

## Prospective Study on Estimation of Stature of Adult from Length of Clavicle in a Tertiary Care Hospital in Tamilnadu

Dhivya Prakash<sup>1</sup>, MN Rajamani Bheem Rao<sup>2</sup>, Vijay Balaji R<sup>3</sup>, R.Raguram<sup>4</sup>, K. Priyatharsini<sup>5</sup>

<sup>1,3,4</sup>Assistant Professor, <sup>5</sup>Associate Professor Department of Forensic Medicine, Government Stanley Medical College, Chennai, <sup>2</sup>Associate Professor, Department of Forensic Medicine, Vels Medical College, Chennai.

**How to cite this article:** Dhivya Prakash, MN Rajamani Bheem Rao, Vijay Balaji R et al. Prospective Study on Estimation of Stature of Adult from Length of Clavicle in a Tertiary Care Hospital in Tamilnadu. Indian Journal of Forensic Medicine and Toxicology/Volume 18 No. 1, January-March 2024.

### Abstract:

Forensic anthropology can play an important role in the identification process. Besides determination of race, sex and age of the unknown individual, estimation of stature enhances the reliability of identification. It is easier to get those data when the whole body or the entire skeleton is available to the forensic anthropologist. However in cases of deliberate mutilation and disposal in parts, interference by wild animal and bomb blast by terrorist attack, recovery of the whole body or complete skeleton may not be possible. In those cases, in the forensic anthropologists have to give this opinion based upon the available supplied skeleton remains. Although approximate stature of the individual can be estimated from most of the long bones using either multiplication factors or regression formulae, studies on estimation of stature from clavicle are limited. In the past, Terry, Oliver and Thieeme have tried to estimate the stature of the individual from clavicle. So the present study is planned to determine the stature from clavicle.

**Keyword:** Forensic anthropology, Clavicular length, stature estimation

### Introduction

In medico-legal cases, establishing an individual's identity is necessary in both living and dead. Various features including bones, body parts, and marks over the body, things associated with the individual, behavioral pattern, etc are used for identification. Forensic anthropology mainly involves the study and analysis of human remains and assists in criminal investigative process. The four important parameters of forensic anthropology are sex, age, stature and race.

Fair information about the individual's identity can be established using these parameters. Among these parameters, stature estimation is an important process of identification when the body parts are dismembered / mutilated or only bones are recovered. Stature estimation is also useful in mass disasters like earthquakes, tsunami, etc. where only bones or body parts of many people are found.

In early days, stature was estimated by rearticulating the skeleton and measuring it. The most common method to estimate stature is using long bones of the body. Karl Pearson, Trotter and Gleser derived regression formulae for estimation of stature using the lengths of different long bones like humerus, ulna, radius, tibia, fibula and the bicondylar length of femur and concluded that maximum length of femur and stature had a linear relationship<sup>1</sup>. In 1967, study conducted by Genoves<sup>2</sup>, in Mesoamerican population, proved that femur and tibia are the best predictors of stature. In 2003, Ozaslan et al<sup>3</sup> conducted study in Turkish population that derived stature from length of leg and in 2007, Petrovecki et al<sup>4</sup> in their study found that tibia is the best predictor in males and humerus is the best predictor in females. Athawale et al<sup>5</sup> conducted a study of Indian population to obtain regression formulae for estimation of stature using forearm bones. His study concluded that there was more significant linear relationship between forearm

**Corresponding Author:** MN Rajamani Bheem Rao, Associate Professor, Department of Forensic Medicine, Vels Medical College, Chennai.

**E-mail:** vijay.medico88@gmail.com

**Submission Date:** Jun 6, 2023

**Revision Date:** Jun 21, 2023

**Publication date:** Jan 19, 2024

length and stature than individual forearm bones and stature.

Various studies have been conducted to correlate stature with foot length, foot bone length, metacarpal and metatarsal length. Steele and McKern<sup>6</sup> found that, utilizing specific segments of the humerus, femur, and tibia, they could estimate the corresponding long bone lengths and provide a reasonable estimate of living stature which was revised by Simmons et al<sup>7</sup>. Patil and Mody<sup>8</sup> determined that height could be estimated from the skull using separate regression formulae for males and females. Several studies on stature estimation using other bones like clavicle, sternum, scapula and various body parts were conducted.

Many studies have been conducted using clavicle in forensic context. The most common studies include determination of age and sex from clavicle and its radiographic estimation using various parameters like length of the clavicle, vertical diameter, sagittal diameter, mid-clavicular circumference, weight, etc. Natalie Renee Shirley<sup>9</sup> conducted a study of age and sex estimation from the human clavicle in American population. In 2015, Falys and Prangle<sup>10</sup> found that sternal end of the clavicle is more reliable factor for estimation of age. Makander et al<sup>11</sup> conducted a study on determination of sex and race from adult clavicle in South Indian population. In 2014, Marjan Mansorvar<sup>12</sup> conducted a study on bone age assessment using hand and clavicle x-ray images.

In 1952, Singh and Sohal<sup>13</sup> conducted a study to estimate stature from clavicle in Punjabi population. Balvir et al<sup>14</sup> estimated stature from the length of clavicle in Vidarbha region of Maharashtra and derived regression formula for estimating stature from clavicle. Rani et al<sup>15</sup> conducted a study on correlation of stature of adult with length of clavicle and derived regression formulae for both males and females separately.

There are only very few studies on estimation of stature from clavicle. This is because long bones proved to be reliable parameter for estimation of stature. But in forensic context, long bones may not be available in every case. So it is important to estimate stature from other bones like clavicle. The current study was undertaken with the aim to add to the current body of knowledge on stature estimation.

The present study was conducted with the objective to find out correlation between length of

right and length of clavicle. Also the regression formula to estimate stature from adult clavicle for both sexes was derived in the study.

## Materials and Methods

The present study was a cross sectional study carried out in Institute of Forensic Medicine, Madras Medical College, Chennai-3. The descriptive component was used to determine mean stature, length of right and left clavicle in both male and female subjects. The analytical component was used to find the correlation between the stature and length of clavicle and to formulate regression equation for stature from clavicular length in both males and females. All cases in the adult age group (>22 years) subjected for medico-legal autopsy from the month of April 2017 - March 2018 were included for the study. Cases with fracture and pathological deformity of clavicle, cases with skeletal deformity and cases not from Tamil Nadu were excluded from the study. The stature of the cadaver was measured initially after noting down the particulars of the deceased. The living stature is obtained from cadaveric stature by deducting 15 mm for males and 20 mm for females. The clavicle from both sides were removed from the body after dissecting sternoclavicular joint and acromioclavicular joint and all muscular attachments of clavicle. The remaining soft tissues attached to the clavicles were removed and clavicles were cleaned. The length of the clavicle is measured using digital vernier caliper.

## Results

In this study, 200 cases which were subjected to medico legal autopsy in mortuary attached to Institute of Forensic Medicine, Madras Medical College were taken as study sample. In the study, 79% of the cases were male and 21% were female. 46.5% of cases belonged to the age category 31 - 50 years while 27.5% and 26% of cases belonged to the age group 51 - 70 years and 23 - 30 years respectively.

The total number of cases was classified into 7 groups according to their stature. 2%, 1.5%, 8.5% and 9.5% of total sample size were in stature group 139.0 - 145.0 cm, 145.1 - 150.0 cm, 150.1 - 155.0 and 155.1 - 160.0 cm respectively. 25.5% & 14% of cases were in stature group 165.1 - 170.0 & 170.1 - 175.0 respectively. The stature group with highest number of cases was 160.1 - 165.0 with 78 cases which constituted 39% of total sample size.

The age group 23-30 consisted of 46 male cases which constituted 29.1% of total male cases and 6 female cases which constituted 14.3% of total female cases. The age group 31-50 consisted of 64 male cases which constituted 40.5% of total male cases and 29 female cases which constituted 69% of total female cases. The age group 51-70 consisted of 48 male cases which constituted 30.4% of total male cases and 7 female cases which constituted 16.7% of total female cases. The p value calculated for the above data was 0.004 which was statistically significant. The stature group 139.0 - 145.0 cm consisted of 2 male cases which constituted 1.3% of total male cases and 2 female cases which constituted 4.8% of total female cases. The stature group 145.1 - 150.0 cm consisted of nil male cases and 3 female cases which constituted 7.1% of total female cases. The stature group 150.1 - 155.0 consisted of 6 male cases which constituted 3.8% of total male cases and 11 female cases which constituted 26.2% of total female cases. The stature group 155.1 - 160.0 consisted of 11 male cases which constituted 7% of total male cases and 8 female cases which constituted 19% of total female cases. The stature group 160.1 - 165.0 consisted of 70 male cases which constituted 44.3% of total male cases and 8 female cases which constituted 19% of total female cases. The stature group 165.1 - 170.0 consisted of 43 male cases which constituted 27.2% of total male cases and 8 female cases which constituted 19% of total female cases. The stature group 170.1 - 175.0 consisted of 26 male cases which constituted 16.5% of

total male cases and 2 female cases which constituted 4.8% of total female cases. The p value calculated for the above data was <0.001 which was statistically significant.

The mean stature of the total sample was 163.9 cm. The mean right clavicle length and the mean left clavicle length of total sample was 145.8 mm and 150.4 mm respectively. The mean stature of the total male population was 165.3 cm while that of female population was 158.6 cm. The mean right clavicle length of total male population was 147.4 mm and that of total female population was 139.9 mm. The mean left clavicle length of total male population was 152.4 mm and female population was 142.8 mm. It is noted that length of left clavicle is more than right clavicle in both male and female.

Table 1 shows independent sample test for stature in both male and female. The p value was calculated for this data and found to be <0.001 which proves that the data is statistically significant. The mean stature of 23 - 30 yrs group is 167.33 cm with minimum stature of 150 cm and maximum stature of 174 cm. The mean stature of 31- 50 yrs group is 164.01 cm with minimum stature of 152 cm and maximum stature of 175 cm. The mean stature of 51-70 yrs group is 160.49 cm with minimum stature of 139 cm and maximum stature of 170 cm. In total, the mean stature of total population is 163.90 cm with minimum stature of 139 cm and maximum stature of 175 cm as shown in table no.2.

**Table 1: Distribution of Mean Stature in Male and Female**

	SEX	N	Mean	Std. Deviation	Std. Error Mean	t value	P value
STATURE	Male	158	165.3101	5.46780	.43499	6.435**	<0.001
	Female	42	158.6190	7.66669	1.18300		

**Table 2: Distribution of Stature among Different Age Groups**

Age in years	N	Mean stature	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	f value
					Lower Bound	Upper Bound			
23-30	52	167.3269	4.67249	.64796	166.0261	168.6278	150.00	174.00	16.792**
31-50	93	164.0108	5.70373	.59145	162.8361	165.1854	152.00	175.00	
51-70	55	160.4909	7.73609	1.04313	158.3996	162.5823	139.00	170.00	
Total	200	163.9050	6.56976	.46455	162.9889	164.8211	139.00	175.00	

The correlation between stature and right clavicle length was calculated using Pearson’s correlation formula and the correlation coefficient was found to be 0.586 and p value was <0.001. (Figure No.1) This proves that there is positive correlation between the stature and length of right clavicle, i.e., when length of right clavicle increases stature of the individual increases and vice versa. Similarly, the correlation

between stature and left clavicle length was calculated using Pearson’s correlation formula and the correlation coefficient was found to be 0.586 and p value was <0.001 (Figure No.2). This proves that there is positive correlation between the stature and length of left clavicle, i.e., when length of left clavicle increases stature of the individual increases and vice versa.

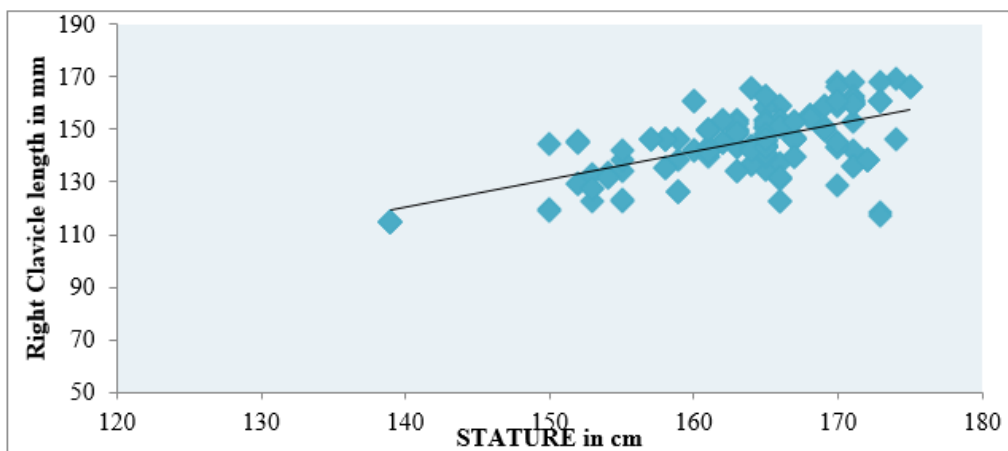


Figure 1: Correlation Between Stature and Length of Right Clavicle

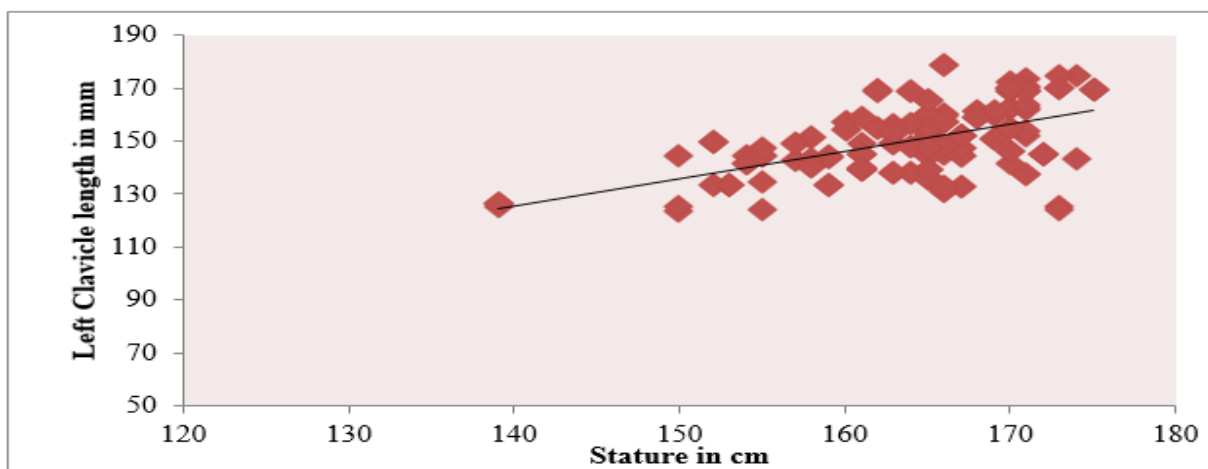


Figure 2: Correlation Between Stature and Length of Left Clavicle

The summary of regression analysis for stature prediction [Predictors (Constant): left clavicle length, right clavicle length] is shown in Table No.3 and

ANOVA table for regression analysis calculated with predictors as left and right clavicle length and stature as dependent variable Table No.4.

Table 3: Summary of Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.590 <sup>a</sup>	.348	.341	5.33225

**Table 4: Anova Table for Regression Analysis (Stature as Dependent Variable)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2987.906	2	1493.953	52.543	.000 <sup>a</sup>
	Residual	5601.289	197	28.433		
	Total	8589.195	199			

From the analysis it was found that length of right clavicle is a good predictor of stature with p value <0.05. On the other hand, the length of left

clavicle is not a good predictor of stature since the p value is >0.05.

**Table 5: Coefficients of Regression Analysis**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	115.506	4.772		24.205	.000
	Right clavicle length	.251	.068	.456	3.694	.000
	Left clavicle length	.078	.066	.146	1.186	.237

A regression formula for estimation of stature of an individual from maximum length of right clavicle irrespective of gender is formulated as  $\text{Stature} = 0.251(\text{Right Clavicle Length}) + 115.506$

The correlation between stature and right clavicle length was calculated using Pearson's correlation formula and the correlation coefficient was found to be 0.498 and p value was <0.001 in males and 0.663 and p value was <0.001 in females. The correlation between stature and left clavicle length was calculated using Pearson's correlation formula and the correlation coefficient was found to be 0.450 and p value was <0.001 in males and 0.592 and p value was <0.001 in females. This proves that there is positive correlation between the stature and length of right and left clavicle in both sexes.

From the regression analysis done for stature estimation in both gender, it is clear that length of right clavicle is a good predictor of stature with p value <0.05. On the other hand, the length of left clavicle is not a good predictor of stature since the p value is >0.05. The regression formula for estimation of stature of an individual from maximum length of right clavicle for male population is formulated as  $\text{Stature} = 0.214 (\text{Right Clavicle Length}) + 128.66$ . The regression formula for estimation of stature of an individual from maximum length of right clavicle for females is formulated as  $\text{Stature} = 0.412(\text{Right Clavicle Length}) + 104.883$ .

## Discussion

The mean stature in the present study was found to be 165.3 cm in males and 158.6 in females. According to Nataraja Moorthy et al<sup>16</sup>, the mean stature of Tamil Nadu population was found to be 173.7 cm. In a study conducted by Angus Deaton et al<sup>17</sup>, the mean stature of Tamil Nadu population was found to be 165.8 cm in males and 153.4 cm in females.

The mean length of right clavicle in males in the present study was 147.4 cm and that of left clavicle was 152.4 cm and the mean length of left clavicle in females in the present study was 139.9 cm and that of left clavicle was 142.8 cm. In a study done by Rani et al<sup>15</sup>, the mean length of right clavicle in males was 149.7cm and that of left clavicle was 146.2cm and the mean length of left clavicle in females in the present study was 118.4cm and that of left clavicle was 115.6 cm.

In the present study, the mean length of right clavicles is less than left clavicles in both males and females which is similar to the study conducted by Sudha et al<sup>18</sup> in south Indian population, Makandar et al<sup>11</sup>.

In the present study, the regression equation was determined to estimate the stature from maximum length of right clavicle in both males and female are as

For male: STATURE = 0.214 (RIGHT CLAVICLE LENGTH) + 128.662

For females: STATURE = 0.412 (RIGHT CLAVICLE LENGTH) + 104.883

In a study conducted by Balvir et al<sup>14</sup>, regression formulae were determined for both males and females from both right and left clavicles.

#### For males:

Right clavicle: STATURE = 1630.58-0.0772 (MAX LENGTH OF RIGHT CLAVICLE)

Left clavicle: STATURE = 1617.47 + 0.0157 (MAX LENGTH OF LEFT CLAVICLE)

#### For females:

Right clavicle: STATURE = 1707.2-1.31 (MAX LENGTH OF RIGHT CLAVICLE)

Left clavicle: STATURE = 1674.58 + 1.0385 (MAX LENGTH OF LEFT CLAVICLE)

### Conclusion

In the present study conducted, it has been concluded that the mean stature is more in males than females. The mean length of right clavicle is less than the mean length of left clavicle in both males and females. The mean length of right and left clavicle is more in males than in females. There is a positive correlation between stature and length of both right and left clavicle in both males and females. Length of right clavicle proved to be a good predictor of stature. The multiplication factor for males and females showed considerable difference. This shows that sex identification prior to stature estimation will give more accurate results. Since the study included only subjects from Tamil Nadu, regression formulae obtained in this study can be used to estimate stature for Tamil Nadu population.

**Declaration of Conflicting Interest:** No conflict of interest

**Funding:** No outside funding was obtained

**Ethical Clearance:** This research has received approval from the Institutional Ethics Committee, Madras Medical College, Chennai.

### References

1. Trotter M, Gleser GC. Estimation of stature from long bones of American Whites and Negroes. *Am J Phys Anthropol* [Internet]. 1952;10(4):463-514. Available from: <http://dx.doi.org/10.1002/ajpa.1330100407>
2. Genovés S. Proportionality of the long bones and their relation to stature among Mesoamericans. *Am J Phys Anthropol* [Internet]. 1967;26(1):67-77. Available from: <http://dx.doi.org/10.1002/ajpa.1330260109>
3. Ozaslan A, Işcan MY, Ozaslan I, Tuğcu H, Koç S. Estimation of stature from body parts. *Forensic Sci Int* [Internet]. 2003;132(1):40-5. Available from: [http://dx.doi.org/10.1016/s0379-0738\(02\)00425-5](http://dx.doi.org/10.1016/s0379-0738(02)00425-5)
4. Petrovecki V, Mayer D, Slaus M, Strinović D, Skavić J. Prediction of stature based on radiographic measurements of cadaver long bones: a study of the Croatian population. *J Forensic Sci* [Internet]. 2007;52(3):547-52. Available from: <http://dx.doi.org/10.1111/j.1556-4029.2007.00419.x>
5. Athawale MC. Estimation of height from lengths of forearm bones. A study of one hundred maharashtrian male adults of ages between twenty-five and thirty years. *Am J Phys Anthropol* [Internet]. 1963;21(2):105-12. Available from <http://dx.doi.org/10.1002/ajpa.1330210203>
6. Steele DG, McKern TW. A method for assessment of maximum long bone length and living stature from fragmentary long bones. *Am J Phys Anthropol* [Internet]. 1969;31(2):215-27. Available from: <http://dx.doi.org/10.1002/ajpa.1330310211>
7. Simmons T, Jantz RL, Bass WM. Stature estimation from fragmentary femora: a revision of the Steele method. *J Forensic Sci* [Internet]. 1990;35(3):628-36. Available from: <http://dx.doi.org/10.1520/jfs12868j>
8. Patil KR, Mody RN. Determination of sex by discriminant function analysis and stature by regression analysis: a lateral cephalometric study. *Forensic Sci Int* [Internet]. 2005;147(2-3):175-80. Available from: <http://dx.doi.org/10.1016/j.forsciint.2004.09.071>
9. Langley-Shirley N, Jantz RL, Mahfouz M. Age and sex estimation from the human clavicle in the American population, 1912-1938 and 1986-1998. ICPSR - Interuniversity Consortium for Political and Social Research; 2014
10. Falys CG, Prangle D. Estimating age of mature adults from the degeneration of the sternal end of the clavicle: Aging Using the Sternal End of the Clavicle. *Am J Phys Anthropol* [Internet]. 2015;156(2):203-14. Available from: <http://dx.doi.org/10.1002/ajpa.22639>

11. Makandar U. Identification of sex and race from the adult clavicle in South India. *Indian J Forensic Med Toxicol.* 2011 Jan 14;Vol.5:48-53.
12. Mansourvar M, Kareem SA, Ismail MA, Nasaruddin FH. Automatic method for bone age assessment based on combined method. In: 2014 International Conference on Computer and Information Sciences (ICCOINS). IEEE; 2014.
13. Singh B, Sohal HS. Estimation of stature from clavicle in Punjabis; a preliminary report. *Indian J Med Res.* 1952;40(1):67-71.
14. Balvir TK, Deshpande JV, Badwaik P, Rahule AS, Kasote A, Shakeel M. Estimation of stature from the length of clavicle in Vidarbha region of Maharashtra. *Int J Biol Med Res.* 2012;3(3):2254-6.
15. Rani Y, Naik SK, Singh AK, Murari A. Original Research Paper Correlation of Stature of Adult with the Length of Clavicle. 2011;33.
16. Moorthy N, Mostapa T, Boominathan A, Raman R. Stature estimation from footprint measurements in Indian Tamils by regression analysis. *Egypt J Forensic Sci.* 2014;4(1):7-16.
17. Deaton A. Height, health, and inequality: The distribution of adult heights in India. *Am Econ Rev* [Internet]. 2008;98(2):468-74. Available from: <http://dx.doi.org/10.1257/aer.98.2.468>
18. Sudha R. Study of clavicle : length and curvatures in South Indian population. *National Journal of Clinical Anatomy* [Internet]. 2014;03(04):198-202. Available from: <http://dx.doi.org/10.1055/s-0039-3401770>
19. Pearson K. IV. Mathematical contributions to the theory of evolution.—V. On the reconstruction of the stature of prehistoric races. *Philos Trans R Soc Lond* [Internet]. 1899;192(0):169-244. Available from: <http://dx.doi.org/10.1098/rsta.1899.0004>
20. Glaister's Medical Jurisprudence and Toxicology. *J Am Med Assoc* [Internet]. 1938;111(19):1792. Available from: <http://dx.doi.org/10.1001/jama.1938.02790450074033>.