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Forensic Medicine

ESTIMATION OF TIBIAL LENGTH - A TOOL TO PREDICT STATURE IN YOUNG INDIAN MALES

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ABSTRACT

BACKGROUND: Long bone length is one of the best–known indicators of human stature.
AIMS AND OBJECTIVE: To estimate the stature of body from tibial length was the aim of the present study and to find out the differences in measurement of right and left side bones and their relationship with the stature.
METHODS AND MATERIALS: The study was initiated by obtaining a complete demographic profile of the students. Total number of cases was divided according to age into four groups (with a year in each subgroup) 18-19 years, 19-20years, 20-21years and 21-22 years. Tibial length was measured by putting the lower limb in such a position so that a constant 90o angle was obtained between the flexor surfaces of thigh and leg. Then most prominent eminence on medial condyle of tibia and medial malleolus were marked. A large sliding calliper was used to measure the distance between the two marked points. RESULT: The calculation of height for the total population gave a range from 150.10 cm to 184.50 cm, SD=6.57 cm. The mean height was 169.54 cm. In 66.5% of cases the length of left tibia was greater than that of right while in 12.5% of cases it was vice-versa. In 21% of cases right and left tibia were of equal lengths.
CONCLUSION: The individuals with greater percutaneous tibial length have, as expected, a higher height.

KEYWORDS : Anthropometry; Correlation coefficient; Regression equation; Maximal tibial length.

INTRODUCTION:

Human remains obtained from mass disasters, traffic accidents, criminal mutilations, airplane crashes etc are always a challenge for any forensic expert where not only it should be separated from the debris and non-human remains but evidences about identity of individuals should be ascertained from small bits and pieces of osteological remnants available [1]. These remains work as important tools for acquisition of information with respect to origin (human or non-human) race, gender, ethnicity and even stature estimation. All these information may be used to create a complete biological profile and subsequently used for personal identification of an individual[2].

The bones frequently received by a forensic expert are from any segment of body but most commonly received are that from the long bones. The estimation of stature can be achieved from knowing the length of humerus, femur and tibia. Next commonly used are the radius, ulna and fibula [3]. Even fragments of these bones can provide relevant data of stature. This is obtained by first estimating the complete bone length by applying linear regression formulas to length of the fragmented part and then computing the stature from the calculated complete bone length [4]. Among the long bones the lower limb bones especially tibia is considered as a strong and most apt tool for estimation of stature of an individual [5]. This can be further utilized for personal identification of an individual in medico-legal autopsies and also during the justice procedural systems as with this estimation a complete biological profile of an individual can be sketched. The stature estimation may also be compared with ante mortem records to include or exclude possible identification of missing persons.

Various racial, ethnic, environmental and nutritional factors affect the stature of populations from different regions [2]. Thus presence of normograms to elicit the standard heights of individuals as well as regression equations for stature estimation from long bone lengths can be a useful tool in forensic anthropology but are scarcely available in literature, more so for Indian population groups[5]

The multifaceted as well as multifactorial problem of identification and reconstruction from skeletal remains is presently the greatest challenge for forensic anthropologists. The identification of individual is the epicentre for anthropological and forensic research and is also necessary in the process of medical jurisprudence. The trunk and limbs show characteristic ratio amongst themselves and also in comparison with the height which are race and ethnicity dependent[6].

AIMS AND OBJECTIVE

1) The aim of the present study is to provide prediction coefficient and regression equations for reconstruction of stature from percutaneous measurement of tibial lengths in young Indian male subjects.
2) The study will also find out the differences in measurement of right and left side bones and their relationship with the stature.

Study design: Cross Sectional Study

The study was conducted on young male medical students of Santosh Medical College, Ghaziabad in the Department of Forensic medicine and toxicology.

Study Period: From November 2009 to October 2012.

SELECTION CRITERIA

Inclusion Criteria:
Male students in the age range of 18-25 years were selected.

Exclusion Criteria:
Possibilities of Nutritional, Hormonal, Metabolic or Physical abnormalities.

MATERIAL AND METHODS:

The study was conducted on young male medical students of Santosh Medical College, Ghaziabad in the Department of Forensic medicine and toxicology. Students who willingly participated and provided written informed consent were enrolled for the study. After appropriate ethical clearance, the study was initiated by obtaining a complete demographic profile of the students. This was done so that only those students who were native of Ghaziabad or around were included to provide a regional data of stature estimation. With the demographic questionnaire and available written informed consent 105 male students in the age range of 18-25 years were selected for further assessment. A detailed medical history followed by clinical examination was ascertained to rule out any possibilities of nutritional,

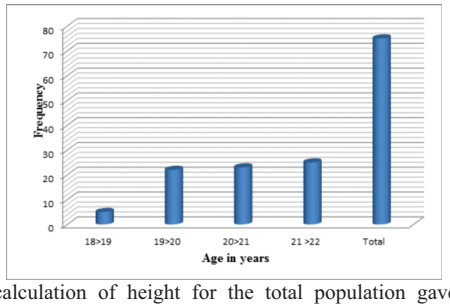
hormonal, metabolic or physical abnormalities. After these assessments, 30 students were eliminated from the study and total of 75 subjects were finally taken for further measurements. Total number of cases was divided according to age into four groups (with a year in each subgroup) 18-19 years, 19-20years, 20-21years and 21-22 years. The height of individual subject was assessed in a normal standardised way by using a validated stadiometer with the person standing in anatomical position [7]. The lower limb or tibial length was measured by putting the lower limb in such a position so that a constant 90° angle was obtained between the flexor surfaces of thigh and leg. Then most prominent eminence on medial condyle of tibia and medial malleolus were marked. A large sliding calliper was used to measure the distance between the two marked points. All the measure was taken in centimetres[8].

OBSERVATIONS:

Present study is focused exclusively on the aspect of estimation of stature by forming the regression equations, using percutaneous length of legs and measurements of feet for expeditious administration of law and justice.

The demographic profile of subjects was used to find the frequency of subjects in each group and is represented in figure no.1.

Fig 1: frequency of subjects in each sub-group



The calculation of height for the total population gave a range from150.10 cm to 184.50 cm, SD=6.57 cm. The mean height was 169.54 cm. The tibial length was also calculated as per the described methodology and is represented in table 1. In 66.5% of cases the left tibia was greater than the right while in 12.5% of cases it was vice-versa. In21% of cases right and left tibia were of equal lengths. This frequency distribution was found to be statistically insignificant with p>0.05 at 95% confidence interval (CI).

Table 1: Tibial length for right and left side.

	TIBIAL LENGTH (In cm)		
Measurement	**Right side**	**Left side**	**P value**
Minimum	25.822	25.900	>0.05 (at 95% CI)
Maximum	46.200	46.200	
Mean	34.903	35.065	
S.D.	3.037	3.060	

Table 2: Linear regression equation with correlation coefficient.

Age group	Right	r	Left	R
18-19	101.625 +1.948 TLRT + 2.216cm	0.910	103.689 + 1.885 TLLT + 2.415cm	*0.892
19-20	97.917 + 2.059 TLRT + 4.219cm	0.819	96.119 + 2.103 TLLT + 4.158cm	0.825
20-21	107.043 + 1.799 TLRT + 3.026cm	0.882	108.043 + 1.761 TLLT + 3.108cm	*0.875
21-22	106.085 + 1.085 TLRT + 3.515cm	0.841	106.452 + 1.787 TLLT + 3.493cm	0.843
Total males	104.971 + 1.850 TLRT + 3.414cm	0.855	105.324 + 1.831 TLLT + 3.436cm	0.862

A linear regression equation was derived separately for estimation of stature from the length of tibia of right and left side in males and is depicted in Table 2.

TLLT = Tibial length left; TLRT = Tibial length right The positive value of *r* is suggestive that there exists a direct relationship between stature and length of tibia. It is evident that by applying linear regression equations the stature can be estimated from the length of tibia (right & left) within the standard error of + 3.4cm. However if the age of the person is known, then better results can be obtained by using the independent linear regression equations for the age group of 18-19, where the standard error is only + 2.216cm for right side and + 2.415 for left side.

Similar to this, curvilinear equations were created to predict height of an individual with tibial length and the results are:

Stature =101.625 +1.948 TLRT + 2.216cm (for age gp.18-19) 'r' =0.910

Stature =136.853+ 0.027 $TLLT^2$ + 2.370cm (for age gp.18-19) V =0.896

Stature =97.911 + 2.059 TLRT + 4.219cm (for age gp.19-20) 'r' =0.819

Stature =96.119 + 2.103 TLLT + 4.158cm (for age gp.19-20) 'r' =0.825

Stature = [107.044 + 1.799 TLRT] + [(-28.314+(-0.105) $TLRT^2$ + 2.576 cm (for age gp.20-21) 'r' =0.917

Stature = (108.043+1.761 TLLT) + [41.452 + (-1.265E-05) $JTLLT^4$ ± 2.683cm (for age gp. 20-21) 'r' =0.910

Stature =106.452 + 1.787 TLRT + 3.493cm (for age gp.21-22) 'r * =0.843

Stature =106.452 +1.787 TLLT + 3.493cm (for age gp.21-22) V =0.843

Stature =104.971 + 1.850 TLRT + [-14.02+(-0.095) $TLRT^2J$ + 3.110cm (for total males) 'r' =0.855.

Stature =143.504 + 1.672 E-05 $TLLT^4$ + 2.593cm (for total males) 'r' =0.902

Curvilinear regression equation derived for individual age group using length of tibia can predict the stature within the standard error of +2.370 cm for 18-19 age group. If the age of the person is not known, then the stature can be ascertained within the range of + 3.110 cm using length of right side tibia and within the range of + 2.593 cm using length of left side tibia. The difference in stature prediction range from linear and curvilinear regression equations was found to be statistically insignificant.

STATISTICALANALYSIS:

All the observations were recorded in excel format and then SPSS statistical analysis was used to devise linear and curvilinear regression equations for estimation of stature for Indian males of the selected regional area.

RESULT:

Linear and curvilinear regression equations were formulated separately for each group and also for total selected population to find out if a single equation can be used for all the age groups or an independent equation will be required separately for an individual age group for the estimation of stature. The right and left sided observations were compared statistically to find out the bilateral difference in the same individual.

DISCUSSION:

Various anthropologists, anatomists and forensic experts took interest in devising ways of reconstructing the stature of living individuals from skeletal remains and it was sought that long bones are of immense importance [9]. Earliest formal table for estimating stature were made available by Rollet in 1888 but it was Pearson in 1899 that developed regression equations for estimation of stature using length of long bones [10, 11]. The work of most of early researchers proved that specific regression formulae are to be used for particular racial or regional population groups. Pearson in 1899 provided regression formulae for males and females for estimation of stature but has not mentioned the range with in which stature could be predicted. When applicability of Pearson's formulae was tested it was found that formulae of one race did not give satisfactory results for other races.

The process of evolution and fast growing civilization has resulted in intermixing of population throughout the world, thus the present study holds significance. Regression equations, linear and curvilinear were derived for estimation of stature using percutaneous measurements of legs. Efforts were also made to find out any bilateral variations in measurements. In the present study for estimation of stature two types of regression equations i.e., linear and curvilinear were devised. The curvilinear regression equations are expected to give better results as it can reduce the standard error.

The observations of the present study reveal variation in length of right and left side of tibia by percutaneous measurement, with left being larger than the right. Similar results were obtained by Mukta et al in their study on 270 males within similar age groups[12]. The bilateral comparison for the present study was statistically insignificant and similar results have been appreciated by early researcher's[13, 14]. The stature estimation study by previous researchers was reviewed and a study on 50 Hindu male medical students of similar age groups; as of present study; was found to be positively correlated [15]. The regression equation could predict the stature within the range of + 8.15 cm. The comparative analysis of standard error of regression equations for estimation of stature from length of tibia is shown in Table - 3.

Table 3: A Comparative analysis of variation of standard error of regression equations for estimation of stature from length of tibia.

Author (Population)	Males		
	Combined	Right	Left
Stevenson 1929 (Chinese)[16]	1.89	-	-
Bfeitinger 1937 (Germans)[17]	4.7	-	-
Trotter & Gleser 1952[18]			
(American Whites)	3.37	-	-
(American Blacks)	3.78	-	-
Trotter & Gleser 1958[19]			
(American Whites)	3.37	-	-
(American Blacks)	3.96	-	-
(Mongoloids)	3.27	-	-
(Mexicans)	3.73	-	-
Albrook 1961[20]			
(Nilohamite students)	-	3.76	-
(Nilohamitetribals)	- .	2.97	-
(Niiotes students)	-	3.65	-
(Bantu students)	-	3.73	-
(British Soldiers)	-	3.46	-
Pateletal 1964 (Gurjat)[15]	-	-	8.15
Genoves 1967[21]	2.81	-	-
(Mongoloids)			
Shitai 1983[22]	4.59	-	-
Badkur 1985 (Madhya Pradesh)[23]	1.9	-	-
Sciulli et al 1990[24]	3.36	-	-
(Native Americans Ohio)			
Sciulli et al 1993[25]	2.74	-	-
(Native Americans Ohio)			
Mohanty 1998 (Oriya)[26]	2.87	-	-
Present Study (Ghaziabad)	-	3.14	3.44

This table depicts that variable values are obtained with respect to different regional population selection. This thus highlights the significance of present study so that a complete database can be created for future reference.

CONCLUSION:

From the regression equations derived in the present study, the stature can be accurately and satisfactorily estimated for medico-legal and forensic purposes. Curvilinear regression equations derived in the present study are found to be no better than the linear regression equations as the range of prediction cannot be reduced by using the former regression equations. Measurements of Left side were found to be bigger than the measurements of right side. The positive value of V i.e., correlation coefficient exists which is suggestive of a direct relationship between tibial length and the stature. The best stature prediction can be done from the length of tibia of right side in males within the standard error of + 3.41c.

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