Stature estimation from regression analysis of facial anthropometry in Indian population

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Abstract

Background: Stature or body height is one of the most important and useful anthropometric parameters which determines the physical identity of an individual. As craniofacial structures have the advantage of being composed largely of hard tissue which is relatively indestructible, the careful study of these can enable reliable determination of stature of the person in life. Studies pertaining to stature estimation from facial measurements are limited in an Indian population. The present investigation attempts to estimate stature from anthropometric dimensions of face.

Materials and Methods: The material for the present study comprises 361 Indian students (151 males and 210 females) in the age range of 21–45 years. Stature and six facial measurements were taken on each participant following standard methods and techniques. Karl Pearson's correlation coefficient and linear regression were done to estimate stature.

Results: The results indicate that facial measurements are strongly and positively correlated ($P < 0.001$) with stature. The accuracy of the computed equations was further tested on 50 randomly selected study participants of each group, which shows close approximation of actual and estimated stature.

Conclusion: Within the limits of this study, we conclude that facial dimensions can be used as a supplementary approach for the estimation of stature but with caution, as these are population-specific approach.

Keywords: Facial anthropometry, regression analysis, stature

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INTRODUCTION

In the field of forensic sciences, the main aim of using anthropometry is to supplement the law enforcement agencies in establishment of identity of unknown human remains. In highly decomposed and mutilated dead bodies, the routine methods have a limited role and it becomes difficult to identify deceased. In such situations, estimation of stature becomes equally important along with other parameters such as age, sex and race (The "Big four" of forensic anthropology).[1-3]

A proportional biological relationship of stature exists with every part of human body including head, face, trunk, extremities, etc., which plays a vital role in forensic examination to calculate the stature from dismembered and mutilated body parts.[3] Reconstruction of stature from

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various bones of the human skeleton has been achieved by many scientists with varying degree of accuracy.[4-7] Even foot and shoe print length are not exempt from scrutiny.[8] It is frequently observed that during forensic and archeological excavations, all the bones of the individual are usually not retrieved, and it is common to have the head amputated from the trunk in mutilated body.[9] Consequently, craniofacial structures being relatively resistant to decay and their anatomical landmarks are standard, well defined and easy to locate;[9-11] therefore, careful study of these can enable reliable determination of stature of the person in life, particularly when preferred predictors such as the pelvis and long bones are destroyed or fragmented.

Looking at the paucity of studies pertaining to estimation of stature from facial anthropometry in India and usefulness of these studies in forensic and legal medicine, the present study was designed to elucidate the anthropometric correlation of facial dimensions with stature and also devises gender-wise regression formulae using these dimensions for stature estimation in the Indian population, the study is further aimed to test the accuracy and validity of these derived regression formulae within the sample.

MATERIALS AND METHODS

Sample

After obtaining the institutional ethical clearance and informed consent from all the participants, a cross-sectional study was done on 361 healthy Indian students (151 males and 210 females) in the age range of 21–45 years from our dental college. Participants with history of orthodontic and orthognathic treatment, craniofacial trauma or surgery, history and/or clinical features suggestive of endocrinal disturbances, hereditary, nutritional and developmental disorders and facial asymmetry were excluded from the study.

Anthropometric measurements and techniques

Stature was measured as the vertical distance from the plane where the participant stands barefooted to the vertex on the head with their back to a standard anthropometer scale. Facial anthropometric parameters were total facial height (TFH) measured as the straight distance from nasion to gnathion; physiognomic facial height (PFH) measured as distance between trichion to gnathion; external biocular width (EBW) measured as distance between ectocanthion; inernal biocular width measured as distance between endocanthion; bizygomatic arch width measured as distance between two prominent zygia and bigonial width (BGW) measured as distance between either side of prominent mandibular gonial angle [Figure 1]. These were taken with the participants sitting on a stool in a relaxed state with the head in an anatomical/natural head position.

Equipment

The measurements were taken with the help of standard anthropometer scale, digital vernier caliper (Mituyoto, Japan, precision value ± 0.01 mm) and Martin's spreading caliper (Biotech Ltd., Agra, India), and these were checked regularly before usage for precision and accuracy.

Statistical analysis

All measurements were entered into Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.). Karl Pearson's correlation coefficient of all facial parameters with stature was calculated. Simple linear regression analysis was done and regression equations were derived to estimate the stature using each of the independent variables for males and females separately. After deriving estimation of stature from these tested equations, the difference between the estimated and observed stature was computed to note the best regressor for estimation of stature. Finally, the accuracy of the computed equations was tested on 50 randomly selected study participants from each group.

RESULTS

The mean age of male participants was 22.4 years (range = 21–30 years) and mean stature was 172.6 cm (range = 161–190 cm), while for female participants, the mean age was 22.2 years (range = 21–32 years) and mean stature was 158.5 cm (range = 146–174 cm).

Karl Pearson's correlation coefficient (r) of stature with facial anthropometric parameters was obtained separately for males and females and subsequently by combining male and female participants. Regression equations have been calculated by regression analysis of the data with stature (y) = a + bx and the values of constants "a" and "b" are calculated where "a" is the regression coefficient of the dependent variable, i.e., stature and "b" is the

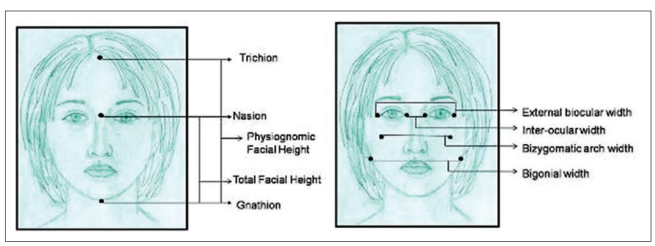

Figure 1: Facial anthropometric parameters

regression coefficient of the independent variable, i.e., any facial measurements considered in the study. The standard error of estimate was calculated for each formula, which depicts the deviation of estimated stature from the actual stature.

All the parameters showed positive correlation with stature significantly ($P < 0.05$) except internal biocular width in males. Our results also suggest that among them, the best regressor for females was physyognomic facial height ($r = 0.300$), followed by TFH ($r = 0.269$) and BGW ($r = 0.263$). For males, the best regressor was bigonial width ($r = 0.445$), followed by physyognomic facial height ($r = 0.282$), EBW ($r = 0.258$) and TFH ($r = 0.257$) [Table 1].

Mean difference between the actual stature and estimated stature (from the derived regression equation) for best regressors were calculated for each group, in 50 randomly selected participants of original sample. On closer examination of the accuracy of the formulas, we found that bigonial width had the least difference between observed and estimated stature (mean) in females (0.19), whereas it was lowest for TFH for males (0.14) [Table 2].

Table 1: Correlation coefficient of stature with facial anthropometry and linear regression analysis

Variable	*r*	Regression equation (y=a + bx)	SEE	*P*
Female group (*n*=210)				
PFH	0.300	y=117.08+0.26 PFH	5.163	0.000*
TFH	0.269	y=132.82+0.24 TFH	5.213	0.000*
EBW	0.171	y=138.84+0.21 EBW	5.333	0.013*
IBW	0.192	y=144.92+0.45 IBW	5.313	0.005*
BZB	0.152	y=143.33+0.15 BZB	5.350	0.028*
BGW	0.263	y=126.82+0.35 BGW	5.222	0.000*
Male group (*n*=151)				
PFH	0.282	y=138.08+0.20 PFH	6.029	0.000*
TFH	0.257	y=142.06+0.27 TFH	6.073	0.001*
EBW	0.258	y=131.05+0.42 EBW	6.071	0.001*
IBW	0.080	y=166.22+0.20 IBW	6.264	0.327
BZB	0.184	y=150.56+0.20 BZB	6.176	0.024*
BGW	0.445	y=107.19+0.66 BGW	5.627	0.000*

*Statistically significant ($P<0.05$). *r*: Correlation with observed stature, y: Stature, x: Variables, b: Regression coefficient, SEE: Standard estimate of error, PFH: Physiognomic facial height, TFH: Total facial height, EBW: External biocular width, IBW: Internal biocular width, BGW: Bigonial width, BZB: Bizygomatic breadth

Table 2: Comparison of actual stature and estimated stature from selected facial measurements in 50 randomly selected participants of each group

Female		Male	
Variable	MD	Variable	MD
PFH	0.36	BGW	0.58
TFH	0.33	PFH	0.30
BGW	0.19	EBW	0.30
-	-	TFH	0.14

MD: Mean difference between actual and estimated stature, PFH: Physiognomic facial height, TFH: Total facial height, BGW: Bigonial width, EBW: External biocular width

DISCUSSION

Stature is an inherent characteristic, which constitutes an essential element in the description of an individual, for physical anthropological and medicolegal investigations.[12] In the past, scientists have used each and every bone of the human skeleton right from femur to metacarpals in estimation of stature.[2,4-7] However, when these bones are not available, measurements from other body parts should be used to predict body height.

Stature estimation from the cephalofacial region can always supplement the identification data collected using the techniques of facial reconstruction and consequently can help in narrowing down the process of forensic investigation.[3] Studies concerning the estimation of stature from facial dimensions are limited in the Indian population. Therefore, the present research aimed to provide the valuable data pertaining to the correlation of stature with facial dimensions for Indians. Here, we used the regression method, as it has been universally concluded that the regression analysis provides best estimate for stature reconstruction in comparison to multiplication method.[3]

Our results suggest that among facial parameters, the highest correlation of stature is found to be with PFH for females and bigonial width for males. Similarly, Kumar and Lilichandra found bigonial width to be the most reliable facial parameter for estimation of stature in males of Manipur.[13] Among all studied parameters, the best independent variables to estimate stature were bigonial width, PFH and TFH. For males, EBW was also among the best variable for estimation of stature. Wankhede *et al.* had studied 470 healthy medical students from the Central India and noted that in males, TFH ($r = 0.19$), whereas in females, nasal height ($r = 0.19$) had greater correlation with stature.[14] The findings of the community-based study done by Kewal Krishan in male Gujjars indicate that the cephalofacial dimensions can also be used for estimation of stature with the fact that cephalic region give better reliability of estimate than that of the facial measurements.[3]

To ascertain the validity of computed regression formulae of individual group, mean difference between observed and estimated stature was calculated for best regressors of each group in 50 randomly selected participants. On closer examination, we found that mean difference between observed and estimated stature ranges from 0.19 to 0.36 cm for females, 0.14–0.58 cm for males. This shows close approximation of actual and estimated stature which is due to the fact that regression equations are calculated from measures of central tendency.

As discussed earlier that these equations are population and age specific, the present study also contributes by the fact that gender specificity of the equations is also required for accurate estimation of stature.

CONCLUSION

- Regression equations generated from facial dimensions can be used as a supplementary approach for the estimation of stature when extremities are not available but with caution as these are population specific and cannot be used on other populations of the world
- Further investigations should be carried out on large sample by considering ethnic and community background.

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Conflicts of interest

There are no conflicts of interest.

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