Original Research Paper

A Study of Estimation of Stature by Foot Length among Students and Staff of Al-Ameen Medical College, Vijayapur

[1]Pratapsingh Rathod, [2]E .S. Goudar

Abstract:

Stature is one of the important parameters in identification of any individual. Estimating stature using various parts of body is important in medico-legal investigations since correlation has been found between stature and different parts of body by many studies. Stature estimation using foot length has been done by many studies in different age groups and different regions. Since stature varies among individuals of different sex, race and regions, present study was done to obtain data of this region. It was cross-sectional study carried out on 200 subjects of both sexes (100 male and 100 female), between 21-40 years from the medical college. Stature was measured using standard height measuring instrument and both right and left foot length was measured using Vernier calipers. The correlation coefficient (r), and regression equation for correlation between right and left foot length and stature in males was found to be 0.677, Stature = 89.297+3.158RFL and 0.707, Stature = 89.163+3.189LFL, respectively. The correlation coefficient (r), and regression equation for correlation between right and left foot length and stature in females was 0.592, Stature = 84.203+3.087RFL and 0.582, Stature = 82.477+3.203LFL, respectively. The correlation coefficient (r), and regression equation for correlation between right and left foot length and stature in pooled subjects was 0.811, Stature = 53.591+4.489RFL and 0.823, Stature = 55.195+4.469LFL, respectively.

Key Words: Stature, Right Foot Length, Left Foot Length, Correlation, Regression.

Introduction:

Identification is the determination of the individuality of a person based on certain characteristics with exact fixation of personality.[1] Personal identification means determination of individuality of a person. It may be complete (absolute) or incomplete (partial). Complete identification means absolute fixation of individuality of a person.

It may be complete (absolute) or incomplete (partial). Complete identification means absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while others still remain unknown. Age, sex and stature are the primary characteristics of identification.[2]

Identification becomes necessary in the living, recently dead persons, decomposed bodies, mutilated and skeletal remains and is required in civil and criminal cases.[3] Among different parameters of identification, stature estimation of an individual is a basic and key part in identification.

Stature is a primary character for the identification of the person. It increases progressively and becomes maximum at the age of 21 years and then remains constant. It is well known that there is a definite relationship between the height of the person and various parts of the body like head, trunk and lengths of

Corresponding Author:
[2]Professor& Head,

Department of Forensic Medicine & Toxicology,
Al-Ameen Medical College, Vijayapur, Karnataka

[1]Assistant Professor,
Department of Forensic Medicine & Toxicology,
D.Y.Patil Medical College, Kolhapur, Maharastra

Email Id: e.s.goudar@gmail.com
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the upper and lower limbs. Assessing the height of an individual, from measurements of different parts, has always been of immense interest to the anatomists, anthropologists and forensic medicine experts.

Like other parts of the body, such as head, trunk, lengths of upper and lower limb, the foot size also displays a definite biological correlation with stature. On the basis of this relationship, it is possible to predict the stature from the foot and its segments.

A forensic specialist is often required to estimate the stature of a person from dismembered body parts and bones. Length of different body parts bears constant relationship with the body length. In view of this, the present study is undertaken to know the approximate relationship between foot length and stature of a person in this region.

Foot prints are often found in crime scene investigation and stature estimation by foot length is helpful in identification of the suspect. Several studies have been conducted to estimate stature using various parameters like-head length, hand and phalangeal length, long bone length superior and inferior extremity length, foot length and foot breadth.[4]

These studies are important but many factors like racial, ethnic, and nutritional factors play an important role in human growth and development and therefore different normograms become necessary for different population. There have been several studies conducted on different population groups in different parts of the world, to estimate stature from different parts of the body. Several workers have shown a significant correlation between foot measurements and stature in different parts of the country.[5]

Such studies have been carried out by anatomists, forensic medicine experts and anthropologists. They have used either the somato-metric measurements of the foot using anthropometric instruments or foot outline measurements by contour tracing method or the foot print measurements to correlate the foot measurements with stature and reconstruct height. Many studies derived several multiplication factors and regression formulae to estimate stature using different foot measurements. These normograms, which were derived, are known to vary from one population group to another, so separate studies for each population group becomes necessary.

Materials and Methodology:

The present study was conducted among the consenting students and staff of the Medical College, Vijayapur, among the age group of 21-40 years, after approval from the Institutional Ethics Committee. Individuals suffering from chronic illness, endocrine disorders (Dwarfism, Gigantism, Cretinism etc), individuals with deformities of foot (Flat Foot), lower limbs (Knock-Knee), and vertebral column (Scoliosis, Kyphosis) were excluded.

***Equipment*:** Vernier Caliper**,** Standing height measuring instrument, calculator

***Methodology*:** The study group was divided in to two groups based on age. Group A consisted of 100 subjects (50 male and 50 female) of age group 21-30 yrs, and Group B consisted of 100 subjects (50 male and 50 female) of age group 31-40 yrs, Stature and foot length of each subject is taken as follows:

Recording of Foot length: The aim and objective of the study was explained and informed consent was taken. Measurements made on the standing subject, his right leg being slightly bent and drawn backwards so that the body rested mainly on the left foot, to measure left foot and vice versa. The vernier calipers was horizontally placed along the medial border of the foot, the fixed part of the outer jaw of the caliper was applied to the most prominent point of the back of the heel (pternion) and the mobile part of the outer jaw was approximated to the tip of the hallux or the tip of the second toe (acropodian) when the second toe was larger than hallux, and it was measured in centimeters approximated to the nearest millimeter.[5,6]

Recording of the stature: The stature of each subject was recorded by asking him/her to stand erect with bare foot on the base of the standard height measuring instrument[7] in a standing position. Then the subjects were asked to stand without support, with arms by the side of the body, head in steady position. The height was measured from the ground to the highest point on the subjectõs head with the help of horizontal thin plate in close contact with the scalp in centimeters to the nearest millimeters.

The data was tabulated, analyzed and subjected to statistical calculations for each group and paired sample t-test was applied to known difference of means in two groups. If there was statistically significant difference ($p<0.01$) in means between the two groups, then further correlation and regression was analyzed separately in each group. If there was no statistically significant difference ($p>0.01$) in means between two groups then both groups data was combined and further correlation and regression was analyzed as a whole group.

Results:

A Cross-sectional study was carried out on 200 students and staff of medical college, Vijayapur. The individuals of both the sexes, aged between 21-40 years, were included in the study. The subjects were later divided in two groups: Group A (21-30yrs) and Group B (31-40yrs). The stature and foot length of the individuals were assessed and an attempt was made to correlate foot length with stature and derive regression equations to calculate stature from foot length.

The age distribution of the study Group A included individuals aged between 21-30 years, with a mean age of 24.32 ± 2.19 years, of both the sexes, i.e., 50 males and 50 females. The Stature of males varied in a range of 155.1 ï 183.0 cm with a mean of 170.74±5.71 cm and that of females ranged from 143.5 ï 174.5 cm, with a mean of 155.69±5.50 cm. The Right foot length in males ranged from 21.71 ï 29.55 cm, with a mean of 25.56±1.33 cm and that of females ranged from 21.24 ï 25.41 cm, with a mean of 23.15±1.03 cm. The Left foot length in males ranged from 20.63 ï 27.51 cm, with a mean of 25.19±1.39 cm and that of females ranged from 20.41 ï 25.21 cm, with a mean of 22.80±1.03 cm.

The Stature of pooled subjects in group A varied in range from 143.50 ï 183.00 cm, with a mean of 163.22±9.40cm. The Right foot length of pooled subjects varied from 21.24-29.55cm, with a mean of 24.36±1.69cm. The Left foot length of pooled subjects varied from 20.41 - 27.51cm, with a mean of 23.99±1.71cm.

The age distribution of the study Group B included individuals aged between 31- 40 years, with a mean age of 35.89 ± 3.03 years, of both the sexes, i.e., 50 males and 50 females. The stature of males varied in a range of 150.5 ï 181.4 cm, with a mean of 168.12±6.92 cm and that of females ranged from 142.5 ï 171.6 cm, with a mean of 156.19±5.88cm. The Right foot length in males ranged from 22.1 ï 27.8 cm, with a mean of 25.19±1.42 cm and that of females ranged from 21.37 ï 25.61 cm, with a mean of 23.32±1.15 cm. The Left foot length in males ranged from 22.11 ï 27.91 cm, with a mean of 25.14±1.48 cm and that of females ranged from 21.14 ï 25.12 cm, with a mean of 23.08±1.02 cm.

The Stature of pooled subjects in Group B varied in range from 142.5 ï 181.4 cm, with a mean of 162.15±8.76cm. The Right foot length of pooled subjects varied from 21.37-27.81cm, with a mean of 24.25±1.59 cm. The Left foot length of pooled subjects varied from 21.14 - 27.91cm, with a mean of 24.11±1.64cm.

Table 1 shows the Comparison of means of two age Groups i.e., Group A and Group B by Paired Sample T-test. It shows that P-value is >0.05 for all the pairs except for male stature i.e., p-value is >0.01 suggesting that there is no statistical significance between Means of Group A and Group B.

Since there is no statistical significance in making two study group, both the groups were combined as a whole study group of 200subjects between 21-40yrs age group.

The Stature of pooled subjects (Group A + Group B) varied in range from 142.5 ï 183.0 cm, with a mean of 162.69±9.08cm. The Right foot length of pooled subjects varied from 21.24 ï 29.55 cm, with a mean of 24.30±1.64cm. The Left foot length of pooled subjects varied from 20.41 -27.95 cm, with a mean of 24.05±1.67cm. The Stature of males varied in a range of 150.5 ï 183.0 cm, with a mean of 169.43±6.45 cm and that of females ranged from 142.50 ï 174.50 cm, with a mean of 155.94±5.67cm. The Left foot length in males ranged from 20.63 ï 27.91 cm, with a mean of 25.17±1.43 cm and that of females ranged from 20.41 ï 25.21 cm with a mean of 22.94±1.03 cm (**Table 2, 3**). (**Graphs 1&2**)

Table: 1 Comparison of means of two age Groups i.e., Group A and Group B by Paired Sample T-test

Pairs	Groups	Mean	Std. Deviation	Std.Error Mean	t-value	Significance P-value
Pair1	A-Stature	163.22	9.40	0.94	0.816	0.417
	B-Stature	162.15	8.76	0.88		
Pair2	A-RFL	24.36	1.69	0.17	0.455	0.650
	B-RFL	24.25	1.59	0.16		
Pair 3	A-LFL	23.99	1.71	0.17	-0.500	0.618
	B-LFL	24.11	1.64	0.16		
Pair 4	A-Male statue	170.74	5.71	0.81	2.192	0.033
	B-Male stature	168.12	6.92	0.98		
Pair 5	A-Male RFL	25.56	1.33	0.19	1.332	0.189
	B-Male RFL	25.19	1.42	0.20		
Pair 6	A-Male LFL	25.19	1.39	0.20	0.175	0.862
	B-Male LFL	25.14	1.48	0.21		
Pair 7	A-Female stature	155.69	5.50	0.78	-0.448	0.656
	B-Female stature	156.19	5.88	0.83		
Pair 8	A-Female RFL	23.15	1.03	0.15	-0.805	0.425
	B-Female RFL	23.32	1.15	0.16		
Pair 9	A-Female LFL	22.80	1.03	0.15	-1.566	0.124
	B-Female LFL	23.08	1.02	0.14		

Table: 2 Comparison of Stature, Right foot length, and Left Foot Length between males and females (Group A + Group B)

	Variables	Minimum	Maximum	Mean ±S.D
Total (Pooled)	Stature	142.50	183.00	162.69±9.08
	RFL	21.24	29.55	24.30±1.64
	LFL	20.41	27.95	24.05±1.67
Male	Stature	150.50	183.00	169.43±6.45
	RFL	21.71	29.55	25.37±1.38
	LFL	20.63	27.91	25.17±1.43
Female	Stature	142.50	174.50	155.94±5.67
	RFL	21.24	25.61	23.24±1.09
	LFL	20.41	25.21	22.94±1.03

Table: 3 Comparison of Mean of Stature, RFL and LFL between Male and Female (Group A +Group B)

Variables	Stature in cm	RFL in cm	LFL in cm
Male	169.43±6.45	25.37±1.38	25.17±1.43
Female	155.94±5.67	23.24±1.09	22.94±1.03
Significance	t=16.380; p<0.001**	t=12.264; p<0.001**	t=12.886; p<0.001**

**P-value<0.001 shows strong significance of Mean between Male and Female.

The Right foot length versus stature correlation coefficient in males was 0.677 and in females, it was 0.592. When both sexes were put together, the correlation was 0.811, at p<0.001 which is strongly significant. The Left foot length versus stature correlation coefficient in males was 0.707 and a female was 0.582. When both sexes were put together the correlation was 0.823, at p<0.001 which is strongly significant (**Table 4**)

Table 4: Correlation Coefficient (r), Regression coefficient (b), and value of Constant (b) between foot lengths and stature (Group A +Group B)

		Total	Male	Female	P-value
RFL Vs. Stature	Correlation Coefficient (r)	0.811	0.677	0.592	p<0.001*
	Regression Coefficient(b)	4.489	3.158	3.087	p<0.001*
	Value of constant (a)	53.591	89.297	84.203	p<0.001*
LFL Vs. Stature	Correlation Coefficient (r)	0.823	0.707	0.582	p<0.001*
	Regression Coefficient(b)	4.469	3.189	3.203	p<0.001*
	Value of constant (a)	55.195	89.163	82.477	p<0.001*

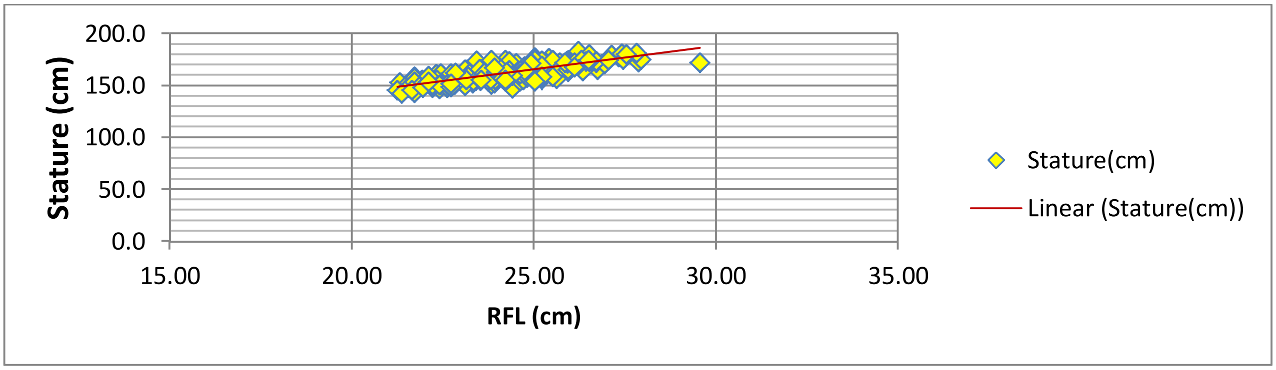
The **Table 5** shows regression equations to calculate stature from right and left foot length by substituting values of foot length in males, and females, as well as when both sexes are combined.

Table 5: Regression equation for the prediction of Stature by Right and Left foot length (Group A + Group B)

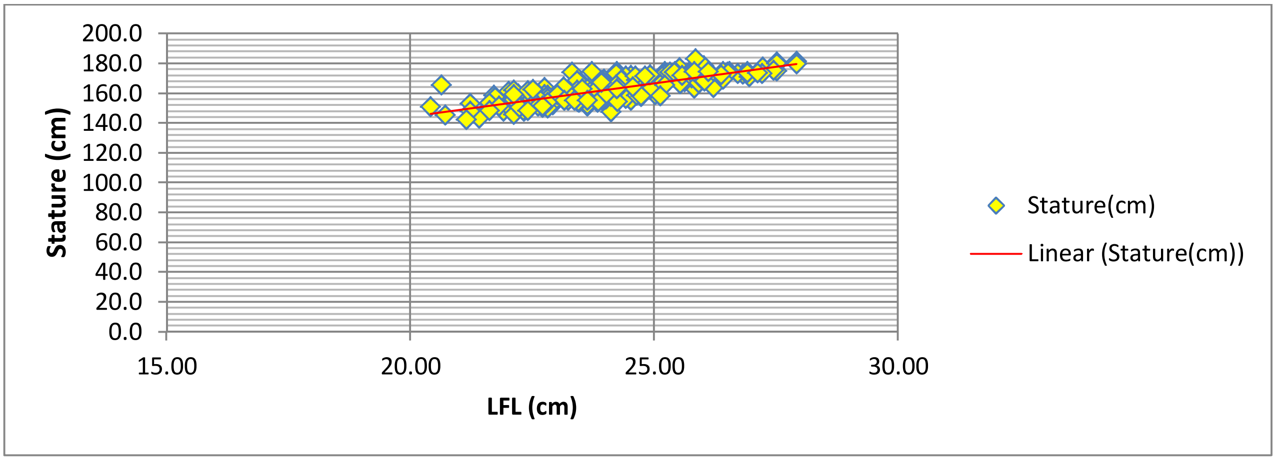
	RFL	LFL
Total (Pooled)	Stature=53.591+4.489× RFL (r^2 = 0.657 p<0.001*)	Stature=55.195+4.469× LFL (r^2 = 0.678 p<0.001*)
Male	Stature=89.297+3.158× RFL (r^2 = 0.459 p<0.001*)	Stature=89.163+3.189× LFL (r^2 = 0.500 p<0.001*)
Female	Stature=84.203+3.087× RFL (r^2 = 0.351 p<0.001*)	Stature=82.477+3.203× LFL (r^2 = 0.338 p<0.001*)

*P-value<0.001 is strongly significant

Graph 1 Scatter Graph Showing Correlation between Right foot length and Stature.



Graph 2 Scatter Graph Showing Correlation between Left foot length and Stature.



Discussion:

Stature estimation is one of the important parameters in the process of identification. Every biometric analysis starts with stature. For years, anthropologists, forensic experts, have carried out varies studies to calculate stature using various body parts.

Stature of a person shows definitive correlation between different body parts of body and this was utilized for estimating stature. Among the different body parts, foot length provides significant correlation which is shown in different studies conducted in different parts of the world.[4]

There are several studies conducted to estimate stature by different parameters; like Brenda et al,[5] Kairulmazidah, et al,[8] Eugene, et al[9] used shoe length and foot length, for estimating stature, but concluded that foot length was more reliable for estimating stature.

Ebimobo, et al,[4] Jaydip, et al[10] Jitendar Pratap, et al[11], Rahul Rai, et al,[12] Rajesh, et al,[13] Arti, et al,[14] Geetha, et al,[15] Chikhalkar, et al,[16] Dayananada, et al,[17] used foot length and foot breadth for correlating stature and found foot breadth to be moderately significant for estimating stature, compared to foot length, which is strongly significant.

Few studies like Moshkdanian, et al[18] and Sumita Agarwal, et al,[19] Chikhalkar, et al[16] used lower limb length, knee length, knee-ankle length, respectively, for estimating stature.

Sonali, et al[20] used hand length and head length, Geetha, et al,[15] Chikhalkar, et al,[16] used hand length dimension for estimating stature, and found mixed significance for estimating stature.

In the present study, only foot length of both sexes was noted and an attempt was made to find the relation between stature and foot length in the study group, using statistical analysis.

Several study groups used different age group ranging from 17-25 years[6] to 18 to 72 years,[21] accounting for difference in stature as age progresses.

In the present study, initially study group was divided in two groups Group A (21-30years) and Group B (31-40 years), since after age of 30 years there is gradual decrease in stature by about 0.6mm per year.[1] Later Paired sample T-test was done on the both age groups, as shown in **Table 1** and it was found that Mean difference of both age groups was not statistically significant ($p>0.01$). Hence, both the age groups were combined and a single study group of 200 subjects (100 male and 100 female) was used for further analysis of foot length and stature.

The paired sample t-test was done by Kemo, et al,[4] Parekh, et al[22] and Geetha, et al[15] for statistical difference between means of male and female and they found that it is highly significant $p<0.001$.

Similar results were found in present study, as shown in **Table 1**, where the difference in male and female mean was highly significant ($p<0.001$).

It is a known fact that there is difference in development in males and females, and hence, several studies compared their findings between males and females; although few studies like Ghazaleh, et al[18] and Karaddi, et al[23] used only male subjects, and Jitendra Singh, et al[11] used only female subjects for their analysis. Several studies gave equal importance to both sexes, like Arif, et al,[6] Keme, et al,[4] Rameswarapu, et al,[25] Verma, et al,[26] Nivedita, et al,[27] Geetha, et al,[15] Sumita, et al,[19] Vinay, et al,[30] using equal number of male and female subjects, where as other studies like Mansue, et al,[6] Mehul, et al,[31] Sonali, et al,[20] Mohanty, et al,[32] Rahul, et al,[12] Seema, et al,[33] and Utsav, et al,[22] used variable number of male and female subjects. In the present study, among the total subjects, 100 males and 100 females were used and separate correlation was obtained between foot length and stature for both male and female.

Many factors influence the foot-length in the same individuals of both limbs such as developmental factors, wearing of footwear, nutrition, weight bearing. Hence length of foot in both may differ. Hence, several studies like Mansul, et al,[6] Mehul, et al,[31] Rahul, et al,[12] Rameswarapu, et al,[25] Rajesh, et al,[13] Rakhee, et al,[26] Nivedita, et al,[27] Chavan et al,[26] and Vinay, et al[30] used both the lower limbs in their studies. However, few studies like Neetu, et al,[21] Patel, et al,[7] Dayananda, et al[17] used only left foot as per the recommendation of the international agreement for paired measurements at Geneva (1910). Few workers like Utsav, et al[22] found no statistical difference between right and left foot ($p>0.005$), hence used only right foot. In the present study, considering variation in right and left foot, both the limbs in both sexes were used and correlation was analyzed separately for both the right and left side.

The observations made by the various studies and the results obtained have been presented in the tables. (**Tables 6 - 11**)

Table 6: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from right foot length(x) in males of different study groups

Study	Study Group	RFL vs Stature, In Male Subjects		
		r	r^2	Regression Equation
Mehul et al 2015	Jamnager, Gujarat	0.752	0.566	y=86.96+3.40x
Rahul et al 2014	Moradabad UP	0.433	0.187	y=116.51+2.07x
Utsav et al 2014	Ahmedabad	0.979	0.958	y=74.75+3.42x
Rameswarapu et al 2013	Ghanapur AP	0.583	0.340	y=82.830+3.468x
Rajesh et al 2015	Puducherry	0.821	0.674	y=98.159+3.746x
Rakhee et al 2015	Ghaziabad	0.877	0.769	y=53.918+4.497x
Niveditha et al 2011	NaviMumbai, Maharastra	0.451	0.203	y=128.951+1.695x
Arti et al 2013	Nagpur	0.97	0.941	y=90.1+5.96x
Sumita et al 2015	Moradabad UP	0.7025	0.494	y=69.99+3.93x
K.D.Chavan et al	Ahmednagar, Maharastra	0.63	0.397	y=167.9+1.145x
Jitender et al	Rohtak, Haryana	0.527	0.278	y=86.620+3.414x
Vijayakumar et al 2013	Davangere	0.37	0.137	y=88.39+3.27x
Saranabasappa et al 2013	Raichur	0.82	0.672	y=86.9+3.40x
Vinay et al 2014	Bagalkot	0.65	0.423	y=92.5+3.0x
Present Study	Vijayapur	0.677	0.458	y=89.297+3.158x

Table 7: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from right foot length(x) in females of different study groups

Study	Study Group	RFL vs Stature In Female Subjects		
		r	r^2	Regression equation
Mehul et al 2015	Jamnager, Gujarat	0.731	0.534	y=77.35+3.605x
Rahul et al 2014	Moradabad UP	0.728	0.530	y=14.75+6.39x
Utsav et al 2014	Ahmedabad	0.988	0.976	y=63.62+3.61x
Rameswarapu et al 2013	Ghanapur AP	0.66	0.436	y=73.523+3.615x
Rajesh et al 2015	Puducherry	0.837	0.701	y=91.242+3.284x
Rakhee et al 2015	Ghaziabad	0.7	0.490	y=78.200+3.427x
Niveditha et al 2011	NaviMumbai, Maharastra	0.421	0.177	y=118.533+1.692x
Arti et al 2013	Nagpur	0.9869	0.974	y=53.0+4.26x
Sumita et al 2015	Moradabad UP	0.4846	0.235	y=89.82+2.95x
K.D.Chavan et al	Ahmednagar, Maharastra	0.75	0.563	y=154.98+3.616x
Jitender et al	Rohtak, Haryana	0.697	0.486	y=73.132+3.721x
Vijayakumar et al 2013	Davangere	0.47	0.221	y=81.29+3.32x
Vinay et al 2014	Bagalkot	0.62	0.384	y=74.27+3.53x
Present Study	Vijayapur	0.592	0.350	y=84.203+3.087x

Table 8: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from right foot length(x) in Pooled subjects of different study groups

Study	Study Group	RFL vs Stature in Pooled subjects		
		r	r^2	Regression equation
Rahul et al 2014	Moradabad UP	0.671	0.450	y=90.32+3.07x
Rameswarapu et al 2013	Ghanapur AP	0.8	0.640	y=47.971+4.782x
Rakhee et al 2015	Ghaziabad	0.892	0.796	y=56.910+4.363x
Sumita et al 2015	Moradabad UP	0.7471	0.558	y=63.00+4.17x
Jitender et al	Rohtak, Haryana	0.869	0.755	y=47.631+4.889x
Present Study	Vijayapur	0.811	0.658	y=53.591+4.489x

Table 9: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from Left foot length(x) in Male subjects of different study groups

Study	Study Group	LFL vs Stature in Male subjects		
		r	r^2	Regression equation
Arif et al 2015	Lahore	0.59	0.348	y=104.455+2.591x
Keme et al 2014	Western Nigeria	0.7	0.490	y=3.858x+71.19
Ghazaleh et al 2014	Iran	0.78	0.608	y=80.693+3.56x
Mehul et al 2015	Jamnager, Gujarat	0.769	0.591	y=84.63+3.49x
Sonali et al 2012	Pune, Maharastra	0.702	0.493	y=72.8+3.7x
Rahul et al 2014	Moradabad UP	0.461	0.213	y=115.45+2.11x
Rameswarapu et al 2013	Ghanapur AP	0.585	0.342	y=80.955+3.547x
Rajesh et al 2015	Puducherry	0.787	0.619	y=97.843+3.651x
Rakhee et al 2015	Ghaziabad	0.869	0.755	y=57.951+4.642x
Niveditha et al 2011	NaviMumbai, Maharastra	0.452	0.204	y=106.265+2.236x
Arti et al 2013	Nagpur	0.9669	0.935	y=85.7+5.96x
GN Geetha et al 2015	Kerala	0.55	0.303	y=98.51+2.42x
Sumita et al 2015	Moradabad UP	0.7027	0.494	y=70.93+3.89x
K.D.Chavan et al	Ahmednagar, Maharastra	0.61	0.372	y=167.9+1.063x
Patel et al 2007	Ahmedabad, Gujarat	0.65	0.423	y=75.45+3.64x
Jitender et al	Rohtak, Haryana	0.525	0.276	y=80.671+3.648x
Vijayakumar et al 2013	Davangere	0.34	0.116	y=92.81+3.10x
Saranabasappa et al 2013	Raichur	0.8	0.640	y=112+2.41x
Vinay et al 2014	Bagalkot	0.72	0.518	y=85.32+3.3x
Present Study	Vijayapur	0.707	0.500	y=89.163+3.189x

Table 10: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from Left foot length(x) in Female subjects of different study groups

Study	Study Group	LFL vs Stature in Female subjects		
		r	r^2	Regression equation
Arif et al 2015	Lahore	0.63	0.397	y=88.210+2.93x
Keme et al 2014	Western Nigeria	0.8	0.640	y=3.578x+73.15
Mehul et al 2015	Jamnager, Gujarat	0.718	0.516	y=78.92+3.53x
Sonali et al 2012	Pune, Maharastra	0.645	0.416	y=90.0+3.2x
Jitender et al 2013	New Delhi	0.583	0.340	y=2.967x+88.235
Rahul et al 2014	Moradabad UP	0.751	0.564	y=7.23x-3.62
Rameswarapu et al 2013	Ghanapur AP	0.653	0.426	y=79.83+3.349x
Rajesh et al 2015	Puducherry	0.876	0.767	y=90.976+3.041x
Rakhee et al 2015	Ghaziabad	0.719	0.517	y=73.568+3.620x
Niveditha et al 2011	NaviMumbai, Maharastra	0.506	0.256	y=128.233+1.726x
Arti et al 2013	Nagpur	0.9848	0.970	y=53.3+4.23x
GN Geetha et al 2015	Kerala	0.412	0.170	y=81.978+2.94x
Sumita et al 2015	Moradabad UP	0.3885	0.151	y=93.17+2.81x
K.D.Chavan et al	Ahmednagar, Maharastra	0.71	0.504	y=154.98+3.481x
Patel et al 2007	Ahmedabad, Gujarat	0.8	0.640	y=75.41+3.43x
Jitender et al	Rohtak, Haryana	0.719	0.517	y=65.194+4.068x
Vijayakumar et al 2013	Davangere	0.47	0.221	y=80.90+3.34x
Vinay et al 2014	Bagalkot	0.6	0.360	y=73.5+3.56x
Present Study	Vijayapur	0.582	0.339	y=82.477+3.203x

Table 11: The Correlation coefficient (r), coefficient of determination (r^2) and regression equation to estimate Stature(y) from Left foot length(x) in Pooled subjects of different study groups

Study	*Study Group*	*LFL vs Stature in Pooled subjects*		
		r	*r^2*	*Regression equation*
Arif et al 2015	*Lahore*	*0.807*	*0.651*	*y=58.101+4.261x*
Keme et al 2014	*Western Nigeria*	*0.8*	*0.640*	*y=4.671x+47.79*
Sonali et al 2012	*Pune, Maharastra*	*0.849*	*0.721*	*y=55.5+1.5x*
Rahul et al 2014	*Moradabad UP*	*0.679*	*0.461*	*y==91.74+3.02x*
Rameswarapu et al 2013	*Ghanapur AP*	*0.602*	*0.362*	*y=50.350+4.691x*
Rakhee et al 2015	*Ghaziabad*	*0.991*	*0.982*	*y=56.088+4.393x*
Sumita et al 2015	*Moradabad UP*	*0.7434*	*0.553*	*y=64.99+4.09x*
Chikhalkar et al 2009	*Byculla, Mumbai*	*0.6102*	*0.372*	*y=79.72379+3.650632x*
Jitender et al	*Rohtak, Haryana*	*0.969*	*0.939*	*y=43.852+5.047x*
Dayananda et al 2014	*Kolar*	*0.636*	*0.404*	*y=69.346+3.663x*
Present Study	*Vijayapur*	*0.823*	*0.677*	*y=55.195+4.469x*

The mean stature in all the studies was found to be significantly greater in males when compared to females, except in Seema, et al,[33] where female mean height was greater. The mean male stature in present study was similar to Vinay, et al[30] may be because his study group region is nearby, and Rahu, et al[12] but variations are present in different study groups. The mean female stature in the present study was similar to Arti, et al[14] and Patel, et al[7] but is inconsistent with other groups. In the pooled subjects, mean stature in the present study was similar to Sumitha, et al[19] but inconsistent with other studies.

The variation in values can be attributed to various reasons like genetic and environmental factors, study group regions, methodology etc. The mean right foot length in pooled subjects in present study was similar to Rameswarapu, et al[25] and Jitender, et al.[34] but slight variations were observed in other studies. The mean right foot length of males in present study was similar to Vinay, et al[31] since their study region is close to the present study region, but the female mean right foot length was similar to that of Rakhee, et al,[26] and Chavan et al.[28] The other studies were inconsistent with our study.

The mean left foot length in pooled subjects in the present study was similar to that of Chikhalkar, et al[16] but variations were observed in other studies. The mean left foot length of males in the present study was similar to that of Dayanand, et al[17] but female mean left foot length was similar to that of Sumitha, et al.[19] The other studies were inconsistent with present study.

The foot length was found to be more in males than in females in most of the study group including the present study group. This may be because the growth of feet stops about two years in female than in males. The Correlation coefficient (r) for correlation between right foot length and stature in males for different study group ranged from 0.37 (Vijaykumar, et al[29]) to 0.979 (Utsav, et al[22]), which indicates moderate to nearly perfect correlation.

The value of r in the present study was similar to that of Vinay et al,[30] which has similar study group and also the r value was similar to Chavan, et al,[28] but it varies considerably with other studies.

In the present study, the correlation between right foot length and stature in males was 0.677 suggesting large correlation. Indicating stature could be predicted with good accuracy using right foot length in males.

The Coefficient of determination (r^2) was lowest in 0.137 in Vijaykumar, et al[29] suggesting that 13.7% of the variation in stature can be explained by right foot length. The highest was in Utsav et al,[22] which was 0.958, whereas the right foot length explains 95.8% variation in stature. In present study, the value of r^2 was 0.458 implying that 45.8% of variation in stature can be attributed to right foot length in males.

The regression equation of present study was similar to that of Vijayakumar, et al[29] and Arti, et al[22] but it varies in other studies, indicating requirement of different equation for different regions. The regression equation has a constant and a multiplication factor. The right foot length was multiplied with the multiplication factor and added to the constant to get the stature.

In the present study, in case of the males, the constant was 89.297 and the multiplication factor was 3.158, which indicated that for every 1cm increase in right foot length, the stature increases by 3.158cm.

As seen in all studies, the value of r, r^2, and regression equation varies in a wide range owing difference in region, age group, and methodology.

The Correlation coefficient (r) for correlation between right foot length and stature in females for different study group ranged from 0.421 (Niveditha, et al[27]) to 0.988 (Utsav et al[22]), which indicates moderate to nearly perfect correlation.

The r value in the present for right foot length in females was similar to Vinay et al,[30] but varied considerably with other studies.

In the present study, the correlation between right foot length and stature in females was 0.592, suggesting large correlation. Indicating stature could be predicted with good accuracy, using right foot length in females.

The values of coefficient of determination (r^2) was lowest, 0.117, in Niveditha et al,[27] suggesting that 11.7% of the variation in stature could be explained by right foot length. The highest was in Utsav et al,[22] which was 0.976 where right foot length explains 97.6% variation in stature. In the present study, the value of r^2 was 0.350 implying that 35.0% of variation in stature can be attributed to right foot length in males.

The regression equation in the present study for females was not similar to any of the above studies indicating essentiality of regression equation for separate sexes.

In the present study, in case of females, the constant was 84.203 and multiplication factor was 3.087, which indicated that for every 1cm increase in right foot length, the stature increased by 3.087cm. This equation can be used to estimate stature in female using right foot length.

The values obtained for pooled subjects in the present study vary considerably with other studies only correlation coefficient was similar to Rameswarapu, et al.[25]

The value of r for between right foot length and stature in pooled sample for different study group ranged from 0.671 (Rahul, et al[12]) to 0. 892 (Rakhee, et al[26]) and value of r^2 ranged from 0.450 to 0.796, indicating large to very large correlation.

In the present study, the correlation between right foot length and stature in pooled subjects was 0.811 and r^2 was 0.658, suggesting large correlation and indicating that stature could be predicted with good accuracy using right foot length in pooled subjects.

The value of r for correlation between left foot length and stature in males for different study group ranged from 0.34 (Vijayakumar, et al[29]) to 0. 9669 (Arti, et al[14]), which indicates moderate to nearly perfect correlation (**Table 9**).

The correlation coefficient in the present study for males in present study was similar to Sumitha, et al[19] and Sonali, et al,[20] but it varied in other studies.

In the present study, the correlation between left foot length and stature in males was 0.707, suggesting very large correlation. Indicating stature could be predicted with very good accuracy using left foot length in males.

The Coefficient of determination (r^2) was lowest in 0.116 in Vijaykumar et al[29] suggesting 11.6% of the variation in stature can be explained by right foot length. The highest was in Arti et al[14] which was 0.935 whereas the left foot length explains 93.5% variation in stature. In the present study, the value of r^2 was 0.500 implying that 50.0% of variation in stature can be attributed to left foot length in males.

The regression equation obtained from different studies varied from present study but it was closer to the value obtained by Vijayakumar, et al.[29]

In the present study of males, the constant is 89.163 and multiplication factor is 3.189 which indicated that for every 1cm increase in right foot length the stature increases by 3.189cm.The Correlation coefficient (r) for correlation between left foot length and stature in females for different study group ranged from 0.3885 (Sumitha, et al[19]) to 0.9848 (Arti, et al[14]), which indicates moderate to nearly perfect correlation (**Table 10**)

In the present study, the correlation between left foot length and stature in females was 0.582 suggesting large correlation and indicating that stature could be predicted with good accuracy using left foot length in females.The value coefficient of determination (r^2) was lowest in 0.151 in Sumitha, et al[19] suggesting that 15.1% of the variation in stature can be explained by left foot length. The highest was in Arti, et al[14] which was 0.970, where left foot length explains 97.0% variation in stature. In present study the value of r^2 was 0.339 implying that 33.9% of variation in stature can be attributed to left foot length in females.

In the present study of females, the constant was 82.477 and the multiplication factor was 3.203, which indicated that for every 1cm increase in left foot length the stature increases by 3.203cm. This equation can be used to estimate stature in female using left foot length.

The correlation coefficient in the present study for female's left foot was similar to that of Jitender, et al.[11] The regression equation of the present study was closer to that of Geetha, et al[15] compared to other studies where variation was more.

The value of r for left foot length and stature in pooled sample for different study groups ranged from 0.602 (Rameswarapu, et al[25]) to 0. 991 (Rakhee et al[26]), and value r^2 ranged from 0.362 to 0.982, indicating large to very large correlation.

In the present study, the correlation between left foot length and stature in pooled subjects was 0.823 and r^2 was 0.677, suggesting large correlation and indicating that stature could be predicted with good accuracy using left foot length in pooled subjects.The r value in pooled subjects for left was closer Keme, et al[4] and regression equation was closer to Rakhee, et al[26] but variations were considerably more, compared to other studies.

By comparing r, r^2 in different study groups, it was seen that the pooled sample had better correlation than individual sex, for estimating stature from foot length in most of the studies, including the present one. It was also observed that left foot length showed better correlation to estimate stature than right foot length in most of the studies, including the present. As regards sex, males showed better correlation as compared to females in most of the studies including present study.

The studies, when repeated to the same study group after many years, will help to detect any micro evolutionary changes. These studies have anthropological importance also.

Conclusion

Different parts of body show correlation with each other. This fact can be utilized to estimate size of one part of part using another part. Using similar theory, stature could be estimated from different body parts.

In the present study, the right and left foot length of both males and females were measured to estimate stature.

The mean difference between two age groups (Group A 21-30 years, Group B 31-40 years) was statistically insignificant, hence further study was conducted as a single group (21-40 years).

The mean values of stature, right foot length and left foot length were found to be greater for males than in females with statistically significant differences.

Both right and left foot length showed positive correlation with stature as seen in correlation coefficient (r) in both males and females. Among sexes males showed better correlation than females, but pooled subjects showed better correlation than individual sexes. Comparatively left foot length showed better correlation coefficient than right foot length in all the subjects.

Linear regression equation were obtained to estimate stature from right and left foot length in both the sexes separately.

Since anthropometric measurements differ in different sex, race, region which are determined by genetic and environmental factors these types of studies are needed for different regions.

These studies are helpful in medico legal investigations were stature estimation becomes the primary identification parameter. Anthropologically these studies are helpful in differences among different population groups.

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