



A STUDY ON RELIABILITY OF STATURE ESTIMATION FROM CRANIAL ANTHROPOMETRIC PARAMETERS.

¹Dr. Churamani Pokhrel, ²Late Prof. Dr. Chandra Bhushan Jha, ³Dr. Surya Raj Niraula and
⁴Dr. Prabhat Ranjan Pokharel

¹Assistant Professor, Department of Human Anatomy, BPKIHS, Dharan, Nepal.

²Department of Human Anatomy, BPKIHS, Dharan, Nepal.

³Professor, School of Public Health and Community Medicine, BPKIHS, Dharan

⁴Additional Professor, Department of Orthodontics and Dentofacial Orthopaedics, BPKIHS, Dharan.

***Corresponding Author: Dr. Churamani Pokhrel**

Assistant Professor, Department of Human Anatomy, BPKIHS, Dharan, Nepal.

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ABSTRACT

The aim of this study is to estimate height and provide correlation of the cranial anthropometric parameters with stature and also to devise regression formulae for estimation of stature. The height, head circumference, head length and head breadth of 312 Nepalese students from B.P. Koirala Institute of Health Sciences with equal distribution of sex of age 18-35 years were measured and analysed. Correlation and regression analysis were done. All parameters were found to be greater in males than females and each was found to be statistically significant. On correlating the parameters, the best regressor for the estimation of stature in males was head length; in case of females, the best regressor were head circumference and head length. Thus, we can conclude that regression equations and analysis generated from cranial anthropometric parameters can be a supplementary approach for the estimation of stature when extremities are not available.

KEYWORDS: Stature, Cranial anthropometry, Head length, Head, Breadth, Head circumference.

INTRODUCTION

Anthropometry is a scientific specialization that has emerged from the discipline of forensic anthropology dealing with 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] These techniques have been successfully applied in the field of forensic and legal medicine to determine age, sex, race and to an extent stature when skeletonized remains are brought for identification.^[1] Cranial anthropometry is a technique comprising of precise and systematic measurement of bones of human skull. In forensic anthropology, the determination of adult stature is one of the four key factors (sex, stature, age, and race) in assessing the biological profile, which is determinant for positive identification of skeletal remains. The anthropological analysis for stature of skeletal material from a forensic context is an integral part of the identification process as it provides relatively fast and accurate data, which could narrow the field of search.^[2] Skull is probably the second-best region of the skeleton for identification purpose as 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.^[3,4,5]

‘Skulls can survive for centuries, even millions of years, and can provide an unrivalled means of identification.’⁵ The method of using skull has several advantages as the anatomical landmarks are standard, well defined and easy to locate,^[4] so careful study of skull can enable reliable determination of stature of the person in life. The present study provides an anthropometric correlation of cranial parameters with stature and 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 Post graduates students of age 18-35 years. Students with history of trauma and surgery of the cranium and skull, craniofacial bony deformity and presence of any systemic and chronic diseases were excluded from the study. The ethical clearance for the study was obtained from Institutional Review committee (IRC), 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 plane where the participant stands bare footed 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. Hair ornaments, buns, braids, etc. were removed to obtain an accurate measurement. 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 2-5 pm to avoid diurnal variation.^[5]

Horizontal Circumference (HC) of the head is the maximum circumference of the head measured from just above the glabella area to the area near the top of the occipital bone (opisthocranium). It was measured by placing a nonstretchable plastic tape (calibrated in centimeters) just on the occipital prominence and the supraorbital ridges, while viewing the participant laterally also to ensure proper placement of the tape. Maximum Head Length (HL) is the straight distance between glabella and the opisthocranium. It was measured with a spreading caliper from glabella to Opisthocranium or Inion.

Maximum Head Breadth (HB) is the maximum biparietal diameter and is the distance between the euryons. It was measured as the maximum transverse diameter between the two euryons with a spreading caliper.

The data from each participant were recorded and analysed. 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) were analysed. A hypothetical regression equation was formulated using the regression coefficients as follows.

$$y = a + bx$$

where,

y = stature i.e, the dependant variable

x = cranial parameters i.e, the independent variable

a = regression coefficient of dependant variable

b = 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 " were then substituted in the standard equation of regression equation. 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 highly significant, and $p > 0.05$ was considered statistically not significant (NS).



Fig 1: Measurement of head breadth



Fig 2: Measurement of head length



Fig 3: Measurement of head circumference.

RESULTS

Statistical analysis was done, correlation of stature and cranial anthropometric parameters among male and

female was compared, and the significant differences were explored.

Table 1: Descriptive statistics of age, stature and cephalometric 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
Cephalometric parameters		
HC (cm)	53.63±2.09	49.00-59.00
HL (cm)	17.81±0.88	14.50-19.96
HB (cm)	14.58±0.74	11.60-16.66

Table 1: Shows the Mean±SD and Range of all parameters of the entire sample size (n=312). According to this table, mean age of all participants was 21.57±2.37 and the age ranges from 18-32 years. The mean height of all participants was 161.41±8.57 and the height ranges from 143-188 cm. Among the cephalometric parameters,

the table shows that the mean head circumference was 53.63±2.09 (ranges from 49.00-59.00 cm), the mean head length was 17.81±0.88 (ranges from 14.50-19.96 cm) and the mean head breadth was 14.58±0.74 (ranges from 11.60-16.66 cm).

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

Variable	Male (n= 156)		Female (n= 156)		t-test	p-value
	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**
Cephalometric- parameters						
HC (cm)	55.06±1.51	51.00-59.00	52.21±1.54	49.00-56.00	16.518	<0.001**
HL (cm)	18.36±0.70	15.76-19.96	17.26±0.67	14.50-19.06	14.223	<0.001**
HB (cm)	14.74±0.73	12.46-16.66	14.41±0.71	11.60-16.10	4.100	<0.001**

** - Correlation significant at the 0.01 level - Statistically highly significant

Table 2: Shows the Mean±SD and range of the variables male (n= 156) and female (n=156). The table showed that male were older than the female participants as the mean age of male was 22.13±2.56 (ranges from 18-32 years), and the mean age of female was 21.01±2.02 (ranges from 18-29 years). The mean height of male was 167.42±6.91 (ranges from 147.90-188.00 cm) and that of female was 155.39±5.17 (ranges from 143.00-170.00 cm), which shows that the male participants were taller than the female participants.

Among the cephalometric parameters, the table showed that the mean head circumference of male was 55.06±1.51 (ranges from 51.00-59.00 cm), and that of female was 52.21±1.54 (ranges from 49.00-56.00 cm). The mean head length of male was 18.36±0.70 (ranges from 15.76-19.96 cm), and that of female was 17.26±0.67 (ranges from 14.50-19.06 cm). The mean head breadth of male was 14.74±0.73 (ranges from 12.46-16.66 cm), and that of female was 14.41±0.71 (ranges from 11.60-16.10 cm).

Table 3: Correlation Co-efficient (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-value
HC	0.155	128.557 + 0.706 HC	6.851	0.054
HL	0.195	131.892 + 1.935 HL	6.801	0.015*
HB	0.112	151.820 + 1.058 HB	6.891	0.166

* - Correlation significant at the 0.05 level - Statistically significant

p >0.05- Statistically not significant

Table 3: Shows the Correlation Co-efficient (r) and the result of Linear Regression analysis in male group (n=156). It is evident from the table that in males only head length showed positive correlation with stature significantly (p<0.05).

Table 4: Correlation Co-efficient (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-value
HC	0.373	89.980 + 1.253 HC	4.808	<0.001**
HL	0.278	118.522 + 2.136 HL	4.979	<0.001**
HB	0.150	139.661 + 1.092 HB	5.124	0.062

** - Correlation significant at the 0.01 level - Statistically highly significant

p >0.05- No statistically significant

Table 4: Shows the Correlation Co-efficient (r) and the result of the Linear Regression analysis in female group (n= 156). According to the table, among the cephalometric parameters except for head breadth, head circumference and head length shows positive correlation with stature significantly (p<0.05). The highest correlation of stature was found to be with head circumference (HC) with highest 'r' value of 0.373 and least standard error of estimate (SEE) value of 4.808.

To test the applicability and reliability of the obtained regression formula in our population, 50 randomly selected male subject (Table 5) and 50 randomly selected females subject (Table 6) were taken. The mean estimated stature was calculated and compared with the mean actual stature of these subjects. There were no statistically significant differences (p>0.05) between the two of each group. In other words, the calculated regression formula holds true for the given population sample and can be used for stature estimation.

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

Variable	Actual stature	Estimated stature	t-test	p-value
	Mean±SD	Mean±SD		
HL	167.69±7.44	167.29±1.15	0.387	0.700

Table 5: Shows that the difference of mean between the actual stature and estimated stature in 50 randomly

selected male subjects was not statistically significant (p>0.05).

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

Variable	Actual stature	Estimated stature	t-test	p-value
	Mean±SD	Mean±SD		
HC	155.92±4.65	156.04±1.87	0.176	0.861
HL	155.92±4.65	155.45±1.54	0.714	0.479

Table 6: Shows that the difference of mean between actual stature and estimated stature in 50 randomly selected female subjects for head circumference and head length is not significant (p>0.05).

DISCUSSION

Stature clearly constitutes an essential element in the description of a human population, or an individual, for physical, anthropological and biomechanical research.^[7]

In our study, the mean age of all participants (n= 312) was 21.57±2.37 and the mean height of all participants was 161.41±8.57; where as the mean male (n=156) and mean female (n=156) age was 22.13±2.56 and 21.01±2.02 respectively. The mean male and mean female height were 167.42±6.91 and 155.39±5.17 respectively. The mean value of male was larger than female similar to many other studies.

The mean values of head circumference of our study in males was 55.06 cm and that of female was 52.21 cm. The findings were very similar to the study done by Kalia et al.^[4] where the mean values for male was 55.0 cm whereas in case of female it was lower than our study. Another study done by Mahesh Kumar et al.^[8] on

Haryanvi Baniyas found the head circumference in male close to the present study i.e 55.95 cm and for females the mean values were higher than the present study i.e 54.61 cm. Studies done by Bale et al.^[9] and Agnihotri et al.^[10] found mean values of head circumference of both male and female higher than the present study.

Ewunonu et al.^[11] did a study on 1000 population in Ebonyi State University, Abakaliki, Nigeria and found out the mean values of head length to be 18.82 cm which was higher than our study. Similar findings were seen in the study done by Agarwal et al.^[12] and Kumar et al.^[13] in case of both male and females.

The mean value of head breadth in our study was 14.58 cm in total sample and 14.74 cm in case of males and 14.41 cm in females. In previous studies, according to Kumar et al.^[13], the mean value of the head breadth was lower than our study, i.e. 13.11cm and 12.95 cm for males and females respectively. The mean value of head breadth according to Agarwal, et al.^[12] in male was 14.86 cm which was larger than the present study and in female was 14.13 cm which was smaller than the present study. Study done by Ewunonu EO et al.^[11] also found higher head breadth than the present study.

Cranial dimensions also have been shown to be a reliable and precise means in predicting the stature in Italian (Introna et al., 1993), Japanese (Chiba & Terazawa, 1998), South African (Ryan & Bidmos, 2007), Turkish (Can Pelin et al., 2010) and Sri Lankan populations (Isurani Ilayperuma, 2010) as in the present study.^[14,15,16,17,18] In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposing cranial remains is vital in establishing the identity of an unknown individual. Therefore, formulae based on the cranial dimensions provide an alternative stature predictor under such circumstances. The cranium has easily identifiable surface landmarks making the measurements possible even in compromised conditions.^[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 Cranial anthropometric parameters, when these remains are brought for forensic examination. All parameters were found to be greater in males than females and each were found to be statistically significant. Linear Regression analysis was done and regression equations were used to estimate the stature using each of the independent variables for the sample for males and females separately.

On correlating the parameters, the best regressor for the determination of stature in males was head length; in case of females, the best regressor were head circumference and head length.

We can conclude that regression equations and analysis generated from cranial anthropometric parameters can be a supplementary approach for the estimation of stature when extremities are not available. 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 and gender 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.

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