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Relationship of Cephalic Index with some anthropometric variables among the rural preschool children of West Bengal, India

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ABSTRACT

Background : Cephalometry is a technique that summarizes the anatomical complexities of the head of a human being living within a geometrical framework. The study of craniofacial relations and variations in humans has been used for different racial groups in physical anthropology. Cephalic variables such as head breadth, head length, head circumference and cephalic index **(CI)** are all anthropometric parameters which are used to deduce the pattern of growth in children.
Objectives : The objective of the present study was to evaluate the relationship of **CI** with some anthropometric variables.
Methods : This study was conducted on 224 rural ICDS children aged 3-6 years from Purba Medinipur district, West Bengal, India.
Results : Significant sex differences in maximum head length ($t=4.55$, $p < 0.001$), and two indices such as, cephalic ($t = 3.0$, $p < 0.01$) and Body Mass index ($t = 2.58$, $p < 0.05$) were noticed. BMI as well as CI showed significant impact of age changes. The mean **CI** gradually decreased with the increase of the age groups of the children of both the sexes. More than 50% of the boys were hyperbrachycephalic, while among the girls, maximum were brachycephalic (32.3%). **CI** was to some extent highly ($p < 0.001$) negatively correlated with age and height among the girls. In case of boys, except age (negatively correlated, $p< 0.05$), neither height nor weight were significantly correlated with CI. BMI was not significantly correlated with **CI.**

Keywords : *Cephalic index, ICDS children, head length, head breadth, height, weight, BMI.*

INTRODUCTION

Study of intra and inter-population variations in different morphological characters have long been an interest of anthropologists. The dimensions of the human body are affected by ecological, biological, geographical, racial, gender and age factors. On the basis of the above factors, anthropological studies have been conducted on the age, gender and racial groups in certain geographical zones (Imami-Mibodi and Mastri-Farahani, 1996). The study of physical characteristics of man and its variation both inside and outside has been a constant concern in the course of time. The proportionately of the different body segments have interested man since antiquity (De La Rosa and Rodriguez-Anez, 2002). Cephalometry is a technique that summarizes the anatomical complexities of the head of a human being living within a geometrical framework (Moyers cited by Ferreira, 2005). The study of craniofacial relations and variations in humans has been used for different racial groups in physical anthropology. Morphology and characteristics of different races and ethnic groups are not randomly distributed but it appears in geographic clusters (Argyropoulos & Sassouni, 1989). Anthropometric study of head is useful in designing various equipments of head and face like helmets, head phones, goggles etc by formulating standard sizes (Singh and Purkit, 2006).

Weight, height, and cephalic variables such as head breadth, head length, head circumference and cephalic index **(CI)** are all anthropometric parameters which are used to deduce the pattern of growth in children. Nutritional levels and environmental conditions favour the full expression of the genetic potential for growth of the above variables (Loesch et al., 2000). The type of head and face depend on many factors such as ethnicity, genetic influence, traditions, nutrition, certain pathology conditions, environment and climate (Rexhepi & Meka, 2008). The **CI** is a widely used anthropometric parameter in determining the racial variations, and very unusual use to determine sex differences, especially in individuals whose identity is unknown (Saha and Jadhav, 2004). Head dimension changes followed pattern in different population. The key factor in the process of head dimension changes is small increase in the growth rate in a specific direction during infancy and childhood. These increases involve the posterior cranial base and occur in a posterior inferior or lateral direction resulting in significant changes of the vault shape (Wescot and Jantz, 2005). Head growth occurs as its most rapid rate during the first year of life. The head grows to almost 80 % of the adult size during the first year of life then grow at slower pace. If the head is too large or growing too quickly or on other hand if the head is too small or growing too slowly, these are signs of possible problems **(**Danborno et al., 2007**).**

The utility of investigating the associations of height, weight and specifically BMI with CI is that there may be age, sex and ethnic variations in these relationships. If so, then such investigations would be very useful in studying not only sexual dimorphism but also age variations in these relationships. More importantly, from the biological anthropological point of view, they will enable us to highlight human population variation in these relationships. Moreover, such studies would help us in elucidating the relationship between overall adiposity (BMI is a proxy measure of overall adiposity) and head form (CI is an indicator of head form) which may be of immense help to human biologists.

Objectives: The objective of the present study was to evaluate the relationship of **CI** with some anthropometric variables.

MATERIALS AND METHODS

Area: This study was conducted in the villages of Argoal Gram Panchayat at Patashpur- II block in Purba Medinipur district, West Bengal, India. The villages were remotely located, approximately 110 km away from Kolkata, the capital of the state. The majority of inhabitants were Hindus. The anthropometric data presented in this paper was collected in by one of the authors (AA).

Subjects This is a cross sectional survey that was conducted in nine villages of Argoal Gram Panchayat at 10 Integrated Child Development Service (ICDS) centers. The subjects were taken randomly from each of these centers. The total sample was 224 (110 boys and 114 girls) between the age group 3 and 6 years. All of the preschool children of the study belonged to Bengalee ethnicity. The children bellow three years of age from different Hindu caste groups enrolled their names to the nearby ICDS centers. Most of the families were dependent on agriculture for their livelihood. The ICDS centers provided food supplementation to these children, in the form of porridge and pre school teaching.

Anthropometry: Anthropometry offers a reliable method to access the nutritional status of the children. Anthropometry is the single most universally applicable, inexpensive and non-invasive method available to assess the size, proportion and composition of human body (WHO, 1995). Weight (kg.) and Height (cm.), maximum head length, maximum head breadth of each subject were taken with the help of Martin's Anthropometer and Standard Weighing Machine and Martin's spreading calipers respectively following the standard methods (Lohman et al., 1988). The **CI** was calculated following standard formula i.e. maximum head breadth divided by maximum head length multiplied by hundred. BMI was also calculated following the standard formula i.e. weight in kg divided by height in meter square.

Statistical analysis: Besides mean (SD), t - test, ANOVA were also done to test the significance level of sex differences and trends of growth respectively. Pearson's correlation coefficient (r) was done to assess the level of correlation between cephalic index and other variables like, height, weight etc.

RESULTS

Table 1 Means, SD and sex differences of the anthropometric variables and indices

Variables	Boys (N=110)		Girls (N=114)		t
	Mean	SD	Mean	Sd	
Height (cm)	97.2	8.1	97.9	6.8	- 0.74
Weight (kg)	13.6	2.1	13.4	2.0	0.89
Maximum head length (cm)	16.0	0.7	15.8	1.2	4.55***
Maximum head breadth (cm)	13.6	0.6	13.2	0.9	1.43
BMI	14.5	2.1	13.9	1.1	2.58*
CI	85.5	4.9	83.5	5.0	3.0**

* $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$

Table 1 presents the means (SD) and sex differences of anthropometric variables and indices. The mean height and weight among the boys were 97.2 (8.1) cm and 13.6 (2.1) kg, whereas, in case of girls these were 97.9 (6.8) cm and 13.4 (2.0) kg respectively. There were no significant sex differences in these variables. The same result also noticed in maximum head breadth. There were significant sex differences in the anthropometric variable like, maximum head length, and two indices such as, cephalic ($t = 3.0$, $p < 0.01$) and Body Mass index ($t = 2.58$, $p < 0.05$). In case of head length there was highly significant ($t=4.55$, $p < 0.001$) sex differences.

Table 2 Age and sex wise distribution of CI among the studied children.

Age	Boys	Girls	t
3	86.8 (4.6)	87.8 (4.7)	n.s.
4	85.2 (4.9)	83.8 (5.0)	n.s.
5	85.1 (4.6)	81.5 (3.9)	n.s.
6	83.3 (5.9)	80.5 (4.1)	n.s.
Total	85.5 (4.9)	83.5 (5.0)	3.0 **

** = $p < 0.01$;

Considering age and sex wise distribution of **CI (Table 2)** among the studied children, mean CI among the boys was to be 85.5 (4.9) whereas, among girls it was slightly lower i.e. 83.5 (5.0). This sexual dimorphism was statistically significant ($p < 0.01$). The mean **CI** gradually decreased with the increase of the age groups of the children of both the sexes. In case of boys the highest CI (86.8) was found to be in the age of 3 year and the lowest (83.3) in the age of 6 years. The same results were found among the girls. There was no age specific significant sex differences among them.

Table 3 Age and sex wise classification of CI among the studied children.

Sex	**Age**	**Categories of CI**			
		Dolicocephalic	Mesocephalic	Brachycephalic	Hyperbrachycephalic
Boys (N=110)	3	1 (0.9)	2 (1.8)	6 (5.5)	22 (20.0)
	4	1 (0.9)	7 (6.4)	14 (12.7)	20 (18.2)
	5	1 (0.9)	3 (2.7)	7 (6.4)	14 (12.7)
	6	1 (0.9)	3 (2.7)	5 (4.5)	3 (2.7)
	Total	**4 (3.6)**	**15 (13.6)**	**32 (29.1)**	**59 (53.6)**
Girls (N=124)	3	-	4 (3.2)	9 (7.3)	12 (9.7)
	4	4 (3.2)	9 (7.3)	14 (11.3)	14 (11.3)
	5	5 (4.0)	16 (12.9)	13 (10.5)	5 (4.0)
	6	1 (0.8)	4 (3.2)	4 (3.2)	-
	Total	**10 (8.1)**	**33 (26.6)**	**40 (32.3)**	**31 (25.0)**
Sex-Cpmbined (N=224)	3	1 (0.4)	6 (2.7)	15 (6.7)	34 (15.2)
	4	5 (2.2)	16 (7.1)	28 (12.5)	34 (15.2)
	5	6 (2.7)	19 (8.5)	20 (8.9)	19 (8.5)
	6	2 (0.9)	7 (3.1)	9 (4.0)	3 (1.3)
	Total	**14 (6.3)**	**48 (21.4)**	**72 (32.1)**	**90 (40.2)**

Percentages are given in the parentheses.

Table 3 displays the age and sex wise classification of **CI** among the studied children. In our study, however, more than 50% (53.6%) of the boys were hyperbrachycephalic followed by brachycephalic (29.1%) and mesocephalic (13.6%). While among the girls, maximum were brachycephalic (32.3%) followed by mesocephalic (26.6%) and hyperbrachycephalic (25.0%). Considering the cephalic index as a whole (sex combined), more than 40.0% were hyperbrachycephalic followed by brachycephalic (32.1%) and mesocephalic (21.4%). Dolichocephal children were very less (6.3%). It is clear from this table that, there was a declining tendency of hyperbrachycephalic children from lower to higher age groups.

Table 4. Age trends in anthropometric variables and indices.

Variables	Boys		Girls		Sex combined	
	Mean (SD)	F	Mean (SD)	F	Mean (SD)	F
Height (cm)	97.2 (8.1)	42.9***	97.9 (6.8)	34.5***	97.5 (7.5)	73.8***
Weight (kg)	13.6 (2.1)	25.6***	13.4 (2.0)	11.7***	13.5 (2.1)	32.7***
Maximum head length (cm)	16.0 (0.7)	8.5***	15.8 (1.2)	7.5***	15.9 (1.0)	13.5***
Maximum head breadth (cm)	13.6 (0.6)	1.6	13.2 (0.9)	0.4	13.4 (0.8)	0.5
BMI	14.5 (2.1)	1.3	13.9 (1.1)	3.2*	14.2 (1.7)	3.5*
CI	85.5 (4.9)	1.8	83.5 (5.0)	9.0***	84.5 (5.0)	8.7***

* p < 0.05; ** = p < 0.01; *** = p < 0.001

Age trends among the boys, girls and sex combined in anthropometric variables was tested by ANOVA (**Table 4)**. The age changes had a great impact on height, weight and maximum head length in all the cases **(p< 0.0001).** The boys didn’t show significant impact of age changes on maximum head breadth and indices, whereas, in case of girls and sex combined, BMI as well as CI showed significant impact of age changes.

Table 5. Correlation of CI with other variables.

Variables	Boys (r)	Girls (r)	Sex combined (r)
Age	-0.198*	-0.433**	-0.32**
Height	-0.165	-0.329**	-0.245**
Weight	-0.146	-0.22*	-0.168*
BMI	0.048	0.181	0.120

* p < 0.05; ** = p < 0.01;

Table 5 presents the Pearson correlation coefficient (r) of CI with that of other variables. It was evident from this table that, **CI** was to some extent highly ($p < 0.001$) negatively correlated with age and height among the girls and considering the children (sex combined) as a whole. In case of boys, except age (negatively correlated, $p < 0.05$), neither height nor weight were significantly correlated with CI. BMI was not significantly correlated with **CI**. The age controlled partial correlation of BMI with CI was 0.061.

Figure 1. Age trends in CI among the subjects.

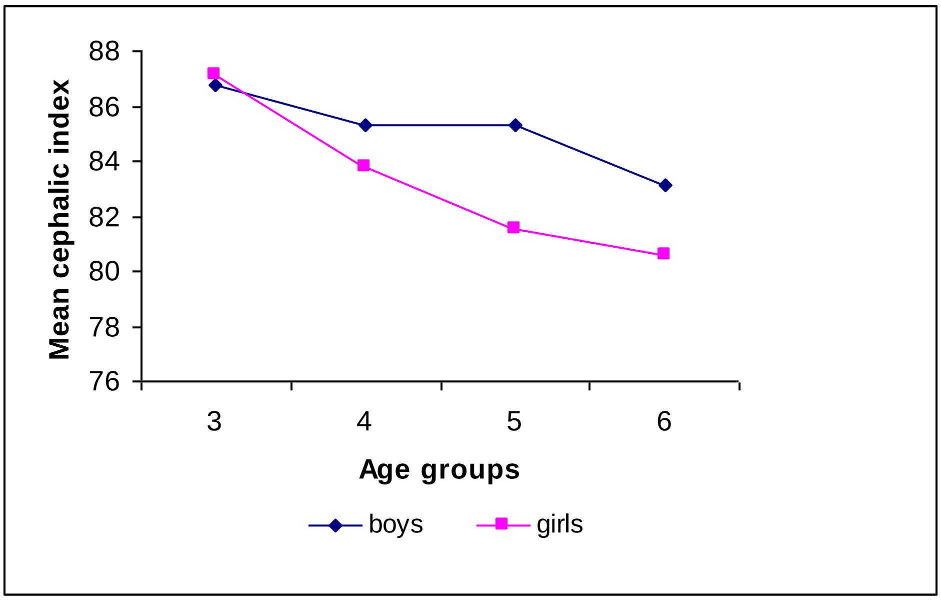

Figure 1 shows an inverse age trend in CI in both the sexes. It is much more pronounced among the girls. This implies that head length increases at a faster rate than head breadth implying differential rate of growth. There is also a sexual dimorphism in this differential growth rate. However, the causes are unknown.

DISCUSSION

In the present study, the average **CI** for boys was 85.5 which was much higher (80.93) than the male children in the Northern Region of Brazil (Alves et al., 2011), students in Gujarat in India with 80.42 (Shah & Jadhav, 2004), in a group of individuals of the Mapuche ethnic group in Region IX in Chile with 80.40 (Del Sol, 2005) and in men in Northern Iran with 80.40 (Golalipour, 2006). In the Eastern region of India out of 130 males the maximum were mesocephalic (41.5%) followed by brachycephalic (40.0%), hyperbrachycephalic (10.85) and dolichocephalic (7.7%). While in female maximum were brachycephalic (48.6%), followed by mesocephalic (28.65), hyperbrachycephalic (14.3%), ultrabrachycephalic (5.7%) and only 2.9% were dolichocephalic (Vijayanath. et al., 2010). In our study, however, more than 50% (53.6%) of the boys were hyperbrachycephalic followed by brachycephalic (29.1%) and mesocephalic (13.6%). While among the girls, maximum were brachycephalic (32.3%) followed by mesocephalic (26.6%) and hyperbrachycephalic (25.0%). The cephalic indices of Japanese children with normal brain development tended to be more brachycephalic (Koizumi et al., 2010).

On the basis of **CI**, statistically significant differences were observed between males and females of same communities as well as between the two communities i.e. Jatsikh and Banias (Kaur et al., 2012). The head length, head breadth and cephalic index showed significant differences between male and females of Ndi Igbo of Abia State of Nigeria (Esomonu and Badamasi, 2012). In case of the present study also, only mean cephalic index of overall boys and girls (sex combined) was significant ($t= 3.0; p< 0.01$). However, on the whole males and females of Jatsikh community showed a brachycephalic profile, whereas, Bania infants exhibited a tendency to shift from mesocephaly to brachycephaly during later months of growth period, as was suggested over half a century back by Shapiro (1965). None of these Punjabi children from birth to 1 year are dolichocephalic (Kaur et al., 2012). Brachycephalization is the result of secular changes in the growth rate in head breadth and head length, both being components of the cephalic index. Moreover, the fact that very rapid secular changes in height and head breadth occur simultaneously suggests that common environmental factors with direct effects on growth would influence both height and head breadth (Kouchi, 2000). In another study, no significant gender differences in the craniofacial variables in a cross-section of Nigerian children under 6 years of age was found. The most prevalent type of head was the mesocephalic type (Ukoha et al., 2013).

Cephalometry helps in identifying various shapes and sizes. As microcephaly depicts the birth history seen in asphyxia neonatorum, hypoxic ischemic encephalopathy, while shape-dolichcephaly & mesocephaly show no evidence of mental retardation (MR), brachycephaly is a predominant feature of Asians show good prognosis while hyperbrachycephaly is a feature of (MR) with bad prognosis (Math et al., 2011). In our study, although the children were predominantly either brachycephalic or hyperbracephalic, they were mentally normal.

The CI also increased down the age classes with mean value greater in girls than in boys (Danborno et al., 2007). While in the present study, decreasing tendency was clearly noticed among both boys and girls. In a study done by Danborno et al., (2007) the correlation matrix showed that all the head dimensions correlates significantly with height and weight in boys and girls ($P < 0.05$, $P < 0.001$) but **CI** showed no correlation with boys' height and weight but it correlates with girls weight and not their height. In comparison, our study revealed that, **CI** was negatively significantly correlated with both height ($p < 0.01$) and weight ($p < 0.05$) among girls whereas, in case of boys no significant correlation was found. Sexual dimorphism was clearly demonstrated between boys and girls in head length and cephalic index in both the studies, Danborno et al., (2007) and the present study. However, in another study, **CI** showed an exception where it showed no association to boys weight, height and girls height but it showed significant difference to girls weight. This could be due to the roles female hormones play in deposition of fat in the body (Jones, 1996; Hauspie et al., 1996; Livshits et al, 2002). This finding also provides a basis why mean cephalic index of girls was relatively larger than that of boys.

The study of Danborno et al., (2007) has also recorded some differences in pattern of head growth in children - while boys have larger head length, girls had larger **CI** as well as head circumference due to a relative larger head breadth which statistically showed no significant difference. The exact mechanism driving this process of change in head dimension is still a subject of debate. It can be deduced that variations in head shapes are due to hereditary factors or environmental which may act as secondary effect (Golalipour et al., 2007). Also affecting head shape pattern are climatic, genetic, ecological, biological, geographical, racial, gender and age factors (Rajlakshmi et al., 2001; Golalipour et al., 2005). To overrule this debate further study need to be done to elucidate the causes and mechanisms of secular change in head dimension (Danborno et al., 2007).

Most importantly, from the biological anthropological viewpoint, this could be effectively used as a biological marker for studying human variation. In other words, whether the magnitude and nature of this trend observed here is similar in other ethnic groups. Thus, future studies should be undertaken to investigate age trends in **CI** (in this age group) in India and elsewhere. The information generated will be useful not only for studying human variability but also help to create a data base. Since India is a country with vast ethnic heterogeneity, there exists immense scope for these studies. Later on, these studies can also be undertaken worldwide. To best of our knowledge, no such study has been undertaken previously from India. This is the uniqueness of our study.

Conflict of interest : None

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