ORIGINAL ARTICLE

Reliability of Stature Estimation from Facial Anthropometric Parameters

C. Pokhrel[1]*, C. B. Jha[1], S. R. Niraula[2], P. R. Pokharel[3]

[1]Department of Human Anatomy, B.P. Koirala Institute of Health Sciences, Dharan, Nepal, [2]Department of Community Medicine, School of Public Health and Community Medicine, B.P. Koirala Institute of Health Sciences, Dharan, Nepal, [3]Department of Orthodontics and Dentofacial Orthopaedics, B.P. Koirala Institute of Health Sciences, Dharan, Nepal

ABSTRACT

Introduction: Identification of an individual is one of the most difficult and challenging subjects that man has confronted. The determination of adult sex and estimation of stature are two of the four key factors (sex, stature, age, and race) in identification of an individual. Facial anthropometric parameters are important tools for forensic anthropologists when it is not possible to apply advanced techniques for identification purposes. The present study provides anthropometric correlation of the facial parameters with stature and also devises regression formulae for reconstruction of stature.

Materials and Methods: A total of 312 Nepalese students from BPKIHS with equal distribution of sex of age 18–35 years were taken for the study, facial height and bizygomatic width were measured. Correlation and regression analysis was done.

Results: The parameters were found to be greater in males than females and each was found to be statistically significant. The mean difference between the actual stature and estimated stature from regression equation was not significant. Thus, regression equations and analysis generated from facial anthropometric parameters can be a supplementary approach for the estimation of stature when extremities are not available.

Key words: Bizygomatic width, facial anthropometry, facial height, stature

INTRODUCTION

Anthropometry is a scientific specialization that has emerged from the discipline of forensic anthropology dealing with the identification of human with the help of metric techniques. In other words, anthropometry means the measurement of human beings, whether living or dead or on skeletal material.[1] Facial anthropometry is a technique used in physical anthropometry comprising precise and systematic measurement of facial bones of human skull.[2] The ultimate aim of using anthropometry in forensic sciences is to help the law enforcement agencies in achieving “personal identity” in case of unknown human remains.[3]

Identification of an individual is a basic assessment in the evaluation of human remains. The identification of human remains, when advance scientific method of fingerprint identification is not possible to apply, then a forensic medicine investigations are undertaken.[4] In forensic anthropology, the determination of adult sex and estimation of stature are two of the four key factors (sex, stature, age, and race) in identification of an individual. The anthropometric analysis for stature estimation from skeletal material is an integral part of the identification process as it provides relatively fast and accurate data, which could narrow the field of search.[5]

***Corresponding author:**
Email: churamani.pokhrel@bpkihs.edu
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Skull is considered as the second best region of the skeleton after pelvis for identification purpose since the skull is composed of hard tissue and is the best-preserved part of skeleton after death; hence, in many cases, it is the only available part for forensic examination.[6-8] Skulls can survive for centuries, even millions of years, and can provide an unrivaled means of identification.[8] The method of using facial measurements has several advantages as the anatomical landmarks are standard, well defined, and easy to locate,[7] so careful study of facial bones may help in the estimation of stature. Various methods such as reconstructing the face from the bones of the skull, new facial soft tissue depth data, ultrasound, computerized tomography scans, and three-dimensional reconstruction computer programs are in full development throughout the world. Stature estimation from the facial region through anthropometry can always supplement the identification data collected using the techniques of facial reconstruction and consequently can help in narrowing down the process of forensic investigations.[9, 10]

Due to the paucity of research on determination of stature in Nepalese population from facial parameters, the present study provides an anthropometric correlation of facial parameters with stature and also devises regression formulae for reconstruction of stature.

MATERIALS AND METHODS

The study was conducted in the Department of Human Anatomy at B.P. Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal. 312 Nepalese students having equal distribution of sex, i.e., 156 male and 156 female students, were taken from MBBS, BDS, Nursing, and Postgraduate students of age 18–35 years. Students with a history of trauma and surgery of the skull, face and spine, craniofacial bony deformity, facial asymmetry, and presence of systemic or chronic disease were excluded from the study. The ethical clearance for the study was obtained from the Institutional Ethical Review Board, BPKIHS. Students were briefed about the study and research information sheet was provided to the participant. The consent was taken from the participants before measurements and they were assured that anonymity would be maintained.

Stature was measured from the greatest distance from the plane where the participant stands barefooted to the vertex on the head with their back to the vertical backboard of the stadiometer. The participant's head was maintained in the Frankfurt horizontal plane position while the examiner lowered the horizontal bar snugly to the crown of the head with sufficient pressure to compress the hair. The bar was locked in place after that the measurement was read and recorded to the nearest 0.1 cm. Stature of each participant was measured between 2 pm and 5 pm to avoid diurnal variation.[11].

Facial height is the straight distance from the nasal root (nasion) to lowest point on the lower border of the mandible in the midsagittal plane (gnathion). The participant was instructed to look forward while the sliding caliper was placed on the nasion of the participant; then, scroll down until it was fixed on the lower border of the mandible in the midsagittal plane (gnathion), then the measurement was taken [Figure 1].

Figure 1: Measuring facial height

Figure 2: Measuring bizygomatic width

Bizygomatic width is the width between the most lateral points on the two zygomatic arch. The participant was instructed to look forward; the extent of the zygomatic arch was first palpated. Using moderate pressure, the tips of the calipers were moved exploring the entire arch until the highest reading was observed on the caliper scale [Figure 2].

The entire measurements were performed by the single examiner, i.e., researcher himself to eliminate interobserver error. All the dimensions were measured 3 times and the average was recorded.

The data obtained from each participant was recorded in the pro forma sheet and the data were transferred into Microsoft Excel Sheet Version 2010. Statistical analysis such as mean, standard deviation (SD), and Student's *t*-test was used to show any significant difference between gender. Karl Pearson's correlation coefficient (r) has been used to establish the relationship between the variables considered, i.e. regression analysis and standard error of estimate (SEE) and were analyzed using Statistical Package for the Social Sciences-11.5 Version; thereafter, a hypothetical regression equation was formulated using the regression coefficients as follows:

$y = a+bx$

Where,
y = stature, i.e., the dependent variable.
x = facial parameters, i.e., the independent variable.
a = the regression coefficient of dependent variable.
b = the regression coefficient of independent variable.

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

Probability of significance has been set at 5% level. $P < 0.05$ was considered statistically significant, $P < 0.001$ was considered statistically highly significant, and $P > 0.05$ was considered statistically not significant (NS).

RESULTS

Statistical analysis was done, and the correlation of stature with facial parameters among male and female was compared, and the significant differences were explored.

Table 1 summarizes that the mean age and SD of all participants was 21.57 ± 2.37 and age ranges from 18 years to 32 years. The mean height was 161.41 ± 8.57 and ranges from 143 cm to 188 cm. The mean facial height was 11.83 ± 0.66 and mean bizygomatic width was 11.70 ± 0.83.

Table 2 summarizes that all parameters are greater in male than female and there exist significant differences in all parameters. Table 2 summarizes that male participants are older than the female participants as the mean age of male is 22.13 ± 2.56 (ranges from 18 years to 32 years), and the mean age of female is 21.01 ± 2.02 (ranges from 18 years to 29 years). The mean height of male is 167.42 ± 6.91 (ranges from 147.90 cm to 188.00 cm) and that of female is 155.39 ± 5.17 (ranges from 143.00 cm to 170.00 cm), which shows that the male participants are taller than the female participants. Among the facial parameters, the mean facial height of male is 14.74 ± 0.73 (ranges from 10.80 cm to 13.60 cm) and that of female was 11.53 ± 0.59 (ranges from 10.10 cm to 12.90 cm). The mean bizygomatic width of male is 12.04 ± 0.68 (ranges from 10.26 cm to 13.86 cm) and that of female is 11.36 ± 0.84 (ranges from 8.50 cm to 14.26 cm).

Table 3 summarizes that the facial parameters in male show positive correlation with stature significantly ($P < 0.05$). Facial height shows a better correlation of stature with higher "*r*" value of 0.327 and lesser SEE −6.552 than bizygomatic with lesser "*r*" value of 0.175 and higher SEE - 6.827.

Table 4 summarizes that the facial parameters in female show positive correlation with stature significantly ($P < 0.05$). Bizygomatic width shows a better correlation with higher "*r*" value of 0.255 and lesser SEE −5.013 than facial height with lesser "*r*" value of 0.205 and higher SEE - 5.073.

Table 5 summarizes that the mean difference between actual and estimated stature in male is NS (0.39 cm with facial height and 0.06 cm with bizygomatic width).

Table 1: Descriptive statistics of age, stature, and facial parameters for total group (***n***=312)

Variable	Total (*n*=312)	
	Mean±SD	Range
Age (years)	21.57±2.37	18–32
Height (cm)	161.41±8.57	143.00–188.00
Facial parameters		
Facial height (cm)	11.83±0.66	10.10–13.60
Bizygomatic width (cm)	11.70±0.83	8.50–14.26

SD: Standard deviation

Table 2: Descriptive statistics of age, stature, and facial parameters for male and female (n=156 each)

Variable	Male (*n*=156)		Female (*n*=156)		*t*-test	*P*
	Mean±SD	Range	Mean±SD	Range		
Age (years)	22.13±2.56	18–32	21.01±2.02	18–29	4.278	<0.001**
Height (cm)	167.42±6.91	147.90–188.00	155.39±5.17	143.00–170.00	17.411	<0.001**
Facial parameters						
Facial height (cm)	12.14±0.57	10.80–13.60	11.53±0.59	10.10–12.90	9.295	<0.001**
Bizygomatic width (cm)	12.04±0.68	10.26–13.86	11.36±0.84	8.50–14.26	7.841	<0.001**

SD: Standard deviation

Table 3: Correlation coefficient (*r*) and linear regression analysis in male group (n=156)

Variable	*r*	Regression equation (y=a + bx) y-stature, x-variables, b-regression coefficient	SEE	*P*
Facial height	0.327	119.179+3.974 FH	6.552	<0.001**
Bizygomatic width	0.175	145.919+1.786 BW	6.827	0.029*

SEE: Standard error of estimate

Table 4: Correlation coefficient (*r*) and linear regression analysis in female group (***n***=156)

Variable	*r*	Regression equation (y=a + bx) y-stature, x-variables, b-regression coefficient	SEE	*P*
Facial height	0.205	134.751+1.790 FH	5.073	0.010*
Bizygomatic width	0.255	137.546+1.571 BW	5.013	0.001**

SEE: Standard error of estimate

Table 6 summarizes that the mean difference between actual and estimated stature in female is NS (0.3 cm with facial height and 0.46 cm with bizygomatic width).

To test the applicability and reliability of the obtained regression formulae in our population, 50 randomly selected male subjects [Table 5] and 50 randomly selected females subjects [Table 6] were taken. The mean estimated stature was calculated and compared with the mean actual stature of these subjects. There was no statistically significant difference ($P > 0.05$) between the mean actual stature and mean estimated stature for each group. In other words, the calculated regression formulae hold true for the given population sample, and therefore, we can conclude here that these formulae can be successfully used for stature estimation in Nepalese population.

In the present study, results indicate that one can successfully estimate stature from facial parameters. The introduction of regression formulae developed in the subjects has enhanced the accuracy of stature estimation. The SEE was calculated separately for each regression formula for the estimation of stature. The SEE tends to predict the deviation of estimated stature from the actual stature. A low value is indicative of the greater reliability of prediction from a particular measurement and the higher value of SEE denotes less reliability of prediction. The regression equation with the least SEE was considered to be the best regressor for the estimation of stature.

DISCUSSION

Various methods were used to establish the identity of unknown human remains. The reliability of each method varies.[3] Estimation of stature, as part of identification process, has a long history in physical anthropology. Stature plays a very important role in the description of a human population, or an individual, for physical, anthropological, and biomechanical research.[11] In the past, scientists have used each and every bone of the human skeleton right from femur to metacarpals in estimation of stature. They all have reached a common conclusion that stature can be estimated with great accuracy even from the smallest bone.[1] Hence, the aim of the present study was to determine the stature using facial anthropometry.

In our study, all parameters were larger in males as compared to females. The mean male and mean female height was 167.42 ± 6.91 and 155.39 ± 5.17, respectively. The mean values of stature of male in the present study were higher than the Indigenous South Africans,[12] Sri Lankans,[13] and Caucasians of Rome (Italy),[14] but lower than the Caucasian population[15] and Indo-Mauritian population.[16] The study when compared with Indian studies on the mean values of stature in males are higher in our study than the Gujarat population,[17] Kabuis of Imphal valley,[18] North Indian Kolis,[19] Central Indian populations,[20] and Northwest Indians,[21] but lower than the Mysorean population (south Indians),[7] North Indian Gujjars,[22] South Indian population,[23] North Indian population,[23] and medical students of Nagpur.[24] The mean values of stature of females in the present study were higher than the Indigenous South Africans[12] and Sri Lankans,[13] but lower than the Caucasians of Rome (Italy)[14] and Indo-Mauritian population.[16] The study when compared with Indian studies on the mean values of stature in females is higher in our study than the Central Indian populations,[20] but lower than the Mysorean population (south Indians),[7] South Indian population,[23] North Indian population,[23] Northwest Indians,[21] and medical students of Nagpur.[24]

The mean value of facial height in our study was 11.83 cm in total sample and the mean facial height of male was 12.14 cm and that of female was 11.53 cm. The mean for male and female facial height was 11.58 cm and 10.86 cm, respectively, in the study conducted by Anibor *et al.*,[25] which was lower than the present study. Prasanna *et al*.[26] in their study found 12.36 cm and 11.7 cm in male and female, respectively, in North Indian populations and

Table 5: Difference between actual stature and estimated stature by in 50 randomly selected male subjects

Variable	Mean±SD		Mean difference	*t*-test	*P*
	Actual stature	Estimated stature			
Facial height (cm)	167.69±7.44	168.08±2.06	0.39	0.393	0.696
Bizygomatic width (cm)	167.69±7.44	167.75±1.13	0.06	0.059	0.953

SD: Standard deviation

Table 6: Difference between actual stature and estimated stature in 50 randomly selected female subjects

Variable	Mean±SD		Mean difference	*t*-test	*P*
	Actual stature	Estimated stature			
Facial height (cm)	155.92±4.65	155.62±1.01	0.3	0.454	0.652
Bizygomatic width (cm)	155.92±4.65	155.46±1.29	0.46	0.627	0.534

SD: Standard deviation

11.97 cm and 10.1 cm in male and female, respectively, in South Indian populations, both the values were larger than the present study in case of North Indian populations and lesser in case of South Indian populations. Olutu *et al*.[27] in their study on facial height of the Igbo ethnic group in Nigeria observed with the males having significantly higher facial height than the females ($P < 0.05$). In that study, the facial height of males and females was 12.25 cm and 11.19 cm, respectively, which was greater than the present study in male and lesser than females. Similar study had been conducted by Kumar and Gopichand,[28] the mean values of the facial height were less as compared with the present study. The mean values of bizygomatic width in our study were 11.70 cm in total sample and 12.04 cm and 11.36 cm in males and females, respectively. Prasanna *et al*.[26] in their study found the mean values of bizygomatic width were 12.22 cm and 10.81 cm in male and female, respectively, in North Indian populations and 11.93 cm and 11.85 cm in male and female, respectively, in South Indian populations. The findings as compared with the present study, in North Indian populations, males had larger bizygomatic width and females had lesser bizygomatic width; whereas in case of South Indian populations, male had lesser bizygomatic width and females had larger bizygomatic width. Mounika and Babu[29] in their study in 30 South Indians subjects entitled, "estimation of stature from the facial width" found out that the mean values of bizygomatic width were 9.432 cm, which was smaller than the present study. Similar type of study was conducted by Kumar and Chandra;[18] they used six facial dimensions to estimate the stature. They had studied 199 subjects and noted that total facial height was a better parameter to estimate the stature. Similar findings were found by Krishan[9] and Agnihotri *et al*.[16]

SUMMARY AND CONCLUSIONS

The present study suggested that like other parts of the human body, stature estimation can also be done by means of facial anthropometry when these remains are brought for forensic examination. While applying these formulae and analysis, one should keep in mind that these are population specific; these cannot be used on other populations of the world.

We can conclude that regression equations and analysis generated from facial anthropometry can be a supplementary approach for the estimation of stature. Further studies should be carried out in a larger Nepalese population with proper racial, ethnic, and community background, so that the obtained formula and analysis can aid in estimation of stature of an unknown body remains with greater accuracy. The data obtained in this study will be helpful to extend the anthropometric data on Nepalese populations. The data will also be useful in criminal investigations, to forensic experts and police department who need the reference for identification purpose and to the surgeons treating congenital or post-traumatic facial disfigurements.

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