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CORRESPONDING AUTHOR:

Sidarth Timsinha

Associate Professor, Birat Medical College and Teaching Hospital, Nepal.

Email: drsidarthforensicmedicine@gmail.com

Orcid: <https://orcid.org/0000-0003-3707-3855>

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Estimation of Stature From Facial Dimensions. A Cross-Sectional Study Among Nepalese Medical Students in Eastern Nepal

Sidarth Timsinha¹, Dikshanta Pokharel², Rajesh Kumar Shah¹, Surya Bahadur Parajuli¹, Sajjad Ahmed Khan³

¹ Associate Professor, Birat Medical College and Teaching Hospital, Nepal.

² Lecturer, Birat Medical College and Teaching Hospital, Nepal.

³ Final MBBS student, Birat Medical College and Teaching Hospital, Nepal.

ABSTRACT

Introduction: Estimation of stature or height is critical in forensic and medicolegal examinations, for establishing the identity of a living or dead individual. Since craniofacial structures are mostly made of hard tissue that is generally indestructible, careful examination of these can provide a good estimate of the stature of an individual.

Objective: To estimate stature from morphological facial height and bizygomatic breadth of the face and to develop regression formulas for estimating stature based on two facial measurements among Nepalese medical students.

Methodology: This prospective cross-sectional study was conducted from December 2022 to June 2023, in the Department of Forensic Medicine at Birat Medical College and Teaching Hospital after obtaining ethical clearance from the Institutional Review Committee (IRC). A total of 216 preclinical Nepalese medical students were included in the study, comprising 107 males and 109 females aged 18 to 26 years. Stature and two facial measurements i.e., morphological facial height and bizygomatic facial breadth were measured on each participant following standard methods and techniques. Karl Pearson's correlation coefficient and linear regression were used to estimate stature.

Results: The average height of males and females was 170.70(±5.59) cm and 156.92(±5.58) cm respectively. The stature and facial measurements of males were significantly higher than females ($p < 0.05$). Morphological facial height showed a better correlation of stature with a higher "r" value of 0.297 in males and 0.268 in females than Bizygomatic breadth with a lesser "r" value of 0.278 in males and 0.214 in females.

Conclusion: The correlation coefficient (r) between stature and morphological facial height and bizygomatic facial breadth measurements was less than 0.5. This implies that the estimation of stature is less reliable with the help of these facial measurements. These facial measurements can be used in the absence of other better parameters such as long bones or when simply facial remains are brought in for forensic examination.

INTRODUCTION

Stature, or body height, is one of the most important parameters to determine the physical identity of an individual.¹ Estimation of stature plays a crucial role in forensic and medicolegal examinations, contributing to the process of identifying and understanding individuals involved in various situations, both living and deceased. The forensic pathologist is often required to give an opinion regarding personal identification of the deceased, especially when unknown, highly decomposed, mutilated bodies and fragmentary like cephalo-facial remains are examined for personal identification.

Stature has a definite biological relationship with all body parts such as extremities, head, trunk, vertebral column, etc.^{2,3,4} Many studies have been carried out on the determination of stature using percutaneous measurements of various body parts including arms, legs, feet, hands, and so on. Sarangi et al did not find any significant

correlation between the stature and the skull measurements.⁵ On the other hand, Introna et al and Chiba and Terazawa reported a significant relationship between stature and skull measurements.^{6,7} Krishna and Kumar successfully developed equations for estimating stature using a set of sixteen cephalo-facial measurements in the north Indian population.⁸ Pelin et al studied the relationship between body height and head and face dimensions in the Turkish population and found that the estimation of body height is not reliable with these cephalo-facial parameters.⁹ These studies were conducted on the male population exclusively and thus failed to show any gender difference. These contrasting findings emphasize the importance of considering various factors when using facial measurements for stature estimation, including the population being studied, the methods used for measurement, and potential variations in anatomical features among different groups. However, population and gender-specific studies concerning stature estimation from facial dimensions by percutaneous measurements are scanty in the Nepalese population. Therefore, an attempt is being made to determine the anthropometric correlation between stature and facial parameters and to develop regression formulas for estimating stature based on these facial measurements.

METHODOLOGY

This was a prospective study conducted from December 2022 to June 2023, in the Department of Forensic Medicine at Birat Medical College and Teaching Hospital. The study was approved by the Institutional Ethical Review Board, of the institution (IRC-PA-257/2078-79). A total of 216 preclinical Nepalese medical students were included in the study, comprising 107 males and 109 females aged 18 to 26 years. Students with a history of trauma or surgery to the skull, face, or spine, craniofacial bone deformity, facial asymmetry, or systemic or chronic disease were excluded from the study. Students were briefed about the study and consent was taken from the participants for taking the measurements and assured that anonymity would be maintained. A prescribed proforma was developed to record the findings. The stature and two facial measurements of each subject were taken by using standard anthropometric instruments, in centimeters, to the nearest millimeters as described by Vallois.¹⁰ The anatomical landmarks used for taking measurements were identified by keeping the head in the Frankfurt horizontal plane. The instruments used for data collection were regularly checked for their accuracy. The following measurements were recorded.

Stature: Stature or height was measured in a standing position from the vertex to the floor. It was measured by a wall-mounted stadiometer. The measurement was obtained by making the subject stand straight and barefooted, with the heels in close contact with each other on the floor. The subject's back was as straight as possible, with the shoulder blocks and buttocks touching the vertical plane. The head was orientated in the Frankfurt Horizontal Plane by repositioning the face so that the lateral palpebral commissure and pinna tip were in a horizontal plane parallel to the feet. All the facial dimensions were measured by making the subject sit erect with each knee

at a right angle, with the upper leg parallel to the floor, and feet flat on the floor.

Morphological Facial Height (MFH): It was measured from the nasion (depressed area directly between the eyes, just superior to the bridge of the nose) to the gnathion (lowermost point on the lower border of the mandible along the mid-sagittal plane). It was measured by a digital sliding vernier caliper. The fixed tip of the digital sliding vernier caliper was placed at the subject's gnathion, and the movable part was moved and placed on the nasion.

Bizygomatic Breadth (BZB): It was measured between the two most lateral points on the zygomatic arches i.e., zygion to zygion by using a spreading caliper. All of the above measurements were taken by one author between 2 and 4 p.m. This was done to remove differences caused by diurnal variation. The measurements were taken three times, and the mean value was considered as the final measurement. A test of normality was carried out on each measurement before opting for a particular parametric or non-parametric test. Statistical analysis such as mean, standard deviation (SD), and independent t-test were used to show any significant difference between genders. Karl Pearson's correlation coefficient (r) was used to establish the relationship between the variables considered, i.e., regression analysis and standard error of estimate (SEE) which were analyzed using Statistical Package for the Social Sciences-23.0 Version; following that, a hypothetical regression equation was formulated using the regression coefficients as follows:

$$y = a + bx$$

Where,

y = stature or dependent variable.

x = facial parameters or independent variable.

a = the regression coefficient for the intercept (constant).

b = the regression coefficient for the facial parameters.

The regression formulae were calculated separately using regression analysis of the parameters with stature to derive the regression coefficients "a" and "b." In the standard regression equation, the appropriate values of constants "a" and "b" were then substituted. SEE has been determined for each regression equation.

RESULTS

The study included 216 healthy subjects, with 107 (49.53%) males and 109 (50.46%) females. The mean age of the study sample was 21.66 ± 1.67 years ranging between 18 to 26 years. The age distribution data is shown in Table 1.

Table 1: Descriptive statistics by age of the total sample

Gender	N (%)	Mean age	Standard Deviation	Minimum	Maximum
Male	107(49.53%)	22.21	1.57	19	26
Female	109(50.46%)	21.13	1.60	17	26
Combined	216(100)	21.66	1.67	17	26

The total sample mean of stature was 163.75± 8.87 while the total sample mean of MFH and BZB was 11.52 ± 1.13 and 11.24 ± 0.91 respectively. The descriptive statistics of stature and two facial dimensions of the total sample are shown in Table 2.

Table 2: Descriptive Statistics of stature and facial dimension of the total sample

Measurement	N	Range	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
Stature	216	40.20	143.90	184.10	163.75	0.60	8.87
Morphological Facial Height (MFH)	216	5.32	8.89	14.21	11.52	0.07	1.13
Bizygomatic Breadth (BZB)	216	4.90	9.02	13.92	11.24	0.062	0.91

The normality test on stature and two facial measurements found the data to be normally distributed as shown in Table 3.

Table 3: Normality test (Shapiro-Wilk) on stature and facial measurements by gender

Measurement	Gender	Statistic	df	P
Stature	Male	0.984	107	0.210
	Female	0.988	109	0.463
Morphological facial Height (MFH)	Male	0.986	107	0.325
	Female	0.989	109	0.490
Bizygomatic Breadth (BZB)	Male	0.989	107	0.538
	Female	0.983	109	0.166

Therefore, parametric tests were used for these measurements. On comparing the equality of means of stature, and facial measurements, there were statistically significant differences between male and female measurements. Descriptive statistics for stature and facial measurements among males and females are shown in Table 4.

Table 4: Descriptive statistics for stature and facial measurements among males and females

	Male (107)			Female (109)			P value
	Mean(±SD) in cm	Minimum	Maximum	Mean(±SD) in cm	Minimum	Maximum	
Stature	170.70(±5.59)	159.37	184.1	156.92(±5.58)	143.9	168.87	<0.001
MFH	12.42(±0.69)	10.68	14.21	10.63(±0.70)	8.89	12.36	<0.001
BGB	11.41(±1.03)	9.02	13.92	11.08(±0.74)	9.13	12.65	0.008

Note: MFH: Morphological Facial Height, BGB: Bizygomatic Breadth

All facial parameters in males and females showed a positive correlation with stature. MFH showed a better correlation of stature with a higher “r” value of 0.297 in males and 0.268 in females and BZB with a lesser “r” value of 0.278 in males and 0.214 in females. The regression analysis was used to determine which facial measurement(s) contributed the most to the variability in stature. In males, MFH alone explained for 9% variation in stature, while BZB explained for 8% of the variation.

Combined, these two variables explained for 17% variation in male stature. In females, MFH alone explained for 8% of the variation in stature, while BZB explained for 5% of the variation. Together, these two variables explained for 13% variation in female stature. Table 5 summarizes the correlation coefficient (r) and linear regression analysis of the facial parameters in male and female groups.

Table 5: Statistical analysis with the derivation of the regression equation

Sex	Variable	r	r ²	Regression equation (y= a +bx)	SEE	P
Male	MFH	0.297	0.088	Y=140.72+2.41MFH	±5.37	0.002*
	BZB	0.278	0.077	Y=153.51+1.50BZB	±5.40	0.004*
Female	MFH	0.268	0.077	Y=134.41+2.11MFH	±5.40	0.005*
	BZB	0.214	0.046	Y=139.01+1.61BZB	±5.47	0.025*

Note: *Statistically significant ($P<0.05$), r: correlation with observed stature, r²: coefficient of determination, y: Stature, a = the regression coefficient of the dependent variable. b: Regression coefficient of independent variable, x: facial parameters, SEE: Standard estimate of error, MFH: Morphological height, BZB: Bizygomatic bread

DISCUSSION

In terms of physical anthropology and medicolegal issues, stature is regarded as an essential element in the description of an individual.¹¹ Researchers have previously estimated stature using various bones from the human skeleton ranging from the femur to the metacarpals. This method is based on the principle that there is a correlation between the stature and the length of certain bones of an individual. Numerous techniques and formulas have been devised to improve the precision of these estimates.^{12,13} If these specific bones are not accessible for measurement, other body parts can be utilized to estimate stature.

A detailed examination of the facial bones may aid in the estimation of stature like other bones. The method of employing facial measures has several benefits because the anatomical markers are uniform, clearly defined, and simple to locate.¹⁴ Studies concerning the estimation of stature from facial dimensions are limited in the Nepalese population. Therefore, the present research aims to provide data on the correlation of stature with facial dimensions in the Nepalese population. In this study, we used the regression method, as it has been universally concluded that the regression analysis provides the best estimate for stature reconstruction in comparison to the multiplication method.¹⁵

In the present study, males had significantly higher measurements than females. The total sample mean and standard deviation of stature was 163.75±8.87 cm. The mean male and female stature were 170.70±5.59 and 156.92±5.58 respectively. The total sample mean stature of males and females in the current study was higher as compared to a few other Nepalese studies conducted earlier.^{16,17,18} Males in our study had higher mean stature than Indigenous South Africans, Sri Lankans, and Caucasians of Rome (Italy), but lower than Caucasian populations and Indo-Mauritian populations.^{1,19,20,21,22} When compared to Indian studies, the mean male stature in our study was higher than the Kabuis of Imphal Valley, North Indian Kolis, Central Indian populations and Northwest Indians but lower than the Mysorean population (south Indians), and North Indian Gujjars.^{14,15,23,24,25} Similarly, the mean female stature in our study was higher than that of Indigenous South Africans and Sri Lankans but lower than that of Caucasians of Rome (Italy)

and the Indo-Mauritian population.^{1,19,20,21} When compared to Indian studies, females had a slightly higher mean stature in our study than in the Central Indian population but lower than the Mysorean population (south Indians).^{14,26} Among the facial measurements, the total sample mean MFH value was 11.52cm, 12.42cm in males and 10.63cm in females. Pokhrel et al reported a total sample mean MFH value of 11.83cm, 12.14 cm in males, and 11.53 cm in females.¹⁷ The male mean value of MFH was lower than in our study, whereas the female mean value of MFH was higher. Reddy et al. conducted a study and reported a total sample mean MFH value of 11.13 cm and male and female mean MFH values of 11.96 cm and 11.25 cm, respectively.²⁷ The male mean value of MFH was lower than in our study, whereas the female mean value of MFH was higher. Furthermore, Prasanna et al. conducted a study on North and South Indian populations and found male MFH mean values of 12.36 cm in North Indian populations, which is lower than our study, and female MFH mean values of 11.7 cm, which is higher than our study. In South Indian populations, he found male MFH mean values of 11.97 cm and female MFH mean values of 10.1 cm which is lower than our study.²⁸

In the present study, the mean BZB for the total sample was 11.24 cm. The mean BZB for males and females in the study sample was 11.41 cm and 11.08 cm, respectively. Pokhrel et al found a mean BZB value of 11.70 cm in the total sample and mean BZW values of 12.04 cm and 11.36 cm in males and females, respectively, which is higher than our findings.¹⁷ Shrestha et al reported a mean BZB of 12.4 in males and 11.9m in females which is higher than our findings.¹⁸ In an Indian study conducted by Mounika and Babu the mean values of BZB were 9.43 cm, which was lower than the current study.²⁹ In our study, comparative statistical analysis among both genders showed a positive correlation between stature and MFH ($r=0.297$ in males and ($r=0.268$ in females) as compared to BZB ($r=0.278$ in males) and ($r=0.214$ in females). Agnihotri et al showed a positive correlation between stature and facial height ($r = 0.32$ in males) and ($r = 0.16$ in females) and facial width ($r = 0.17$ in males and $r = 0.27$ in females). Their findings revealed that in males facial height is a more suitable parameter than facial width for estimation of stature while in females it is vice versa.¹ Pokhrel et al found the highest correlation of stature with MFH ($r=0.327$ in males) and BZB ($r=0.255$ in females).¹⁷ Shrestha et al found that cranial measurements such as maximum cranial length (MCL)

and bi-zygomatic breadth (BZB) have a stronger correlation with stature than other measurements such as minimum frontal breadth (MFB), maximum cranial breadth (MCB), and parietal chord (PC) in males and the overall study sample.¹⁸ Krishna and Kumar examined 252 Koli male adolescents to determine stature from cephalo-facial measurements and discovered that cephalic measurements such as horizontal head circumference, maximum head length, and maximum head breadth predict stature better than facial parameters.⁸ Kumar and Chandra used facial measures to estimate stature in 199 individuals aged 18 to 45 years and found the strongest correlation between stature and bigonial breadth.²⁴ In terms of correlation strength, values greater than 0.5 are normally considered statistically significant. The correlation coefficients (r) of stature and facial measurements in the current study are all less than 0.5 in both sexes.

CONCLUSION

It can be concluded that two facial measurements (morphological facial height and bizygomatic facial breadth) are less reliable parameters for estimating stature in the Nepalese population. Despite their limited reliability, these facial measurements can still be utilized in the absence of other better parameters such as long bones or when only facial remains are brought for forensic examination.

LIMITATIONS OF THE STUDY

One of the limitations of the study is that it cannot be generalized as the sample was collected from a small population. As the Nepalese population is ethnically diverse it is recommended that similar studies should be conducted in other ethnic groups within Nepal to develop population-specific regression equations for more accurate identifications from human remains.

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CONFLICT OF INTEREST

None

FINANCIAL DISCLOSURE

None

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