Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 13 (1)

Sexual Dimorphism in Cephalic Index and its Relationships with Height, Weight and BMI among Primary School Children in Sabon Gari Local Government Area of Kaduna State, Nigeria

*[1]Tanko M, [1]Aliyu J, [1]Ibrahim AA, [1]Sadeeq AA, [1]Peter AS, [2]Okwubenat OL

[1]Department of Human Anatomy, Faculty of Basic Medical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria

[2]Department of Medicine, Faculty of Clinical Sciences, College of Medical Sciences, Ahmadu Bello University, Zaria

Corresponding Author: Tanko M
Email: tankomurdakai@yahoo.com; +2348029314944

ABSTRACT

The study of head measurements or Cephalometric/Craniometrics demonstrated that head shape varies in different races and population across the world and is related to the cephalic index. Also the cephalic dimensions can be related to other body measurement which is important for Medical, Forensic and legal investigation as some body parts can be obtained at the crime or accident scenes. The purpose of this study was to establish specific standards data for sex determination from the cranium and to determine the relationship between cranial anthropometry with height, weight and BMI among primary school in north Nigerian population. The present study was carried out with 351 apparently healthy subjects (180 male & 171 females) attending Aminu LEA Model Primary school Sabon Gari, Zaria Kaduna State of Nigeria. Cranial measurements including cranial length, cranial width and cranial circumference as well as height and weight were taken using standard measuring tape as well as stadiometer and weighing balance respectively; data were tabulated and statistically analyzed. The mean cephalic index was 81.83±9.58. The mean cephalic index for male was 81.85±9.48 and for female was 81.82±9.71. No significant sex differences was observed in the cephalic index ($p = 0.982$). Cephalic index predicted height positively in the general population (HT= -0.288*CI+151.673, $r = 0.318$, $p < 0.001$) as well as in males (HT=-.253*CI+149.344, $r = 0.290$, $p<0.001$) and females (HT=-.323*CI+153.993, $r = 0.346$, $p<0.001$) respectively. This study will serve as basis for comparison on other geographical region population in future studies.

Keywords: Forensic Sciences, height, Craniometric, Northern Nigerian population

INTRODUCTION

Cephalic index is one of the important parameter that helps to differentiate between different human races [1]. Cephalometry is the most widely used anthropometric methods in the differentiation of race and ethnicity which is achieved through the use of head (cranium) dimensions. The most important of cephalometric dimension are length and width of head (cranium) which are used in cephalic index determination [2]. It has been reported that factors like race, ethnicity, genetic interaction, traditions, nutrition, environment and climate influences head types [3]. Craniometry is also employed in the measurement of cranial features in order to classify people according to race, criminal temperament, intelligence, and so forth. The underlying assumption of craniometry is that skull size and shape determine brain size which determines such things as intelligence and capacity for moral behavior[4, 5].

Comparison of changes in cephalic index between parents, offspring and siblings can give a clue to genetic transmission of inherited characters[6].

The importance of age, gender and population specific cephalometric data is paramount because comparison between cephalic indices and the head shapes with age, sex and race is crucial, and are essentials for treatment monitoring and prediction of orthodontic treatment at the same time the knowledge is valuable in plastic and reconstructive surgeries concerned with craniofacial deformities[7]. Nowadays it is mainly used to describe individual's appearances and estimating age of fetuses for legal, obstetrical reasons [8-12]. Also, it provides the roots for diagnostic comparison as in cases of Dolicocephalic (less prone to Otosis media), and in the individuals with Apert's syndrome who are Hyperbrachicephalic [13, 14].

Stature has a proportional biological relationship with every part of the human body, i.e. head, face, trunk, extremities. This relationship helps in calculating stature from dismembered and mutilated body parts in forensic examinations [15]. For such a calculation, two methods, i.e. regression method and multiplication method have been used, and it has been universally agreed that the regression analysis provides best results for stature estimation[16]. These regression equations are developed to estimate stature for a similar population. The estimated stature is then compared with both recorded and reported stature of missing individuals. If several of the identification factors, such as gender, ethnicity and age, as well as stature, concur with one individual, then he/she is generally considered identified.

The relationships in dimensions of the parts of the human body and whole body drew the attentions of Anatomists, Anthropologists and scientists for many years [17]. However this relationship between body parts has been used to investigate variations between sexes or ethnic groups and link them to their life style, pattern of locomotion as well as energy expenditure[18]. The purpose of the present study was to establish sexual dimorphism in cephalic index and its relationship with other anthropometric parameters.

It is an established fact that, relationships between body measurements does occur on account of variation in population and ethnic origin which could be linked to differences in nutrition and physical activity[19] .

There is scarcity of literature regarding cephalometric studies and its relationship with other anthropometric study in Nigerian population especially across the age group of 5-12years. This study can serve as an additional way of ascertaining the identity of victims using the available body fragments found in an accident scenes or even decomposed and mutilated body parts. And this is paramount especially in recent times due to increase cases of natural and man-made disasters like earthquakes and bomb blasts among others. Thus developing ways of making proper identification of victims using predictive equations is of great importance. Since height can be considered as one of the key elements in the identification. The objectives of the current study were to find the sexual dimorphism in cephalic indices and other anthropometric parameters. To also generating formulae for the estimation of height from cephalometric dimensions as well as other parameters of some body parts in Sabon Gari, Local government of Kaduna state Nigeria.

MATERIALS AND METHODS

Study location: The study was carried out among students attending Aminu LEA Model Primary school Sabon Gari, Zaria Kaduna State of Nigeria. The population of Sabon Gari is cosmopolitan as people from southern part of the country found settlements in the area. The largest Hallmark in the local Government is the Sabon Gari Market, which constitute peoples of different ethnic groups running their businesses on a daily basis. The neighbourhoods of Tudun Wada and Zaria city are predominantly occupied by indigenous Hausa that lives in traditionally mud-made houses Gihring [20].

Study population: This is cross sectional study consisting of 180 males, 171 females, summing up to 351 subjects aged between. Informed consent was obtained from the students and/ parent or guardian before commencement of data collection. In order to encourage more candidate and reliable responses, participants were made to complete a self-administered questionnaire. Apparently healthy volunteers were enrolled in this study with age range of 5-12years years belonging to the indigenous people of Sabon Gari Local government of Kaduna state only; participants with no obvious physical deformities were included. Exclusion criteria include participants who are less than 5years of age or older than 12 years of age. Also any participants who has amputated limb(s), those with diseases that will affect the desired measured parameters like edematous limbs, grossly deformed limbs or vertebral bone deformities like kyphosis or lordosis.

Anthropometry: Data were collected from participants using a predesigned questionnaire, sociodemographic statuses including Age, sex, were collected using the questionnaire while the anthropometric were measured using spreading vernier caliper, Stadiometer, Inelastic measuring tape and weighing balance at a point and positions respectively as follows:

Table 1: The general descriptive statistics for the study variables

Variables	Measurements	Instrument
Height	Subject was taken in th e anthropometric standing position with the head in the frankfort plane. Standing at one side of the subject using a mounted anthropometer. Vertical distance was measured between the standing surface and the top of the head (vertex) to the nearest 0.1cm	Stadiometer
Weight	The subject was barefooted and lightly dressed. Weight was taken to the nearest 0.1kg	Weighing balance
Body mass index	Calculated as weight (Kg) per height (m^2)	Formula
Head Length	It was measured in centimeter as the linear distance between the glabella and the opisthocranion.	spreading vernier caliper
Head Breadth I.	It was measured using a spreading vernier caliper were the bi -parietal diameter is taken	Spreading vernier caliper
Head Circumference	It was taken using an elastic tape , were the tape was wraped around the widest position of the head from the most prominent part of the forehead(often 1-2 fingers above the eyebrow) around to the widest part of the back of the head.	Inelastic Tape
Cephalic Index	Calculated as cranial width per cranial length times 100	Formula

Statistical analysis: The data were expressed as mean ± standard deviations (SD). Differences in means between male and female were obtained using student's t-test for continuous variables while Chi-suare tests for categorical variables respectively. Relationships between anthropometric measurements were investigated using the Pearson's correlation coefficient. Simple linear regression analyses were used estimate height from other anthropometric parameters. SPSS statistical software version 22 was used for all the analyses. $P \leq 0.05$ was set as level of significance.

RESULTS

Table 1 showed the general descriptive statistics for the study variables. From the table, this study showed the average height and cephalic index of the population are 128.11 ± 8.68 and 81.83±9.58 respectively which placed them in Brachicephalic type of head.

Table 2 showed the sex differences in study variables among the study population. From the table this study showed no significance sexual dimorphism in all the parameters ($P > 0.05$) even though men have higher mean values than females.

Table 3 showed correlation matrix of the study population n = 351. Height showed positive and strong correlations with weight in the total population and males than the other studied parameters while height showed strong correlation with age in female populations than the other parameters. Inverse weak correlation is seen between height and the cephalic index in both males and females and they are statistically significant.

Table 4 shows the equations for height estimation from anthropometric measurements of head dimensions and other body anthropometric parameters in the general population. The weight showed the strong correlation coefficient with better estimation ability as explained by the coefficient of determination (R^2) followed by age and then head circumference and head length respectively.

Table 5 shows equations for height estimations from anthropometric parameters of head dimension and some other body parameters in males (n = 180), weight predict height better than other parameters considered in the study.

Table 6 shows the equations for height estimation from anthropometric parameters of head dimension and some other body parameters in females (n = 171), weight predict height better than the other parameters followed by age and then head circumference and head length respectively.

Table 7 showed Sexual dimorphism in frequency distribution of head morphology based on their cephalic indices (n = 351), Brachycephalic is the predominant head type, but when gender was considered, male showed prevalent of brachycephalic while female showed prevalent of Hyperbrachycephalic but it's not statiscally significant as indicated by the Chi-square test.

Table 1: General descriptive statistics for the study variables

Parameters	Min – Max	Total n= 351 Mean ± SD
Age(years)	5 – 12	9.62±2.032
Height (cm)	99.0 -155.0	128.11 ± 8.68
Weight (kg)	15.0 - 50.0	26.140 ± 4.96
BMI (kg/m^2)	11.6 - 22.6	15.79 ±1.77
HC(cm)	45.0-54.6	50.39±1.48
HL (cm)	8.1-17.9	14.60±1.49
HB(cm)	8.8-15	11.87±1.23
CI	57.8-135.80	81.83±9.58

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 2: Student's test for sex differences in the study variables

Parameters	Males N= 180 Mean ± SD	Females N= 171 Mean ± SD	t	P
Age(years)	9.74±1.942	9.49±2.12	1.139	0.255
Height (cm)	128.61±8.284	127.57±9.07	1.116	0.265
Weight (kg)	26.52±4.95	25.74±4.96	1.462	0.145
BMI (kg/m^2)	15.89±1.74	15.68±1.81	1.114	0.266
HC(cm)	50.45±1.3799	50.33±1.5711	0.750	0.454
HL (cm)	14.65±1.49	14.56±1.50	0.586	0.558
HB(cm)	11.91±1.19	11.83±1.28	0.57	0.564
CI	81.85±9.48	81.82±9.71	0.022	0.982

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 3: Pearson's correlation (r) of anthropometric variables of the study population (n=351)

	Height		
Variables	All	Male	Female
Age(years)	0.686**	0.663**	0.704**
Weight(kg)	0.811**	0.809**	0.687**
BMI(kg/m^2)	0.186**	0.204**	0.318**
HC(cm)	0.519**	0.462**	0.571**
HL(cm)	0.516**	0.467**	0.681**
HB(cm)	0.177**	0.178*	0.364**
CI	-0.318**	-0.290**	-0.295**

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 4: Linear regression equations for estimations of height from anthropometric parameters of head dimension and some other body parameters of the study population n= 351)

Parameters	Predictive Equations	R	R^2	SEE	F	P
Age(years)	HT = 2.931*AGE + 99.916	0.686[a]	0.471	6.3201026	310.694	0.001
WT(kg)	HT= 1.418*WT + 91.032	0.811[a]	0.657	5.0873191	669.152	0.001
BMI(kg/m^2)	HT=0.909*BMI+113.748	0.186[a]	0.035	8.5379231	12.482	0.001
HC(cm)	HT=3.053*HC+-(25.707)	0.519[a]	0.269	7.4274488	128.652	0.001
HL(cm)	HT=2.995*HL+84.354	0.516[a]	0.267	7.4407072	126.951	0.001
HB(cm)	HT=0.164*HB+126.114	0.103[a]	0.011	8.6431639	3.732	0.054
CI	HT= -0.288*CI+151.673	0.318	0.101	8.238	39.259	0.001

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 5: Linear regression equations for estimations of height from anthropometric parameters of head dimension and some other body parameters in males (n = 180)

Parameters	Predictive Equations	R	R^2	SEE	F	P
Age(years)	HT=2.830*AGE+101.051	0.663[a]	0.440	6.2175337	139.770	0.001
WT(kg)	HT=1.355*WT+92.682	0.809[a]	0.654	4.8851523	336.747	0.001
BMI(kg/m^2)	HT=0.973*BMI+113.144	0.204[a]	0.042	8.1328200	7.724	0.006
HC(cm)	HT=2.775*HC+(-11.380)	0.462[a]	0.214	7.3665876	48.369	0.001
HL(cm)	HT=2.580*HL+90.799	0.467[a]	0.218	7.3468374	49.588	0.001
HB(cm)	HT=1.239*HB+113.855	0.178[a]	0.032	8.1753877	5.795	0.017
CI	HT=-.253*CI+149.344	0.290[a]	00.084	7.9506580	16.332	0.001

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 6: Linear regression equations for estimations of height from anthropometric parameters of head dimension and some other body parameters in females (n = 171)

Parameters	Predictive Equations	R	R^2	SEE	F	P
Age(years)	HT=3.011*AGE+98.996	0.704[a]	0.496	6.4537626	166.457	0.001
WT(kg)	HT=1.486*WT+89.331	0.813[a]	0.660	5.3002670	328.356	0.001
BMI(kg/m^2)	HT=.820*BMI+114.725	0.164[a]	0.027	8.9700724	4.649	0.032
HC(cm)	HT=3.261*HC+-36.556	0.565[a]	0.319	7.5012596	79.310	0.001
HL(cm)	HT=3.417*HL+77.830	0.564[a]	0.318	7.5083798	78.840	0.001
HB(cm)	HT=1.23*HB+113.04	0.174[a]	0.030	8.9542149	5.264	0.023
CI	HT=-.323*CI+153.993	0.346[a]	0.120	8.5311974	16.332	0.001

BMI=body mass index, HC=head circumference, HL= Head length, HB= Head breadth, CI =Cephalic Index,

Table 7: Sexual dimorphism in frequency distribution of head morphology based on their cephalic indices (n = 351) Chi-square (X^2 = 2.952, DF = 5, P = 0.707)

Head Shapes	Males(180)	Females(171)	Total(351)
Hyper-dolichocephalic	17(44.7%)	21(55.3%)	38(100.0%)
Dolichocephalic	22(48.9%)	23(51.1%)	45(100.0%)
Mesocephalic	32(55.2%)	26(44.8%)	58(100.0%)
Brachycephalic	47(57.3%)	35(42.7%)	82(100.0%)
Hyperbrachycephalic	34(46.6%)	39(53.4%)	73(100.0%)
Ultrabrachycephalic	28(50.9%)	27(49.1%)	55(100.0%)
Total	180(51.3%)	17148.7%)	351(100.0%)

DISCUSSION

The results of the findings in this study indicate that one can estimate height from different cephalic dimensions in situations where cephalo-facial remains are available for forensic examinations.

The height or stature estimation in these cases can complement the other personal identification data like estimation of age, gender, race, and identification from facial morphological characteristics as well as peculiar individualistic features [21].

The estimated stature would then be compared with both recorded and reported stature of missing individuals. If various identification factors, such as gender, ethnicity and age, and of course stature, are same with one individual, the identity is considered established.

The findings of the study show that the three cephalic measurements in both males and females are significantly correlated with stature.

However, according to Krishan [15], it must be kept in mind that precise prediction of stature from cephalic dimensions may be unachievable and unnecessary because there would always be an estimation error of a few centimeters.

It is a known fact that gender difference is an important factor in the morphological variation of human populations. This is because the rate of skeletal maturity in males and females vary during the course of growth and development[22]. In the present study, it was discovered that the male subjects had greater stature and cephalic dimensions when compared to the females although was not statistically significant (Table 2). The gender dimorphism observed in the study contradict previous observations by Ilayperuma [23] who reported that the males had significantly greater stature and cranial dimensions than the females, and Asha and Lashkmi [24] who stated that the males had significantly higher height and cephalic dimensions. Kumar et al [25] in their study also reported that the males had significantly higher stature and cephalic dimensions than their female counterparts.

The regression equation derived for estimating stature for this would be population-specific. Pearson's correlation test (Table 2) showed significant correlation between stature and head length, as well as between stature and head circumference in both genders. The highest correlation was found between stature and head length in both females (0.68; $p<0.001$) and male (0.467, $p<0.001$). The result implied that head length was a better predictor of stature in both females and males than the head breadth and head circumference, contradicting with research by Krishan (2008) but and supporting the study done by Asha and Lashkmi [24]. The significant correlation coefficients of stature and cephalic dimensions seen in this study contradicted the studies by Asha and Lashkmi [24]. The present study however is in line with the study by Krishan (2008) whose highest correlation was 0.781.

The degree of correlations in the present study proved that different body length could be used in height estimation in Nigeria. The study will help medical and legal practitioners to properly identify individuals in situation where body parts like hands or legs of body are available in accident, crime or disaster scenes [17]. The present study intends to establish these equations as addition to building anthropological baseline data for the Nigerians.

CONCLUSION

Male Hausa tend to have larger body proportion compared to female. Height showed positive and strongest correlations with weight length in the overall population, HT= 1.418*WT + 91.032. $R = 0.811^a$ and $R^2 = 0.657$which explains the accuracy and reliability of weight in height estimation of this study population than the other studied anthropometric parameters of this study. However, in terms of cephalometric dimensions, head length showed a better estimation ability than the other dimensions in this study population HT= 2.995*HL+84.354. $R = 0.516^a$ and $R^2 = 0.267$.

Conflict of Interest: None

Funding: None

Acknowledgments: I would like to thank the entire staff and management of Aminu Model Primary School Sabon – Gari Zaria, as well as the parents/guardians, and students that gave consent for this research to be conducted and made it possible.

Conflict of Interest: The authors declare that no conflict of interest.

REFERENCES

1. Kumar A. and Nagar M. Morphometric Estimation of Cephalic Index in North Indian Population: Craniometrics Study. International Journal of Science and Research (IJSR), 2015; 4 (4).
2. Vojdani, Z., S. Bahmanpour, S. Momeni, A. Vasaghi and A. yazdizadeh et al.,Cephalometry in 14-18 years old girls and boys of Shiraz, Iran high school. Int.J. Morphol., 2009; 27:101-104.
3. Rexhepi, A and M. Vjollca. Cephalofacial morphological characteristics of Albanian kosova population. Int. J. Morphol., 2008; 26:935-940.
4. Morant GM, Woo TL. A preliminary classification of Indian and Asiatic races. Biometrika. 1932; 24:108- 134.
5. Bolt C. Victorian attitudes to race. Routledge and Kegan paul, London, 1971; 212.
6. Shah GV and Jadhav HR. The study of cephalic index in students of Gujarat. J. Anat. Soc. India. 2004; 53 (1):25-26.
7. William P, Dyson M, Dussaak JE, Bannister LH, Berry MM, Collins P, Ferguson MWJ. Gray's Anatomy. In: Skeletal system, 38th Edn. Elbs with Churchil Livingston, London. 1995; 607-612.
8. Dubowitz, LMS, Goldberg C. Assessment of Gestation by ultrasound in various stages of pregnancy in infants differing in size and ethnic origin. Journal of Obstetrics and Gynecology, British common wealth. 1981; 88:225-229.
9. Gray DL, Songster GS, Parvin CA, Crane, JP. Cephalic index: A gestational age – Dependent biometric parameter. Obstetrics and Gynecology. 1989; 74(4):600-603.
10. Guihard Coasta AM. Estimation of fetal age from cranio facial dimensions. Bulletin of association of Anatomy (Nancy). 1988; 2(217-218):15-19.
11. Hadlock FP, Deter R, Carpenter RJ, Parker SK. Estimating fetal age: Effect of head shape on BPD. American Journal of Roentgenology. 1981; 137:83- 85.
12. Hern WM. Correlation of fetal age and measurements between 10 and 26 weeks of gestation. Obstetrics and Gynecology. 1984; 63(1):26-32.
13. Stolovitsky JP, Todd NW. Head shape and abnormal appearance of Tympanic membrane. Otolaryngol Head, Neck Surg., 1990; 102:322-325.
14. Cohen MM and Kreiborg S. Cranial size and configuration in the Apert's syndrome. Journal of craniofacial genetics and developmental biology. 1994; 14:95-102.

facial anthropometry in north Indian population. Forensic Sci Int. 2008. 181: 52.e1–52.e6.
16. Iscan MY. Forensic anthropology of sex and body size. Forensic Sci Int. 2005; 147: 107–12.
17. Jaafar Aliyu, Barnabas Danborno, Wilson O. Hamman, Ibrahim S. Aliyu, Lawan H. Adamu, Usman Affan. Sexual Dimorphism and Estimation of Height from Body Length Anthropometric Parameters among the Hausa Ethnic Group of Nigeria. Arab Journal of Forensic Sciences & Forensic Medicine; 2017; 1(6): 612-624 doi: 10.26735/16586794.2017.009
18. Ilayperuma I, Nanayakkara BG, Palahepitiya KN. A model for reconstruction of personal stature based on the measurements of foot length. Galle Med J. 2008; 13(1):6-9. https://doi.org/10.4038/gmj.v13i1.885
19. Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a Northn Indian population. J Forensic Leg Med., 2007; 14(6):327-32.https://doi.org/10.1016/j.jcfm.2006.10.008, PMid: 17239650
20. Gihring T. Intraurban activity patterns among entrepreneurs in a West African setting. *Human Geography (GeografiskaAnnaler Series)*. 1984; 66(1): 17–27.
21. Ukoha U. Ukoha, Kosisochukwu E. Umeasalugo, Onochie O. Udemezue, Lasbery A. Asomugha. Estimation of stature from Cephalic dimensions in a Nigerian Population Rev Arg de Anat Clin; 2015; 7 (1): 17-25
22. Williams PL, Bannister LH, Berry MM, Collins P,Dyson M, Dussek JE.. Gray's Anatomy: The anatomical basis of medicine and surgery.38th edition, New York, Churchill Livingstone. 2000
23. Ilayperuma I. On the prediction of personal stature from cranial dimensions. Int J Morphol 2010; 28: 1135-40.
24. Asha KR, Lakshmi PR. Estimation of stature from cephalic dimensions in Indian population. Anatomica Karnataka. 2011; 5: 1-5.
25. Kumar AA, Kachhwaha S, Googoolye K, Anishta A. Estimation of stature from cephalofacial dimensions by regression analysis in Indo-Mauritian population. J Forensic Leg Med., 2011; 18: 167-72.