Penile length, digit length, and anogenital distance according to birth weight in newborn male infants

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Purpose: Anogential distance (AGD) and the 2:4 digit length ratio appear to provide a reliable guide to fetal androgen exposure. We intended to investigate the current status of penile size and the relationship between penile length and AGD or digit length according to birth weight in Korean newborn infants.

Materials and Methods: Between May 2013 and February 2014, among a total of 78 newborn male infants, 55 infants were prospectively included in this study. Newborn male infants with a gestational age of 38 to 42 weeks and birth weight>2.5 kg were assigned to the NW group (n=24) and those with a gestational age<38 weeks and birth weight<2.5 kg were assigned to the LW group (n=31). Penile size and other variables were compared between the two groups.

Results: Stretched penile length of the NW group was 3.3±0.2 cm, which did not differ significantly from that reported in 1987. All parameters including height, weight, penile length, testicular size, AGD, and digit length were significantly lower in the LW group than in the NW group. However, there were no significant differences in AGD ratio or 2:4 digit length ratio between the two groups.

Conclusions: The penile length of newborn infants has not changed over the last quarter century in Korea. With normal penile appearance, the AGD ratio and 2:4 digit length ratio are consistent irrespective of birth weight, whereas AGD, digit length, and penile length are significantly smaller in newborns with low birth weight.

Keywords: Anthropometry; Newborn infants; Penis
Penile and digit length and anogenital distance

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Penile and digit length and anogenital distance to the fourth finger length (2:4 digit ratio) in adult men reflects fetal androgen exposure [7]. Studies on penile length in newborns have been very rarely conducted, especially in Korea. In 1987, a study on penile length and testicular size was conducted with 1,071 Korean children including 49 newborn infants [8]. In newborns, the mean and standard deviation (SD) of stretched penile length (SPL) was 3.3±0.5 cm. Early diagnosis of abnormalities in penile size is important both medically and psychologically [9]. The exact penile size is a most important factor in diagnosing penile problems such as micropenis, which is defined as an SPL<2.5 SDs below the mean for age with normal function and structure [10].

Until now, no reports have addressed penile length according to birth weight and its relationship with birth weight and AGD or digit length in newborn infants. This study was preliminarily performed to update the normal SPL values that can be used for Korean newborns. We also intended to investigate the current status of penile length and the relationship of penile length with AGD or digit length according to birth weight in Korean newborn infants.

MATERIALS AND METHODS

1. Patient characteristics

This cross-sectional study was performed in the neonatal unit of our institution between May and January 2014. Of a total of 78 newborn male infants, 55 infants were prospectively enrolled in this study. Exclusion criteria were penile diseases, including hypospadias, concealed penis, cryptorchidism, and varicocele, and other growth problems such as chronic renal failure and endocrinologic disorders [11]. Therefore, most newborn infants who were considered to be normal and healthy except for their birth weights were included in the current study. The infants were divided into two groups. The normal weight group included newborns with a gestational age of 38 to 42 weeks and birth weight≥2.5 kg (NW, n=24). The low birth weight group included newborns with gestational age<38 weeks and birth weight<2.5 kg (LW, n=31).

2. SPL and variables

The penile length was measured as the SPL. The length was measured twice for each infant and the mean of the two measurements was recorded. The SPL was measured with a ruler by compressing the fat tissue with one end of the ruler through the pubic ramus; then the penis was fully stretched and the distance to the glans of the stretched penis was plotted [11]. None of the 55 infants had been circumcised. Foreskins of the uncircumcised infants were not involved in the measurement. Testicular size was measured by using Prader orchidometry (mL). Genital distances were measured with the male infant in a supine and frog-leg position [12]. AGD1 was the distance from the anterior aspect of the penis to the anal verge (Fig. 1A). AGD2 was the distance from the posterior aspect of the penis to the anal verge. AGD3 was the distance from the posterior aspect of the scrotum to the anal verge as measured by use of a caliper [13]. Digit lengths were measured by using a ruler on the left hand. Digit lengths were measured twice for each infant and the mean of the two measurements was recorded. The measurement was taken from the basal crease to the tip on the ventral surface of the hand at a point midway across a line perpendicular to the base by using rulers (Fig. 1B).
For all infants, age, SPL, height, body weight, testicular size, digit lengths of the second and fourth fingers and the ratio between them, and AGDs and their ratios were measured. Penile size and other variables were also compared between the two groups.

3. Interobserver variability
SPL was measured in 55 infants by two observers (an urologist and a pediatric doctor) to estimate interobserver difference. Differences in the measurements of penile length were evaluated by using paired t-tests for the LW group and Wilcoxon’s signed rank test for the NW group.

4. Statistical analysis and ethics statement
Data analysis was performed by using the software package SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were expressed as the mean±SD. Differences in SPL, height, body weight, and testicular size between the study in 1987 and the current study were evaluated by Student t-test. Variables in the NW and LW groups were compared by Mann-Whitney U test. A p-value of <0.05 was accepted to be statistically significant.

This study was approved by the Institutional Review Board of Ulsan University Hospital (IRB No. 2013028). Clinical data were prospectively collected and the medical records of all the participants were reviewed.

RESULTS
1. SPL compared with the previous study (1987)
The SPL of the NW group (n=24, >2.5 kg) was 3.3±0.2 cm. Compared with the previous study results reported in 1987, there was no significant change in the SPL (p=0.445). Among the anthropometric measurements of Korean children, there was a significant decrease in height (49.8±1.9 cm), whereas there were no significant changes in body weight (3.2±0.5 kg) or testicular size (1.1±0.4 mL) (Table 1).

Table 1. Changes in stretched penile length and anthropometric data compared with a previous study conducted in 1987

| Variable     | Present data (n=24) | 1987 Data (n=49) | p-value |
|--------------|---------------------|-----------------|---------|
| Penile size (cm) | 3.3±0.2             | 3.3±0.5         | 0.445   |
| Testis size (mL) | 1.1±0.4             | 1.2±0.2         | 0.248   |
| Height (cm)    | 49.8±1.9            | 52.5±2.5        | <0.001  |
| Weight (kg)    | 3.2±0.5             | 3.3±0.4         | 0.393   |

Values are presented as mean±standard deviation. Modified from Chung KH, et al. Korean J Urol 1987;28:255-8 [8].

Table 2. Differences in penile length, digit lengths, anogenital distances, and anthropometric data according to birth weight

| Variable     | Normal birth weight group (n=24) | Low birth weight group (n=31) | p-value |
|--------------|---------------------------------|------------------------------|---------|
| Penile size (cm) | 3.3±0.2                          | 2.9±0.4                      | <0.001  |
| Testis size (mL) | 1.1±0.4                          | 0.8±0.4                      | <0.001  |
| Height (cm)    | 49.8±1.9                         | 44.1±2.9                     | <0.001  |
| Weight (kg)    | 3.2±0.5                          | 2.1±0.4                      | 0.006   |
| SPL/height (×10^-2) | 6.9±0.5                         | 6.3±0.4                      | <0.001  |
| Digit 2 (cm)   | 2.6±0.2                          | 2.2±0.2                      | <0.001  |
| Digit 4 (cm)   | 2.8±0.3                          | 2.4±0.2                      | <0.001  |
| Digit 2/4 ratio | 0.92±0.03                        | 0.93±0.05                    | 0.419   |
| AGD 1*(cm)     | 4.2±0.3                          | 3.6±0.4                      | <0.001  |
| AGD 2*(cm)     | 3.5±0.3                          | 3.1±0.3                      | <0.001  |
| AGD 3*(cm)     | 2.3±0.2                          | 2.0±0.2                      | <0.001  |
| AGD 3/height (×10^-2) | 4.8±0.5                       | 4.6±0.4                      | 0.056   |
| AGD 1–3 (cm)   | 1.8±0.3                          | 1.6±0.3                      | <0.001  |
| AGD 1–2 (cm)   | 0.6±0.1                          | 0.5±0.1                      | 0.003   |
| AGD (1–2)/(1–3) ratio | 0.35±0.05                   | 0.34±0.05                    | 0.478   |

Values are presented as mean±standard deviation.
SPL, stretched penile length; AGD, anogenital distance.
*AGD1 was the distance measured from the anterior aspect of the penis to the anal verge.
*AGD2 was the distance measured from the posterior aspect of the penis to the anal verge.
*AGD3 was the distance measured from the posterior aspect of the scrotum to the anal verge.
2. Penile length, digit length, and AGD according to birth weight

The SPLs of the NW and LW groups were 33±0.2 cm and 29±0.4 cm, respectively (p<0.001). All parameters including height, weight, penile length, testicular size, AGD1–3, and the length of the second and fourth fingers were significantly lower in the LW group than in the NW group. However, there were no significant differences in the AGD ratio or in the 24 digit length ratio between the two groups (Table 2).

3. Interobserver variability in penile length

In the NW group, there was no significant difference in SPL between two observers (33±0.2 cm and 32±0.3 cm, p=0.165); however, there was a significant difference between two observers in the LW group (29±0.4 cm and 27±0.4 cm, p=0.001).

DISCUSSION

The penile length in children has increased significantly [11]; however, the penile length of newborn infants has not changed over the last quarter century. Biological and environmental changes and changes in feeding patterns during the rapid economic growth since 1987 may have affected the growth and development of the human body. The height and weight of Korean children have increased significantly compared with 1987 [11]. However, according to the current study results, there has been no significant change in the birth weight of newborn infants, whereas there has been a reduction in their heights compared with 1987. It may be that Korean mothers today intentionally keep fetal weight under control for a safe and problem-free delivery. The exact causes of the decreased height for infants are unknown and must be evaluated in the future. There is no apparent relationship between gestational age and penile length at 37 to 42 weeks [14]. Therefore, we compared the current data with similar data reported in 1987 for a gestational age of 38 to 42 weeks and birth weight ≥ 2.5 kg. Although the two studies were conducted in geographically different places, one in Ulsan and the other in Seoul in Korea (1987), and penile length was measured by different individuals, both studies were conducted with Korean populations and penile length was measured by the SPL technique.

In humans, AGD differs by sex; boys have a longer AGD than do girls [15]. Additionally, numerous studies have shown sex differences in the 24 digit length ratio, and males have a lower 24 digit length ratio than do females [16]. Longer male AGD may be determined by an androgen effect during the presumptive masculinization programming window before 11 to 13 weeks of gestation as in rodents [1]. No formal studies have yet reported AGD in patients with complete androgen insensitivity, which would provide definitive proof that fetal androgens determine the longer AGD in human males [13]. However, a study conducted with Caucasian infants reported a significant reduction in AGD in boys with hypospadias (42 control and 77 infants with hypospadias, p=0.002) [17]. In another study conducted with 116 adults, a significant positive correlation between AGD and testosterone levels was demonstrated [6].

Some problems with AGD measurement need to be resolved. AGD3 is the distance from the posterior aspect of the scrotum to the anal verge. AGD3 is also called the anocrotal distance and appears to be the most reliable and repeatable measurement [15,18]. In the current study, AGD1, 2, and 3 were measured as the reference to utilize basic epidemiologic data [13].

There is also some conflict as to which hand presents the most sexually different 24 digit length ratio. At birth, sex difference in the 24 digit length ratio is significant only for the left hand [19]. In the current study, we measured digit length for the second and fourth fingers on the left hand. The largest study to date, which included 360 young men from a normal population, found no relationship of 24 digit length ratio with testis or semen parameters [20]. Other studies showed significant negative associations between 24 digit length in men and reproductive success; in those studies, the 24 digit length ratio was higher in infertile men than in fertile men [21,22]. There are no reports on the relationship between the 24 digit length ratio and the occurrence of cryptorchidism or hypospadias.

Until now, there has been no report regarding the relationship between birth weight and AGD or digit length in newborn infants. We thus intended to investigate these variables. In the current study, all parameters including height, weight, penile length, testicular size, AGD1–3, and the length of the second and fourth fingers were significantly lower in the LW group than in the NW group. The difference may have been caused by a difference in total body size. In the current study, we excluded newborn infants with hypospadias, concealed penis, cryptorchidism, varicocele, and other growth problems such as chronic renal failure or endocrinologic disorders. We thus assumed that the testosterone exposure of the subjects in this study was at a normal level. The current study results suggested that birth weight is not associated with the AGD ratio or with the 24 digit length ratio. In terms of interobserver variability, there was no difference in newborn males with normal
birth weight between the raters. However, interobserver variability cannot be completely excluded in the LW group. It is possible that there may have been a difference according to the time of measurement of penile length of newborn males [14]. The penile length measured within 12 hours after birth was 0.31 cm shorter than that remeasured at 1 to 7 days of age in 63 infants.

CONCLUSIONS

The penile length in children has increased significantly, whereas that in newborn infants has not changed over the last quarter century in Korea. With a normal penile appearance, the AGD ratio and the 24 digit length ratio are consistent irrespective of birth weight, whereas the AGD, digit length, and penile length are significantly smaller in newborns with low birth weight. It is possible that the difference in penile length may have resulted from interobserver variability.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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