ORIGINAL ARTICLE

Correlation Between the Stature and Cranial Measurements in Population of North India

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ABSTRACT

Introduction: Height has been one of the impressive factors for personal identification of individuals since long ago & has always been of immense interest to anthropologists & for medico-legal purposes in Forensic Medicine. **Methods:** The present study was conducted on 800 Students (400 male & 400 female) medical students of cosmopolitan origin, ranging from age group of 17 – 25 years of Western U.P. The measurements were taken at fixed time between 2 to 5 p.m. to eliminate the discrepancies due to diurnal variation. **Results:** Gender differences with respect to the mean cranial length, cranial breadths were found to be significantly larger in males compared to females. Correlation coefficient between the stature and measured cranial dimensions were found to be statistically significant and positive in both males and females. Independent linear regression analyses for predicting the stature using the head length and head breadth in both genders were:

Male - Stature = 109.97+3.18 x hl; Stature = 107.64+4.19 x hb

Female - Stature = 121.54+2.03 x hl; Stature = 114.88+2.58 x hb.

For height & cranial dimensions measurements, all three estimates yielded a very high degree of precision (TEM < 0.5 cm, rTEM < 0.84%, and R ≥ 0.98). These results suggest that both height and cranial dimensions a are sufficiently precise for anthropometric research applications. **Conclusion:** If one of the parameter is known the other can be known by applying the regression equations and this is of paramount importance to the forensic and anthropology sciences.

Keywords: Correlation, Cranial dimensions, Gender, Stature

INTRODUCTION

Height has been one of the impressive factors for personal identification of individuals since long ago & has always been of immense interest to anthropologists & for medico-legal purposes in Forensic Medicine.

Dimensional relationship between body segments and stature has been the focus of scientists for last two decades. Only few studies have utilized the cranial dimensions in this regard.[1-3] Scientists always face problems to correlate the metric traits of the skeletal remains with the stature.

Many workers have derived their own formulae for calculating the stature from long bones, but till now no universally acceptable formula has been derived as to the relationship between height and long bone, which differs according to race, age, sex & side of the body.[4] Although many formulae for stature estimation have been proposed, but regarding the accuracy of the use of population specific formulae on other human populations is debatable.[5,6] Evidence shows a clear racial variation in the cranial dimensions among different populations such as Koreans, Caucasians, Indians, Turkman and native Fars groups, Turkey, Zulu populations and Mapuche individuals in Chile.[7-14]

Estimation of height from length of head has also attracted many workers to derive a formula[15] but results concerning estimation of stature from cranial dimensions are scanty. Hence in the present study an attempt has been made to find out the correlation (if any) between head length, head breadth and body height in the Population of North India.

MATERIALS AND METHOD

The present study was conducted on 800 Students (400 male & 400 female) medical students of cosmopolitan origin, ranging from age group of 17 – 25 years of Western U.P. The subjects have similar socio-economic status. The measurements were taken at fixed time between 2 to 5 p.m. to eliminate the discrepancies due to diurnal variation. The subjects were apparently healthy and without any craniofacial deformity. Undue pressure was avoided while taking the measurements. All the measurements were taken

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by one observer in order to avoid inter-observer bias employed.

Instrument

Measurements were taken with the help of **"SPREADING CALIPERS"**.

Method

With the help of **"SPREADING CALIPERS"** Cranial dimensions were measured with *Hrdlicka's method*. The *head length* (maximum anteroposerior diameter) measured from *Glabella* (point above the nasal root between the eyebrows and intersected by mid sagittal plane) to *Inion* (the tip of external occipital protuberance).

The *head breadth* (maximum transverse diameter) measured between the *Porion* (point on the posterior root of the zygomatic arch above the middle of upper border of external auditory meatus) of each side.

The measurements were taken with the student sitting in the chair, in relaxed condition and the head in anatomical position.

The height of the individual was measured between vertex and the floor, when the person is standing erect, in anatomical position and the head in the Frankfurt's plane, using Stadiometer. Height was measured to the nearest 0.1 cm.

Regression equations were computed and Pearson's correlation coefficient was calculated to establish the correlation between the stature and cranial measurements using excel on window professional 2007. The significance of results was tested using Student's t-test. P-value of less than 0.001 was considered as significant.

Standardized anthropometric instruments used in all studies, yet there is lack of uniformity between methods and the degree of measurement error associated. This is significant because high amounts of measurement error can invalidate statistical results. Targets for anthropometric assessment have been put forward by Zerfas,[16] using a repeat- measures protocol. In present study, intraobserver precision estimates for measures of height & cranial dimensions were evaluated from two repeated measures on 800 subjects and then mean of two was taken. From this replicate data, three precision estimates were calculated: the technical error of measurement (TEM), the relative technical error of measurement (rTEM), and the coefficient of reliability *(R),[17] for reliability analysis*.

Technical error of measurement (TEM) is a measure of error variability that carries the same measurement units as the variable measured. Its interpretation is that differences between replicate measurements will be within ± the value of TEM two-thirds of the time.[18] Similarly, 95% of the differences between replicate measurements are expected to be within±/2_/TEM,[19] which is referred to as the 95% precision margin. Intra-observer TEM is estimated from differences between replicate measurements taken by one observer, while interobserver TEM is estimated from single measurements taken by two or more observers.

From TEM, the coefficient of reliability (R) can be determined, which ranges from 0 (not reliable) to 1 (complete reliability) although there are no recommended values for R, Ulijaszek and Kerr (1999)[20] suggested that a cut-off of 0.95 be used (i.e. a human measurement error of up to 5%). So a reduction in error indicates improvement in measurement technique between observers, and greater quality control.

RESULTS

Descriptive statistics for stature, head length and head breadth among males and females are shown in Table 1.

Correlation coefficient (r) was determined using Karl Pearson's formula & P-Value using t-test as depicted in Table 2.

Independent linear regression equations of stature from head length and head breadth in both sexes in Table 3. The mean height of the study group was found to be significantly different (P<0.001) between genders. Gender differences with respect to the mean ± Standard deviation cranial length, cranial breadth were found to be significantly larger in males compared to females (P<0.001) (Table 1). Correlation coefficient between the stature and measured cranial dimensions were found to be statistically significant and positive in both males and females (Table 2).

The technical error of measurement (TEM) can be determined which is an accuracy index and measures the standard deviation between repeated measures. The formulation of TEM depends on how many observers have taken the measurement. If the same observers has measured on two occasions (a measure of intra-TEM) or two observers have measured the same, then the formula for TEM is where D is the difference between the two measurements, and N is the sample size, as shown in Table 4.

$$\sqrt{\frac{\sum D^2}{2N}}$$

It is also possible to compute the relative TEM (%TEM), which provides an estimate of the error magnitude relative to the size of the measurement (expressed as a percentage) and is analogous to the coefficient of variation (see below).

$$\%TEM=\frac{TEM}{\bar{X}}*100$$

From TEM, the coefficient of reliability (R) can be determined, which ranges from 0 (not reliable) to 1 (complete reliability), where SD is the standard deviation of all measurements.

$$1-\left(\frac{(TEM)^2}{SD^2}\right)$$

For height & cranial dimensions measurements, all three estimates yielded a very high degree of precision (TEM < 0.5 cm, rTEM < 0.84%, and R ≥ 0.98) (Table 4).

Observations

Table 1: Mean±standard deviation values of stature, head length and head breadth

Parameters	Male	Female	P-value
Height (cm)	169.45±6.04	156.93±5.05	<0.001
Head length (cm)	18.24±0.64	17.39±0.62	<0.001
Head breadth (cm)	14.86±0.71	14.13±0.54	<0.001

Table 2: Correlation coefficient (r value) & P-value of stature and head measurements

Parameters	Male (r-value)	P-value	Female (r-value)	P-value
Stature with head length	+0.215	<0.001	+0.341	<0.001
Stature with head breadth	+0.232	<0.001	+0.291	<0.001

Table 3: Independent linear regression analysis for predicting the stature using the head length and head breadth

Study group	Regression equation	R^2 value
Male	Stature=109.97+3.18xhl	1.19
	Stature=107.64+4.19xhb	0.31
Female	Stature=121.54+2.03xhl	2.09
	Stature=114.88+2.58xhb	4.34

Table 4: Three precision estimates of reliability as TEM, rTEM and R for different

Parameters	TEM (cm)	rTEM (%)	R
Height	<0.5	<0.84	>0.98
Head length	<0.5	<0.84	>0.98
Head breadth	<0.5	<0.84	>0.98

DISCUSSION

There are various methods to estimate stature from bones but the earliest and reliable method is by regression analysis.[22] Height estimation by measurements of various long bones, head measurements, hand, foot length etc. has been attempted by several workers with variable degree of success.

In previous studies by Saxena et al[15]on Agra population, Jadav HR, Shah GV[2] on Gujarat population, Sudhir PE et al[21] on Maharashtra population, Seema and Mahajan A[23] on Punjab population, Santosh et al[24] on Rajasthan population, Richards, Elizabeth[25] on an American White population, Ryan I, Bidmos MA[26] on South African population have shown correlation coefficients between stature and head length as +0.2048, 0.53, 0.62, 0.52, 0.94 (males),0.85 (females), ranging from 0.343 to 0.447 for females and 0.285 to 0.357 for males & ranged between 0.40 and 0.54. respectively.

In the present study, correlation coefficient between,

Stature with Head length = +0.215 and Stature with Head breadth = +0.232 of males.

Stature with Head length = +0.341 and Stature with Head breadth = +0.291 of females.

Thus significant positive correlation coefficient is evident in both groups for head length and breadth which is in concurrence with the above mentioned studies. Data regarding estimation of stature from head measurements in Indian population is scanty. According to Glastier,[27] head length is 1/8 of the total height of an individual. Linear regression equations using either head length or head breadth were found to be helpful in estimating stature. Stature, head length and head breadth were significantly greater ($p<0.001$) in males when compared with females, which is in concurrence with studies. [3,28-30] Age of puberty being two years later in males as compared with females gives them extra time for growth. This suggests that the formula for one sex cannot be applied to estimate stature for the other sex. These results suggest that both stature & cranial dimensions are sufficiently precise for anthropometric research applications.

CONCLUSION

The prediction of the stature from incomplete and decomposed cranial remains is essential in establishing the identity of unknown individuals in incident of murder, accidents or natural disasters. If one of the parameter is known the other can be known by applying the regression

equations and this is of paramount importance to the forensic and anthropology sciences. The results of this study are however applicable only when an intact skull is examined. Measurement reliability of intraobserver reliability of the measurement, differences between replicate measurements taken by one observer was <0.5 cm & relative TEM as <0.84%. And even so, coefficients of reliabilities above 0.95 are indicative of good quality control. These results suggest that both height and cranial dimensions a are sufficiently precise for anthropometric research applications.

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