Arm Span to Estimate Stature among the South Indian Population State of Telangana

Gunti Damodar[1], Nishat Ahmed Sheikh[2]

> **How to cite this article:**
> Gunti Damodar, Nishat Ahmed Sheikh. Arm Span to Estimate Stature among the South Indian Population State of Telangana. Indian J Forensic Med Pathol. 2020;13(2):263–269.

Abstract

Background: Stature estimation provides relevant data for personal identification, in the events of murders, accidents or natural disasters, which results in highly decomposed, fragmentary and mutilated human remains.

Aim and Objective: To determine body stature of both sexes using arm span and find the relationship between stature and arm span.

Place of Study: The present study was carried out in the department of Forensic Medicine and Toxicology at Kamineni Institute of Medical Sciences and Research Center, Nalgonda District of State Telangana.

Type of Study: Descriptive cross sectional study with analytical and comparative components

Material and Method: Arm span length was measured using a calibrated steel tape to the nearest millimeter in bare feet on a level flat surface with peer backs and buttocks, heel against the wall giving the support.

Observation and Discussion: observation among study subjects n = 150, where 85 (56.7%) were males and 65 (43.3%) were girls. Height and arm span in boys (164.7 ± 10.92 cm and 162.38 ± 8.02 cm respectively) was significantly (p < 0.000) more than girls (157.1 ± 9.1 cm and 156.8 ± 6.5 cm respectively). Height to Arm span ration HAR of boys and girls according to age of the subjects are shown and overall mean Height to Arm span ration was 0.9961 ± 0.0183. In the present study the correlation between stature and arm span showed a strong positive correlation (r = 0.8651, p < 0.000). This result is an support to the widely accepted positive correlation between height and arm span in adults.

Conclusion: Using regression equation for estimation of stature is more acceptable, and result of this study and regression equations may be considered in clinical practice and in medico legal cases for estimation of stature from arm span in south Indian population of Nalgonda District of Telangana.

Keywords: Stature; Arm Span; Regression equations.

Authors Affiliation: [1]Associate Professor, Dept of Forensic Medicine, Kamineni Institute of Medical Sciences and Research Center, Nalgonda, Telangana 508254, India. [2]Associate Professor, Department of Forensic Medicine and Toxicology. All India Institute of Medical Sciences (AIIMS), Gorakhpur, State Uttar Pradesh 273008, India.

Corresponding Author: Gunti Damodar, Associate Professor, Department of Forensic Medicine, Kamineni Institute of Medical Sciences and Research Center, Nalgonda, Telangana 508254, India.

E-mail: drguntidamodar@gmail.com

Received on 12.02.2020, **Accepted on** 16.03.2020

Introduction

In scientific literature the well known factor is measurement of body height is important in many settings, it has an important measure of body size as well gives an assessment regarding nutritional status. The main aim of anthropometry is to establishment of Identity of unknown and to supplement the law enforcement agencies. Limitations are with routine methods especially in highly mutilated bodies where identification is difficult. Stature estimation becomes equally important in such forensic investigation along with

other identification parameters like age, race sex etc.[1-3]

Stature estimation provides relevant data for personal identification, in the events of murders, accidents or natural disasters, which results in highly decomposed, fragmentary and mutilated human remains.[4] One of the most important elements of Identification in individual is its stature, it is very essential in cases when only fragmentary remains of human body found at the scene of crime.[5] The maximum distance measured from the point where heel touches the floor to the highest point of the head in an erect position of person is termed as stature.[6]

Stature estimation question may arise in scenarios like from mass disasters i.e. bomb blasts, airplane crash, stampede, tsunami, earthquake, flood, cyclones, Terrorist attack, close compartment fire, wars, public vehicle (train, bus, ship, plane etc) accidents etc. Possibility of Mutilation of the body could be by humans, animals or by a natural process of decomposition. It is possible that hand print and foot print left at the crime scene, identification and exclusion of a person involved in a crime can be made.[7]

Human body represents a certain relationship with length of certain bones and appendages in the form of proportion to height.[8] After having completed the skeletal maturity the proportion does not alter with age, quantitative or qualitative measurement of personality is Height.[9] However in some scenario it is not possible to measure the person stature because of deformities in limbs or the person who have undergone amputations or in an unknown cadavers where limbs, trunk is either absent or mutilated. In such scenarios stature need to be estimated using other body parameters[10] lime foot length, hand length, sitting height, knee height, length of vertebral column, sternum, length of scapula cranial sutures as well arm span.[11]

Correlation between stature and arm span in comparison to other all body parameters was found to be very reliable[12] maximum distance between the tip of longest fingers of both hands is termed as Arm span while the person extends both arms at the level of shoulders.[13] Different ethnic and racial groups vary arm span and body weight.[14] It was Torres et al. who applied Bland Altman analysis and observed a poor agreement between height and arm span although these correlate good. It shows that arm span measurements are an inappropriate proxy for stature estimation in certain group of population. In forensic anthropology measurements of height and arm span relationship between them had

applied a clear significance as well in plastic and cosmetic surgery and other allied clinical sciences.[15] The present study aim and objective is to determine body stature of both sexes using arm span and find the relationship between stature and arm span.

Materials and Methods

The present study was carried out in the department of Forensic Medicine and Toxicology at Kamineni Institute of Medical Sciences and Research Center, Nalgonda District of State Telangana. In the present research, stature and arm span measurements of 150 volunteers (85 male & 65 female) of ages 18–25 years were done. All of them belonged to Nalgonda district of Telangana state. As such subjects were selected irrespective of their caste, religion, dietary habits and socio-economic status. The study was a predominantly descriptive cross sectional study with analytical and comparative components. Sufficient permissions and consents were procured before the measurements of the students taken and clearance from the Institutional Ethical committee was obtained in advance.

Stature Measurements

Using the stadio-meter, the subject was made to stand barefoot in the standard standing position on its baseboard. Both feet are in close contact with each other and head oriented in Frankfurt's plane. The height was then recorded in centimeter from the standing surface to the vertex in the weight bearing position of foot.

Arm Span Measurements

Arm span length was measured using a calibrated steel tape to the nearest millimeter in bare feet on a level flat surface with peer backs and buttocks, heel against the wall giving the support. The subjects head was in the Frankfort horizontal plane and the arms outstretched at right angles to the body with palms facing forwards. Measurements were taken from one middle fingertip to the other middle finger tip with the help of measuring tape passing. To avoid diurnal variations measurements were taken twice and an average of the both reading was calculated.

Exclusion Criterion

Volunteers morphologically showing the congenital malformations, Dwarfism/Achondropl-asia, features of nutritional deficiencies and injuries

to extremities, using medication thought to alter growth, neuromuscular weakness or abnormal tone or with any other major medical illnesses or growth disturbance were excluded from the study.

Statistical Part

Data divided into 2 group male and female. The basic statistics like mean, mean ± SD etc. of stature (In cm) and arm span length (In cm) of body of male, female and combined was done. We observed the relationship between stature (In cm) and arm span length (In cm) by scatter diagram. All associations are positively exist. The arm span lengths (In cm) of male, female & combined group are positively correlated with stature. Therefore, the simple regression of stature on arm span length (In cm) was calculated by mathematically, also we calculated the stature value on the arm span length (In cm). Compared the actual value and predicted value of stature by using t-test and observed the significance at 5% level of significance. The complete statistics was doing in MS-Excel.

Results

The simple regression equation of stature on arm spam length (In cm) of male, female and combined group are as given bellow.

Male Stature (In cm) = 24.92 + 0.841* Arm span length (In cm)

Female Stature (In cm) = 26.99 + 0.827* Arm spam length (In cm)

Combined Stature (In cm) = 25.2 + 0.839* Arm span length

In our study the observation among study subjects $n = 150$, where 85 (56.7%) were males and 65 (43.3%) were girls. Height and arm span in boys (164.7 ± 10.92 cm and 162.38 ± 8.02 cm respectively) was significantly ($p < 0.000$) more than girls (157.1 ± 9.1 cm and 156.8 ± 6.5 cm respectively). Height to Arm span ration HAR of boys and girls according to age of the subjects are shown and overall mean Height to Arm span ration was 0.9961 ± 0.0183. This ratio was used to calculate expected height from the arm span data for residual analysis.

Group wise data was tested by Pearson correlation (r), the findings in all the groups showed statistically significant positive correlation between height (cm) and arm span (cm). In study the Age group wise correlation coefficients between height and arm span. Fig. 1 shows the linear regression scatter plot of height and arm span in boys. The correlation coefficient showed a strong positive

Table 1: Descriptive Statistics of stature and arm span

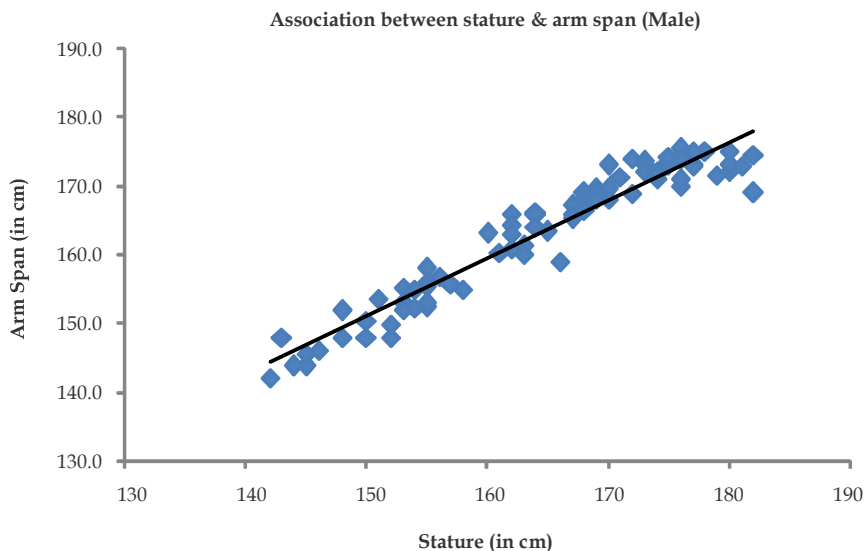| Variables	Stature		Arm Span	
	Mean	Mean ± SD	Mean	Mean ± SD
Male	164.7	164.7 ± 10.92	163.5	163.5 ± 9.53
Female	157.1	157.1 ± 9.1	156.9	156. ± 7.9
Combined	161.4	161.4 ± 10.8	160.6	160.6 ± 9.4

Fig. 1: Scatter diagram showing relation between Stature and Arm span in Males.

correlation (r = 0.8640, p < 0.000). The regression equation was Y = 24.92 + 0.841* Arm span length (In cm). Which may be interpreted as Height (cm) = 0.841* arm span (cm) + 24.92.

Fig. 2 shows the linear regression plot of height and arm span in girls. The correlation coefficient also showed a strong positive correlation, (r = 0.8534, p < 0.000). The regression equation was Y = 26.99 + 0.827* Arm spam length (In cm). When the height and arm span data of boys and girls were taken combined, and correlation and regression analysis were carried out, it showed a positive correlation coefficient (r = 0.8651, p < 0.000). The regression equation was Y = 25.2 + 0.839* Arm span length (In cm). This equation was used to obtain estimated height from the arm span data for residual analysis. When residual analysis was carried out between
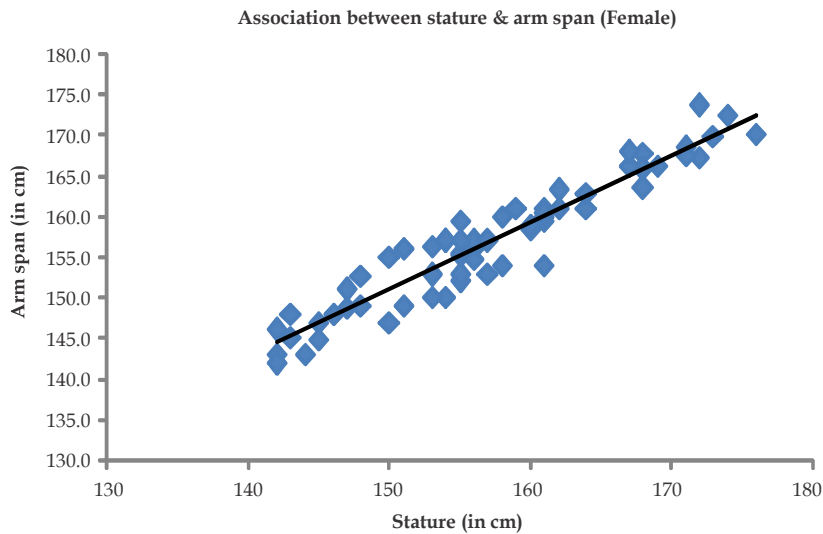

Fig. 2: Scatter diagram showing relation between Stature and Arm span in Females.

Table 2: Correlation between stature and arm span

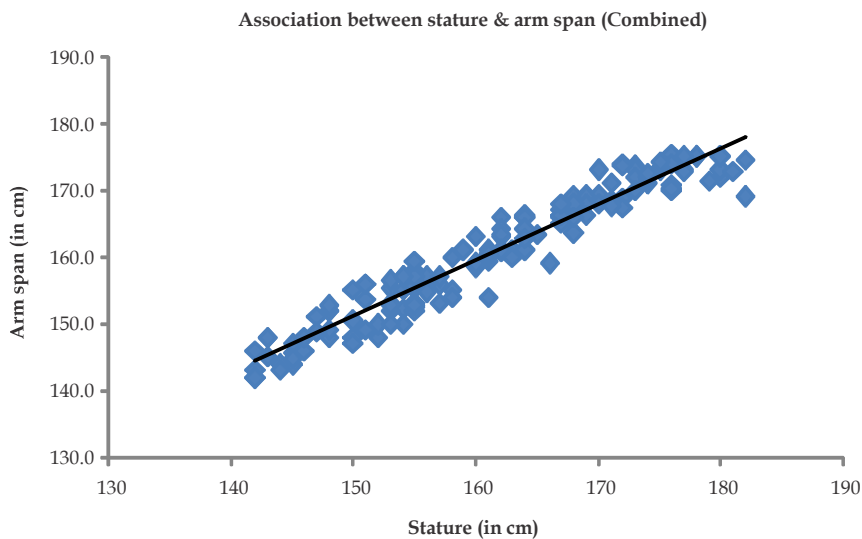| Variables	Correlation (r)	t-test	P-Value	Significance
Male	0.8640	15.6	0.0000	
Female	0.8534	13.0	0.0000	All are highly significant
Combined	0.8651	21.0	0.0000	

Fig. 3: Scatter diagram showing relation between Stature and Arm span (Combined).

Table 3: Comparison between actual and calculated values

Variables		Actual Stature	Calculated Stature	*P*-Value	Significance
Male	Mean	164.66	162.38		
	Mean ± SD	164.7 ± 10.92	162.38 ± 8.02	0.1233	
Female	Mean	157.10	156.80		All are not significant
	Mean ± SD	157.1 ± 9.1	156.8 ± 6.5	0.8332	
Combined	Mean	161.40	159.96		
	Mean ± SD	161.4 ± 10.8	159.96 ± 7.88	0.2000	

arm span and residuals calculated from regression equation (i.e., difference between actual height and estimated height from the regression equation), it showed practically a zero slope, it indicates no interdependence between variables.

Discussion

Even in mutilated and dismembered bodies it is possible to estimate stature as well in fragmentary remains, arm span length can be used for estimation of stature in living subjects and also in those it is not possible to measure the stature due to deformities.

In our study the result showed that in majority of study subject arm span was relatively more than the stature. Our study is supports findings made by Dorjee B et al. in west bengal state India[16] as well with the study made by Esomonu UG et al. in Nigeria[20] also in other studies like[17,18-21] all showed from India that arm span is more than the height.

In the present study, a total of 150 (85 males and 65 females) subjects between the age of 18 and 25 years were enrolled. Since maximum height of an individual is attained between 18 and 25 years, these individuals were selected for the study. In other studies like Agnihotri AK et al., Rajkumar CM and Krishna K[23-25] they too enrolled subjects of same age group. A study from Thailand[26] has made the findings that the decrease in the correlation between arm span and stature with increasing age, as stature decreases with age and Arm span does not, even though earlier study[22] found contribution of age is insignificant in estimation of stature, we considered age and regression equations are derived for different age groups.

In the present study the correlation between stature and arm span showed a strong positive correlation ($r = 0.8651$, $p < 0.000$). This result is an support to the widely accepted positive correlation between height and arm span in adults. Dorjee B et al. found more strong correlation (male $r = 0.978$, female $r = 0.972$) than the result of this study.[16]

However, they took a larger sample ($n = 240$) while this study was conducted out on a smaller sample size ($n = 150$). There is a possibility that difference between sample size and sample age range may be the contributing factors behind the difference in the results.

Regression equations were established for male and female separately. Overall regression equation was $Y = 25.2 + 0.839*$ Arm span length in cm. This equation was used to estimate height from arm span data and compared with the actual height.

Regression equations for stature estimation from other anthropometric parameters are widely available for adult population. Tandon R et al., used foot length to estimate height in adult population from the established regression equation in their study.[27] Similarly Mondal MK et al., came up with regression equation for estimation of height from ulnar length in adult population.[28]

These all above stated studies were carried out on adult population. In an study made by Chowdavarapu RR et al., observed that head length can be used to estimate height in 8–12 years children.[29] It was Bardale RV et al., and Sen J et al., observed that height can be estimated from index and ring fingers in adult population.[30,31]

On the contrary it is true that appropriate measurement of smaller segments of the body like finger length, foot length, and head length needs calipers and intra-observer and inter-observer variation may give a proportionate error in height estimation.[32-41] Whereas arm span can be measured with simple measuring tape. Arm span is almost similar to stature in length; hence, chances of error in estimation would be comparatively less for estimated height from arm span.

Conclusion

Stature can be estimated from measured arm span using regression equations. Using regression equation for estimation of stature is more

acceptable, and result of this study and regression equations may be considered in clinical practice and in medico legal cases for estimation of stature from arm span in south Indian population of Nalgonda District of Telangana.

Source of funding: Nil

Competing Interests: Authors have declared that no competing interests exist.

References

1. Krishan K. Anthropometry in forensic medicine and forensic science-'Forensic Anthropometry'. The Internet Journal of Forensic Science 2007.

2. Sheta A, Hassan M, Elserafy M. Stature estimation from radiological determination of humerus and femur lengths among a sample of Egyptian adults. Bull Alex Fac Med 2009;45:479–86.

3. Krishan K. Estimation of stature from cephalo-facial anthropometry in North Indian population. Forensic Sci Int 2008;181:52.e1-6.

4. Jasuja OP, Singh G. Estimation of stature from hand and phalange length. Journal of Indian Academy of Forensic Medicine 2004;26:100–06.

5. Patel PN, Tanna JA, Kalele SD. Correlation between Hand Length and Various Anthropometric Parameters. International Journal of Medical Toxicology and Forensic Medicine 2012;2(2):61–63.

6. Lohman TG, Roche AF, Mattorell R. 'Segment Length', Anthropometric Standardization Reference Manual, Human: Kinetics Publishers Inc, Illinois 1988;18–20.

7. Anitha oommen et al. A study of correlation between hand length and foot length in humans. J Anat Soc 2005;54(2):55–57.

8. Chawla M, Rajkumar, Tomar S, et al. Relationship between arm span and height in adult males of north Indian Punjabi population. Journal of Evolution of Medical and Dental Sciences 2013;2(4);332–39.

9. Datta B, Sudip. Arm span as a proxy measure for height and estimation of nutritional status: A study among Dhimals of Darjeeling in West Bengal India. Annals of Human Biology 2011;38(6):728–35.

10. Shah RK, Nirvan AB, Patel JP, et al. Estimating Stature From Arm Span Measurement in Gujarat Region. GCSMC J Med Sci 2013;2(2):30–32.

11. Shah RP, Kumar A, Bhaskar RK. Body height and its estimation utilizing arm span measurements in population of Birgunj Area of Nepal: An Anthropometric study. Journal of College of Medical Sciences-Nepal 2013;9(4):9–14.

12. Shah RK, Nirvan AB, Patel JP, et al. Estimating Stature From Arm Span Measurement in Gujarat Region. GCSMC J Med Sci 2013;2(2):13(30–32).

13. Lohman TG, Roche AF, Mattorell R. 'Segment Length', Anthropometric Standardization Reference Manual, Human: Kinetics Publishers Inc, Illinois 1988;18–20.

14. Brown JK, Feng JY, Knapp TR. Is self-reported height or arm span a more accurate [15] alternative measure of height. Clin Nurs Res 2002;11(4):417–32.

15. Kasunka LGK, Raj JO, Arulsingh W. Correlation between standing height and arm span in young adults: A cross-sectional study. Applied Research Journal 2015;1(4):242–46.

16. Dorjee B, Sen J. Estimation of stature from arm span, arm length and tibial length among Bengalee children aged 3-11 years. Human Biology Review 2016;5:128–45.

17. Aggarwal AN, Gupta D, Ezekiel LM, et al. Statistical estimation of height from arm span in north Indian subjects. Indian J Physiol Pharmacol 2000;44:329–34.

18. Mohanty SP, Babu SS, Nair NS. The use of arm span as a predictor of height: A study of South Indian women. J Orthop Surg 2001;9:19–23.

19. Singh A, Kumar A, Chavali KH, et al. Use of arm-span and foot length for estimation of height of the person. J Punjab Acad Forensic Med Toxicol 2012;12:87–91.

20. Esomonu UG, Ijomone OM, Mba C, Oranusi A. Estimation of stature using arm span length amongst Bekwara ethnic group of Cross River State, Nigeria. Ann Bioanthropol 2015;3:55–58.

21. Forman MR, Zhu Y, Hernandez LM, et al. Arm span and ulnar length are reliable and accurate estimates of recumbent length and height in a multiethnic population of infants and children under 6 years of age. J Nutr 2014;144:1480–87.

22. Hossain S, Begum JA, Akhter Z. Measurement of stature from arm span: An anthropometric study on Garo Tribal Bangladeshi females. Banglad J Anat 2011;9:5–9.

23. Agnihotri AK, Agnihotri S, Jeebun N. Googoolye K Prediction of stature using hand dimensions. J Forensic Leg Med 2008;15:479–82.

24. Rajkumar CM. The relationship between hand breadth and height in adult males of north Indian Punjabi population. J Evol Med Dent Sci 2013;2:1880–7.

25. Krishna K. Estimation of stature from footprint and foot outlines dimensions in Gujjars of

North India. Forensic Sci Int 2007;14:1–9.

26. Manonai J, Khanacharoen A, Theppisai U, et al. Relationship between height and arm span in women of different age groups. J Obstet Gynaecol Res 2001;27:325–7.

27. Tandon R, Yunus SM, Faruqi NA, Asghar A. Measurements of hand and foot: A predictor of stature in adult human population of Uttar Pradesh. International Journal of Anatomy, Radiology and Surgery 2016;5(1):12–15.

28. Mondal MK, Jana TK, Giri (Jana) S, Roy H. Height prediction from ulnar length in females: A study in burdwan district of West Bengal (Regression Analysis). J Clin Diagn Res 2012;6(8):1401–04.

29. Chowdavarapu RR, Challa S, Hussain MS, Gangam S. Developing a predictive model for estimation of height of a normal child using head length in South Indian children. Int J Res Med Sci 2015;3:3465–69.

30. Bardale RV, Dahodwala TM, Sonar VD. Estimation of stature from index and ring finger length. J Indian Acad Forensic Med 2013;35:353–57.

31. Sen J, Kanchan T, Ghosh A, et al. Estimation of stature from lengths of index and ring fingers in a North-eastern Indian population. J Forensic Leg Med 2014;22:10–15.

32. Perugu Vanishri, Nishat Ahmed Sheikh. Anthropometric Measurements of Hand Length and Breadth for Estimation of Stature in South Indians. Indian J Forensic Med Pathol. 2019;12(2):124-130.

33. B. Vasant Nayak, Ch. Laxmanrao, Nishat Ahmed Sheikh. Estimation of Stature from Length of Little Finger in the Population from South India. Indian J Forensic Med Pathol. 2019;12(2):113-118.

34. Vasant NB, Sheikh NA. Regression Equation Analysis on Inter-Acromial Length for Stature Estimation in South India Population. Indian J Forensic Med Pathol. 2019;12(1):13-17.

35. Perugu V, Sheikh NA. Stature Estimation from Foot Length of School Age Group Children, Indian Journal of Forensic Medicine and Pathology. 2017;10(1):11-16.

36. Sutay SS,Sheikh NA, Garg K, Gupta R. Study of Stature by Per-cutaneous Ulnar Length in Madhya Pradesh Population of India, International Journal of Medico-legal Update. 2016;16(1):173-177.

37. Sheikh NA, Ramanaiah TV. Stature Estimation from Forearm Length. Indian Journal of Forensic Medicine and Pathology.2014;7(2):59-64.

38. Krishna VM, Sheikh NA. Estimation of Stature from Foot Length of school age group children in Telangana State. International Journal of Current Research.2015;7(1):11659-11663.

39. Gunti Damodar, Nishat Ahmed Sheikh. Estimation of Stature from Footprints measurements by Linear Regression analysis in South India Population. Indian J. Forensic Med Pathol. 2020;13(1):94–101.

40. Nishat Ahmed Sheikh, Perugu Vanishri. Odontometric Approach for Stature Estimation in South Indian Population: A Cross Sectional Analysis. Indian J Forensic Med Pathol. 2019;12(3):209-215.

41. K Rajesham, Nishat Ahmed Sheikh. Estimation of Stature by Per-Cutaneous Measurements of Distal Half of the Upper Limb. Indian J Forensic Med Pathol. 2017;10(2):109-114.