPL) and EPL.\(^19\) Most of the measurements in these literatures are taken at room temperature and in a standing or supine position.\(^18\),\(^19\),\(^22\) Measurement disturbances can occur due to vasoconstriction of the penis due to a surge of adrenaline because of unpleasant examination conditions.\(^19\) Another affecting factors are patient’s anxiety, level of arousal at the time of measurement, and recent ejaculation.\(^21\),\(^22\) Further, to obtain good measurement results, measurements can be made twice or the average of three measurements.\(^19\)

SPL measurement is conducted by measuring the length of the flaccid penis that is maximally stretched, parallel to the floor (forming an angle of 90° with the body), measured on the dorsal part of the penis, from the symphysis pubis to the tip of the penile glans.\(^8\),\(^9\),\(^19\),\(^21\) There are lots of inter-individual variation in penile length when the penis is not stretched.\(^12\) Measurements using the pubo-penile skin junction to the tip of the penile glans (skin-to-tip) are widely used in research, although measurements from the pubic bone to the tip of the glans penis (bone-to-tip) are also
used.\textsuperscript{21,23} Research conducted by Habous, et al. showed that skin-to-tip measurements are less accurate than bone-to-tip measurements because they are affected by body mass index.\textsuperscript{23} The SPL measurement can estimate the penile size when erect (±10%) and can be used if it is not possible to measure the EPL.\textsuperscript{9,19,20} Several studies found a significant difference ranging from 1-3.75 cm until 5-6 cm between SPL and EPL.\textsuperscript{8,24} The bias in SPL results is due to the need for a tension force of 450g to achieve full penile erection length, whereas clinicians usually stretch less than this value.\textsuperscript{19,25} SPL will also be different in young and old men due to differences in biomechanics.\textsuperscript{8}

The rigid phase in penile erection is used to measure EPL.\textsuperscript{19} To obtain maximum erection measurement, personal stimulation can be conducted by the patient (visual or manual) if there is no erectile dysfunction, or by giving a phosphodiesterase type 5 inhibitor, or by giving intra-cavernous injection with prostaglandin E1 or papaverine-phenolamine.\textsuperscript{19,20} A limitation while measuring EPL in research is the difficulty in obtaining and maintaining an appropriate erection.\textsuperscript{26} The dorsal penile skin-to-tip linear distance was used to measure FPL.\textsuperscript{20,27} The pubic adipose pad should be pressed against the bone for bone-to-tip measurements.\textsuperscript{18,21} EPL prediction is not effective while using FPL measurement.\textsuperscript{19,21}

In measuring the penile circumference and diameter of penile glans, a caliper or measuring tape can be used during this process.\textsuperscript{20,28} While most researchers use the center of the corpus penis to measure the circumference of the penis, other researchers have uses the base of the penis as well as the corona.\textsuperscript{20,28} Several other ways to measure the penile volume are using ultrasonography, Doppler ultrasound, radioisotope, three-dimensional photography, calculating the stretching function of the corpus cavernosum, dispensability of the tunica, and intra-cavernous pressure, as well as magnetic resonance imaging.\textsuperscript{19,22} Until now, the measurement of penile size has not had universal parameters and standardization, so it can lead to non-standardized and inaccurate measurements.\textsuperscript{21,27}

2.3 Histopathology assessment

The Johnsen score has widely used for evaluating histological specimen of the testis. Johnsen scores were arranged for quantifying spermatogenesis in seminiferous tubule section. The score is given according to the presence of cell arranged in the order of maturity. Score 10, 9, and 8 are given for the presence of spermatozoa in tubule. Score 7 or 6 for the presence of spermatids with no further mature cells are presence. Scores 5 or 4 describe that spermatocyte are presence with no presence of further mature cells. Score 3 is given when spermatogonium is the only germ cell presence in the tubule. Score 1 is given when Setoli cells is the only cell presence in the tubule. While score 1 describes all cells are absence in the tubule.

Ito et al develop a toll for determining Johnsen scores automatically using artificial intelligence. Promising result with the average precision 99.5% has been reported for the first time in 2021.\textsuperscript{8} More studies are needed for determining the benefit of this artificial intelligence tool.

\textbf{Imaging:}

1. Ultrasound

Ultrasound have been improved significantly in the last few decades. It is well known that Ultrasound (US) B-Mode offers greater accuracy in testicular measurement than orchidometer especially in specific clinical conditions (i.e. hydrocele, inguinal testis, etc), several pathologies in the testis and epididymis. Color Doppler US may assess vascular characteristic in the testis and plexus pampiniformis. While transrectal ultrasonography (TRUS) are useful for assessing obstructive azoospermia.

Ultrasound strain elastography has been developed to asses tissue stiffness as an image. Compression produces strain within the tissue. The strain resulted would be low in stiff tissue while the strain would be high in softer tissue. Based on this principle, the stiffness of tissue can be quantify using the strain value. K{"u}c{"u}kdurmas et al found that strain ratio are significantly different between patients with normal and abnormal semen parameters. They also found that there is a negative correlation between strain value of testicular tissue and sperm concentration in abnormal semen parameters group.\textsuperscript{9}

Moreover, Li et al conducted a study evaluating strain ratio between obstructive and nonobstructive azoospermia patients and revealed that average or low strain was seen more in NOA patients (81.7%) compared to OA patients (16.3%).\textsuperscript{10} Briefly, it can be stated that strain elastography may be more sensitive and objective than palpation for determining testicular consistency.
2. MRI

MR imaging is better than transrectal US for examining male infertility patients. It’s better soft-tissue contrast and multiplanar abilities can portray the detail anatomy of male reproductive tract including seminal vesicles, prostate, and ejaculatory ducts. It is recommended to use MRI in patients with inconclusive TRUS finding.\textsuperscript{11} The minimal magnetic field strength for pelvis imaging is 1.5 T.\textsuperscript{12} Higher field strength facilitates higher signal-to-noise ratio. MRI using 3.0 T may reduce the use of uncomforted endorectal coil for prostate examination.\textsuperscript{13} The strongest magnetic used for MRI is 10.5 T, but no publication the use of this highest magnetic field for male infertility.

Artificial neural network for predicting the presence of spermatozoa in azoospermia cases

The prediction of spermatozoa presence prior testicular biopsy is remain a challenge. The processes is clinician dependent until now. Samli and Dogan developed an artificial neural network for predicting the presence of spermatozoa prior to surgical sperm retrieval in men with nonobstructive azoospermia and compared it to standard logistic regression model. The model which using age, infertility duration, hormonal levels, and testicular volumes had a clinically acceptable sensitivity as they reported significantly higher sensitivity than the logistic regression model (68\% vs 28\%, \( p < 0.0001 \)).\textsuperscript{14}

3. Treatment

3.1 Automatic sperm selection

One potential sperm selection technique that could be used for automated system is sperm electrophoresis. Electrophoresis able to separate spermatozoa based on their surface charge. It has been known that spermatozoa with negative surface charge (NCS) seem to be more mature and having more intact chromatin or lower DNA damage.\textsuperscript{15–17} NCS sperm also give better IVF outcome including fertilization rate, blastocyst rate, implantation rate and clinical pregnancy rate.\textsuperscript{17} Interestingly, it also reported that more female embryos are resulted by this zeta method combine with DGC compared to DGC only.\textsuperscript{15}

There are two methods of sperm electrophoresis: electrophoretic and microelectrophoresis sperm separation. Using both methods, motile, and morphologically normal spermatozoa could be isolated automatically. We have found 4 prospective studies that support the benefits of the zeta method of sperm selection in increasing pregnancy rates and no study has revealed any disadvantages of this method to date. However, a meta-analysis is still needed to further confirm the benefits of this method.\textsuperscript{15,18–20}

Individual sperm should be remained chosen directly by the operator based on morphology and motility assessment for ICSI. Javadi and Mirroshandel developed an artificial intelligence for detection of abnormal sperm morphology that work well for unstained sperm and low-resolution images. Their study reported that their algorithm had achieved F0.5 scores of 84.74\%, 83.86\%, and 94.65\% for detection of abnormality in acrosome, head, and vacuole.\textsuperscript{21}

Image analysis software for highlighting of the most fertile sperm by color automatically has been marketed (see: https://www.radicalindia.com/life-ICSI.php). However, no publication found about the result of the ICSI result between this computerized and manual sperm selection.

3.2 Robotic ICSI

The first paper reported robotic intracytoplasmic sperm injection (ICSI) is published in 2011. The system developed require minimal human involvement (a few mouse clicks).\textsuperscript{22} However, no report about the application of this system for human until now. One of the reasons is the oolemma penetration before sperm injection using image processing algorithms remain unreliable. Electrical resistance increase is reported can be used for confirming oolemma penetration and would become one important step for developing a more reliable robotic ICSI in the
future. More studies are needed for the application of robotic ICSI in the future.

3.3 Automatic sperm cryopreservation

Programmable freezing provides a precisestep of cooling rates through the use of automated programmmable liquid nitrogen freezers. Sperm samples which mixed with cryoprotectants are put into cryovial then arranged on a plate. Samples are frozen using a freezing rate of decreasing the temperature from room temperature to a first temperature set point. Next, the freezing rate is increased until second temperature set point. Once the second temperature set point is achieved, samples will be plunged into liquid nitrogen (-196 °C).

Manual sperm ultra-rapid freezing using cryovial showed significant decrease of motility compared to slow programable freezing. However, no difference in DNA damage in both results. Meanwhile, Kalludi et al showed no significant different in term of motility, viability, and DNA damaged between manual rapid freezing with slow freezing with programable device. It can be concluded that programable device is not superior to manual method if the cooling step is near to similar.

The usefulness of automatic sperm cryopreservation is also limited in conditions when a high number of samples are required to be cryopreserved at the same time. It may be explained why this machine is more commonly used in veterinary field. Furthermore, programmable sperm freezing is not as efficient as it thought because of latent heat released by the sample leading to delays in freezing rates, thus being detrimental for spermatozoa.

4. Conclusion

Several devices have been marketed for replacing/reducing manpower in the medical field including male infertility. Several technology updates can be applied in male infertility field while the others need more studies before their application. Prudent choice based on valid studies is needed in order to give a comprehensive management to patient with male infertility without using useless technology.

Conflict Of Interest

The authors state there is no conflict of interest.

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