PREDICTION OF STATURE BASED ON FOOT LENGTH

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Abstract

Background
Estimation of body height from its segments or dismember parts has important considerations for identifications of living or dead human body or remains recovered from mass disaster or other similar conditions.

Objective
Stature is an important consideration in determining the identity. Our aim of the study was to investigate the relationship between foot length and body height and to derive a regression equation for stature estimation from foot length and to find out the correlation between body height and foot length.

Methods
The present study was conducted on 200 medical students of age group 18 to 23 years studying in MGM Medical College, Navi Mumbai, Maharashtra. India. Body height and foot length were measured in centimeter. All the measurements were taken by using standard measuring devices and standard anthropometric techniques.

Results
Correlation coefficients between stature and foot dimensions were found to be positive and statistically highly significant. Prediction of stature was found to be most accurate by multiple regression analysis.

Conclusions
In population similar to our subjects, stature and gender estimation can be done by using foot measurements and it will be helpful for Anatomists, Anthropologists and forensic experts to calculate stature based on foot length.

Keywords: *Body Height, Stature, Foot length, Correlation, Regression Equation.*

Introduction

Anthropometry as adopted by medical scientist is described as a technique of expressing the form of human body quantitatively as it is the systematic collection and correlation of measurement of the human body.[1] Dimensional relationship between body segments and the whole body has been the focus of anatomists, scientists, and anthropologists for many years.[2] Body proportions and the dimensions of various body segments, including the long bones of their limbs and the bones of the foot and hand have been used to estimate stature.[3] Furthermore, the relationship between body

segments has been used to compare and highlight variations between different ethnic groups and to relate them to locomotor patterns, energy expenditure, and lifestyle. Prediction of the dimensions of body segments is useful in many areas of modern science.[4] The long bones of the limbs, however, have been the most widely studied.[5] Determination of stature from incomplete skeletal and decomposing human remains is predominantly important in personal identification. Stature of a person can be said to be the sum of the length of certain bones and appendages of the body. Stature provides insight into various features of a population including nutrition, health and genetics. Various studies in past have been undertaken to study the relation between height of a person and various body parts but not much has been done to have it from the foot length. Therefore purpose of the present study is to study the anthropometric relationship between foot length and body height in normal young adults and its sexual dimorphism.

Material and Methods

Two hundred medical students (100 male and 100 female) of age group 18 to 23 years studying in MGM Medical College, Navi Mumbai, Maharashtra, India were the subject for this study. Ethical clearance was obtained from the IERC [Institute Ethical Review Committee] before starting the study. Informed consent of participants was taken and socio-demographic indices like age and sex was noted. Each student was studied for the measurements of stature and foot length. The measurements were taken by using standard anthropometric instruments. The height of the individual was measured between the vertex and floor, with the person standing erect, in anatomical position and the head in the Frankfort plane, using a standing height measuring instrument. Foot length for the both sides was measured as the distance from the most prominent part of the heel backward to the most distal part of the longest toe (2nd or 1st). Measurements were recorded in centimeters to the nearest millimeter using standard anthropometrical instrument. Students having any disease, deformity, injury, fracture, amputation or record of any surgical procedures of either hand or foot were disqualified from the study. The measurements were taken at a fixed time between 2.00 to 4.00pm to eliminate the possibility of diurnal variation and by only one observer in order to avoid inter-observer error. The data obtained were computed and analyzed using SPSS (Statistical Package for Social Sciences) computer and results drawn. The linear and multiple regression models with the explanatory variables or regressors, foot length and hand length was used as a statistical model to explain the relation or the variation in stature, the response or dependent variable.

Results

Table 1. Descriptive statistics for stature and measurements (in cm) of feet in male and females.

A. For Male

Variable	Male [N = 100]				
	Mean	**SD**	**SEM**	**Min.**	**Max.**
Age in year	18.99	0.785	0.0785	18	22
Body weight in kg	70.58	13.797	1.38	46	108
Stature	172.246	5.8727	0.5873	158.9	186.0
Right foot length (RFL)	25.541	1.5633	0.1563	22.4	29.5
Left foot length (LFL)	25.506	1.5399	0.1540	22.3	29.6

B. For Female

Variable	Female [N = 100]					t- value (Sex diff. M vs F)	p value Significance (of 2 tables)
	Mean	**SD**	**SEM**	**Min.**	**Max.**		
Age in year	18.77	0.908	0.091	18	23	1.832	.068 (NS)
Body weight in kg	55.27	10.084	1.008	35	81	8.955	<0.001
Stature	158.091	6.3102	0.6310	136.3	172.8	16.421	<0.001
Right foot length (RFL)	23.381	1.5712	0.1571	20.4	28.8	9.745	<0.001
Left foot length (LFL)	23.177	1.4269	0.1427	20.0	26.4	11.094	<0.001

Table 2. Bilateral differences in measurement (in cm) of feet in males & females.

Variable	Males [N = 100]		p value	Female [N = 100]	t - value	p value
	Mean difference (right – left)± SD	t - value		Mean difference (right – left)± SD		
FL	0.035 ± 0.3374	1.037	0.32	0.204 ± 0.7802	2.615	0.010*

P value significant at <0.05 ; *Significant ; FL -Foot length

Table 3. Linear and multiple regression equation for estimation of stature (cm) from measurement of feet.

Males		Females	
Linear regression equations $\underline{+}$**SEE**		**Linear regression equations** $\underline{+}$ **SEE**	
S = 128.951+1.695(RFL)	0.339	S = 118.533 +1.692 (RFL)	0.368
S = 106.265 +2.236 (LFL)	0.385	S = 128.233 +1.726 (LFL)	0.344
Multiple regression equations$\underline{+}$**SEE**		**Multiple regression equations**$\underline{+}$**SEE**	
S = 128.039+0.761 (RFL)+0.971 (LFL)	3.176	S = 106.623+0.297(RFL)+2.520 (LFL)	1.492

S= Stature   RFL = Right foot length   LFL = Left foot length

Table 4. Comparison of actual stature and stature estimated (cm) from measurement of feet.

Estimated stature using regression Equations for	Males			Female		
	Estimated stature			Estimated stature		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Right foot length	166.90	179.00	172.20	153.00	167.30	158.10
Left foot length	166.70	179.30	172.30	151.00	165.30	158.10
Actual stature	158.90	186.00	172.24	136.30	172.80	158.09

Discussion

The conducted study is a cross sectional descriptive Study and performed in year 2010-11 in Department of Anatomy, MGM Medical College, Navi Mumbai as per the study design. Measurement by standard anthropometric instruments of stature and foot length were taken of two hundred young and healthy students (100 males and 100 females), in the 18 to 23 year age group.

The mean age (in years) among males was 18.99 with SD of 0.785 , the mean age in years among female was 18.77 with SD of 0.908 and it was not found to be statistically significant .The mean body weight among male subjects was found to be 70.58 ±13.79 kg and that among females was 55.27±10.08 kg. The difference in body weight among male and female subjects were found to be statistically significant (p value<0.001). Our finding is similar to the study conducted by Ozden H et al (2005)[6] conducted in Turkey in this regard. The mean stature of male was found to be 172.24± 5.87 cm and that among female was 158.09± 6.31 cm. The difference in stature between two gender were found to be statistically significant (p value<0.001). The mean foot length on both sides in male was larger than female. The difference in these measurements was found to be statistically significant between male and female (p- value< 0.001). These findings are in line to the study conducted by H. Ozdan et al (2005)[6] in Turkish

population, Sanli et al (2005) [7] and Krishan and Sharma (2007) [8] amongst North Indian population (Rajputs), in which foot length and foot breadth on both sides were statistically significantly greater in males when compared to females. The difference in right and left foot length among males were found to be statistically insignificant. However the difference in female foot length was found to be statistically significant. Male stature was found to be significantly correlated with right foot length (r=0.451, p<0.001) and left foot length (r=0.452, p<0.001). Similar statistically significant correlation was seen between stature and right (r=0.421) and left (r=0.506) foot dimensions of females. Our finding replicates the finding of the study conducted by Krishan and Sharma (2007)[8] in the North Indian population (Rajputs) which found that bilateral hand and foot length in both male and females exhibit statistically significant correlation coefficient with stature. Our finding also replicates the finding of study conducted by Sen and Ghosh (2008) [9], in which the statistically significant correlation was found between stature of both sex and their foot length. Similar conclusion was drawn by Patel SM et al (2007) [10] and Mansur DI et. al (2012) [11] that if either of the measurement (foot length 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. Linear

and multiple regression equation were evolved and it was found that applying these equations, the calculated estimated mean stature was found to be almost same as mean actual stature using various explanatory variables.

Conclusion

This study indicates that stature can be predicted accurately by linear and multiple regression analysis even when identity is unknown from foot length - a problem frequently encountered in medico-legal investigations. This study also found that foot measurements can be used to calculate stature with reasonable accuracy using statistical considerations and it is revealed that a single dimension can estimate the stature of a person with a great accuracy and small standard error. Sexual dimorphism with female consistently having smaller stature, lesser body weight and smaller foot length compared to their male counterparts was also found. Our findings suggest that the relationship between stature and foot length is of practical use for anatomists, medico-legal, anthropology, archaeological and other related studies.

References

1. **Wilbur AK.** The utility of hand and foot bones for the determination of sex and the estimation of stature in a prehistoric population from west-central Illinois.International Journal of Osteoarchaeology 1998; 8:180–191.

2. **Charnalia VM.** Anthropological study of the foot and its relationship to stature in different castes and tribes of Pondicherry state.Journal of Anatomical Society of India 1961; 10: 26-30.

3. **Telkka A.** On the prediction of human stature from the long bones.Acta Anat. (Basel) 1950; 9: 103–317.

4. **Athawale MC.** Anthropological study of height from length of forearm bones: A study of one hundred Maharashtrian male adults of ages between twenty five and thirty years. American Journal of Physical Anthropology 1963; 21: 105-12.

5. **Sharma VK, Garg RK, Chattopadhyay PK.** Calculation of stature from foot measurements: a study of Gaur Brahmins. Coll. Antropol 1978; 2: 194–195.

6. **Ozden H, Balci Y, Demiru̇stu̇ C, Turgut A, Ertugrul M.** Stature and sex estimate using foot and shoe dimensions. Forensic Sci Int. 2005; 147:181–184.

7. **Sanli SG, Kizilkanat ED, Boyan N, Ozsahin ET, Bozkir MG, Soames R et al.** Stature Estimation Based on Hand Length and Foot Length. Clin.Anat. 2005;18:589–596.

8. **Krishan K, Sharma A.** Estimation of stature from dimension of hand and feet in a north Indian population. J Forensic and Legal Medicine, Aug. 2007; 14(6):327-332.

9. **Sen J, Ghosh S.** Estimation of stature from foot length and foot breadth among the Rajbanshi: an indigenous population of North Bengal. Forensic Sci. Int. 2008; 181:55e1–55e6.

10. **Patel SM, Shah GV, Patel S.V.** Estimation of height from measurements of foot length in Gujarat region. J. Anat. Soc. India 2007; 56(1): 25-27.

11. **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. KUMJ 2012;10(1): 16-19.

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