PREDICTION OF STATURE BY THE MEASUREMENT OF HEAD LENGTH IN POPULATION OF RAJASTHAN

Santosh Kumar, Rohin Garg, Khushboo Mogra, Rajuram Choudhary

1. Dental Surgeon, Department of Anatomy, S.M.S. Medical College, Jaipur.
2. PG Student, Department of Anatomy, SMS Medical College, Jaipur, Rajasthan,
3. PG Student, Department of Anatomy, SMS Medical College, Jaipur, Rajasthan,
4. PG Student, Department of Anatomy, SMS Medical College, Jaipur, Rajasthan,

CORRESPONDING AUTHOR:
Dr. Santosh Kumar,
81/16, Sector-8, Pratap Nagar, Sanganer,
Jaipur, Rajasthan, PIN-302033.
E-mail: drsantoshgupta22@gmail.com

ABSTRACT: BACKGROUND: Estimation of stature has a significant importance in the field of forensic anthropometry for the identification of an individual. AIMS: Study was carried out to assess and correlate head length and the stature and to predict the stature of an individual by head length using regression analysis. MATERIALS & METHODS: Total 300 (150 males and 150 females) medical students of S.M.S medical college, Jaipur (Rajasthan) were selected. Head length and height of the individual were measured. RESULTS: Correlation coefficient between height & head length were r=0.941 for Male & r= 0.85 for Female suggestive of strong positive correlation. Regression equations were derived to calculate height of unknown individual from head length. CONCLUSION: Present study has established definite correlation between stature and head length. If either of the measurement (total height or head length) is known, the other can be calculated. It will help in medico-legal cases in establishing identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc.

KEY WORDS: Anthropometry, Body Height, Cephalometry, Identification.

INTRODUCTION: Anthropometry, the typical and the traditional tool of physical anthropology, provides the scientific methods and the techniques for estimating the various measurements and the observations on the living as well as the skeleton of man. Human body height (Stature) is one of the most important elements in the identification of an individual. To assess the height of an individual, from measurements of different parts of the body, has always been of immense interest to Anatomists, Anthropologists and Forensic experts.

It is well known that there is a definite relationship between the height of the person and various parts of the body like head, trunk and lengths of extremities. The relationship between body segments has been used to compare and highlight variations between different ethnic groups and to relate them to locomotor patterns, energy expenditure, and lifestyle.1,2 Reconstruction of stature from various bones of the human skeleton has been achieved by many scientists with varying degree of accuracy. Establishment of alternative methodologies for personal height estimation is important for a number of reasons. Firstly, in instances where height estimates needed to be made from fragments of bones in archeological procedures or in forensic examinations after mass disasters or genocide.3 Secondly, estimates of pharmacokinetic parameters and evaluation of nutritional status rely on accurate measurement of not only body
weight but also height. However, a number of common disease or deformities of the vertebral column make it difficult to accurately measure standing height in many patients.4

Knowledge on the cephalometry is important in the study and comparison of the crania of populations from different racial, geographic and dietary backgrounds. Such information is also useful in studies of primate phylogeny. In clinical practice, population and age specific data on cranial dimensions gives an indication of growth and development of an individual and also any abnormalities of cranial size and shape.5 Although a wide variety of long bones have been employed for stature estimation only few studies have utilized the cranial dimensions in this regard.6,7,8,9 Although many formulae for stature estimation have been proposed, there is concern regarding the accuracy of the use of population specific formulae on other human populations.10,11 It is obvious that there are no universally applicable formulae as the relationship between head dimensions and cranial capacity is influenced by the race, sex and age of an individual. Thus, the need for race, age and sex specific stature estimation formulae is proved beyond doubt.3

Despite its significance and potential practical utility, little is known concerning the relationship between head length and stature among population of Rajasthan (India). Hence, this study was carried out to assess and correlate the head length & the stature and to propose population and gender specific regression equations for stature estimation using the head length.

MATERIALS & METHODS: For present study, total 300 subjects (150 males and 150 females) asymptomatic, apparently healthy medical students of S.M.S medical college, Jaipur (Rajasthan) were selected. The age ranged between 18-25 years. Head length was measured between two craniometric points- glabella and inion. Inion is the most prominent projecting point of occipital bone at base of skull and glabella is the point on protuberance of lower forehead above nasal root and between the eyebrow ridges intersected by mid sagittal plane. This was measured by placing the anterior caliper tip on glabella while allowing the posterior caliper tip to slide inferiorly along the median plain of the occipital bone until the maximum length was reached. Measurements were taken using blunt ended spreading caliper. Instrument was held in such a manner that the tips of the caliper were free to touch the head. Undue pressure was avoided while taking the measurement. [Figure] Height of the individual was measured in standing erect anatomical position. It is the vertical distance between vertex and heel touching the floor (ground surface). The measurements were taken at fixed time between 2 to 5 p.m. to eliminate the discrepancies due to diurnal variation and by the same person to avoid personal error in methodology. To minimize subjective errors, all the measurements were taken three times and then mean was taken. The armamentarium comprised of stature meter, spreading caliper (blunt ended).

The obtained data was analyzed to find out mean, standard deviation (S.D.), coefficient of correlation. Regression equations were derived to calculate height of unknown individual from foot length and hand length.

RESULTS: Linear regression analysis was done to estimate the stature from Head length as independent variables. Pearsons correlation coefficient was used to find the relation between the Head length & personal height. Correlation coefficient between height & head length (r=0.941 for Male & r= 0.85 for Female). It means that there is strong positive correlation between height & head length of study population. The regression equation for height & head length

4.知识在头颅测量中的应用对研究和比较不同种族、地理和饮食背景的人群颅骨非常重要。这些信息在灵长类生物种系的研究中也非常有用。在临床实践中，人口和年龄特定的数据表明颅骨的尺寸和容量指示了个体的生长和发育，以及颅骨大小和形状的任何异常。尽管长骨的种类多种多样，但只有少数研究利用了颅骨的尺寸。6,7,8,9 尽管许多公式用于身高的估算，但有关在其他人类群体中使用特定人口公式的影响存在担忧。10,11 显然，没有一个通用的适用公式，因为颅骨尺寸和颅骨容量的关系受到种族、性别和年龄的影响。因此，需要种族、年龄和性别特定的身高等估公式。3

5. 尽管其重要性和潜在的实际应用性显著，但关于拉贾斯坦邦（印度）人群中颅长和身高的关系，目前了解甚少。因此，本研究旨在评估和相关颅长与身高的关系，并提出基于颅长的身高压估计的回归方程。

6. 材料与方法：本研究中，共选取300名受试者（150名男性和150名女性），没有症状，看起来健康的学生，来自S.M.S医科大学，Jaipur（拉贾斯坦邦）。受试者的年龄范围在18-25岁之间。颅长的测量在两个颅位点之间进行，即前额的额突和枕骨的枕突。在前额的额突上放置前部卡钳，使其后部卡钳沿正中矢状面滑下，直到达到最大长度。测量时使用钝尖拨开卡钳。仪器被握持的方法使其两尖端自由接触头。在测量时避免过度压力。[图]身高为受试者站立时的解剖位置。它是顶峰到脚后跟的垂直距离。这些测量在下午2到5点之间固定时间进行，以消除昼夜变化的影响，并由同一人进行以避免方法学上的个人误差。为了减少主观误差，所有测量至少进行了三次，并取平均值。使用的装备包括身高计，钝尖拨开卡钳。

7. 通过分析获得的数据，计算出均值、标准差（S.D.），相关系数的系数。通过回归方程计算出未知个体内身高从脚长和手长。

8. 结果：进行了线性回归分析，以颅长为自变量来估计身高。使用皮尔逊相关系数来研究身高与颅长的关系。身高与颅长的皮尔逊相关系数为r=0.941（男性）和r=0.85（女性）。这表明拉贾斯坦邦（印度）人群中，身高与颅长之间存在强正相关。
length was found to be $Y = 138.87 + 1.87X$ for male & $Y = 128.07 + 1.82X$ for female, where $Y$ = total body height in cm, $X$ = head length in cm. [Table-1, Graph]

**DISCUSSION:** In forensic examinations and anthropological studies, prediction of stature from incomplete and decomposing skeletal remains is vital in establishing the identity of an unknown individual.\(^{12}\) There are various methods to estimate stature from the bones but the easiest and the reliable method is by regression analysis.\(^{13}\) Height estimation by measurement of various long bones, head measurements, hand, foot length etc. has been attempted by several workers with variable degree of success. Each researcher has derived his own formula for calculating the stature from these parameters. However, hand and foot measurement has not frequently been used for this. It was Rutishauser who for the first time showed that reliability of prediction of height from foot length was as high as that from long bones.\(^{14}\)

Various workers have shown significant correlation between height and different parts of the body. Singh and Sohal\(^ {15}\), Jit and Singh\(^ {16}\) have shown a significant correlation between height and length of clavicle. Charnalia\(^ {17}\), showed the significant correlation between height and foot-length, where correlation coefficient was 0.46. Athawale\(^ {18}\), derived a regression equation between total height and forearm bones. Shroff and Vare\(^ {19}\), have also derived the height from the length of superior extremity and its segments.

It is stated that the racial characters are best defined in the skull.\(^ {3}\) As a result cranial dimensions constitute one of the most important characters for determining the racial difference.\(^ {3,20}\) Variety of non-metric and metric parameters has been utilized in the assessment of ethnic and gender differences in cranio-facial morphology. The non-metric parameters are subjective as no quantitative techniques are devised. On the other hand, features that can be expressed as actual measurements, like cranial dimensions, provide more objective racial and gender diversity assessment of the crania.\(^ {3}\)

Correlation coefficients between the total height and head length among population of Rajasthan were found to be statistically significant and positive indicating a strong relationship between the two parameters. Previous studies have shown correlation coefficients of 0.62 (Sudhir PE et al.)\(^ {7}\), 0.53 (Jadav HR et al.)\(^ {6}\) & 0.52 (Seema and Mahajan)\(^ {9}\) between head length and height, whereas in the present study it was 0.94 for males and 0.85 for females which is suggestive of strong positive correlation between these two parameters. [Table-2] Regression equations for their respective population were also derived by previous workers.\(^ {6,7,8,9}\) Regression equations for stature prediction were formulated using head length and estimated statures in present study for study population and were compared with the actual statures to check the accuracy. The results further confirmed that head length provides an accurate and reliable means in stature prediction.

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 head length provide an alternative stature predictor under such circumstances. The cranium has easily identifiable surface landmarks making the measurements possible even in compromised conditions.

The present study for the first time documents gender specific regression models for stature prediction in adult population of Rajasthan. These formulae are valid for the age group (18-25 years) of the subjects. It is widely accepted that cranial morphology varies with the age of an individual.\(^ {21}\) In addition the height is also shown to progressively decrease with advancing age due to spinal cord shrinkage.\(^ {10}\) The population and gender specific regression equations
proposed will be of immense practical use in medico-legal, anthropological and archeological studies where the total height of a subject can be calculated if the head lengths are known. It will help in medico-legal cases in establishing identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. It will also help in establishing identity in certain civil cases.

**CONCLUSION:** The present study has established definite correlation between stature & head length and also regression equations have been established. It will help in medico-legal cases in establishing identity of an individual when only some remains of the body are found as in mass disasters, bomb explosions, accidents etc. If either of the measurement (head length or total height) is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts. It will also help in establishing identity in certain civil cases. There are lot of variations in estimating stature from cranial measurements among people of different region & race. Hence there is a need to conduct more studies among people of different regions & ethnicity so that stature estimation becomes more reliable & identity of an individual is easily established.

**REFERENCES:**


Table-1: Observations of Head length, Correlation coefficient and Regression equation.

<table>
<thead>
<tr>
<th></th>
<th>HEAD</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>MALE</td>
</tr>
<tr>
<td>Mean length(cm.)</td>
<td>18.047+/-2.54</td>
</tr>
<tr>
<td>Correlation Coefficient (r)</td>
<td>0.941</td>
</tr>
<tr>
<td>Regression analysis</td>
<td>Y*=138.87+1.87X†</td>
</tr>
</tbody>
</table>

Here * Estimated body height, †head length (cm).
Table-2: Estimation of stature from Head length (Comparative Analysis).

<table>
<thead>
<tr>
<th></th>
<th>Jadav HR et al.⁶</th>
<th>Sudhir PE et al.⁷</th>
<th>Ilayperuma I⁸</th>
<th>Seema, mahajan A.⁹</th>
<th>Present study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No. of cases</strong></td>
<td>728(M*+468, F+259)</td>
<td>406(M-198,F-208)</td>
<td>400(M-220,F-180)</td>
<td>400(M-210,F-190)</td>
<td>300(M-150,F-150)</td>
</tr>
<tr>
<td></td>
<td>Gujar region</td>
<td>Maharashtra region</td>
<td>Sri Lankans</td>
<td>Punjab zone</td>
<td>Rajasthan region</td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td>17-22</td>
<td>17-22</td>
<td>20-23</td>
<td>18-23</td>
<td>18-25</td>
</tr>
<tr>
<td><strong>Year</strong></td>
<td>2004</td>
<td>2010</td>
<td>2010</td>
<td>2011</td>
<td>2012</td>
</tr>
<tr>
<td><strong>Mean head length(cm.)</strong></td>
<td>17.65 +/-0.97</td>
<td>17.92 +/-0.83</td>
<td>18.0 +/-1.1(M)</td>
<td>17.81 +/-0.96</td>
<td>18.047 +/-2.54(M)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>17.19 +/-1.01(F)</td>
<td></td>
<td>16.921 +/-1.56(F)</td>
</tr>
<tr>
<td><strong>Mean total height(cm.)</strong></td>
<td>165.92 +/-8.96</td>
<td>163.29 +/-9.36</td>
<td>162.95 +/-9.025(M)</td>
<td>166.93 +/-8.94</td>
<td>170.432 +/-4.6(M)</td>
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<td>152.48 +/-11.498(F)</td>
<td></td>
<td>157.32 +/-3.58(F)</td>
</tr>
<tr>
<td><strong>Correlation coefficient</strong></td>
<td>+0.53</td>
<td>+0.629</td>
<td>0.715(M)</td>
<td>+0.52</td>
<td>+0.941(M)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.470(F)</td>
<td></td>
<td>+0.85(F)</td>
</tr>
<tr>
<td><strong>Regression equation</strong></td>
<td>Y=138.77+1.77X(M)</td>
<td>Y=58.15+6.11X(M)</td>
<td>Y=101.83+3.69X(M)</td>
<td>Y=136.88+1.89X(M)</td>
<td>Y=138.87+1.87X(M)</td>
</tr>
<tr>
<td></td>
<td>Y=128.03+1.72X(F)</td>
<td>Y=71.21+4.87X(F)</td>
<td>Y=226.60+3.86X(F)</td>
<td>Y=127.05+1.81X(F)</td>
<td>Y=128.07+1.82X(F)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Y=103.72+3.38X(T)</td>
<td>Y=77.89+4.98X(T)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Y=38.03+6.99X(T)</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td>Y=58.15+6.11X(M)</td>
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</tbody>
</table>

Here * Male, † Female, ‡ Estimated body Height, § head length (cm), ¶ Total population (Male & Female).

Graph: Pearson correlation between head length and body height (Total population including male & female) r=0.685; p<0.001 (N=300)