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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

INTRODUCTION

Deficient androgen exposure during fetal masculinization results in smaller sized testes, prostate, seminal vesicles, and penis in adulthood and is associated with an increased risk of hypospadias and lower testosterone levels [1-4]. It is well established that normal penile development is dependent on testosterone, its conversion via steroid 5-alpha-reductase to dihydrotestosterone, and a functional androgen receptor [5]. Penile length increases slowly until 4 years of age, after which follows a steady phase and then a rapid increase with puberty. Androgen deficiency is also known to be associated with a reduction in anogenital distance (AGD) in adults [6], and it is postulated that the ratio of the second

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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).

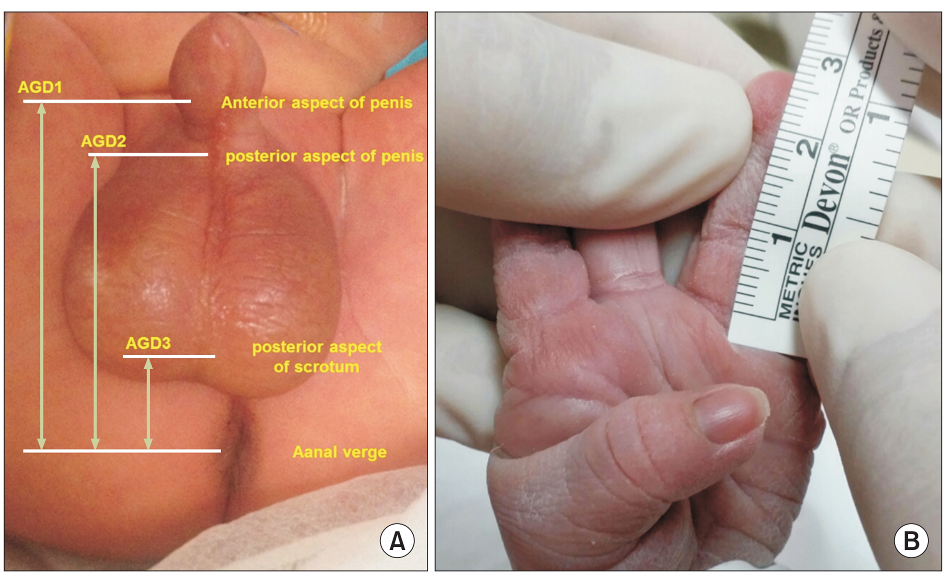

Fig. 1. Measurement of anogenital distance (AGD) and 2:4 digit lengths. (A) AGD has been measured in three ways (AGD1, AGD2, AGD3), AGD3 appears to be the most reliable and repeatable measurement. (B) Digit lengths is measured form the basal crease to the tip on the ventral surface of the hand at the point midway across a line perpendicular to the base using rulers.

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 ($\times 10^{-2}$)	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[a] (cm)	4.2±0.3	3.6±0.4	<0.001
AGD 2[b] (cm)	3.5±0.3	3.1±0.3	<0.001
AGD 3[c] (cm)	2.3±0.2	2.0±0.2	<0.001
AGD 3/height ($\times 10^{-2}$)	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.
[a]:AGD1 was the distance measured from the anterior aspect of the penis to the anal verge. [b]:AGD2 was the distance measured from the posterior aspect of the penis to the anal verge. [c]:AGD3 was the distance measured from the posterior aspect of the scrotum to the anal verge.

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2. Penile length, digit length, and AGD according to birth weight

The SPLs of the NW and LW groups were 3.3±0.2 cm and 2.9±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 2:4 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 (3.3±0.2 cm and 3.2±0.3 cm, $p=0.165$); however, there was a significant difference between two observers in the LW group (2.9±0.4 cm and 2.7±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 2:4 digit length ratio, and males have a lower 2:4 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 anoscrotal 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 2:4 digit length ratio. At birth, sex difference in the 2:4 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 2:4 digit length ratio with testis or semen parameters [20]. Other studies showed significant negative associations between 2:4 digit length in men and reproductive success; in those studies, the 2:4 digit length ratio was higher in infertile men than in fertile men [21,22]. There are no reports on the relationship between the 2:4 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 2:4 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 2:4 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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REFERENCES

1. Welsh M, Saunders PT, Fisken M, Scott HM, Hutchison GR, Smith LB, et al. Identification in rats of a programming window for reproductive tract masculinization, disruption of which leads to hypospadias and cryptorchidism. J Clin Invest 2008;118:1479-90.
2. Macleod DJ, Sharpe RM, Welsh M, Fisken M, Scott HM, Hutchison GR, et al. Androgen action in the masculinization programming window and development of male reproductive organs. Int J Androl 2010;33:279-87.
3. van den Driesche S, Scott HM, MacLeod DJ, Fisken M, Walker M, Sharpe RM. Relative importance of prenatal and postnatal androgen action in determining growth of the penis and anogenital distance in the rat before, during and after puberty. Int J Androl 2011;34(6 Pt 2):e578-86.
4. Drake AJ, van den Driesche S, Scott HM, Hutchison GR, Seckl JR, Sharpe RM. Glucocorticoids amplify dibutyl phthalate-induced disruption of testosterone production and male reproductive development. Endocrinology 2009;150:5055-64.
5. Kim KS, Liu W, Cunha GR, Russell DW, Huang H, Shapiro E, et al. Expression of the androgen receptor and 5 alpha-reductase type 2 in the developing human fetal penis and urethra. Cell Tissue Res 2002;307:145-53.
6. Eisenberg ML, Jensen TK, Walters RC, Skakkebaek NE, Lipshultz LI. The relationship between anogenital distance and reproductive hormone levels in adult men. J Urol 2012;187:594-8.
7. Buck JJ, Williams RM, Hughes IA, Acerini CL. In-utero androgen exposure and 2nd to 4th digit length ratio-comparisons between healthy controls and females with classical congenital adrenal hyperplasia. Hum Reprod 2003;18:976-9.
8. Chung KH, Choi H, Kim SW. Penile and testicular sizes of Korean children. Korean J Urol 1987;28:255-8.
9. Wiygul J, Palmer LS. Micropenis. ScientificWorldJournal 2011;11:1462-9.
10. Tsang S. When size matters: a clinical review of pathological micropenis. J Pediatr Health Care 2010;24:231-40.
11. Lee JH, Ji YH, Lee SK, Hwang HH, Ryu DS, Kim KS, et al. Change in penile length in children: preliminary study. Korean J Urol 2012;53:870-4.
12. Kim TH, Lee HH. Anogenital distance in newborns. Reprod Biomed Online 2014;29:771.
13. Dean A, Sharpe RM. Clinical review: anogenital distance or digit length ratio as measures of fetal androgen exposure: relationship to male reproductive development and its disorders. J Clin Endocrinol Metab 2013;98:2230-8.
14. Matsuo N, Ishii T, Takayama JI, Miwa M, Hasegawa T. Reference standard of penile size and prevalence of buried penis in Japanese newborn male infants. Endocr J 2014;61:849-53.
15. Thankamony A, Ong KK, Dunger DB, Acerini CL, Hughes IA. Anogenital distance from birth to 2 years: a population study. Environ Health Perspect 2009;117:1786-90.
16. Manning JT. Digit ratio (2D:4D), sex differences, allometry, and finger length of 12-30-year olds: evidence from the British Broadcasting Corporation (BBC) Internet study. Am J Hum Biol 2010;22:604-8.
17. Salazar-Martinez E, Romano-Riquer P, Yanez-Marquez E, Longnecker MP, Hernandez-Avila M. Anogenital distance in human male and female newborns: a descriptive, cross-sectional study. Environ Health 2004;3:8.
18. Swan SH, Main KM, Liu F, Stewart SL, Kruse RL, Calafat AM, et al. Decrease in anogenital distance among male infants with prenatal phthalate exposure. Environ Health Perspect 2005;113:1056-61.
19. Ventura T, Gomes MC, Pita A, Neto MT, Taylor A. Digit ratio (2D:4D) in newborns: influences of prenatal testosterone and

maternal environment. Early Hum Dev 2013;89:107-12.
20. Lu H, Huo ZH, Liu YJ, Shi ZY, Zhao JL. Correlations between digit ratio and infertility in Chinese men. Early Hum Dev 2012;88:865-9.
21. Manning JT, Barley L, Walton J, Lewis-Jones DI, Trivers RL, Singh D, et al. The 2nd:4th digit ratio, sexual dimorphism, population differences, and reproductive success. evidence for sexually antagonistic genes? Evol Hum Behav 2000;21:163-83.
22. Auger J, Eustache F. Second to fourth digit ratios, male genital development and reproductive health: a clinical study among fertile men and testis cancer patients. Int J Androl 2011;34(4 Pt 2):e49-58.