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ASSESSMENT OF GROWTH PATTERN USING CORMIC INDEX: A STUDY AMONG A GROUP OF EARLY ADOLESCENTS OF WEST BENGAL, INDIA

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Abstract: Sitting height-to-height ratio or Cormic Index (CI) provides the relative contribution of leg length to height. CI varies across age and sex categories. This cross-sectional study aimed to examine the age and sex-wise variations in CI among 300 (boys: 145, girls: 155) early adolescents of 11–13 years from West Bengal, India. Height (Ht) and sitting height (SH) were measured using standard protocol, while leg length (LL) was derived by subtracting SH from total Ht. The CI was calculated following standard formulae. Descriptive statistics, independent sample t test, one way ANOVA and Pearson correlation were performed using SPSS (version 20.0). Results revealed in case of boys, LL, became higher compared to girls after the age of 12. Among girls SH and CI decreased with age. CI showed a negative correlation with age only for boys. This study advocates for the integration of the CI with segmental growth monitoring since it appeared to be a more comprehensive approach to assessing adolescent health. This tool of assessing segmental growth may enhance early detection of growth abnormalities and associated health risks. However, validating these findings requires longitudinal studies with larger and more diverse samples to better understand adolescent growth patterns, after controlling the confounding factors, and long-term health implications.

Keywords: Adolescence; Segmental growth; Sitting height; Cormic index; Growth pattern.

Introduction

Height of an individual is influenced by genetic, environmental, and nutritional factors. Height (Ht) can be divided into three primary components: sitting height (SH), leg length (LL) and sitting height to height ratio or Cormic index (CI) (Burton, 2020). CI is a bi-variate measure of body shape, reflecting the relative proportions of the trunk and lower limbs. It provides insight into the segmental growth patterns, and relationship of environment with segmental growth pattern (Bogin & Varela-Silva, 2008).

A lower CI is argued to be an indicator of better nutrition and health, while higher CI for chronic undernutrition (Malina, 1991; Woodruff & Duffield, 2002). Thus stunted children typically have a higher CI, compared to non-stunted children. CI varies across ethnic groups and is a key measure of body size (Woodruff & Duffield, 2002). For example, CI is ~52% among Europeans and Mediterranean population, ~51% in African (longer legs), 53-54% in Asians (shorter legs), and 48% in Australian Aboriginal population (longest legs) (Norgan, 1994).

Human growth follows a cephalo-caudal pattern, with legs growing faster than other post-cranial segments between birth and puberty (Bogin & Varela-Silva, 2010).

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The effect of age on CI is evident; since LL contributes more to Ht than SH during childhood. For example, one study from the state of West Bengal, India showed CI has a negative correlation with age (Ghosh & Bandyopadhya, 2005) during mid-childhood, indicating lower contribution of LL to Ht. Research highlights a sharp shift in CI with the adolescent growth spurt (Pathmanathan & Prakash, 1994; Rao & Kanade, 2000; Woodruff & Duffield, 2002; Al-Isa et al., 2008). In adolescence, the growth rate of lower limb higher compared to trunk growth (or SH) and continues till the later stages, leading to a rise in CI during late adolescence (Tanner et al., 1976; Malina & Bouchard, 1991; Ghosh & Bandyopadhyay, 2005). Environmental factors like nutrition and physical activity shape body proportions, making CI a dynamic indicator of growth patterns across populations (Ukwuma, 2009). For example, adequate nutrition during childhood and adolescence promotes balanced growth between the trunk and limbs, while malnutrition or stunted growth can disproportionately impact leg length, resulting in high CI (Rao & Kanade, 2000). Lifestyle factors, such as low level of physical activity, can hinder leg growth, resulting in a relatively higher CI (Malina & Bouchard, 1991). Additionally, children from lower socio-economic backgrounds may face stunted leg growth due to malnutrition and inadequate healthcare, leading to a higher CI compared to their well-nourished counterparts who avail better medical care (De Onis & Blossner, 2003; Bogin & Varela-Silva, 2008). SH and CI help for the early detection of disproportionate growth and to diagnose achondroplasia, hypochondroplasia, and Marfan syndrome (Hall, 2002). But in children and adolescents, a higher CI value often indicates environmental adversity. It offers a more holistic picture of adolescent development, and assesses not only the extent of growth but also how the body is proportioning and adapting and providing a more robust means of identifying developmental abnormalities (Fredriks et al., 2005).

The present study examined the contribution of SH to Ht ratio and explore sex-based variations in the Cormic Index (CI) among a group of early adolescent boys and girls belonging to Bengali speaking Hindu populations.

Materials and Methods

Study area

This cross-sectional study was conducted among a group of boys and girls of the state of West Bengal, India, who were at the stage of early adolescent. Data were collected from two secondary schools namely—Debiswari Vidyaniketan Girl's High School and Amarendra Vidyapith located in Uttarpara, Hooghly. These two schools were selected for their similar tuition fees, ensuring a comparable socioeconomic background. School selection was based on operational convenience, and prior permission was obtained from authorities.

Study Participants

A total of 330 students were initially recruited based on inclusion criteria: aged between 11 and 13 years, had no reported history of any chronic health disorders (digestive tract diseases and endocrine disorders, like thyroid, diabetes) that can affect the growth pattern (Khadilkar et al., 2013). Thirty students were excluded for age mismatch (n=12) or not having parental consent (n=16), and were under regular medication (n=2). Finally, 300 participants (145 boys, 155 girls) were included after obtaining informed consent.

Measurements

Anthropometric measurements, including height (Ht) and sitting height (SH), were taken following standard protocols (Lohman et al., 1988). Ht was measured to the nearest 0.1 cm using a GPM anthropometric rod, standing without shoes on a horizontal surface. SH was measured with participants seated upright on a bench, ensuring a Frankfurt horizontal plane alignment (Dangour et al., 2012). Leg length (LL) was derived by subtracting SH from Ht (Bogin & Varela-Silva, 2008). The Cormic Index (CI) was calculated as (SH/Ht) × 100. The study was conducted from April to September 2023.

Statistical Analysis

Descriptive statistics were used to determine the mean, standard deviation, and frequency of the participants by age and sex. The Kolmogorov-Smirnov test was used to assess the distribution of the anthropometric variables. Independent sample t-test and ANOVA were used to compare variations in the anthropometric variables between the sex and across the age groups respectively. Pearson's correlation examined the relationships between anthropometric variables and age. A p-value < 0.05 was considered statistically significant. Data analysis was conducted using SPSS 20.0 (IBM corporation, 2011).

Results

Age (Years)	Boys (n=145)	Girls (n=155)	Total (n=300)
11	54 (37.2)	47 (30.3)	101 (33.6)
12	48 (33.1)	37 (23.8)	85 (28.3)
13	43 (29.6)	71 (45.8)	114 (38)
Total	145 (100.0)	155 (100.0)	300 (100.0)

Figures in the parentheses indicate percentage values

Table 1: Distribution of the study participants by age and sex

It appeared from table 1 that the majority of the boys belong to the age group of 11(37.2%) years, followed by 12 (33.1%) and 13 years (29.6%). The majority of the girls belonged to the age group of 13 years (45.8%), followed by 11 years (30.3%) and 12 years (23.8%).

Anthropometric Variables		*Boys (n=145)*	*Girls (n=155)*	*t test*	*p value*
Ht (cm)	11 years	139.45±6.76	146.39±7.12	5.02	0.001
	12years	147.43±8.28	146.72±5.43	0.45	0.65
	13years	151.91±6.78	150.79±5.04	1.02	0.32
SH (cm)	11 years	71.11±4.04	75.25±4.21	4.98	0.0001
	12years	74.44±4.07	75.89±3.72	1.69	0.09
	13years	76.39±4.34	78.28±3.58	0.24	0.01
LL (cm)	11 years	68.33±4.77	71.14±5.63	2.67	0.009
	12years	72.98±5.21	70.82±3.57	2.26	0.02
	13years	75.51±4.40	72.51±3.69	3.74	0.0001
CI	11 years	51.01±2.05	51.43±2.32	0.96	0.34
	12 years	50.52±1.49	51.73±1.67	3.53	0.001
	13 years	50.29±1.80	51.92±1.73	4.79	0.00

Ht-Height, SH-Sitting height, LL-Leg length, CI-Cormic index

Table 2: Sex differences in the anthropometric variables of the participants by age categories (n=300)

Table 2 showed that at age 11, girls were significantly taller than boys (p = 0.001). However, by ages 12 and 13, the Ht differences were no longer significant. Girls consistently exhibited a longer SH than boys, leading to a higher CI. After reaching 12 years, boys had longer legs compared to girls. Interestingly, for 11 years age group, except CI, rest of the anthropometric variables showed statistically significant sex difference.

Anthropometric variables		11 years	12years	13years	ANOVA	p value
Ht (cm)	Boys	139.45±6.76	147.43±8.28	151.91±6.78	36.63	0.00
	Girls	146.39±7.12	146.72±5.43	150.79±5.04	10.30	0.00
SH (cm)	Boys	71.11±4.04	74.44±4.07	76.39±4.34	20.40	0.00
	Girls	75.25±4.21	75.89±3.72	78.28±3.58	10.12	0.00
LL (cm)	Boys	68.33±4.77	72.98±5.21	75.51±4.40	28.03	0.00
	Girls	71.14±5.63	70.82±3.57	72.51±3.69	2.38	0.10
CI	Boys	51.01±2.05	50.52±1.49	50.29±1.80	2.07	0.13
	Girls	51.43±2.32	51.73±1.67	51.92±1.73	0.91	0.41

Ht-Height, SH-Sitting height, LL-Leg length, CI-Cormic index

Table 3: Age-sex comparison of anthropometric variables and derived index of study participants

Table 3 revealed that Ht and SH differed significantly across the age groups irrespective of sex, but LL differed significantly only for boys. While, among the boys, there is a slight decline in CI with increase in age, the trend is reverse among the girls.

Anthropometric variables	*Age (in years)*			
	Boys (n=145)		*Girls (n=155)*	
	Pearson correlation (r)	*p value*	*Pearson correlation (r)*	*p value*
Ht (cm)	0.58	0.00	0.32	0.00
SH (cm)	0.47	0.00	0.33	0.00
LL (cm)	0.53	0.00	0.14	0.07
CI	-0.17	0.05	0.11	0.18

Ht-Height, SH-Sitting height, LL-Leg length, CI-Cormic index

Table 4: Pearson correlation coefficient of anthropometric variables with age

Table 4 showed a significant positive correlation between Ht, SH, LL and age among the boys, and a significant negative correlation between CI and age; whereas in girls significant positive correlation exists, only between Ht, SH with age.

Discussion

This study found that girls who were aged 11 years were taller than boys of the same age group. This observed growth differences can be attributed to the variations in the timing of puberty. On an average, girls enter puberty around 11 years of age, whereas the pubertal development among the boys typically begin around 13 years (Rogol et al., 2002; Ramoshaba et al., 2018). As a result, girls reach their peak growth velocity earlier, contributing to their initial advantage in Ht gain. However, since boys experience a later onset of puberty, their leg growth continues for a more extended period, ultimately leading to greater gain in the overall Ht. In our study, girls consistently exhibited a longer SH than boys which, corroborating to the findings of Patil et al. (2018). The earlier closure of epiphyseal growth plates in girls, occurring approximately 1.5 years before boys, contributes to the observed growth patterns (Sánchez et al., 2017). An earlier pubertal onset in girls compared to boys leads to a rapid but shorter growth phase, whereas boys continue growing at a steady rate for a longer period. This also explains why boys ultimately achieve greater adult height than girls despite a delayed growth spurt (Tanner et al., 1976; Malina & Bouchard, 1991).The present study shows that there is a slight decline in the CI with age among boys, but not among girls corroborating to one previous study (Ghosh et. al.,2005). Scholars argue boys experience more prominent lower limb growth during adolescence, which contributes to a gradual decline in CI (Ramoshaba et al., 2018; Bundak et al., 2014). The later peak height velocity (PHV) in boys also contributes to this trend, as their legs continue to grow longer before the trunk experiences substantial growth (Rogol et al., 2002).A significant negative correlation of CI with age in boys suggests a faster increase in LL compared to SH, resulting in a lower sitting height-to-height ratio. The absence of a significant correlation in girls suggests a more balanced growth pattern between trunk and LL, possibly due to their earlier pubertal onset and earlier growth completion. This sex-based difference in CI trends is an important indicator of growth tempo and timing, aligning with the established developmental and anthropometric research (Malina et al., 2004; Tanner, 1989). Boys show a linear increase in both trunk and lower limb during adolescence suggesting an intense growth spurt as found in other studies (Ramoshaba et al., 2018; Bundak et al., 2014). But in case of girls, there is an increase in stature and trunk length with age, but not in leg length. These findings highlight the importance of precisely understanding proportional growth patterns in relation to age, nutrition, and developmental differences among adolescence.

The present study has certain limitations. The study was cross-sectional in nature. The data on socio-demographic characteristics was not included as the majority of the participants could not provide information about their parents' education, income, expenditure, etc. Comparison between two age groups, pre-adolescence and post-adolescence could provide better understanding of age wise changes in CI.

Conclusion

This study highlights the value of combining the Cormic Index (CI) with segmental growth monitoring for assessing adolescent health. This study shows age-sex based differences in CI trends, the boys exhibit a slight decline in the CI with age, the trend is reverse among the girls. Boys show linear growth in both trunk and legs, while girls exhibit increased stature and trunk length with minimal growth in leg length. To strengthen these findings and enhance their applicability, future longitudinal studies with larger, more diverse samples are essential. Such research will be crucial in deepening our understanding of adolescent growth patterns and the complex factors that influence them.

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