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Original Article

The relationship of body mass index to penile length and testicular volume in adolescent boys

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Abstract

Background Evidence suggests that obesity may be related to early onset of puberty in girls. However, few studies have found a link between body mass index (BMI) and puberty onset in boys. More study is needed to assess the relationship of BMI to penile length and testicular volume.

Objective To investigate the relationship of BMI to penile length and testicular volume in adolescent boys.

Methods A cross-sectional study was carried out on adolescent boys aged 9 to 14 years in Secanggang District, Langkat Regency, North Sumatera Province in August 2009. Subjects' BMIs were calculated by dividing body weight (BW) in kilograms by body height (BH) in meters squared. Penile length (cm) was measured with a spatula. We took the average of three measurements from the symphysis pubis to the tip of the glans penis. Testicular volume (mL) was estimated by palpation using an orchidometer. Pearson's correlation test (r) was used to assess the relationship of BMI to penile length and BMI to testicular volume.

Results There were 108 participants, consisting of 64 primary school students and 44 junior high school students. Subjects' mean age was 11.7 (SD 1.62) years; mean BW was 35.2 (SD 8.48) kg; mean BH was 1.4 (SD 0.11) m; mean BMI was 17.5 (SD 2.34) kg/m^2; mean penile length was 4.5 (SD 1.25) cm; and mean testicular volume was 3.6 (SD 1.20) mL. We found no significant association between BMI and penile length (r=–0.25, P=0.06), nor between BMI and testicular volume (r=–0.21; P=0.09).

Conclusion There was no significant relationship of BMI to penile length nor BMI to testicular volume in adolescent boys.

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Keywords: *body mass index, penile length, testicular volume, adolescent boys*

Puberty marks the transition from childhood to adulthood through the development of secondary sexual characteristics up to the achievement of adult stature. In boys, an increase in testicular volume to 4 ml is usually the first pubertal sign.[1] Visible sexual maturation in boys usually begins with testicular enlargement between the ages of 9.5 and 13.5 years. The average duration of puberty for boys is 3 years, with a range of 2 to 5 years.[2]

Puberty-timing measures have historically been used as indicators of adequate nutrition and growth. Both contemporary and historical studies of puberty timing have focused on girls' age at menarche.[3] The evidence published to date also suggested that obesity may be causally related to earlier puberty in girls, rather than earlier puberty causing an increase in body fat. In contrast, few studies have observed a link between BMI and puberty in boys.[4]

Future study is needed to assess the relationship between body composition, penile length and testicular volume, as well as other influencing factors. There

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have been few reports on the relationship of BMI to penile length and testicular volume in adolescent boys in Indonesia. The aim of this study was to investigate the relationship of BMI to penile length and testicular volume in adolescent boys.

Methods

This cross-sectional study was carried out on adolescent boys aged 9 to 14 years. Participants were volunteers recruited by consecutive sampling from the following 3 schools: SD Negeri 050707 Desa Telaga Jernih, SMP Swasta Maju and SMP Muhammadyah in Secanggang District, Langkat Regency, Sumatera Utara Province in August 2009.

Subjects had no physical abnormalities and most came from the lower socio-economic sector of the population. Subjects were healthy at the time of investigation and had no chronic or acute illnesses. Children with history of long-term steroid therapy, radiotherapy, or chemotherapy were excluded from the study. The study was approved by the Ethics Committee for Research, University of North Sumatera Medical School. Subjects' parents or guardians provided informed consent.

All participants underwent medical history-taking and physical examination by a physician. We measured BH to the nearest 0.5 cm using a portable Microtoa 2 M. Body weight was measured by Camry Scale with a precision of 0.5 kg. Subjects were weighed without shoes and wearing light clothing. All measurements were taken twice and repeated a third time if the first two measurements differed by more than 0.5 cm for BH or 0.5 kg for BW. BMI was calculated by BW in kilograms divided by BH in meters squared. For each subject, these measurements were compared to the BMI of males aged 2- 20 years on the Centers for Disease Control and Prevention (CDC) growth chart 2000.[5] Obesity was defined as BMI at the 95th percentile or above.

Pubertal staging was determined by physical assessment. Genitalia and pubic hair were classified into five stages of development, as described by Marshall and Tanner.[6] Penile length (cm) was measured with the aid of spatula. We took the average of three measurements from the symphysis pubis to the tip of the glans penis. Testicular volume (ml) was estimated by palpation to the nearest 1 ml using an orchidometer. If the testicular volumes of the two testes were not equal, the larger testis measurement was used. Pubertal onset was defined as stage 2 or higher for genitalia (G2+) and/or pubic hair development (P2+).

Data analysis was performed using SPSS version 17.0. Data is presented as mean and standard deviation (SD) for numerical variables, or as size and percentage values for categorical variables. Pearson's correlation test (r) was used to evaluate the relationships of BMI to penile length and testicular volume. Student's t test was performed to determine the differences in pubertal onset between the obese and non-obese groups. A P value of < 0.05 was considered to indicate statistical significance.

Results

The 108 subjects consisted of 64 primary school students and 44 junior high school students. Fifty-nine boys were excluded because of malnutrition (48), refusing the examination (10), or scrotal inflammation (1). Basic characteristics of subjects are shown in **Table 1**.

Table 2. Differences in penile length and testicular volume between the obese and non-obese groups

Variable	Obese (n=6)	Non-obese (n=102)	P
Mean penile length, cm (SD)	2.6 (0.48)	4.4 (1.00)	0.0001
Mean testicular volume, mL (SD)	1.7 (0.31)	3.2 (1.77)	0.0001

The relationship of BMI to penile length and testicular volume are presented in **Figures 1 and 2,** respectively. Pearson's correlation analyses revealed that BMI was not significantly associated with penile length ($r=-0.25$; $P=0.06$) nor with testicular volume ($r=-0.21$; $P=0.09$).

As shown in **Table 2**, subjects were divided into two groups, obese (n=6) and non-obese (n=102).

Student's t test revealed that penile length and testicular volume were significantly lower in the obese group than in the non-obese group.

Table 1. Basic characteristics of subjects

Characteristics	n=108
Mean age, years (SD)	11.7 (1.62)
Mean BW, kg (SD)	35.2 (8.48)
Mean BH, m (SD)	1.4 (0.11)
Mean BMI, kg/m^2 (SD)	17.5 (2.34)
Mean penile length, cm (SD)	4.5 (1.25)
Mean testicular volume, mL (SD)	3.6 (1.20)
Tanner stage, n (%)	
- G1 P1	89 (82.4)
- G2 P1	19 (17.6)

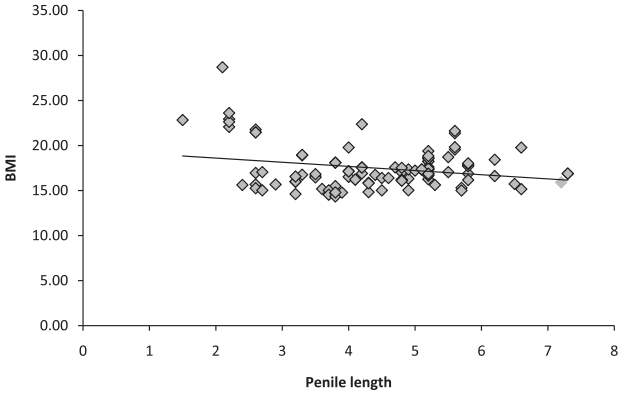

Figure 1. The relationship between BMI and penile length

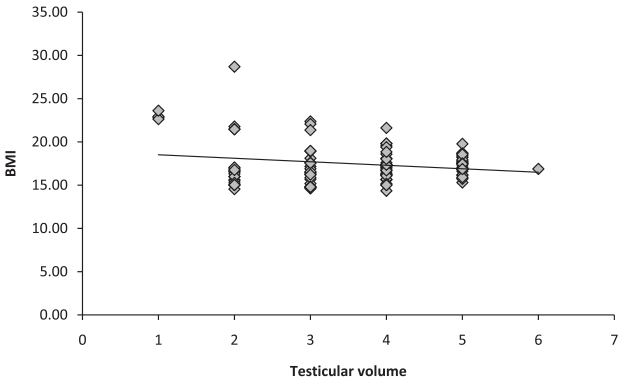

Figure 2. The relationship between BMI and testicular volume

Discussion

In this study, we used BMI measurements to determine the nutritional status of subjects. BMI has been recommended as an appropriate measure of adiposity in clinical settings. It is an attractive measure because it is relatively easy to obtain in a variety of settings and is reliable.[7] Since there have been few published studies evaluating the relationship of BMI and the appearance of secondary sexual characteristics in boys,[3] we aimed to evaluate the relationships of BMI to penile length and testicular volume.

In boys, the first visible sign of puberty and the hallmark of Tanner stage 2 is testicular enlargement, beginning as early as 9.5 years of age.[8] A longitudinal study in urban South Africa reported that the age at initiation of genitalia development in boys has remained stable over the past 10 to 15 years, pubic hair development has shown a statistically significant decrease in age at initiation between 1992 (12.4 years) and 2004 (10.8 years).[9]

The mean age of our subjects was 11.7 years, and the most were prepubertal. In contrast, a combined cross-sectional and longitudinal study in Denmark showed that the change of puberty onset occurred at mean age of 11.66 years. Decreased mean age of puberty onset in Denmark was associated with the coincident increase in BMI.[10] It is possible that our findings were influenced by the lower socio-economic and under nutrition status of our subjects, compared to subjects in a developed country, like Denmark.

We found no significant relationship between BMI and penile length. Similarly, a cross-sectional study in Korea revealed no relationship between BMI and any parameters of penile size.[11] A study of Taiwanese boys revealed that the average penile length increased with chronological age.[12] However, a significant correlation between penile length and BMI of boys aged 0 to 5 years was observed in Turkish children.[13]

When we divided our subjects into 2 groups, obese and non-obese, we found that mean penile length was significantly lower in obese subjects than in non-obese subjects. Similarly, a cross-sectional study in Surabaya reported a significant difference in the mean penile length in obese children and children with normal age-related BMI.[14]

We found no significant relationship between BMI and testicular volume. Ku *et al*. reported a weak

correlation between testicular volume and BMI. They found that demographic and environmental factors may affect testicular size and suggested that body size may be important in determining testicular size in late adolescence.[15] Also, a Korean study showed that testicular volume had a weak, direct correlation with BMI.[16] These findings were supported by a post mortem study that showed mean testicular volume to be significantly weakly correlated with nutritional state.[17]

A previous cross-sectional study reported that obesity was negatively associated with sexual maturation in boys.[18] However, the Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) study did not suggest that body composition 1 - 2 years before puberty influenced the onset of puberty. This study concludes that higher prepubertal BMI may influence how quickly children progress through puberty resulting in an earlier attainment of later pubertal stages.[19]

Another longitudinal study showed that adolescent boys in the highest BMI group had a greater relative risk of being prepubertal, compared to adolescent boys in the lowest BMI group.[20] While we found no significant relationship of BMI to penile length and testicular volume, our study was limited by its small sample size, its cross-sectional design with no multivariate analysis, and the possibility of selection bias. Additional studies about the relationship of factors influencing puberty are needed for further evaluation and to explore public health implications.

There were no significant relationships between BMI and penile length and testicular volume in adolescent boys. However, there was a significant difference in penile length and testicular volume between obese and non-obese subjects, though we had a small number of subjects in the obese group. Future studies are needed to investigate the relationship between BMI and sexual maturity in older boys in Indonesia.

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