e-ISSN: 0975-1556, p-ISSN:2820-2643

Available online on www.ijpcr.com

International Journal of Pharmaceutical and Clinical Research 2023; 15(5); 2235-2244

Original Research Article

A Study of Stature Estimation from Facial Anthropometric Parameters by Regression Analysis in Central Indian Population

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Received: 20-03-2023 / Revised: 11-04-2023 / Accepted: 05-05-2023

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Conflict of interest: Nil

Abstract

Introduction: Forensic identification of human remains is important for both legal and humanitarian reasons. In forensic science sex, age, race and stature plays key role in human identification. Stature can be best estimated using long bones such as femur and tibia. Sex and race of and individual can be identified by pelvis and skull. Estimation of stature in case of destroyed, fragmented and mutilated limbs become difficult. Keeping this in mind the present study has been conducted to find out the correlation between facial anthropometric parameters and stature in Central Indian population.

Materials & Methods: The study was conducted in the department of Anatomy at Sri Aurobindo Medical college & P. G. Institute, Indore, Madhya Pradesh. Present study was carried out from August 2022 to December 2022. A total of 500 (250 male & 250 female) students in the age group of 18 to 25 years were taken with equal distribution of both genders. 250 students from each sex were taken from MBBS, BDS, BPT, Nursing courses. Height was measured by using stadiometer, facial length & width were measured by using Vernier calipers. Karl Pearson's correlation coefficient was used for correlation between facial parameters and stature followed by regression equation was derived. SPSS version 26 was used for statistical analysis.

Results: The correlation coefficient between stature and facial length was 0.560 with p value 0.001 and between stature and facial width it was 0.449 with p value 0.001.

Conclusion: Both facial length and facial width have positive correlation with stature, i.e. if anyone of the parameters increases or decreases accordingly the stature increase or decreases. The regression formula derived from this study to estimate stature from facial length and width in central Indian population is,

Stature (in cms) = (6.184 X Facial length + 4.252 X Facial width) + 46.550.

Keywords: Anthropology, Body Height, Human Remains, Human Identification.

Introduction

Anthropometry is a science which deals with expressing human form in numbers. This is widely used for human identification in forensic science for legal or for humanitarian purpose via features like sex, age, race and stature. Determination of sex and stature of an individual is the most important aspect of human identification apart from race and age [1]. Relationship between various body measurements and the stature was first conducted by Rollet in the year 1888-89 [2]. Stature estimation is very important and considered as one of the "big four" (age, sex, stature and ancestry or race) component of human identification in forensic anthropology [3].

Proportional biological relationship of stature exists with every part of human body including face, head, trunk and extremities etc. Pearson in his study mentioned regression equation derived for various parameters and stature were population specific [4]. Determination of sex and estimation of stature of a subject is one of the most important aspects of medicolegal cases and anthropological research [1,2].

The anthropometric analysis for sex and stature estimation provides relatively fast and accurate data from skeletal material. Pelvis and Skull are most reliable bones for sex determination [5] and for the stature estimation long bones such as femur and tibia are most reliable [6,7,8]. Skull is an integral part of the identification process and it is preferred because it is considered as the second-best region after the pelvis for purposes of identification. It is composed of hard tissue and it is the best-preserved part of the skeleton after death, hence in many cases it is the only part available for forensic examination [5,6].

It is frequently noticed that during forensic and archaeological excavations, all the bones of the individual are usually not retrieved, and it is frequently observed 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 [9,10,11]. Therefore, careful study of these can enable reliable determination of stature of the person. Sex and race of and individual can be identified by pelvis and skull. For estimation of stature in case of destroyed, fragmented and mutilated limbs become difficult. Importance of such studies in forensic science and legal medicine, keeping this in mind and also the paucity of data pertaining to estimation of stature from facial anthropometry by regression analysis in central India, the present study has been carried out.

Aim: To find out the correlation between facial anthropometric parameters and stature in Central Indian population.

Objectives:

- To study the correlation between stature and various facial parameters (facial length and facial width).
- To find out gender differences between stature and facial parameters.
- To derive the regression formula to predict the stature using different facial parameters

Material and Methods

The study was conducted in the department of Anatomy at Sri Aurobindo Medical College & P. G. Institute, Indore, Madhya Pradesh. It was cross sectional study conducted between August 2022 to December 2022. After ethical clearance (SAIMS/IEC/18/22) and consent, 500

students were included in the study with equal distribution in male and female. 250 students from each sex were taken from MBBS, BDS, BPT, Nursing courses. The students were within the age group of 18 to 25 years. Sample size was calculated as mentioned below.

Sample Size – Sample size formula for correlation, C=0.5. Ln (1+r)/(1-r)

N= (z+zC) 2 +3 (Ref as per 11)

Where,

z= 1.96 at 5% level of significance z= 1.2816 at 90% lower of test r = correlation coefficient value from reference article (i.e 0.152).

As per the formula the minimum sample required was 451 students.

Inclusion Criteria - Healthy individuals without any skeletal deformity in between the age group of 18 to 25 years were included.

Exclusion Criteria:

- Students with a history of trauma or surgery of the skull, face and spine, craniofacial bony deformities and facial asymmetry.

The subjects were studied for the following parameters:

- Height.
- Morphological facial length.
- Facial width / bizygomatic width.

The instruments used in this study were: Spreading calipers, Sliding caliper, Stadiometer.

Measurements: Informed consent was taken before taking measurements. One female volunteer took the measurement of all female subjects, whereas one male volunteer took the measurements of all male subjects. The data obtained from each subject was recorded with their basic information and the statistical analysis was done.

Stature: It is a measure of vertical distance from vertex to floor height. Height was measured from vertex to floor by stadiometer, with the subject standing erect on an even or plane smooth floor. Subject was standing barefoot with heels together and weight evenly distributed between both feet. The subject was advised not to change the position while measurements was taken. Also, the back was kept as straight as possible with no slouching. The measurements were taken between 2pm to 5pm, which was done to negate any diurnal variation in the measurements. The head was kept in the Frankfurt plane to accurately record the stature of the individual as shown in the Table/fig 1.

Frankfurt plane - It is the plane passing through the lowest points on the infraorbital margins and the tragion. Tragion is the notch just above the tragus of the ear.

Facial height: It is the straight distance from the nasion to the gnathion. Nasion - It is the median point at the root of the nose, where the internasal suture meets with the frontonasal suture. Gnathion - It is the lowest point of the lower border of the mandible, in the midsagittal plane. The subject was instructed to relax the jaw such that the teeth are not clenched and also the jaws were closed without any movement. The subject was instructed to look forward while the sliding caliper is scrolled down from nasion to gnathion as shown in the table/fig 2 and the facial height was recorded.

Facial width: It is the width between the most lateral points on the two zygomatic arches. The participant or subject was asked to look forward. The extent of the zygomatic arches was first palpated. Then the tips of the caliper were moved most outward pints on the zygomatic arches to measure the width as shown in the table/fig 3.

Figure 1- Stature Measurement **Figure 2 Facial height measurement**

Figure 3 Facial width measurement

Statistical analysis: The data was collected and entered in MS excel 2010. Statistical analysis was performed using SPSS version 26 (trial version). Karl Pearson's correlation coefficient of all facial parameters with stature was calculated. Simple linear regression analysis was done and regression equation was derived to estimate the stature using each of the independent variables for males and females separately.

Results

All the data of 500 students (250 males and 250 females) recorded, tabulated and statistically analyzed, and the correlation of stature with facial parameters (facial length and facial width) among male and female within an age group of 18 to 25 years were compared as shown below. In the sample size of 500 (250 each males and females) the mean age of subjects (n=500) was 20.24 years with Standard Deviation (SD) of 1.377. Minimum age of subjects was 18 and maximum age was 25 as shown in the table/fig 4. The means (along with SD) of stature, facial length and facial width have been depicted in the table/fig 4. The mean stature was 163.01 cm (range 144 cm to 194 cm). To find out the relation between facial parameters like facial length and facial width with stature, the Karl Pearson's correlation coefficient

was used followed by regression analysis was done. From the above observations from Table/fig 5 & 6, it can be conferred that, the facial length and facial width have significant correlation with stature ($p < 0.001$). It was also observed that Pearson's correlation value (r value) between facial length and stature is 0.560 and 0.449 is between facial width and stature indicating positive correlation. These correlations are positive and statistically significant ($p < 0.001$) i.e. if any of the above parameter increases or decreases the height of the subject also increases or decreases respectively. The r value for facial length is slightly higher than 0.5 and for facial width its slightly less than 0.5, so we can say these are positively correlated with stature in central Indian population. Unpaired T test was used to find out the gender differences among facial parameters and stature. The mean values of stature, Facial length and Facial width are higher for males than those for females and the difference is found to be statistically significant ($p<0.05$) as shown in table/fig 7. Regression analyses enable us to predict the values of one variable on the basis of another variable (Table/fig. 8, 9). In our study we have included both facial length and facial width (independent variables) together to calculate the stature (dependent variable).

$Y = a + bX$, Where, Y = Height (dependent variable), X = independent variable (facial parameters), a = intercept (constant) and b = regression coefficient. Regression formula, Dependent Variable: Stature (cm), Stature = 6.184×Facial length + 4.252×Facial width + 46.550.

Table 4: Shows mean, standard deviation and range of (Age, stature, facial length & facial width) in subjects

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
Age	500	18	25	20.24	1.377
Stature (cm)	500	144.00	194.00	163.0138	9.36439
Facial length (cm)	500	9.20	13.40	10.9498	0.69831
Facial width (cm)	500	9.10	13.60	11.4668	0.64997

Table 5: Correlation between stature and facial parameters

Parameters	Correlation coefficient value	P-Value
Stature Vs Facial length	0.560	0.001
Stature Vs Facial width	0.449	0.001

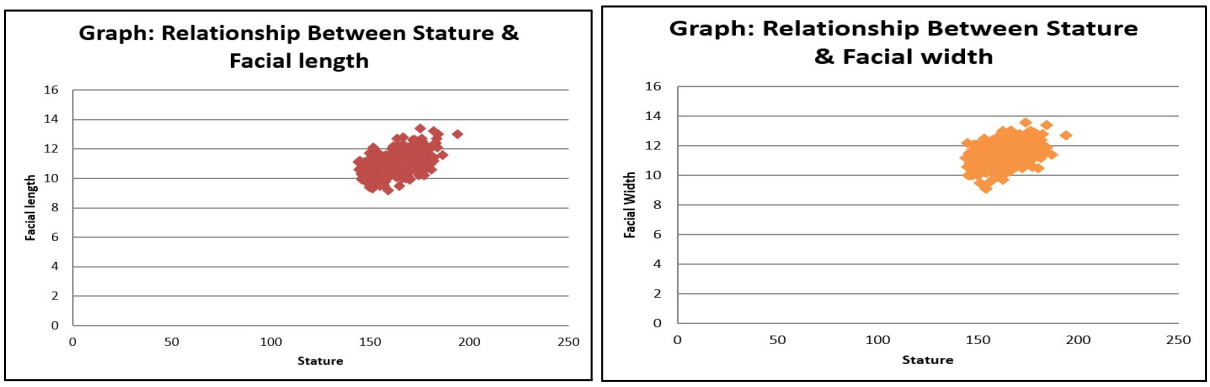

Figure 6: Relation between stature and facial parameters (Facial length and facial width)

Table 7: Gender differences between stature and facial parameters

S. No.	Parameter	Female (Mean ± SD)	Male (Mean ± SD)	Independent T test	DF	P-value
1	Stature (cm)	156.119 ± 5.744	169.909 ± 6.876	24.336	498	0.001
2	Facial length(cm)	10.62 ± 0.551	11.28 ± 0.676	11.898	498	0.001
3	Facial width(cm)	11.14 ± 0.565	11.79 ± 0.564	12.807	498	0.001

Table 8: Regression variables

Model Fit	R	R Square	F test	DF	Sig. F Change
ANOVA	.625[a]	.391	159.261	497	.000

Table 9: Derivation of regression formula to predict the stature using facial parameters

Parameters	Unstandardized Coefficients		Standardized Coefficients	t	P-value
	B	Std. Error	Beta		
(Constant)	46.550	6.721		6.926	0.000
Facial length (cm)	6.184	0.498	0.461	12.413	0.000
Facial width (cm)	4.252	0.535	0.295	7.944	0.000

Discussion

The present study was cross-sectional and carried out to find out the correlation between stature and facial parameters. The correlation coefficient between stature and facial length was 0.560 with p value 0.001 and between stature and facial width it was 0.449 with p value 0.001. indicating both facial length and facial width have positive correlation with stature, i.e. if anyone of the parameters increases or decreases accordingly the stature increase or decreases. The regression formula derived from this study to estimate stature from facial length and width in central Indian population is, Stature (in cms) = (6.184 X Facial length + 4.252 X Facial width) + 46.550. Comparative statistical analysis among both genders revealed that values of facial parameters are significantly higher in males as compared to females. The result of present study showed that the stature can be estimated from the facial dimensions by applying regression equation. Stature estimation has been considered as one of the important parameters in forensic anthropology which will assist in establishing the biological profile of an individual. Studies concerning to the estimation of stature from head and facial dimensions are relatively less common as compared to the estimation of stature from extremities [12]. The stature estimation from various other body parts such as extremities, bones and facial parameters varies not only because of the sex differences but also because of ethnic, dietary, climatic variation among individuals [13,14].

In present study (central Indian population), correlation coefficient of stature vs facial length in was 0.560 but study done by Krishnan K et al it was 0.455 (north Indian population) but he took only male participants under consideration in his study [13], whereas we have taken both male and female participants. The result of the present study

is compared with similar available studies of specific population / areas of India (table/fig 10) [13 to 24]. Our present study includes the Central Indian population, a similar type of study on central Indian population conducted by Wankhede KP et al [15], the correlation coefficient was 0.197 in males and 0.144 in females, indicating very weak positive correlation between facial parameters and stature as compared to our study. Similarly, another study on central Indian population done by Kanchan et al also showed weak positive correlation [19]. The only study showed negative correlation between stature and facial width in males as well as females was carried out on Managundi population Dharwad, however it is not statistically significant [24]. In the present study the regression formula was formulated including both facial parameters. Facial length and facial width were also compared with other studies shown in the table/fig 11. In the present study the mean Facial length was 11.28 ± 0.68 cm in males and 10.62 ± 0.55 cm in females and gender differences in mean facial length in our study was statically significant indicating higher values in males.

The studies conducted by Krishan K [13], Krishan K & Kumar R [14], Jibonkumar [16] & Priti [23] Lilinchandra [16] derived their regression equation for estimation of Stature separately by using both variables (Facial length & Facial width). Wankhede KP [15] et al. also derived the regression equation using same method but he has not taken facial width as criteria in his study and given equations individually for males and females for stature estimation using facial length, but in the present study we have derived the regression equation for stature estimation by incorporating both independent variables i.e. (Facial length & Facial width) and the regression formula is, Stature = 6.184×Facial length + 4.252×Facial width + 46.550. Such type of studies are of utmost important in medico-legal cases in forensic sciences and forensic investigations where the first priority is of establishing the identity of the deceased specially in incidences where the body parts have been mutilated or only a part of the body is available. From anthro-pological point of view such studies will help in knowing the differences between different populations.

Table 10: Comparison of correlation coefficient and linear regression equation of stature, facial length and facial width, FL- Facial length, FW- Facial width, S- stature

Author	Country/ Region (sample drawn)	Gender	Correlation coefficient		Regression Equations	
			Facial Length	Facial Width	Facial Length	Facial width
Krishan K 2008 [13]	North Indian	M	0.455	0.462	121.869 + 4.618FL	109.991 + 6.48FW
Krishan K & Kumar R 2007 [14]	North Indian	M	0.345	0.449	122.461 + 2.983FL	122.200 + 8.371FW
Wankhede KP et al 2012 [15]	Central Indian	M	0.197		156.34 + 1.28FL	
		F	0.144		144.96 + 1.12FL	
Jibonkumar & Lilinchandra 2006 [16]	Manipur	M	0.213	0.365	141.261 + 1.869 FL	107.004 + 3.913FW

Sahni et al.2010 [17]	North Indian	M	0.219	0.064		
		F	0.181	0.047		
Kharyal et al [18]	Himachal Pradesh	M	0.39			
		F	0.35			
Mahesh Kumar et al [19]	Haryanvi	M	0.177			
		F	0.15			
Sichal Datta et al [20]	Maharashtrian	M	0.1669	0.2502		
		F	0.2721	0.2495		
Agnihotri et al [21]	Indo Mauritian	M	0.32			
		F	0.16			
Priti et al [22]	Maharashtrian	M	0.560	0.631	S=4.5001FL+119.41	S=7.3336FL+99.191
		F	0.661	0.503	S= 5.2863FL+102.5	S= 4.3624+118.37
C.Pokhrel et al [23]	Nepalese	M	0.327	0.175	S= 119.179+3.974 FH	S=145.919+1.786 FW
		F	0.205	0.255	S=134.751+1.790 FH	S= 137.546+1.571 FW.
Pooja et al [24]	Managundi,Dharwad	M	0.45	- 0.06		
		F	0.369	-0.100		
Present study	Central India	Both	0.560	0.449	S= 6.184×FL + 4.252×FW + 46.550	

Conclusion

The present study was carried out on 500 students. The facial parameters such as facial length and facial width have significant correlation with stature ($p < 0.001$). It was also observed that Pearson's correlation value (r value) between facial length and stature is 0.560 and 0.449 is between facial width and stature indicating positive correlation in Central Indian population. As the r value for both facial length and width is around 0.5, so the regression equation generated can be used as supplementary approach to determine the stature in Central Indian population when other body parts and extremities are not available. The regression formula derived can be used as supplementary approach to estimate the stature in Central Indian population only, as it is population specific.

Source of Funding: This research is funded by ICMR.

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