

CORRELATION OF HUMAN HEIGHT WITH FOOT LENGTH IN INDIAN INDIVIDUALS

Girish Shiv Shankar ¹, Veena Vidya Shankar ^{*2}, Shailaja Shetty ³, Radhika K ³.

¹ MBBS, 3rd year student, Ramaiah Medical College, Bangalore, Karnataka, India.

² MBBS, MD, Associate Professor, Department of Anatomy, Ramaiah Medical College, Bangalore, Karnataka, India.

³ MBBS, MD, Professor & Head, Department of Anatomy, Ramaiah Medical College, Bangalore, Karnataka, India.

⁴ Lecturer cum Statistician, Department of Community Medicine, Ramaiah Medical College, Bangalore, Karnataka, India.

ABSTRACT

Introduction: The height estimation is as important as other parameters like age, sex and race especially in medico-legal cases. The environmental and genetic factors influence the development of various parts of body. Although bilateral symmetry is a feature seen in humans, there is asymmetry in the foot length without gender or handedness bias.

Aim: To study the relationship of human height with foot length and to derive a mathematical module to predict the height from foot length.

Materials and Methods: This is a Cross-sectional study carried out in Ramaiah Medical College, Bangalore in 234 individuals aged between 18 and 25 years of age. Descriptive statistics, Pearson's correlation coefficient and linear regression were employed for the Statistical analysis of the data

Results: The overall mean foot length observed was 22.82 ±1.10 cms. There was significant difference in the mean values between right and left foot length which was statistically significant (P value = <0.001). The height showed a statistically significant positive correlation with left foot length in both males and females. Linear regression equation was derived to predict height from foot length in both males and females.

Conclusion: In the present study, there was a statistically significant difference in right and left side mean foot length measurements in both sexes. A positive correlation was observed between height and foot length and left foot length had better correlation with height in both sexes. It was concluded from further analysis that other parameters need to be considered for better predictability of height.

KEY WORDS: Foot length, Stature, Height, Regression equations, Correlation coefficient.

Address for Correspondence: Dr. Veena Vidya Shankar, Associate Professor, Department of Anatomy, Ramaiah Medical College, Bangalore – 560054, Karnataka, India.
Contact No.: Mobile – 9980308735 **E-Mail:** veena24shankar@gmail.com

Access this Article online	Journal Information
Quick Response code  DOI: 10.16965/ijar.2017.516	International Journal of Anatomy and Research ICV for 2016 90.30 ISSN (E) 2321-4287 ISSN (P) 2321-8967 https://www.ijmhr.org/ijar.htm DOI-Prefix: https://dx.doi.org/10.16965/ijar 
	Article Information
	Received: 29 Nov 2017 Peer Review: 29 Nov 2017 Revised: None
	Accepted: 02 Jan 2018 Published (O): 05 Feb 2018 Published (P): 05 Feb 2018

INTRODUCTION

The information about the size and shape of bones in feet can be from the foot length of

individuals [1]. The relationship between foot length with general body size, circumference of ankle and calf and body weight has been

studies by various authors [2]. There are also various studies of stature estimation from foot length and breadth, small bones of foot and foot prints [3]. The height estimation is as important as other parameters like age, sex and race especially in medico-legal cases [4].

The environmental and genetic factors influence the development of various parts of body [3]. Sex determination can be done from foot index, foot shape and foot bones. Although bilateral symmetry is a feature seen in humans, there is asymmetry in the foot length without gender or handedness bias [2]. Rutishauser has documented that stature estimation from foot length and length of long bones share same reliability. As foot ossification and maturation is earlier compared to that of long bones in adolescent age group, foot length can be used to predict stature of an individual [5]. The foot length has been correlated with weight and height even in dead fetuses thereby making possible the estimation of foetal age and body dimensions with precision [6].

Aim: To study the relationship of human height with foot length. To derive a mathematical module to predict the height from foot length.

MATERIALS AND METHODS

Study Design: Cross-sectional study

Source of data: Individuals aged between 18 and 25 years of age in and around Bangalore

Place of study: Ramaiah Medical College, Bangalore

Duration of study: 6 months

Sample size: Based on a previous studies conducted by Harsh Vardhan et al(1), Meena et al(7) and Suman Babu et al(8), the correlation coefficient varied from 0.4 to 0.6. Assuming the correlation coefficient to be around 0.58 with the power of 80% and alpha error of 5, sample size was estimated to be 234.

Criteria: **Inclusion criteria:** Individuals aged between 18 and 25 years in and around Bangalore, **Exclusion criteria:** Individuals with features suggestive of dysmorphic syndromes

Parameters studied:

Foot length: Foot length was measured in centimetres (cms) using a calibrated foot board.

Height: The height of the participant was measured in centimetres (cms) using Stadiometer – a wall mounted height measuring device.

The measurements were taken three times to avoid intraobserver variation and their mean value has been considered. Data so collected has been entered in a master chart in Microsoft® Excel and has been analyzed using the SPSS version 17.0. Informed consent has been taken from all participants. The ethical clearance has been obtained from the institution.

Statistical Methods: Descriptive statistics such as mean and standard deviation has been computed for height and foot length Pearson's correlation coefficient has been used to find the correlation between stature and foot length. Multiple Linear regression has been used to predict height from foot length of an individual

RESULTS

The study consisted of 234 subjects, out of which 136 were males and 98 were females. The overall mean foot length observed was 22.82 ± 1.10 cms. Mean length of foot between the two sides were compared and it was found to be 24.95 ± 1.15 cms for right foot and 20.70 ± 0.94 cms for left foot and t test revealed that there was significant difference in the mean values between right and left foot length which was statistically significant (P value = <0.001) (Table – 1)

There was no significant difference in mean values of right foot in males and females and the same was observed with left foot length of males and females (Table – 2).

The height and mean foot length showed a positive correlation on both sides ($p=0.249$ on right side; $p=0.264$ on left side) which was statistically significant (Table -3). The height showed a positive correlation with left foot length in males which was statistically significant ($r=0.196$, $p = 0.022$) (Table – 4). Similarly, correlation of height with foot length in females also revealed a statistically significant positive correlation on left side ($r=0.244$, $p=0.016$) (Table – 4). Linear regression equation was derived to predict height from foot length in both males and females. Regression equation to predict height in males, right foot: Y (height) = $0.233 + \{-0.068 X \text{ right foot length}\}$

Regression equation to predict height in males, left foot: $Y (\text{height}) = 1.033 + (0.251 \times \text{left foot length})$

Regression equation to predict height in females, right foot: $Y (\text{height}) = 0.019 + (0.003 \times \text{right foot length})$

Regression equation to predict height in females, left foot: $Y (\text{height}) = 1.85 + (0.241 \times \text{left foot length})$

The co-efficient of determination obtained for the above regression equations were found to be 0.04, which indicates that the proportion of variability in the height that can be explained by foot length alone is only 4%. Hence, it can be concluded that other parameters need to be considered for better predictability of height.

Table 1: Mean measurements of foot length (mean ± S.D)

	Mean right foot length (cms)	Mean left foot length (cms)	Overall mean foot length (cms)
Mean	24.95 ±1.15	20.70±0.94	22.82±1.10
P value	<0.001		-

Table 2: Mean measurements of right and left foot lengths in males and females.

	In males		In females	
	Mean Right Foot Length	Mean Left Foot Length	Mean Right Foot Length	Mean Left Foot Length
Mean	25.23	20.94	24.57	20.38
SD	1.17	0.97	1	0.79
P value	<0.001		<0.001	

Table 3: Correlation of height with right and left foot length.

	Correlations	Mean Right Foot Length	Mean Left Foot Length
Height	Pearson Correlation	0.249**	0.264**
	P value	<0.001	<0.001

Table 4: Correlation of height with right and left foot length in males and females.

Sex			Mean Right Foot Length	Mean Left Foot Length
Males	Height	Pearson Correlation	0.134	0.196*
		P value	0.119	0.022
Females	Height	Pearson Correlation	0.182	0.244*
		P value	0.074	0.016

Table 5: Various studies of correlation between foot length and height.

Study	Sample Size	Males	Females	Parameters
Anitha Oommen et al[2], 2005	100	50	50	Hand & foot length
Patel SM et al[5], 2007	502	278	224	Height & foot length
Shailesh M Patel et al[9], 2011	285	149	136	Height & foot length & breadth
Mansur DI et al[10], 2012	440	258	182	Height & foot length
Mohanty BB et al[11], 2012	300	206	94	Height & foot length
Nivedita Pandey et al[12], 2012	200	100	100	Height & foot length
Pradeep Pawar et al [13], 2012	298	146	152	Height & foot length
M.C.Meena et al[7], 2013	250	0	250	Height & foot length
Suman Babu et al[8], 2013	104	54	50	Height & foot length
Utsav Parekh et al[4], 2014	200	116	84	Height & foot length
Rakhee Verma et al[15], 2015	150	75	75	Height & foot length
Twisha et al[3], 2015	160	128	32	Height and sex with shoulder width, arm and foot length
HarshVardhan et al[1], 2016	184	91	93	Height & foot length
Charu Taneja et al [14], 2016	481	481	0	Height & foot length
Present study, 2016	234	98	136	Height & foot length

DISCUSSION

A highly significant correlation ($p < 0.0001$) has been documented between hand length and foot length on both sides and in both sexes by Anitha et al [2] and hence if one is known the other can be predicted. Patel SM et al [5] and Utsav Parekh et al [4] have reported a statistically significant correlation between foot length and height in individuals from various regions of Gujarat. Shailesh M Patel et al [9] have found that there is a strong association between foot length and foot breadth and also between stature and foot breadth. They have opined that stature can be more accurately calculated by foot breadth than by long bones. Mansur et al [10], Mohanty et al [11], Nivedita Pandey et al [12], M.C. Meena et al [7] and Suman Babu et al [8] have established a definite correlation between stature and foot-length and also derived the regression equations. Pradeep Pawar et al [13] have concluded that the height of an individual is 6.5 times the length of their foot. Charu Taneja et al [14] have reported a positive correlation between stature and foot length in male tribals of Udaipur district of Rajasthan.

Rakhee Verma et al [15] have reported that foot length is a reliable predictor of stature in both sexes. Twisha Shah et al [3] have stated that if shoulder width, foot length or arm length is known, height and sex can be calculated. Harshvardhan et al [1] have concluded that the foot length provided medium reliability and accuracy in estimating stature in males and females. In the present study, a positive correlation between height and foot length has been reported and regression equations have been derived similar to other studies reported. (Tab.5)

CONCLUSION

There was a statistically significant difference in right and left side mean foot length measurements in both males and females. A positive correlation between height and foot length was observed which was statistically significant. The left foot length had better correlation with height in both sexes. It was concluded from further analysis that other parameters need to be considered for better predictability of height.

Conflicts of Interests: None

REFERENCES

- [1]. Harsh Vardhan, Naval Kishore Pandey. Personal height of an individual person from measuring foot length. *International Journal of Medical and Health*. 2016;2(8):14-17.
- [2]. Anitha Oommen, Avinash Mainker, Tom Oommen. A Study of the Correlation between Hand Length and Foot Length In Humans. *J.Anat.Soc. India*. 2005;54(2):1-9.
- [3]. Twisha Shah, Patel MN, Nath S, Shobhana K Menon. A Model for Construction of Height and Sex from Shoulder Width, Arm Length and Foot Length by Regression Method. *J Forensic Sci Criminol*.2015;3(1):102.
- [4]. Utsav Parekh, Reekee Patel, Pratik Patel. A Study of Relation of Stature with Foot Length in Natives of Gujarat State. *NHL Journal of Medical Sciences*. 2014;3(1):22-25.
- [5]. Patel S. M., Shah G. V., Patel S. V. Estimation of height from measurement of foot length in Gujarat region. *J. Anat. Soc. India*. 2007;56(1):25-27.
- [6]. Mandarin-de-Lacerda CA. Foot length growth related to crown rump length, gestational age and weight in human staged fresh fetuses. An index for anatomical and medical use. *Surg Radiol Anat*.1990;12:103.
- [7]. Jitender Pratap Singh, Mahesh Chand Meena, Yashoda Rani, Girish Kumar Sharma. Stature Estimation from the Dimensions of Foot in females. *Antrocom Online Journal of Anthropology*. 2013; 9(2):237-241.
- [8]. Babu, Deepika.V, Potturi.BR. Estimation Of Stature From Foot Length. *International Journal of Pharmacy and Biological Sciences*. 2013; 3(3):266-270.
- [9]. Shailesh M. Patel, Vikash Doshi, Srushti Ruparelia, Ankur Zalawadia, Dhara Parekh, S. P. Rathod, et al. Anthropological Study of the Foot and it's relationship between different parameters and Stature in an Adult Population of different areas of Gujarat. *NJIRM*. 2011;2(3):67-70.
- [10]. 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.
- [11]. Mohanty BB, Agarwal D, Mishra K, Samantsinghar P, Chinara PK. Estimation of height of an individual from foot length; A study on the population of Odisha. *Int J Rev Life Sci*. 2012; 2(2):69-74.
- [12]. Nivedita Pandey, Suresh Roshan, Rahul Kharate, Monali Sonawane, Varsha Bhivate, Narpal Singh Ujwal. Prediction of Stature Based On Foot Length. *Journal of Nobel Medical College*.2012;31(5):66-70.
- [13]. Pradeep K Pawar, Abhilasha Dadhich. Study of correlation between human height and foot length in residents of Mumbai. *Int J Biol Med Res*. 2012;3(3):2232-2235.
- [14]. Charu Taneja, Hitesh Babel, L.K. Jain. An Anthropometric Study of Stature Estimation among Males from the Measurements of Feet in Udaipur District of Rajasthan. *Int J Cur Res Rev*.2016; 8(17):41-44.
- [15]. Rakhee Verma, Syed Esam Mahmood. Regression Equations for Stature Estimation among Medical Students of Ghaziabad. *National Journal of Community Medicine*. 2015; 6(4):478-482.