Estimation of Stature from Right Upper Limb Measurements

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ABSTRACT

Stature is an important & useful anthropometric parameter to determine the physical identity of an individual and as such, stature prediction occupies a relatively central position in the anthropometric research. Earlier workers in India have studied percutaneous measurement of different bones of upper & lower extremities or feet measurement alone but hardly any work has been done in correlating the length of right upper limb for estimation of stature. The present study has been undertaken with a view to correlate right upper limb measurements with the stature. Analysis is based on the 150 (75 males & 75 females) young & healthy students studying in the Santosh Medical College, Ghaziabad India. Regression formulae were constructed for males& females related to the real body height measurement in the erect standard position. The results indicate that right upper limb length measurements studied were strongly & positively correlated with stature. In conclusion, the study suggested that estimation of a living height can be made possible by the percutaneous measurements of the upper extremity.

Key words: *Stature, Identity, Anthropometry, regression, right upper limb length.*

INTRODUCTION

Anthropometry is often viewed as a traditional and perhaps the basic tool of biological anthropology, but it has a long tradition of use in forensic sciences and it is finding increased use in medical science especially in the discipline of forensic medicine[1]. One of the questions when people find new remnants of skeleton is what the height of the person was when he was alive. This question forms the basis of identification, Forensic anthropologists have taken interest since a long time in determining the heights of individuals from dimensions of bones. With increasing frequency of mass disasters, identification of an isolated upper extremity and the determination of the stature of individuals have created problems for investigators in identifying victims. Identification becomes necessary in the living, recently dead persons, decomposed bodies, mutilated & skeletal remains & is required in civil and criminal cases[2]. Study of upper arm length for estimation of stature has been attempted by various workers. One such study conducted by Nath, Garg and Krishan[3] for estimation of stature through percutaneous measurements of upper and lower limbs among 160 male Rajput's of Dehradun in age group of 16-35 years. The earthquake in Turkey in august 1999 and terrorist attack on world Trade Centre in September 2001 created great challenges to identification effort. Stature has a definite and proportional biological relationship with each and every part of the body like leg length, arm span, arm length, hand measurements, foot dimensions to mention a few. The relationship helps a forensic scientist to calculate stature from dismembered and mutilated body parts in forensic examinations[1]. Two methods of stature estimation have been established. Mathematical method is that of Trotter and Glesser[4]. The present study aims at providing anthropometric correlation of upper limb with stature.

MATERIAL AND METHODOLOGY

The data for the present study was collected by examining 150 healthy students aged 18 to 22in the department of Forensic Medicine & Toxicology, Santosh Medical College, Santosh University, Ghaziabad, India. Apart from taking detailed medical history, clinical examination of all the subjects was conducted to rule out any case having any significant disease or deformities, which can affect the general or bony growth. Since the maximum height of an individual is attained between 18 to 22 years, only those individuals were selected for the study.

Equipment: Following standardized anthropometric measuring equipment's were used for various body measurements:

1. Stadiometer
2. Sliding calipers
3. Lukfins retractable measuring tape

METHODS

The aims and objectives of the intended study were explained to the subjects and informed consent was taken on the pro-forma sheet. General physical examination of the subjects was conducted to know the health status and to rule out any deformity, disease, injury in the subjects. To minimize subjective error, all the measurements were taken three times and then mean was taken for statistical calculations. Measurements were taken in centimeters.

STATURE (Standing Height)

The height of each subject was recorded by asking him/her to stand erect with bare foot on the base of the standard stadio-meter in a standard standing position i.e.; to stand with both feet in close contact with one another, trunk braced along the vertical board on the stadio-meter with the head oriented in eye-ear

plane. The face was adjusted to keep the lateral palpebral commissure and the tip of the auricle of the pinna in a horizontal plane parallel to that of the feet. Then the measurement was taken in centimeters by bringing the projecting horizontal sliding bar to the vertex.

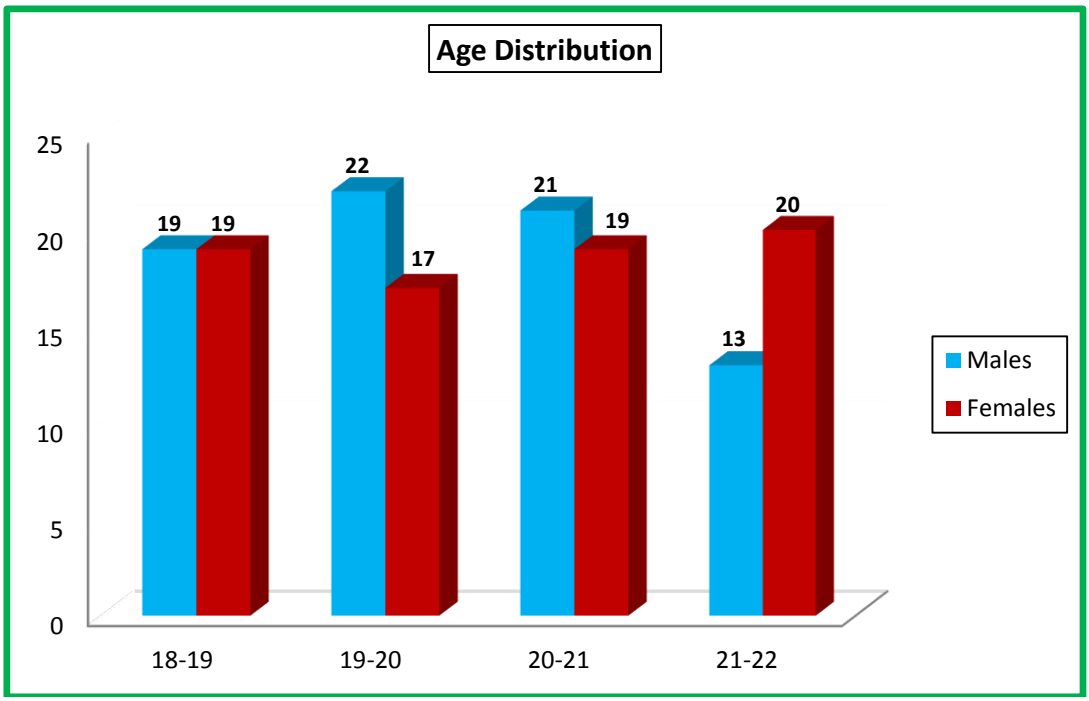
RIGHT UPPER LIMB LENGTH

Subject were asked to stand upright with weight evenly distributed on both feet, the shoulders relaxed and arms straight by the sides of the body such that the subject is directed away from the examiner. After demonstrating the correct position, the anatomical site was marked for measurement i.e.; acromion on the right shoulder. This was done by locating the end of the spine of the right scapula by following the scapula out of the arm until it makes a V-turn to the front of the body. Using cosmetic pencil, a horizontal line was drawn on the upper most edge of the posterior border of the spine extending from the acromion process. This was followed by taking the measurements by holding the zero end of the measuring tape at this mark and extend the tape down the surface of the right arm to the tip of the middle finger taking the measurements to the nearest 0.1 cm. The above data was tabulated and subjected to statistical calculations and the final result was further analyzed.

Data was analyzed using statistical package for the social sciences (SPSS) version 14(SPSS, including Chicago, IL) means, standard deviation & ranges were used to summarize the anthropometric measurements.

RESULTS

The study conducted showed that there exists a significant correlation between stature and the right upper limb length(RULL), by forming the regression equations, using percutaneous length of right upper limb for expeditious administration of law and justice. For this purpose, 150 (75 males and 75 females) young and healthy individuals fulfilling the inclusion criteria between the age group of 18-22 were included. In the study, total number of cases, both males and females were divided according to age in four groups and were subjected to statistical computations. Linear and curvilinear regression equations were formulated separately for each group and also for the total population together to find out if a single equation can be used for all age groups or an independent equation will be required separately for an individual age group for the estimation of stature. The bar diagram below represents age distribution of the students.



Stature: The stature measured by making a person stand in eye ear plane on Stadiometer varied from 155 cm to 183 cm among males with mean value of 169.4 cm and standard deviation (S.D) being 5.71 cm. The stature in females varied from 140 cm to 176 cm with mean value of 157.6 cm and standard deviation being 6.62 cms.

Right Upper Limb Length(RULL): In case of males, length of the right upper limb(RULL) varied from 72 cm to 85 cm with mean value of 78.6 cm and standard deviation(S.D) as 4.35 cm. In case of females RULL varied from 61

cm to 84 cm with Mean of 71.59 cm and S.D being 3.76 cm. Linear and curvilinear regression equations were derived separately for the estimation of stature from the length of right upper limb.

S = 72.968 + 1.227 * RULL & r= 0.936 (For total males)& "P" is less than 0.01

$S= -211+8.46*RULL+(-0.046)*(RULL)^2$ & V=0.940(For total males)

In case of females RULL varied from 61 cm to 84 cm with Mean of 71.59 cm and S.D being 3.76 cm.

S=38.145+1.668*RULL & r=0.947& "p" value is less than 0.01 (for total females)

$S=18.01+2.24*RULL+(-0.004)*(RULL)^2$ & V=0.948 (for total females)

'S' is the stature & 'RULL' is the right upper limb length. The positive value of correlation coefficient "r" is suggestive that there exists a direct relationship between stature and length of right upper limb. Calculated statures from these equations are close to the actual height. Multiplication factors were also derived from percutaneous length of right upper limb. The value of (r) was found to be more in case of females (r= 0.947) as compared to that in males (r= o.936), but such a little difference is statistically insignificant.

Table

Subjects	Mean height	Mean RULL	Avg.corcoeff(r)
Males	169.4	78.6	0.936
Females	157.6	71.59	0.947

DISCUSSION

Many Studies have been conducted on the estimation of stature from the human skeleton/percutaneous measurements. There are various methods to estimate stature but the easiest and reliable method is by regression analysis. All the studies conducted most often have chosen medical students, as in this study also because of the easy availability of the study population and also easy for obtaining highest cooperation. In the present study correlation coefficient(r) between height and RULL in males is equal to r= 0.936 and in females is equal to r=0.947 which is highly significant. Table X below shows the statistical data obtained in the study which suggests a strong correlation between stature & RULL.

Table X: Comparison of statistical data for stature reconstruction

Parameter	Gender	Mean (cm)	SD (cm)	Corre Coeff (r)	Tests of significance	S.E (±cm)	Significance at P<0.05
Stature	Males	169.4	5.71	1.000	-	-	-
	Females	157.6	6.62	1.000	-	-	-
RULL	Males	78.6	4.35	0.936	24.719	2.025	Significant
	Females	71.59	3.76	0.947	25.188	2.131	Significant

It is clear that if either of the measurements (RULL or total height) is known, the other can be calculated and this fact may be of practical use in medico-legal investigations and in anthropometry. Multiple regression equations resulted in a better estimation of the body parts when compared with simple regression equations; thus, it is better to use multiple regression equations when possible. The stepwise analysis demonstrated an accuracy rate close to the direct approach. Females were found to have a lower SEE in all equations compared with males. This difference can be attributed to a wider variability in male size compared with similarity in female size. Trotter & Gleser in 1958 provided the regression equations for estimation of stature from long bone lengths in American White, Black, Mongoloid and Mexican Males[4]. Living population of British and East African Males was explored by Allbrook in 1961[5]. Other authors who have contributed towards the problem of estimation of stature from long bones are Genoves in 1967, George K. Neuman in 1967, Shitai in 1983[6,7,8]. Ebeye Oladunni A, formulated regression equations for the estimation of stature in Urhobo-population of South Nigerian from length of upper extremity long bone measurements. The standard error in linear regression equation can be compared with those values found in this study[9]. Akhlag M, Hajibeygi M, Zamani and Moradi B, in 2010, presented regression for determining height from upper limb (left side) on 100 right-handed Iranian medical students aged between 21-26. Correlation of coefficient ranged from 0.310 – 0.696 in males and 0.290 – 0.735 in females[10]. The highest correlation coefficient between stature & foot length in males & foot breadth in females indicates

that the foot length provides the highest reliability and accuracy in estimating stature of unknown male & female[11]. V. K. R. Waghmare in 2011 studied 200 adult males, measurements of stature and length of right and left side were taken .This study showed a significant (p less than 0.001) positive correlation between the stature and hand lengths[12]. Relationship between hand length, foot length, and stature using multiple linear regression analysis based on sample of male and female adult Turks residing in Adana was determined with Multiple correlation coefficient, (R=0.928)[13]. The analysis of fleshed bodies and body parts is also a common scenario. For stature estimation in these types of cases, a study found that the stature estimates derived from anthropometric data provides a good result and removes the necessity for dissection when worked with fleshed body portions[14]. Evaluated knee height equations for stature estimation were tested through the validation sample and the results showed high accuracy[15]. Intact long bones of the upper and lower extremities have been used in the derivation of regression equations for the estimation of stature in different population groups[16].

CONCLUSION

The study indicates that stature can be predicted accurately by linear/curvilinear and multiple regression analysis even when identity is unknown from RULL-a problem frequently encountered in medico legal investigations. Establishing identity of an individual when only some remains of the body are found as in mass disaster, terror events, bomb explosions, accidents, wars etc. If either of the measurement is known the other can be calculated and this would be useful for forensic medicine experts and anthropologists. It will also help in establishing identity in certain civil cases. There are lot of variations in estimating stature from limb measurements among people of different region and race. Hence there is a need to conduct more studies among people of different regions and ethnicity, so that stature estimation becomes more reliable and identity of an individual is easily established. These regression equations can be routinely used for the estimation of stature from the fragmentary remains discovered in the city of Ghaziabad and surrounding area. Therefore it will be of immense importance in the field of crime detection.

CONFLICT OFINTERESTS: None

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