

Estimation of stature from head length in western Indian Gujarati adolescent population

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Abstract

Introduction and Objectives: Stature is a very useful indicator of a person's physical identity. One of the main objective of forensic investigation is establishing the identity especially when body parts are missing or mutilated. Stature estimation is an important step in positive identification of a person's identity and various body parameters can be used to correctly estimate the stature. The current study was aimed at developing regression equations and to find out correlation between stature and head length in Gujarati adolescent population.

Material and Methods: The study was conducted in 150 apparently healthy, adolescent medical students from various regions of Gujarat, India. The age of subjects ranged between 18 to 22 years. Head length and stature of the selected subjects were measured in erect posture. Obtained data were analysed to find correlation and derive regression equations for estimation of stature from head length.

Result: The mean stature and head length was significantly different in males and females. Both the mean stature and mean head length were higher in males than females. Pearson's correlation between stature and head length was significantly positive in both the sexes. We were also able to derive linear regression equations to correctly predict stature from the head length.

Conclusion: Significant positive correlation was found between stature and head length in the present study. We also present the gender specific regression equation models in order to estimate the stature from the head length in Gujarati adolescent population.

Keywords: Correlation, Head length, Stature.

Received: 23rd August, 2017

Accepted: 16th November, 2017

Introduction

Estimation of stature is one of the most important step in determining the identity of unknown, highly decomposed or mutilated human bodies as stature is one of the most important anthropometric parameter that determines the physical identity of an individual. Stature like other body parameters is determined by many factors such as genetics, environment and nutrition etc.¹ Stature has definite and proportional relationship with each and every part of human body and this relationship varies greatly in people of different area, race, ethnicity etc. By measuring the different body parts and stature of the healthy subjects, one can use the regression analysis method which is universally accepted to provide the best estimates for stature calculation for accurately predicting the stature in particular population or race.²

Establishment of identity is paramount in forensic examination where only some parts or fragments of the body are available. This is usually seen in incidents like earthquake, bomb blast, aeroplane crash, mutilation by animal etc.,

where calculating the stature correctly can prove to be a major step forward in establishing personal identity of an individual. Many studies have been done in the past to estimate the stature from various body parameters such as long bones, hand length, hand breadth, foot length, arm span etc³⁻¹⁴ but it has been found that cranial dimensions are more reliable in predicting the stature correctly.¹⁵⁻¹⁷ The aim of the current study was to establish the anthropometric correlation between stature and head length and to derive regression equations for correct estimation of stature in Gujarati adolescent population. The linear regression equations derived from this study can give the investigator an opportunity to estimate the height of an individual from the head length in forensic investigations. Determining an individual's physical description is also very useful in anthropological studies as well.

Material and Methods

For current study, total 150 apparently healthy, adolescent medical students from

different parts of Gujarat and the age ranged between 18 to 22 years. Out of 150, 72 were boys and 78 were girls. Necessary permission was taken from Institutional authorities. Stature was measured in standing erect anatomical position vertically in midline from heel to vertex. Head length was measured as a straight distance from the glabella to the opisthocranium using the spreading caliper (Fig. 1). All the measurements were taken in centimetres and during fixed time of the day to avoid any diurnal variation and by the same person to avoid personal error in methodology. Obtained data was statistically analysed by linear regression analysis.

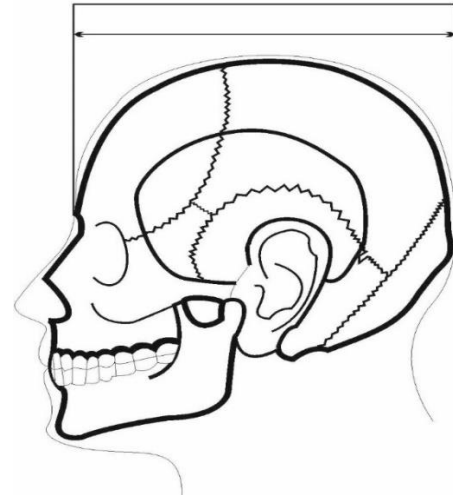


Fig.1: Showing measurement of head length as a straight distance from glabella to opisthocranium

Results

Table 1. Statistical analysis of stature and head length measurements in all subjects

	All (Male and Female)		Male		Female	
	Stature (cm)	Head length (cm)	Stature (cm)	Head length (cm)	Stature (cm)	Head length (cm)
Range(cm)	144.2-191	16.2-20.5	158.8-191	17.3-20.5	144.2-174.5	16.2-18.7
Mean(cm)	168.234	18.183	175.947	18.553	161.114	17.841
Standard Deviation (SD)	9.396	0.675	5.917	0.604	5.620	0.547
Correlation (r)	0.662 (p = 0.000)		0.262 (p = 0.026)		0.692 (p = 0.000)	
Regression Co-efficient (b)	9.207		2.521		7.109	
Constant of Regression equation(a)	0.822		129.173		34.290	

As shown in Table 1, head length varied from 17.3 cm to 20.5 cm with an average of 18.553 ± 0.604 cm of SD whereas the stature in males varied from 158.8 cm to 191 cm with an average of 175.947 ± 5.917 cm SD. In females, head length ranged from 16.2 cm to 18.7 cm with mean head length of 17.841 ± 0.547 cm SD, while the stature ranged from 144.2 cm to 174.5 cm with mean stature of 161.114 ± 5.620 cm SD.

The linear regression analysis of the obtained data has provided the regression equations for the estimation of stature and are as follows:

Stature (ST) = value of constant (a) + [regression coefficient (b) x head length (HL)]

For all (male and female): $ST = 0.822 + 9.207 (HL)$

For male: $ST = 129.173 + 2.521 (HL)$

For female: $ST = 34.290 + 7.109 (HL)$

Table 2: Comparison of measured stature with estimated stature from head length

Variable	Estimated Stature (cm) using Regression equation		P value representing the significance of difference between the measured stature and the estimated stature	Standard error of estimation (SEE)
	Range (cm)	Mean \pm SD (cm)		
All	149.975 - 189.566	168.229 \pm 6.218	0.994 (Not significant)	0.3258
Males	172.786 - 180.854	175.945 \pm 1.523	0.997 (Not significant)	0.1833
Females	149.456-167.228	161.222 \pm 3.891	0.987 (Not significant)	0.0375

Table 2 shows the comparison between the estimated stature and actual stature. The difference between the estimated stature and actual stature is non-significant. So, it can be said that stature can be predicted near accurately from head length using the regression equations.

Discussion

The estimation of stature from measurements of various parameters such as long bones, foot, hand, arm span, head has been attempted previously. Every race or population is different genetically and there by having differences in body parameters and therefore data analysis of one race or population cannot be applied to the others. Further, when the body is mutilated or only few body parts are available for examination, an accurate estimate of stature can be made if the relationship of different body parameters with stature is known in a particular race or population.

Table 3. Comparison of studies done by various authors

		Stature Mean \pm SD (cm)	HL Mean \pm SD (cm)	Correlation coefficient	P value
Chaurasia et al ¹⁸	M	170.905 \pm 11.339	18.420 \pm 1.272	0.241	0.000
	F	153.374 \pm 20.544	17.260 \pm 0.597	0.173	0.006
Ilayperuma et al ¹⁹	M	162.95 \pm 9.025	18.0 \pm 1.112	0.715	---
	F	152.48 \pm 11.498	17.19 \pm 1.011	0.470	---
Kalia S et al ²⁰	M	171.6 \pm 5.578	17.6 \pm 0.95	0.13	0.009
	F	155.67 \pm 5.266	16.4 \pm 0.59	0.00	0.712
Krishnan K ²¹	M	172.31 \pm 6.83	17.832 \pm 0.892	0.775	< 0.001
Zakia A et al ²²	F	152.79 \pm 5.62	17.49 \pm 0.58		0.774
Santosh Kumar et al ²³	M	170.432 \pm 4.6	18.047 \pm 2.54	0.941	---
	F	157.32 \pm 3.58	16.921 \pm 1.56	0.85	---
Agnihotri et al ²⁴	M	173.4 \pm 7.70	18.66 \pm 0.79	0.331	0.004
	F	157.36 \pm 6.17	18.13 \pm 0.91	0.159	0.176
Mahesh kumar et al ²⁵	M	-	18.75 \pm 1.386	0.174	0.0004
	F	-	17.75 \pm 0.847	0.190	0.0001
Present study	M	175.947 \pm 5.917	18.553 \pm 0.604	0.262	0.026
	F	161.114 \pm 5.620	17.841 \pm 0.547	0.692	0.000

M = Male, F = Female, HL = Head length

As shown in Table 3, the mean head lengths measured in this study were greater than Chaurasia RS et al,¹⁸ Ilayperuma I et al,¹⁹ Kalia S et al,²⁰ Krishan K,²¹ Zakia et al,²² Santosh Kumar et al,²³ but it was smaller than Agnihotri AK et al²⁴ & Maheshkumar et al²⁵ (male subjects) which indicates that cranial morphometry is greatly dependent on variety of factors like race,

age, nutritional factors etc. Although variety of methods have been used to estimate stature from various bone dimensions, regression analysis is one of the easiest as well as reliable method. Correlation coefficients between stature and head length in present study was 0.662 for all subjects, 0.262 for males and 0.692 for females.

Previous studies have shown correlation coefficient for males to be 0.241 by Chaurasia RS et al.,¹⁸ 0.715 by Ilayperuma I,¹⁹ 0.13 by Kalia S et al.,²⁰ 0.775 by Krishan K,²¹ 0.941 by Santosh Kumar et al.,²³ 0.331 by Agnihotri AK et al.,²⁴ and 0.174 by Maheshkumar et al.²⁵ Correlation coefficient for males in our study was found to be 0.262 which is more than that of Chaurasia RS et al.,¹⁸ Kalia S et al.,²⁰ and Maheshkumar et al.,²⁵ but it is less than correlation coefficient derived in the studies of Ilayperuma I,¹⁹ Krishan K,²¹ Agnihotri AK et al.,²⁴ and Santosh Kumar et al.²³ Similarly, in previous studies correlation coefficient for females was found to be 0.173 by Chaurasia RS et al.,¹⁸ 0.470 by Ilayperuma I,¹⁹ 0.00 by Kalia S et al.,²⁰ 0.850 by Santosh Kumar et al.,²³ 0.159 by Agnihotri et al.,²⁴ and 0.190 by Maheshkumar et al.²⁵ In the study of Zakia An et al.²² on Bangladeshi Garo adult females correlation between head length and stature was not significant while in our study we found a significant correlation ($r = 0.692$) between head length and stature. It is known that sexual dimorphism is an important factor producing morphological variations in biological populations.²⁶ The same gender divergence in cranial morphometry was also seen in the present as well as previous studies. In the present study, gender specific regression equations are obtained for adolescent population of western Indian Gujarati population.

Variety of factors such as age, race, gender and nutritional status affect the development and growth of the body and therefore separate regression models are required not only for the different populations but also for different genders within the same population. Therefore, we derived separate regression equations for all subjects, males and females. Using those regression equations, we were able to calculate the estimated stature from the measured head length. A comparison was made between measured stature and estimated stature and there was no significant difference between the measured and estimated stature for the head length. This indicates the effectiveness of the corresponding regression equation in the estimation of stature.

It is stated that racial characters are best defined in the skull.²⁷ Cranial dimensions constitute most important character for determining racial difference.²⁷ Stature varies greatly in different race. Based on this statistical analysis, it was found that head length is a good parameter to predict the stature correctly. This result further confirm that the cranial morphometric analysis provides precise and

good means in stature prediction. One should also remember that even though the regression equations show good accuracy, there would always be some error in estimation of stature.

Conclusion

The present study was carried out to investigate the possibility of estimating the stature of a person from head length by application of regression analysis. The regression equations derived were found to be fairly effective as estimated stature did not differ much from the measured stature and can be used in medico-legal, anthropological and clinical scenarios. As these data are population specific, the data of one population cannot be applied to other population or region.

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