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Penile circumference and stretched penile length in prepubertal children: A retrospective, single-center pilot study

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Purpose: To determine references for penile circumference according to age in prepubertal children and whether this measurement can be used as a basic penile parameter along with stretched penile length in prepubertal children.

Materials and Methods: A total of 750 children (mean age, 4.2±3.4 years) aged under 14 years without penile problems were enrolled in this study. Children with penile or testicular abnormalities were excluded. All data were gathered at the outpatient clinic by a single pediatric urologist from July 2017 to April 2020. Penile parameters (baseline and stretched penile length, penile circumference) and testicular volumes were measured by using an elastic ruler and a Prader orchidometer, respectively.

Results: Mean baseline and stretched penile lengths were 3.0±1.0 cm and 4.2±1.0 cm, respectively. The mean penile circumference was 4.2±0.9 cm. The stretched penile length was similar to penile circumference (p=0.425). This similarity was found for each age group except for the 0–1-year-old and 3–4-year-old age groups (p=0.001 and p=0.034, respectively). As children grow into adolescence, stretched penile length increases significantly compared to penile circumference.

Conclusions: Penile circumference increased with age like stretched penile length and testicular volume in prepubertal children. Stretched penile length and penile circumference were found to be similar. This study can be used as a basic reference for penile circumference values in prepubertal children.

Keywords: Child; Nomograms; Penis; Reference values; Testis

INTRODUCTION

Reference values for penile parameters including stretched penile length and penile circumference are clinically very important for the accurate diagnosis and treatment of children with penile problems such as micropenis and concealed penis [1,2]. In 1987 and 2016, studies on stretched penile length and testicular volume were conducted at different institutions in Korea [3,4]. Those studies revealed that stretched penile length shows a gradual increase with age, with a steep increase at around the age of 13 years. Moreover, in the 2016 study, the change in testicular volume was not statistically significant in children aged 0 to 9 years. After the age of 9, testicular volume gradually increased

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with age, with a rapid increase at 12 to 14 years. However, in these studies, only stretched penile length was used as a penile measurement factor.

In the case of adults, stretched penile length and penile circumference have been used as penile parameters to define a normal penis. These parameters can be divided into flaccid and erect state depending on the condition [5]. However, in the case of children, only data on flaccid penile state are available because it is difficult to measure penile parameters during an erection. Moreover, in children, especially younger children, there are some difficulties in measuring stretched penile length in an outpatient clinic because of anxiety about physical examination, physical discomfort, and difficulty with cooperation. By our literature review, there has been little study of the penile circumference as a penile parameter in children.

Thus, the aim of this study was to obtain references for penile circumference according to age in prepubertal children and to determine whether this measurement could be used as a basic penile parameter along with stretched penile length to evaluate penile parameters in prepubertal children.

MATERIALS AND METHODS

1. Study design

We enrolled children aged less than 14 years without penile problems on external genital physical examination among children transferred to Pusan National University Children's Hospital for urological symptoms diagnosed in a primary clinic (Table 1). All parameters were measured at the outpatient clinic by a single pediatric urologist (JM Chung) between July 2017 and April 2020. In this study, children with penile abnormalities (concealed penis, webbed penis, trapped penis, buried penis, micropenis, hypospadias, and chordee) or testicular abnormalities (hypogonadism, bilateral cryptorchidism, and other genetic disorders associated with testicular function) were excluded from the study. Therefore, most children who visited the clinic for a general periodic examination, urinary tract infections, enuresis, or lower urinary tract symptoms were included in the current study. All data were gathered by reviewing the children's medical records retrospectively.

Penile parameters (baseline and stretched penile length, penile circumference) were measured by using a plastic tape measure. Testicular volumes were acquired with a Prader orchidometer (mL) at room temperature. Stretched penile length was measured from the pubo-penile junction (pubic ramus) of the penis to the tip of the glans on the dorsal surface. The prepubic fat pad was pushed to the bone fully stretched but in a still flaccid state with maximal extension of the penis. Penile circumference was measured at the middle of the shaft [5-7]. Baseline penile length was measured as the linear distance along the dorsal side of the penis extending from the pubic skin level to the tip of the glans in the flaccid state. Medical history, results of a physical examination, age, height, and weight were gathered from medical records. Body mass index (BMI) was calculated by using the formula of weight (kg)/[height (m)]^2. Penile parameters (stretched penile length, baseline penile length, and penile circumference) and testicular volume were compared and analyzed according to age.

Table 1. Characteristics of the patients

Characteristic	Value
Age (y)	4.2±3.4
Height (cm)	97.5±27.1
Weight (kg)	17.7±12.4
Body mass index (kg/m^2)	17.9±3.7
Reasons for referral	
Retractile testis	327 (43.6)
Hydrocele	144 (19.2)
LUTD	70 (9.3)
Cryptorchidism	44 (5.9)
UTI	23 (3.1)
Phimosis	16 (2.1)
Hydronephrosis	15 (2.0)
Varicocele	12 (1.6)
VUR	12 (1.6)
Others	87 (11.6)
Total	750 (100.0)

Values are presented as mean±standard deviation or number (%).
LUTD, lower urinary tract dysfunction; UTI, urinary tract infection; VUR, vesico-ureteral reflux.

2. Ethical considerations

The protocol of the present study was reviewed and approved by the Institutional Review Board of Pusan National University Yangsan Hospital (approval number: 05-2020-155). The clinical information of the patients was collected by reviewing the medical records retrospectively.

3. Statistical analysis

Results are presented as mean±standard deviation for quantitative variables and as frequency (percentage) for categorical variables. All statistical analyses were performed by t-test using the statistical software SPSS version 26.0 for Windows (IBM Corp., Armonk, NY, USA). A p-value less than 0.05 was considered statistically significant.

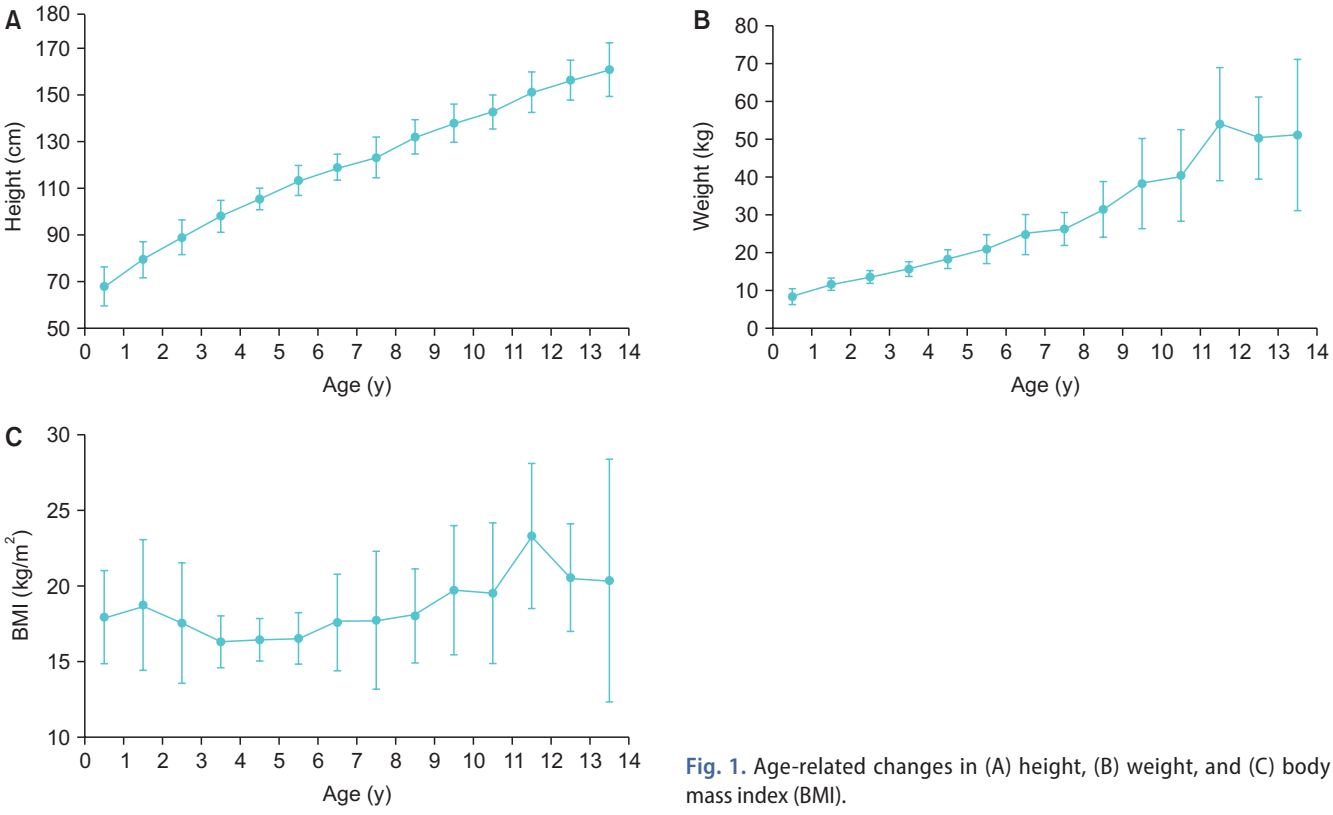

Fig. 1. Age-related changes in (A) height, (B) weight, and (C) body mass index (BMI).

Table 2. Penile parameters and testicular volume of the patients

Parameter	Value	p-value[a]
Baseline penile length (cm)	3.0±1.0	
Stretched penile length (cm)	4.2±1.0	0.425
Penile circumference (cm)	4.2±0.9	
Testicular volume (mL)		0.443
Right	2.5±2.2	
Left	2.5±1.9	

Values are presented as mean±standard deviation.
[a]:t-test.

Table 3. Characteristics of patients in the preschool-aged group versus the school-aged group

Parameter	Preschool-aged group	School-aged group	p-value
Age (y)	0–7	8–14	
No. of patients	633	117	
Height (cm)	88.3±18.7	141.1±15.3	0.001
Weight (kg)	13.5±5.5	40.2±15.3	0.001
Body mass index (kg/m^2)	17.5±3.3	19.6±4.9	0.001
Baseline penile length (cm)	2.8±0.6	4.2±1.9	0.001
Stretched penile length (cm)	4.0±0.6	5.6±1.8	0.001
Penile circumference (cm)	4.0±0.4	5.3±1.5	0.001
Testicular volume (mL)			
Right	2.1±0.4	4.8±4.7	0.001
Left	2.0±0.4	4.6±3.8	0.001

Values are presented as mean±standard deviation.

RESULTS

1. Characteristics of patients

The mean age of a total of 750 patients was 4.2±3.4 years. Mean height, weight, and BMI were 97.5±27.1 cm, 17.7±12.4 kg, and 17.9±3.7 kg/m^2, respectively (Fig. 1). Two common reasons for referral of these patients were retractile testis (n=327) and hydrocele (n=144) (Table 1).

2. Penile and testicular parameters

Mean baseline and stretched penile lengths were 3.0±1.0 cm and 4.2±1.0 cm, respectively. Mean penile circumference of the penis was 4.2±0.9 cm. There was no statistically significant difference between stretched penile length and penile circumference (p=0.425). There was no statistically significant difference between right and left testicular volumes (p=0.443) (Table 2). There were significant differences in penile measurements between the preschool-aged group and the school-aged group (Table 3).

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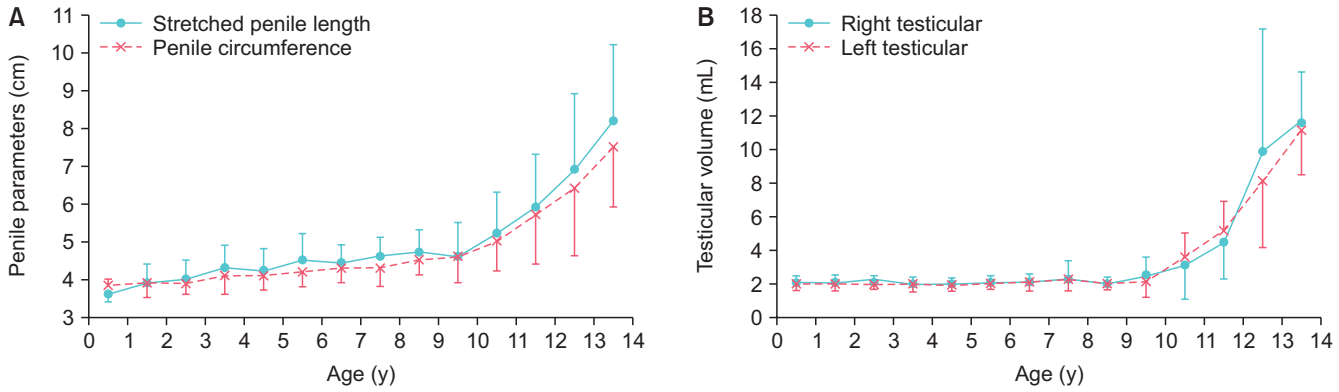

Fig. 2. Age-related changes in penile parameters. (A) Stretched penile length and penile circumference. (B) Testicular volume.

Table 4. Penile parameters according to age group

Age (y)	No. of patients	SPL (cm)	-2SD of SPL (cm)	Penile circumference (cm)	-2SD of penile circumference (cm)	p-value (SPL vs. circumference)
0–1	180	3.6±0.4	2.8	3.8±0.4	3.0	0.001
1–2	137	3.9±0.5	2.9	3.9±0.4	3.1	0.803
2–3	83	4.0±0.5	3.0	3.9±0.3	3.3	0.196
3–4	74	4.3±0.6*	3.1	4.1±0.5	3.1	0.034
4–5	71	4.2±0.6	3.0	4.1±0.4	3.3	0.271
5–6	43	4.5±0.7	3.1	4.2±0.4	3.4	0.068
6–7	45	4.4±0.5	3.4	4.3±0.4	3.5	0.367
7–8	20	4.6±0.5	3.6	4.3±0.5	3.3	0.091
8–9	22	4.7±0.6	3.5	4.5±0.4	3.7	0.573
9–10	15	4.6±0.9	2.8	4.6±0.7	3.2	0.713
10–11	16	5.2±1.1	3.0	5.0±0.8	3.4	0.669
11–12	14	5.9±1.4	3.1	5.7±1.3	3.1	0.769
12–13	16	6.9±2.0	2.9	6.4±1.8*	2.8	0.539
13–14	14	8.2±2.0	4.2	7.5±1.6	3.3	0.352

Values are presented as mean±standard deviation.
SD, standard deviation; SPL, stretched penile length.
*p<0.05 (compared with previous age group).

3. Natural course of penile and testicular parameters

Height and weight increased continuously as a lineal curve with age (Fig. 1). On the other hand, stretched penile length, penile circumference, and testicular volume increased as an exponential curve with age. Penile circumference increased with age in the same manner as stretched penile length and testicular volume in prepubertal children (Fig. 2). Table 4 and 5 show penile parameters and testicular volume according to age group. Stretched penile length and penile circumference were similar for each age group except for the 0–1-year-old and 3–4-year-old age groups (p=0.001 and p=0.034, respectively). However, stretched penile length was longer than penile circumference after the age of 10 (p>0.05).

DISCUSSION

As a means of diagnosing penile problems simply, stretched penile length is usually used as a penile parameter. In fact, the penis is cylindrical. When defining the volume of a cylindrical structure, not only the height but also the circumference is an important factor. Therefore, penile circumference is also an important parameter of penile size in terms of volume. However, to the best of our knowledge, few studies have been done on the correlation between stretched penile length and penile circumference in children. Such penile parameters are mainly studied in adults. Therefore, this study is meaningful in that it is the first in Korea on the correlation between stretched penile length and penile circumference in prepubertal children, although it was a retrospective single-center pilot study.

Table 5. Testicular volume according to age group

Age (y)	No. of patients	Left testicular volume (mL)	Right testicular volume (mL)	p-value (right vs. left testis volumes)
0–1	180	2.0±0.4	2.1±0.4	0.716
1–2	137	2.0±0.4	2.1±0.4	0.526
2–3	83	2.0±0.3	2.1±0.4	0.830
3–4	74	2.0±0.5	2.0±0.4	0.850
4–5	71	2.0±0.4	2.0±0.4	0.606
5–6	43	2.0±0.3	2.1±0.4	0.820
6–7	45	2.1±0.5	2.1±0.5	0.996
7–8	20	2.2±0.6	2.3±1.1	0.805
8–9	22	2.0±0.3	2.0±0.4	0.496
9–10	15	2.2±1.0	2.5±1.1	0.550
10–11	16	3.6±2.5	3.1±1.9	0.636
11–12	14	5.1±2.8	4.5±2.4	0.591
12–13	16	8.1±3.9*	9.9±7.3*	0.733
13–14	14	11.2±2.7*	11.6±3.0*	0.577

Values are presented as mean±standard deviation.
*p<0.05 (compared with previous age group).

Accurate measurement of penile size is important when children have problems with genital development such as micropenis and concealed penis. Micropenis is defined as below 2.5 standard deviations of mean stretched penile length [8,9]. In contrast, concealed penis refers to an "inconspicuous penis" with normal penile length [10]. Thus, stretched penile length is important to distinguish between micropenis and concealed penis, and accurate references for age-related stretched penile length are needed. However, sometimes it may not be enough to distinguish these problems by stretched penile length alone. Therefore, the penile circumference could provide additional information to these traditional definitions.

More studies on penile size measurement have been done in adults than in children. For example, Veale et al. [5] created nomograms of measurements of male penis size in a meta-analysis of research data from 20 studies for males over 17 years old. In these data, penile length was measured as the length from the root of the penis to the tip of the glans while the prepubic fat pad was completely pressed to the pubic bone, and penile circumference was measured around the midshaft or base of the penis. Veale et al. [5] reported that in males after adolescence, there is a correlation (odds ratio, 1.01) between penile length and penile circumference. However, between stretched penile length and penile circumference, the odds ratio was 0.70. In other words, stretched penile length grows faster than penile circumference in adults. Moreover, there was a significant correlation between penile length and height.

Ponchietti et al. [7] aimed to determine normal variations in the size of male external genitalia with 3,300 males aged 17 to 19 years. In that study, penile length and penile circumference were measured by using a tape measure. Penile length was measured as the length of the dorsal side from the tip of the glans to the pubopenile skin junction in the flaccid state, and penile circumference was measured as the circumference of the midshaft of the penis. They reported that in young males aged 17 to 19 years, penile length was correlated with height and weight. However, penile circumference was only correlated with height.

There have been several studies on penile size in children [11-17]. In neonates, Soheilipour et al. [11] determined values for stretched penile length and the cutoff value for micropenis in a study of 587 Iranian neonates born between 28 and 42 weeks of gestational age. Penile parameters were measured by using a digital caliper. Both stretched penile length and penile circumference were correlated with gestational age and body weight. However, this study did not include a detailed description of how to measure penile circumference. Moreover, the upper and lower limits of their measurement of penile circumference were described as 10.46 mm and 2.78 mm in infants. Those values are too small to believe that they were the result of a usual measurement method of penile circumference. In addition, since their study was conducted only in neonates, further study about penile parameters should be extended to children of all ages.

Two studies about the stretched penile length of children were published in Korea in 2016 and 1987. These studies reported some differences in age-related stretched penile length. The data for stretched penile length in the 2016

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study [4] were longer than in the previous study [3]. These differences were statistically significant in the age groups of 0–1, 1–2, 7–8, and 13–14 years [3,4]. In this study, stretched penile length increased as an exponential curve with age, as in these previous Korean studies. Moreover, we found that penile circumference also increased with age in the same manner as stretched penile length and testicular volume in prepubertal children.

Park et al. [4] suggested that the reasons for the above difference were the different numbers of patients between the two studies, the different residential areas of patients, and the occurrence of bias due to multiple researchers. There might also have been differences in the parameter values used for different studies as a result of different methods being used to measure the parameter and different measurement environments. For example, a penile parameter can be measured with a caliper, an elastic ruler, or a syringe. Testicular volume can be measured by an orchidometer or by ultrasonography or can be calculated by direct measurement with a caliper or an elastic ruler. In addition, the temperature of the room at the time of measurement, the patient's condition, erection before measurement, and the patient's posture during measurement can cause bias [5,6].

Thus, to obtain accurate results, measurements and comparisons should be made under the same weight and height conditions for each age group. In reality, however, it is difficult to obtain such data.

Measuring the stretched penile length can be subjective. However, it is one of the most reliable values for comparing penile sizes [4,18-21]. If there is difficulty in measuring stretched penile length in children because of low compliance, it may be difficult to accurately evaluate the penile size. In this case, using a penile circumference that is statistically similar to the stretched penile length can reduce bias in the measurement process.

As mentioned earlier, reference values for age-related stretched penile length are important for discriminating penile problems. However, it is often difficult to measure the exact value of stretched penile length in uncooperative children. Therefore, when it is difficult to measure the stretched penile length, we tried to find a substitutional penile parameter that could be easily measured. We found that penile circumference could be easily measured. Our data also showed that the growth in stretched penile length and that of penile circumference were similar. Therefore, penile circumference can also be used as an important parameter for determining the size of the penis. Our results suggest that the penile circumference as a basic penile parameter can be used as a substitute for stretched penile length in prepubertal children. This study can be used as a basic reference on penile circumference in prepubertal children.

Limitations

This study had several limitations. First, the age distribution of the patients was not even. It varied, with infants making up the highest proportion. Second, this study was a retrospective cohort study conducted in a single institution. Third, this study did not include unreferred, healthy children. Although penile diseases were thoroughly excluded, study results obtained from patients with diseases may not be applicable to all healthy children. However, since the correlation between the diagnoses of our patients (hydrocele, retractile testis, urinary tract infection, and lower urinary tract symptoms, so on) and the penis has not been proven, this study was conducted on children with these genitourinary system abnormalities without penile diseases.

CONCLUSIONS

Penile circumference increased with age in the same manner as stretched penile length and testicular volume in prepubertal children. Stretched penile length and penile circumference were found to be similar. This study can be used as a basic reference on penile circumference in prepubertal children.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

AUTHORS' CONTRIBUTIONS

Research conception and design: Jae Min Chung. Data acquisition: Jae Min Chung. Statistical analysis: Si Kyun Park and Kobiljon Ergashev. Data analysis and interpretation: Si Kyun Park and Kobiljon Ergashev. Drafting of the manuscript: Si Kyun Park. Critical revision of the manuscript: Jae Min Chung. Obtaining funding: Jae Min Chung. Supervision: Sang Don Lee. Approval of the final manuscript: Jae Min Chung and Sang Don Lee.

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