Bangladesh Journal of Anatomy January 2019, Vol. 17, No. 1, pp. 5-9

Original Articles

Estimation of Stature from Radiographic Foot Length in Bangladeshi Male by Regression Analysis

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Abstract

Context: *Stature or height in upright position has an important role in medico-legal practice. In many tragic events or in crime scenes, direct identification of the victims is difficult because only mutilated, decomposed and amputed body fragments may be found. In such situations estimation of stature helps in establishing the biological profile of the victims through examination of the dismembered body parts remain.This study was aimed to investigate the correlation between stature and foot lengths, to derive regression equations for stature estimation from foot lengths and to make comparison with previous studies on other populations.*

Materials & Methods: *This cross-sectional study was carried out at the Anatomy Department of Sir Salimullah Medical College, Dhaka, Bangladesh from January 2017 to December 2017 on 50 male medical and dental students aged between 21 and 26 years. Full foot length (FFL) and truncated foot length (TFL) were measured by MB ruler software. Relationships between stature and foot lengths were obtained by Pearson's correlation coefficient test.*

Results: *Both FFL and TFL showed significant positive correlation with stature (r = 0.709 and 0.618 respectively). The linear regression equation for stature estimation derived from FFL and TFL were 60.954 + 4.571FFL and 81.687 + 4.915TFL respectively. The linear regression equations derived from FFL have larger correlation coefficient (R), coefficient of determination (R^2), adjusted coefficient of determination (adj R^2) and smaller standard error of estimation (SEE) than those derived from TFL*

Key words: *Stature estimation, full foot length, truncated foot length, linear regression equation.*

Introduction

Stature is the natural height of a person in an upright position. It has an important role in identification of a person which is often required in medico-legal practice. Tragic events such as mass disasters, wars, explosions, airplane crashes, criminal mutilation and dismemberment often make direct identification of the victims difficult. In such situations estimation of stature helps in establishing the biological profile of the victims through examination of the dismembered body parts remain. To formulate the biological profile of an unidentified remain, estimation of living stature may be inevitable.[1]

There are two methods of stature estimation – anatomical method and mathematical method.[2] In anatomical method, lengths of various segments of the body including skull, vertebral column and lower limb are added and a correction factor for soft tissue is applied.[3] With mathematical methods, regression equations have been derived for stature estimation particularly from lengths of long bones of upper and lower limbs.[4-9]

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Although long bones are most reliable for estimation of stature, they are not usually recovered in intact form due to their fragility.[10] On the other hand, integrity of the small bones of the foot is more likely to be discovered undamaged in mass disaster due to protection offered by footwear and the particular feature of their own tissue. For this reason, it is important to develop regression equations to determine stature from foot dimensions.

Many studies were carried out in different parts of the world to formulate regression equations for stature estimation from foot dimensions. But these equations have limited application as they are specially computed for a particular population. Since climate, heredity and nutritional status have an effect on stature and bones of the foot, estimation of stature from these formulae is not appropriate for other population.[11]

So far it is known that there is no published article on this topic in Bangladesh. The present study was designed to see the relationship between stature and foot lengths through radiographic means and to develop regression equation for estimating stature from radiographic foot lengths for Bangladeshi male population.

Materials and Methods

This cross-sectional study was carried out at the Anatomy Department of Sir Salimullah Medical College, Dhaka from January 2017 to December 2017. The study recruited a sample of 50 male medical and dental students aged between 21 and 26 years of Sir Salimullah Medical College by purposive sampling method. Informed consent was obtained from every study subject with explanation of the purpose and nature of the study. Nationality and age of the study subject was confirmed from his national identity card. Those with any apparent disease, nutritional and developmental disorders, orthopedic deformities and history of injury or surgery of foot were excluded from the study.

Stature was measured by the stretch stature method using a stadiometer. Stature is the maximum distance from the floor to the vertex of the head with the study subjects placed in anatomical position while maintaining equal weight on both feet.[12] The vertex is defined as the highest point on the skull when the head is held in the Frankfort horizontal plane. The measurements were taken at fixed time between 8 am and 10 am to avoid diurnal variation in stature.

Digital radiographs of left foot in lateral view were taken at the Radiology and Imaging Department of Sir Salimullah Medical College & Mitford Hospital, Dhaka. The subject was in standing position and the cassette was placed against the lateral aspect of the left foot. The X-ray beam was given from medial side of foot, perpendicular to the cassette and centered on the lateral cuneiform.[13] Then these radiographs were imaged with a digital camera according to scale and were transferred to a computer. From these images full and truncated foot lengths were measured by using MB ruler software. Full foot length (FFL) was measured as the bony distance from the most posterior point of the calcaneus to the distal point of the most distal phalanx and truncated foot length (TFL) was measured as the bony distance from the most posterior point of calcaneus to the most distal point on the first metatarsal head (Fig-1).

Fig.-1: *Photograph of digital radiograph of left foot in lateral view showing full foot length (FFL) and truncated foot length (TFL).*

Data were analyzed with Statistical Package for Social Sciences (IBM SPSS Statistics Base, version 22) software. Relationships between stature and foot lengths were obtained by Pearson's correlation coefficient test and by scatter diagrams drawn by plotting foot lengths against stature. Significance of relation was measured at 5% level of significance. Linear regression equations were derived by regression analysis for estimation of stature from the foot lengths.

Ethical clearance

The study was approved by the Ethical Review Committee of Sir Salimullah Medical College, Dhaka.

Results

Table-I

Descriptive statistics of stature and foot lengths (n=50)

Variables	Mean±SD	Range
Stature (cm)	165.18±8.28	145-182
Full foot length (cm)	22.80±1.28	19.23-25.92
Truncated foot length (cm)	6.99±1.04	14.17-19.33

FFL and TFL showed significant positive correlation with stature (r = 0.709 and r = 0.618 respectively). The R, R^2 and adj R^2 are greater and SEE is smaller in regression equations derived from FFL and TFL (Table II).

The linear regression equations were tested using the mean, minimum and maximum stature with their corresponding foot lengths The stature estimated from FFL was always closer to the actual stature than the stature estimated from TFL (Table III).

Scatter diagram showed a significant positive correlation between stature FFL and TFL (Figure 2,3).

Table -II

Linear regression equations for stature estimation derived from the foot lengths

Variables	Regression equation	R	R^2	Adj R^2	SEE	p value
FFL (cm)	S = 60.954 + 4.571 x FFL	.709	.502	.492	5.900	.000
TFL (cm)	S = 81.687 + 4.915 x TFL	.618	.381	.369	6.576	.000

FFL = Full foot length, TFL =Truncated foot length, S = Stature, R = correlation coefficient, R2 =coefficient of determination, Adj R^2 = adjusted coefficient of determination, SEE = standard error of estimation

Table-III

Comparison of actual stature, stature estimated from full foot length and stature estimated from truncated foot length

Variables	Mean ± SD	Minimum	Maximum
AS (cm)	165.18 ± 8.28	145	182
FFLS (cm)	165.17 ± 5.86	148.85	179.43
TFLS (cm)	165.12 ± 5.11	151.33	176.69

AS = actual stature, FFLS = stature estimated from full foot length, TFLS = stature estimated from truncated foot length

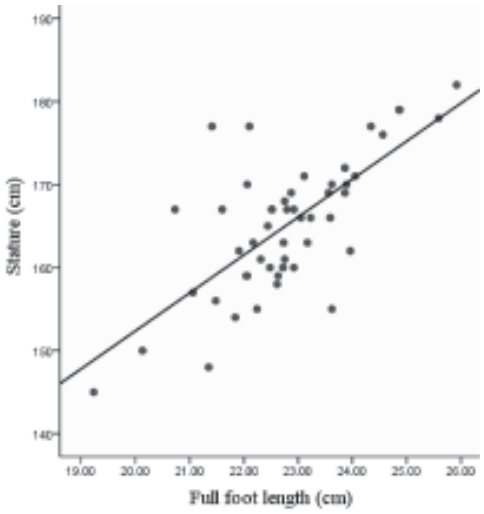

Fig.-2: *Scatter diagram showing significant positive correlation between stature and FFL*

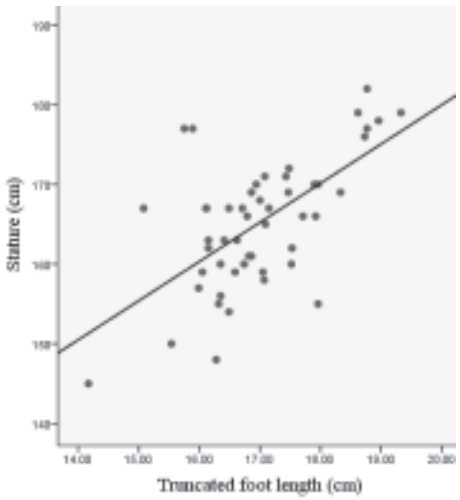

Fig.-3: *Scatter diagram showing significant positive correlation between stature and TFL*

Discussion

The mean FFL of the present study population was lower than that of Saudi Arabian,[14] Nigerian[1] and American[15] population. The mean TFL was also lower than that of Nigerian[1] and American[15-17] population.

The stature had significant positive correlation with both FFL and TFL. In agreement with the present study, significant positive correlation between stature and FFL was found in Nigerian,[1,18] Saudi Arabian,[14] Jordanian,[19] Turkish,[20] Korean,[21] Nepalese[22] and Indian Rajasthani[23] population. Significant positive correlation between stature and TFL was found in Nigerian[1] population.

In the present study, FFL has been found to have a higher correlation with stature than TFL. This can be observed from the larger R, R^2 and adj R^2 as well as the smaller SEE in regression equations derived from FFL compared to those derived from the TFL. But in contrary to the present study Gwani et al[1] reported that TFL is the best parameter for estimation of stature than FFL.

Conclusion

This study was conducted using a relatively small sample of young adults. So, caution must be exercised when interpreting result or generalizing our findings. Further studies in a larger sample are however recommended to substantiate these findings.

Acknowledgement

The authors acknowledge all those students of SSMC who made themselves available as study subjects with their time, patience and cooperation. The authors convey special thanks to Mr. Md. Mahbub Alam, medical technologist (Radiography), Department of Radiology & Imaging, Sir Salimullah Medical College, Dhaka who took all the radiographs of the study subjects.

References

1. Gwani AS, Salihu AT, Garba IS, Rufa'i AA. Estimation of stature from radiographic measurement of foot dimensions: Truncated foot length may be more reliable than full foot length. J Forensic Leg Med. 2017;46:53-7.
2. Lundy JK. The mathematical versus anatomical methods of stature estimate from long bones. Am J Forensic Med Pathol. 1985;6(1):73-6.
3. Duyar I, Pelin C, Zagyapan R. A new method of stature estimation for forensic anthropological application. Anthropol Sci. 2006;114(1):23-7.
4. Nor FM, Abdullah N, Mustapa AM, Qi Wen L, Faisal NA, Ahmad Nazari DA. Estimation of stature by using lower limb dimensions in the Malaysian population. J Forensic Leg Med. 2013;20(8):947-52.
5. Formicola V. Stature reconstruction from long bones in ancient population samples: an approach to the problem of its reliability. Am J Phys Anthropol. 1993;90(3):351-8.
6. Trotter M, Gleser GC. Estimation of stature from long bones of American whites and Negroes. Am J Phys Anthropol. 1952;10(4):463-514.
7. Celbis O, Agritmis H. Estimation of stature and determination of sex from radial and ulnar bone lengths in a Turkish corpse sample. Forensic Sci Int. 2006;158(2-3):135-9.
8. Ahmed AA. Estimation of stature using lower limb measurements in Sudanese Arabs. J Forensic Leg Med. 2013;20(5):483-8.
9. Mall G, Hubig M, Büttner A, Kuznik J, Penning R, Graw M. Sex determination and estimation of stature from the long bones of the arm. Forensic Sci Int. 2001;117(1-2):23-30.
10. Rodríguez S, González A, Simón A, Rodríguez-Calvo MS, Febrero-Bande M, Cordeiro C, Muñoz-Barús JI. The use of computerized tomography in determining stature and sex from metatarsal bones. Leg Med (Tokyo). 2014;16(5):252-7.
11. Narde AL, Dongre AP. Body height estimation based on foot length and foot breadth. J Indian Acad Forensic Med. 2013;35(3):245-8.
12. Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a North

Indian population. J forensic Leg Med. 2007; 14:327-32.

13. Lamm BM, Stasko PA, Gesheff MG, Bhave A. Normal foot and ankle radiographic angles, measurements, and reference points. J Foot Ankle Surg. 2016;55:991-8.
14. AlQahtani FN. Prediction of stature from radiographic study of foot and hand in modern Saudi at Baha Province. Int J Med Sci Public Health. 2015;4(8):1035-41.
15. Williams DS, McClay IS. Measurements Used to Characterize the Foot and the Medial Longitudinal Arch: Reliability and Validity. Phys Ther. 2000;80(9):864-71.
16. Lautzenheiser SG, Kramer PA. Linear and angular measurements of the foot of modern humans: A test of Morton's foot types. Anat Rec. 2013;296:1526-33.
17. Saltzman CL, Nawoczenski DA, Talbot KD. Measurement of the Medial Longitudinal Arch. Arch Phys Med Rehabil. 1995;76:45-9.
18. Egwu OA, Nto NJ, Bello EF, Egwu EO, Ukoha UU, Ajah D. Stature Estimation from Foot Dimensions of an Adult Nigerian Population. Anatomica Karnataka. 2012;6(2):08-12.
19. Mashali AA, El taweel E, Ekladious E. Stature Prediction from Anthropometry of Extremities among Jordanians. J Forensic Sci Criminol. 2017;5(2):1-8.
20. Ozaslan A, Karadayi B, Kolusayin MO, Kaya A, Afsin H. Predictive role of hand and foot dimensions in stature estimation. Rom J Leg Med. 2012;XX(1):41-6.
21. Jee S, Kwon S, Yun MH. Analysis of stature prediction from foot anthropometry: a South Korean case study. Aust J Forensic Sci, 2017;49(1):9–21.
22. Mansur DI, Haque MK, Sharma K, Karki RK, Khanal K, Karna R. Estimation of Stature from Foot Length in Adult Nepalese Population and its Clinical Relevance. Kathmandu Univ Med J. 2012;10(37):16-9.
23. Sharma S, Yadav JP. Foot and Its Relationship to Stature of Adult Population – An Anthropological Study. Int J Recent Sci Res. 2018;9(5C):26672-4.