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CRANIAL MEASUREMENTS;
ESTIMATION OF STATURE FROM CRANIAL MEASUREMENTS

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ABSTRACT… Human body exhibits regular age, sex and race dependent proportions amongst its various segments relative to its height. Knowledge of the cranial morphometry is important from clinical and forensic view point. The stature of a person being genetically predetermined is an inherent characteristic, the estimation of which is considered to be important assessment in identification of human remains. Norms of regression formulae for calculation of height are required for different populations. **Objectives:** To document norms for cranial dimensions and present linear regression formulae for stature prediction in adult male and female population of Southern Punjab. **Place and duration of study:** The study was conducted at the Multan Medical and Dental College, Multan and took about fourteen months to complete. **Material and methods:** The study was conducted on 672 adult individuals (430 males and 242 females) from in and around the city of Multan in Punjab. Measurements of the head including maximum cranial length (glabella-inion length), maximum cranial breadth (maximum bi-parietal diameter) and maximum auricular head height were taken. Results were expressed as mean ± SD. Height was measured in standing anatomical position. Correlation coefficient of Pearson was used to find the relationship between various cranial dimensions using which the linear regression formulae to predict the stature were derived. **Results:** The mean height of the study population was found to be significantly different between genders. The males appeared to be considerably taller than females. The mean cranial length, cranial breadth and auricular head height the measurements were larger significantly in the males as compared to females. Pearson's correlation coefficient between stature and cranial measurements was found to be highly positive for both sexes. Linear regression formulae to predict the stature from the cranial dimensions were derived. **Conclusion:** The study is conducted to document norms for cranial dimensions and it presented gender specific linear regression models for stature prediction in adult South Punjab population.

Key words: Stature, cranial measurements, cephalometry, craniometry, Pearson's correlation coefficient, linear regression model

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INTRODUCTION

Human body is marvelous in that it exhibits regular proportions amongst its various segments relative to the total height. The quotients between various body segments are genetically determined and depend uponthe age, sex and race of a person.[1] The bony skeleton because of its solid nature and prominent measurable features appears to be the most suitable part for the purpose of precise observation of these ratios. Rebuilding the stature from diverse human bones has remained a subject of interest. Most of the work has been done on long bones or vertebral column.[2] It may be difficult to accurately measure the standing height of a person in case of deformities of the vertebral column.[3] The association of long bones and vertebral column with the cranial dimensions are a more reliable and precise means of predicting the stature.[4] The bony landmarks on the skull are easily identifiable and allow accurate measurements possible.

There is clear evidence that various cranial dimensions vary among populations; such observations have been described amongst Korean, Indian, Turkish. Zulu people and Mapuche tribes in Chile.[5-8] It follows therefore that cranial morphometry has its significance in not only eliciting racial and geographic peculiarities but may also reflect the dietary status of a population.

Such specific measurements with reference to age and sex may also be helpful to the clinician because they will indicate a person's growth and development and by comparison may also indicate any abnormalities of cranial size and shape.[9]

Estimation of stature is an important tool in forensic examination especially when the identity of a person is not known and the remains are decayed, fragmented and damaged. The pathologist is usually expected to give his opinion on identity and height of the unidentified subject for identification. The importance of such estimation in archeological skeletal remains is undeniable. The stature of an individual being genetically predetermined and an inherent characteristic its estimation is considered to be important assessment in identification of human bony remains. The assessment of health and the nutritional status of a patient also depend upon accurate weight and height measurements and therefore have clinical implications.

Since diverse factors such as age, gender, race, and dietary status have a direct relation to the human growth and development different normal values of regression formulae designed for calculation of height are required for different populations. This study leads in documenting the norms for cranial measurements and dimensions and provides with gender specific linear regression formulae for stature prediction in adult population of Southern Punjab.

MATERIAL AND METHODS

The study conducted on 672 adult individuals (430 males and 242 females) that volunteered from in and around the city of Multan in Southern Punjab. Only healthy subjects without any apparent craniofacial deformity and belonging to different socio-economic strata were included. The age range was 20 to 62 years. Following linear measurements were recorded:

1. **Maximum cranial length (Cl:** glabella-inion length). It is the distance between glabella, the most prominent point at the root of the nose to the most prominent point on the occipital bone in the median sagittal plane. To measure this distance one tip of the calipers was placed at the glabella while the other tip was slid posteriorly to reach the inion so that maximum length was achieved.

2. **Maximum cranial breadth (CB:** maximum bi-parietal diameter). It is the distance between the most lateral points of the parietal bones. The tips of the calipers were allowed to slide on the parietal bones to achieve maximum distance.

A digital sliding calipers (Mitutoyo, Japan) which is capable of measuring up to 0.01 mm was used to record these measurements.

3. **Maximum auricular head height (Ch):** It is the distance from external acoustic meatus to the bregma (the highest point on the vertex). Measurements were taken on both sides using a Todd's head spanner.

All the measurements were taken by the same person three times, the mean of which was then recorded for further analysis. Results were expressed as mean ± SD and analyzed using the Statistical Package for Social Sciences (SPSS), 15th version. The mean values were compared for the males and the females using the t-test and Z-test respectively. P value < 0.05 was considered statistically significant. The height was measured to the neasest 0.1 cm from vertex to floor in a standing anatomical position of the subject using a height measuring instrument.

The formula for regression equation was as follows:

$Stature = a + b(x)$

Where:

'a' is the regression coefficient of the dependent variable i.e. stature.

'b' is the regression coefficient of independent variable i.e., any of the cephalofacial measurement.

'x' is any head measurement.

RESULTS

The mean ages of the study subjects (male: 42±12.31; female 37±14.43) were not significantly different between the males and the females (Table-I). The mean height of the male population was found to be significantly high; males appeared to be considerably taller as compared to the females.

Parameter	Male Mean ± SD (n=430)	Female Mean ± SD (n=242)	Combined Mean ± SD (n=672)
Age in years	42±12.31	37±14.43	38±12.56
Height in cm	172±11.37*	160±16.34	164±15.78

Table-I. Height and age of subjects

*P□ 0.05

A significant gender difference was observed where the mean cranial length, cranial breadth and auricular head height were found to be significantly more in males as compared to females (Table-II).

Parameter (in mm)	Male Mean ± SD (n=430)	Female Mean ± SD (n=242)	Combined Mean ± SD (n=672)
Cranial length (Cl)	188.03 ± 9.71*	173 ± 7.87	180.30 ± 8.84
Cranial breadth (Cb)	151.72 ± 6.33*	144.14 ± 5.42	148 ± 5.76
Auricular cranial height(Ch)	144 ± 9.87*	139 ± 7.98	141 ± 8.43

Table-II. Cranial dimensions in male and female subjects

*P□ 0.05

For estimation of stature cranial length, cranial breadth and auricular head height were used as independent variables for drawing linear regression analyses. For both male and female population the relation between the cranial measurements and their height was examined using Pearson's correlation coefficient. The Pearson's correlation coefficient (r) was found to be significant in both genders (Table-III).

Parameter	Male	Female	Combined
	r	*r*	*r*
Cranial length (Cl)	0.8143*	0.7632*	0.7521*
Cranial breadth (Cb)	0.5311*	0.3210*	0.4810*
Auricular cranial height (Ch)	0.6743*	0.7654*	0.7101*

Table-III. Pearson's correlation coefficient *(r)* between stature and cranial measurements for male and female subjects

*significant at $p < 0.05$.

Linear regression formulae to predict the stature using cranial dimensions were derived and are presented in table-IV.

Parameter	Male	Female	Combined
Cranial length (Cl)	154.70+0.8143(Cl)	142.85+0.7632(Cl)	151.63+0.7521(Cl)
Cranial breadth (Cb)	161+0.5311(Cb)	154+0.3210(Cb)	156+0.4810(Cb)
Auricular cranial height (Ch)	165+0.6743(Ch)	154+0.7654(Ch)	157+0.7101(Ch)

Table-IV. Gender specific linear regression models for stature prediction [Stature = a + b(x)]

DISCUSSION

It has been established that racial characteristics of a certain population are best depicted in the skull.[2] Cranial measurements constitute one of the most reliable parameters for racial discrimination.[2,5,10] A variety of metric and non-metric methods have been employed for this purpose. Non-metric methods being subject are not reliable whereas metric methods such as cranial dimensions provide with actual measurement which can be statistically expressed and more reliable analyses can be derived from them to reach objective conclusions regarding racial and gender diversity. The present study has for the first time provided basic data on cranial dimensions and its relationship with stature in the adult population of Multan region in southern Punjab.

The mean cranial morphometric values observed and recorded in our study were greater than those described for Turkman, Indians, Native Fars and Turkish populations[6,7,11] but was noted to be smaller when compared with the Koreans and Caucasians.[5,12] Such a difference in cranial morphometry is attributable to racial and geographic diversity.

The correlation coefficient drawn between the height and each of the cranial measurement in our sample were not only statistically significant but also highly positive establishing a strong correlation between the two parameters. The correlation coefficient for these measurements described in previous studies ranges between 0.20 to 0.78[14-16] while in our study it was 0.810 for the males which is slightly higher but still consistent with the previous studies. This difference could be attributed to genetic and racial differences in the population studied.

Regression models for predicting the stature were calculated using the major cranial measurements and were checked by comparing the estimated stature against actual height for accuracy. The results confirmed that cranial dimensions provide reliable means to predict stature from cranial dimensions. Our results also indicate that sexual dimorphism is also an important element in skeletal structural variation in various populations.[17]

The variation amongst the male and female population as observed in our results supports the previous studies in this area.[5,6.11.12] The data is significant in that it can be applied with confidence to an individual within the given population. In order to establish the identity of an unknown person from skeletal remains as in forensic examinations or in anthropological excavations it would be immensely useful to apply and utilize the data for such purposes.

CONCLUSION

Human development and growth depends upon a variety of factors such as race, geographic location, gender, age and nutrition. Therefore each group of population has its own specific normograms.[18-20] The present study is the first of its kind in presenting normal values and specific linear regression models for the adult male and female population of South Punjab. This data will not only be useful for clinical studies pertaining to the nutritional status of the subjects but also in medico-legal, anthropological and archeological studies.

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