Anthropometric investigation of cephalic parameters for stature estimation: Through regression analysis

ABSTRACT

Background: Stature or body height is one of the most important and useful anthropometric parameters which determines the physical identity of an individual. Cranium encompasses hard tissue components with approximately immortal behavior, reason being cranial measurements were selected for the present study for estimation of stature.

Objective: This investigation aimed to assess the stature of unknown using cephalometric parameters by creating equations through regression analysis.

Materials and Methods: We selected 361 dental students for the present research; among them, 210 were females and 151 were males in the age range of 21–32 years. Stature and cephalic parameters, i.e., fronto-occipital circumference, head length, and head breadth were measured for each contributor following standard methods and techniques. Cephalic Index was calculated by using the formula: Cephalic Index (CI) = (Head width/Head length) ×100. Karl Pearson's correlation coefficient of stature with cephalic parameters was calculated, and regression analysis was done to generate the formulae for stature estimation.

Results: Results indicated that all cephalic measurements have strong correlation with stature, and among them, circumference of head was found to be the most reliable predictor.

Conclusion: Stature of unknown or deceased can be identified using cephalic parameters as an auxiliary practice.

Keywords: Anthropometric, cephalic, regression analysis, stature

INTRODUCTION

Estimation of stature of an individual from unknown highly decomposed, fragmentary, and mutilated human remains had obvious significance in the personal identification for forensic analysis especially in the events of the murders, accidents, or natural disasters.[1] In human, evolutionary proportionate correlation prevails between the stature and other body parts which definitely provide a complementary requisite to evaluate the stature from disfigured body parts in forensic analysis.[2] In restoration of human body stature, estimation from various bones of the skeleton has been executed by various researchers with diversified values of precision.[3-12] In extreme situations where the evidences are incomplete and fragmented, sections of long bones have also been used for the estimation of stature by forensic anthropologists with great accuracy.[13] It is very common to miss some bones

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during the retrieval of unknown dismembered body, and usually in such cases, head is severed from the rest of body.[14] Relatively cranium does not decompose easily, and due to the presence of conventional and distinct landmarks,[14-16] we can make the use of skull in determining the height of unknown especially when more favorable interpreters like long bones or pelvis are not available or extremely disintegrated. For estimation, regression method and multiplication method have been extensively used by various anthropologists all over the world, and it has been invariably proposed that the regression analysis bring forth the synonymous stature in reconstructing the corpse that means it was universally concluded that the regression analysis provides best estimate for stature reconstruction.[2]

The current investigation was drafted to interpret the anthropometric interrelationship of cephalic parameters with stature and as well formulate gender-specific regression formulae.

MATERIALS AND METHODS

The present anthropometric investigation was carried out on selected 361 dental students, among which 210 were females and 151 were males in the age range of 21–32 years. Ethical clearance was obtained from the designated committee of our institute (Buddha Institute of Dental Sciences and Hospital with ref no. 851/BIDSH dated 06/09/22), and consent from all the contributors was prevailed. Participants who have undergone with any form of orthodontic or orthognathic treatment and craniofacial trauma or surgeries were excluded from the study as it will hinder further investigation results. Any subject with facial asymmetry or clinical features indicative of endocrinal disturbances, hereditary, nutritional, or developmental disorders were also eliminated from the study.

Anthropometric measurements and procedure followed:

Computation of stature was done when the participant was standing barefooted with their back to a caliber anthropometer scale and defined as the upright interspace from the plane to the vertex on the head.

Cephalic variables considered were maximal fronto-occipital circumference (CF), head width (HW), and head length (HL). CF was measured by placing non-stretchable plastic tape on occipital prominence and the supraorbital ridges around the head; HW and HL were measured using Martin's Spreading Caliper (Biotech Ltd., Agra, India); HW between the most lateral points of the skull, i.e., from euriyon- euriyon and HL from opisthocranion to glabella [Figure 1]. All the cephalic parameters were measured when the participant sitting on a stool in an ease posture with the head in a natural anatomical position.

Cephalic Index was calculated by using the formula given by Andres Retzius[17]:

Cephalic Index (CI) = (Head width/Head length) ×100

Statistical Package for Social Science (SPSS) version 10 was utilized for the computation of all the measurements. Descriptive statistics to note the mean and standard deviation of all variables were computed separately for males and females. Karl Pearson's correlation coefficient of all cephalic variables with stature was determined. Simple linear regression analysis was intended to generate the equations for estimation of stature using each of the independent parameters with gender specificity. Further, verification of these equations was done by assessing the difference between estimated and observed stature, and simultaneously, the best regressor was also determined by comparing these two.

RESULTS

In the present study, mean age of selected male subjects was 22.4 years (range = 21–30 years), while for female subjects, mean age was 22.2 years (range = 21–32 years). Mean stature for male participants was on higher side, i.e., 172.6 cm (range = 161–190 cm) as compared to female

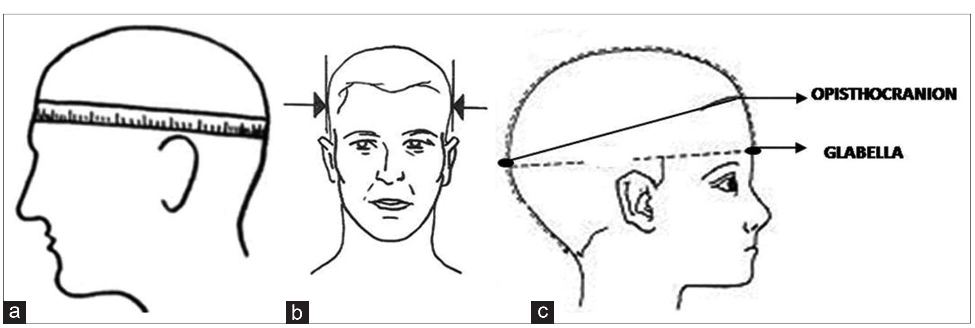

Figure 1: (a). Fronto- occipital c ircumference, (b). head width (euriyon- euriyon), (c). head length (opisthocranion to glabella)

participants, where mean stature was 158.5 cm (range = 146–174 cm). All cephalic measurements recorded exhibited statistically significant sexual dimorphism ($P < 0.05$) [Table 1].

Karl Pearson's correlation coefficient (r) was determined between stature and cephalic parameters with gender specificity. Regression analysis of the collected statistics generates the equations with formulae: stature (y) = a + bx, and the values of constants "a" and "b" are evaluated, where "a" is the regression coefficient of the dependent variable, i.e., stature, and "b" is the regression coefficient of the independent variable, i.e., different cephalic parameters considered in the present investigation. The deviation of estimated stature from the actual stature was determined using standard error of estimate (SEE) for each regression equation separately.

In our study, on analysis of cephalometric parameters, head circumference was found to be the best regressor with highest correlation coefficient followed by head length and head width; however, Cephalic Index was not showing positive correlation with stature. For females, SEE range is from 5.197 to 5.408 and from 5.995 to 6.278 for males [Table 2].

DISCUSSION

Stature is a structural feature which describes the identity of an individual in general and also for investigations pertaining to medico-legal cases.[18] Over the years, researchers not exempted any bone or part of the human skeleton starting from femur to metacarpals in stature determination.[1,3-12] Still there are conditions when these bones are not accessible, such situations forcing us to estimate body height from obtainable other body parts. Skull being identical to other bones of our body, therefore skull dimensions can also be genetically determined[19]; but as they also depend on environmental and dietary factors, their measurements are unique for each race and geographical region.[20] Henceforth, the present investigation was taken up to bring forth the statistics in defining the interrelationship of stature and cephalic measurements.

In our investigation, among cephalometric parameters, head circumference was found to be the best regressor (that means it shows highest correlation with stature) followed by head length and head width for both male and female participants. Two other researchers have reported similar findings in Indian population. Krishan[2] found head circumference to be the best cephalic variable in estimating stature for his study on 996 randomly selected adult males from 16 villages near Chandigarh City. Jadav and Shah[21] also assessed the association of cephalic length and stature in their study on Gujarati medical students and found a positive correlation.

Table 1: Descriptive statistics of age, stature, and cephalometric parameters for males and females with univariate analysis

Variable	Female			Male			*t*	*P*
	Mean	SD	Range	Mean	SD	Range		
Age	22.2	2.09	21-32	22.4	1.82	19-30	1.221	0.223
Stature	158.5	5.40	146-174	172.6	6.26	161-190	22.836	0.000*
CF	53.29	1.33	50-57	56.14	1.45	53-60	19.248	0.000*
W	13.06	0.63	11.4-15	13.61	0.74	11.1-15.7	7.623	0.000*
L	17.41	0.66	16-19.5	18.47	0.66	16.8-20	15.019	0.000*
CI	0.75	0.04	0.64-0.90	0.74	0.04	0.63-0.85	2.806	0.005*

*: Statistically significant

Table 2: Correlation coefficient of stature with cephalometry and linear regression analysis

Variable	*r*	Regression equation (y=a+ bx) [y→stature, x→variables, b→regression coefficient]	SEE	*P*
Female group (*n*=210)				
CF	0.280	y=98.32+1.13 CF	5.197	0.000*
W	0.147	y=142.16±1.25 W	5.354	0.034*
L	0.250	y=122.94+2.04 L	5.241	0.000*
CI	− 0.041	y=162.288 – 5.02 CI	5.408	0.558
Male group (*n*=151)				
CF	0.299	y=99.95+1.29 CF	5.995	0.000*
W	0.179	y=152.82+1.45 W	6.191	0.035*
L	0.194	y=138.66+1.84 L	6.165	0.017*
CI	0.044	y=168.09+6.10 CI	6.278	0.593

SEE: Standard estimate of error; *r*: correlation with observed stature. *: Statistically significant ($P<0.05$)

While it is interesting to note that Shalini *et al*.[14] also found higher correlation of head circumference with stature in 100 Mysorean population, the highest correlation was observed when they added three parameters together, i.e., combined mesiodistal width of maxillary anterior teeth, head circumference, and skull diameter. Reddy *et al*.[22] findings also indicate that all CF measurements are positively and significantly correlated with stature. The findings of the present study are also supported by Zakia *et al.*[23] They established ethnic specific anthropometric data for the Bangladeshi Garo tribal population, and in their results, head circumference showed significant positive correlation with stature.

In contrast, Sarangi *et al.* reported that the correlation coefficient between stature and somatometry of skull including maximum anterior–posterior length, maximum transverse length, and circumference in 220 autopsied cases was insignificant ($P > 0.5$). On the other hand, Chiba and Terazawa successfully estimated stature from somatometry of skull (diameter and circumference) in 124 Japanese cadavers. In their study, after excluding data from subjects aged 70 or more, the correlation coefficient became higher, rising from 0.38 to 0.60. It is possible that Sarangi *et al.* included many data from subjects aged 70 or more, as they did not mention the age of the subjects, which may have contributed to such a low correlation coefficient.[24] It is widely accepted that cranial morphology varies with the age of an individual (Wolf *et al.*, 2003; Knutson *et al.*, 2001). In addition, the height is also shown to progressively decrease with advancing age due to spinal cord shrinkage (Williams *et al.*).[25] Therefore, the derived equations should be population and age specific to attain accuracy.

So, the cranial dimensions have been shown to be a reliable and precise means in predicting the stature in Italian (Introna *et al.*, 1993),[26] Japanese (Chiba and Terazawa, 1998),[24] South African (Ryan and Bidmos, 2007),[27] Turkish (Can Pelin *et al.*, 2010),[28] and Sri Lankan populations (Ilayperuma, 2010)[25] as in Indians. In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposing cranial remains is vital in establishing the identity of an unknown individual. Therefore, formulae based on the cranial dimensions provide an alternative stature predictor under such circumstances. The cranium has easily identifiable surface landmarks making the measurements possible even in compromised conditions.[25]

CONCLUSION

From the present research, it has been concluded that equations created through regression analysis of cephalic parameters can be employed as an auxiliary practice in defining the stature of unknown when other long bones are not provided.

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Conflicts of interest

There are no conflicts of interest.

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