Original Article

Indian Journal of Forensic Medicine and Pathology
Volume 11 Number 1, January - March 2018
DOI: http://dx.doi.org/10.21088/ijfmp.0974.3383.11118.3

A Cross-Sectional Study of Foot Dimensions for Determining Partial Identity among South Indians

Ravi Raj K.G.[a], Madhu Sudhana Reddy D.[b], Lohith Kmar R.[c], Abhishek Yadav[d]

Abstract

Individual identification from mutilated body remains is a challenge to Forensic Experts. When incomplete skeletal material is available the stature estimation and sex differences are to be made out. Various formulae have been computed in the past using long bones but the accountability of them due to differing ethnicity and other factors like race and nutritional factors is a question. Most often a foot is brought for identification of an individual in mass disasters; natural or manmade, in assault cases where the body could be mutilated to conceal the identity of the victim. In such cases identification may not be complete, but partial identification would be of importance which helps to proceed in further investigation. One such estimate of stature of an individual by measuring foot length is of considerable value in the process of identification. Studies in the past have showed significant correlation between foot dimensions with stature and sex of an individual. It has been observed that dimensions from lower extremity have a greater correlation with the body height than those of the upper extremity. Ossification and maturation of bones of foot occur earlier than the long bones and height would be more accurately predicted from foot measurement as compared to that from long bones. This study is an effort to find correlation between foot length and stature and sex difference in this part of India and help in partial identification of the individuals.

Keywords: Forensic Anthropology; Stature; Gender; Foot Dimensions.

Introduction

Individual identification from mutilated body remains, a challenge to Forensic Experts. When incomplete skeletal material is available the stature estimation and sex differences are to be made out. Various formulae have been computed in the past using long bones but the accountability of them due to differing ethnicity and other factors like race and nutritional factors is a question. Most often a foot is brought for identification of an individual in mass disasters; natural or manmade, in assault cases where the body could be mutilated to conceal the identity of the victim [1-7]. In such cases identification may not be complete, but partial identification would be of importance which helps to proceed in further investigation. One such estimate of stature of an individual by measuring foot dimensions is of considerable value in the process of identification. Studies in the past have showed significant correlation between foot dimensions with stature and sex of an individual. It has been observed that dimensions from lower extremity have a greater correlation with the body height than those of the upper extremity. This study is an effort to find correlation between foot dimensions with stature and gender in this part of India and help in partial identification of the individuals.

Objectives of the Study

1. To estimate stature of the individual by use of Foot dimensions.
2. To identify the sex of the individual by Foot dimensions.

Authors Affiliation: [a]Assistant Professor, Dept of Forensic Medicine & Toxicology, Vydehi Institute of Medical Sciences & Research Centre, - Bengaluru, Karnataka 560066, India. [b]Senior Resident, Sri Venkateshwara Medical College, Tirupathi, Andhra Pradesh 517507, India. [c]Assistant Professor, Department of Forensic Medicine & Toxicology, Shimoga Institute of Medical Sciences, Shivamogga, Karnataka 577201, India. [d]Assistant Professor, Department of Forensic Medicine and Toxicology, All India Institute of Medical Sciences (AIIMS), Ansari Nagar, New Delhi 110029, India.

Corresponding Author: Madhu Sudhana Reddy, Senior Resident, Sri Venkateshwara Medical College, Tirupathi Andhra Pradesh 517507, India.
E-mail: lohithkumar1612@gmail.com

Received on 21.11.2017, **Accepted on** 23.11.2017

3. To develop a correlation index for foot dimensions in relation to Stature and Sex of the individual.

Materials & Methodology

Data was collected during the period from November 2009 to October 2010, from students, 100 males and 100 females whose age ranged between 17 completed years and 22 completed years who were from South India region which included states of Karnataka, Andhra Pradesh, Tamil Nadu and Kerala population. Age, sex, date of birth, residing place, place of origin, family history, personal history, medical history, weight of the individual; RFL(right foot length), LFL (left foot length), RFB (right foot breadth), LFB (left foot breadth), Ht (height), of individuals were collected accordingly.

For the foot lengths before measuring the length it was ensured that both the feet were firmly placed on a flat surface and ensuring that both feet bear the body weight evenly. The length is measured between most backward and prominent part of the heel (pternion) and the most distal part of the longest toe of the foot (acropodion). Second toe was considered as most prominent while measuring the foot length; wherever it was longer than the great toe. For the foot breadths distance between the most prominent point on the inner side of foot (metatarsal-tibiale) and the most prominent point on the outer side of foot (metatarsal- fibulare). Were measured manually by the use of scaled graph sheets.

Stature of the individual was measured as the distance between vertex and floor using standard metric scaled measuring stand. Maximum effort was done to avoid any errors by making the individual to stand erect in barefoot against the wall, both feet kept close together and the hands hanging down on the sides. Data were collected by single examiner at fixed time between 12.30 pm to 2.30pm, to avoid errors due to stature variation and personnel errors.

Statistical analyses was done using descriptive analytical methods which included Mean, Standard deviation, Correlation coefficient (r)/ Regression coefficient (b) and constant (a). The formulae adopted are shown as below and along with the usage of SPSS software system. All the data mentioned above were collected with prior informed consent from each individual and strict confidentiality was maintained. The following Individuals were excluded from the study:

- With pedal deformity or injury.
- With abnormalities of spine.
- With abnormal heights like gigantism, dwarfism etc.,
- Others who are not from the region of South India.

Observations & Results

The study group comprised 200 individuals. Their age ranged between 17 completed years and 22 completed years. There were 100 males and 100 females. Among males, mean height was 171.74, mean values of rfl, lfl, rfb and lfb were 26.051, 35.230, 9.46 and 9.482 respectively. Among females, mean height was 158.69,mean values of rfl, lfl, rfb and lfb were 23.836, 23.816, 8.81 and 8.930 respectively. Manually as well as SPSS Software statistical tool correlation coefficient, regression coefficient, constant of all the variables, were estimated and derived at a formula for whole male as well as whole female sample groups. In the similar manner each individual age group with sex differentiation can be estimated by applying the same linear regression formula.

After statistical analysis results in our study showed "rfl" showed significant correlation in stature estimation with (r) value of 0.771, (a) value of 58.544,(b) value of 4.476. The S.D for height was 6.555 among male population. Among the females it was "lfl" which showed the higher significance with (r) value of 0.700, (a) value of 78.398, (b) value of 3.371. The S.D for height was 6.533.

The Derived Formula with the Above Values

Y = 58.544 + 4.276 * (X). {Males}

Y = 78.398 + 3.371 * (X). {Females}.

The Observation and Results were Tabulated below

Coefficients (Males)

Table 1: Depicting the (a) and (b) values for rfl against Ht. [Males]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta	B	Std. Error
1	(Constant)	58.544	6.274		9.331	.000
	Rfl	4.276	.251	.771	17.029	.000

a Dependent Variable: ht

Model Summary

Table 2: Depicting the (r) value for rfl against Ht. [Males]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.771(a)	.594	.592	5.903

a Predictors: (Constant), rfl

Coefficients (Females)

Table 3: Depicting the (a) and (b) values for lfl against Ht. [Females]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t B	Sig. Std. Error
1	(Constant)	78.398	8.254		9.499	.000
	Lfl	3.371	.346	.700	9.743	.000

a Dependent Variable: ht

Model Summary

Table 4: Depicting the (r) value for lfl against Ht. [Females]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.700(a)	.489	.484	4.691

a Predictors: (Constant), lfl

General

Table 5: Depicting the Pearson correlation in the whole sample size. Female Correlations

		Age	Sex	HT	RFL	LFL	RFB	LFB
Age	Pearson Correlation	1	-.002	.244(**)	.073	.016	.186(**)	.121
	Sig. (2-tailed)		.977	.000	.307	.827	.009	.088
	N	200	200	200	200	200	200	200
Sex	Pearson Correlation	-.002	1	-.708(**)	-.666(**)	-.090	-.420(**)	-.282(**)
	Sig. (2-tailed)	.977		.000	.000	.206	.000	.000
	N	200	200	200	200	200	200	200
HT	Pearson Correlation	.244(**)	-.708(**)	1	.771(**)	.059	.561(**)	.342(**)
	Sig. (2-tailed)	.000	.000		.000	.410	.000	.000
	N	200	200	200	200	200	200	200
RFL	Pearson Correlation	.073	-.666(**)	.771(**)	1	-.014	.570(**)	.372(**)
	Sig. (2-tailed)	.307	.000	.000		.846	.000	.000
	N	200	200	200	200	200	200	200
LFL	Pearson Correlation	.016	-.090	.059	-.014	1	.031	.032
	Sig. (2-tailed)	.827	.206	.410	.846		.663	.653
	N	200	200	200	200	200	200	200
RFB	Pearson Correlation	.186(**)	-.420(**)	.561(**)	.570(**)	.031	1	.666(**)
	Sig. (2-tailed)	.009	.000	.000	.000	.663		.000
	N	200	200	200	200	200	200	200
LFB	Pearson Correlation	.121	-.282(**)	.342(**)	.372(**)	.032	.666(**)	1
	Sig. (2-tailed)	.088	.000	.000	.000	.653	.000	
	N	200	200	200	200	200	200	200

Table 6: Depicting the Pearson correlation in the Female population

		Age	Sex	HT	RFL	LFL	RFB	LFB
Age	Pearson Correlation	1	.(a)	.201(*)	-.014	-.003	-.008	.000
	Sig. (2-tailed)		.	.044	.891	.975	.940	.999
	N	101	101	101	101	101	101	101
Sex	Pearson Correlation	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
	Sig. (2-tailed)	.		.	.	.	.	.
	N	101	101	101	101	101	101	101

HT	Pearson Correlation	.201(*)	.(a)	1	.637(**)	.700(**)	.388(**)	.361(**)
	Sig. (2-tailed)	.044	.		.000	.000	.000	.000
	N	101	101	101	101	101	101	101
RFL	Pearson Correlation	-.014	.(a)	.637(**)	1	.927(**)	.425(**)	.377(**)
	Sig. (2-tailed)	.891	.	.000		.000	.000	.000
	N	101	101	101	101	101	101	101
LFL	Pearson Correlation	-.003	.(a)	.700(**)	.927(**)	1	.434(**)	.390(**)
	Sig. (2-tailed)	.975	.	.000	.000		.000	.000
	N	101	101	101	101	101	101	101
RFB	Pearson Correlation	-.008	.(a)	.388(**)	.425(**)	.434(**)	1	.866(**)
	Sig. (2-tailed)	.940	.	.000	.000	.000		.000
	N	101	101	101	101	101	101	101
LFB	Pearson Correlation	.000	.(a)	.361(**)	.377(**)	.390(**)	.866(**)	1
	Sig. (2-tailed)	.999	.	.000	.000	.000	.000	
	N	101	101	101	101	101	101	101

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Male Correlations

Table 7: Depicting the Pearson correlation in the Male population. Report

		Age	Sex	HT	RFL	LFL	RFB	LFB
Age	Pearson Correlation	1	.(a)	.495(**)	.212(*)	.022	.376(**)	.201(*)
	Sig. (2-tailed)		.	.000	.036	.826	.000	.046
	N	99	99	99	99	99	99	99
Sex	Pearson Correlation	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)	.(a)
	Sig. (2-tailed)	.		.	.	.	.	.
	N	99	99	99	99	99	99	99
HT	Pearson Correlation	.495(**)	.(a)	1	.497(**)	-.021	.436(**)	.156
	Sig. (2-tailed)	.000	.		.000	.840	.000	.123
	N	99	99	99	99	99	99	99
RFL	Pearson Correlation	.212(*)	.(a)	.497(**)	1	-.156	.439(**)	.223(*)
	Sig. (2-tailed)	.036	.	.000		.124	.000	.027
	N	99	99	99	99	99	99	99
LFL	Pearson Correlation	.022	.(a)	-.021	-.156	1	-.014	.005
	Sig. (2-tailed)	.826	.	.840	.124		.889	.962
	N	99	99	99	99	99	99	99
RFB	Pearson Correlation	.376(**)	.(a)	.436(**)	.439(**)	-.014	1	.560(**)
	Sig. (2-tailed)	.000	.	.000	.000	.889		.000
	N	99	99	99	99	99	99	99
LFB	Pearson Correlation	.201(*)	.(a)	.156	.223(*)	.005	.560(**)	1
	Sig. (2-tailed)	.046	.	.123	.027	.962	.000	
	N	99	99	99	99	99	99	99

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 8: Depicting the Descriptive data of the whole sample size in total and age-wise. Male population

Age	Sex		HT	RFL	LFL	RFB	LFB
17	0	Mean	165.89	25.368	25.458	8.60	8.674
		N	19	19	19	19	19
		S.D	3.914	1.3195	1.1466	.462	.4331
	1	Mean	158.50	24.629	24.750	8.42	8.521
		N	14	14	14	14	14
		S.D	6.260	.9450	.9011	.464	.4492

	Total	Mean	162.76	25.055	25.158	8.52	8.609
		N	33	33	33	33	33
		S.D	6.190	1.2166	1.0935	.464	.4397
18	0	Mean	170.70	26.015	25.765	9.60	9.640
		N	20	20	20	20	20
		S.D	7.263	1.4225	1.6220	.881	.9139
	1	Mean	157.97	23.513	23.461	8.96	9.045
		N	38	38	38	38	38
		S.D	6.092	1.0758	1.2323	.527	.5436
	Total	Mean	162.36	24.376	24.255	9.18	9.250
		N	58	58	58	58	58
		S.D	8.883	1.6925	1.7560	.728	.7427
19	0	Mean	173.04	26.339	51.575	9.77	9.908
		N	36	36	36	36	36
		S.D	6.140	1.1282	149.9743	.703	.7024
	1	Mean	156.22	23.335	23.226	8.84	9.039
		N	23	23	23	23	23
		S.D	7.746	1.3145	1.3689	.590	.5433
	Total	Mean	166.48	25.168	40.524	9.41	9.569
		N	59	59	59	59	59
		S.D	10.678	1.8992	117.3375	.799	.7697
20	0	Mean	174.00	26.053	26.247	9.44	9.094
		N	17	17	17	17	17
		S.D	5.466	.9592	.8032	.636	2.2582
	1	Mean	161.99	25.021	24.975	9.16	9.279
		N	14	14	14	14	14
		S.D	4.732	1.1963	1.3684	.481	.4080
	Total	Mean	168.57	25.587	25.673	9.32	9.177
		N	31	31	31	31	31
		S.D	7.911	1.1761	1.2529	.580	1.6735
21	0	Mean	178.67	27.367	27.133	9.83	9.900
		N	3	3	3	3	3
		S.D	1.155	.6351	1.1504	.289	.6083
	1	Mean	162.18	23.475	23.513	8.00	8.150
		N	8	8	8	8	8
		S.D	3.384	.7760	.8236	.428	.3071
	Total	Mean	166.67	24.536	24.500	8.50	8.627
		N	11	11	11	11	11
		S.D	8.223	1.9510	1.8974	.937	.8990
22	0	Mean	178.25	25.875	26.125	9.88	10.025
		N	4	4	4	4	4
		S.D	.500	1.1815	1.0813	.250	.0957
	1	Mean	161.75	23.575	23.875	9.00	8.975
		N	4	4	4	4	4
		S.D	9.069	.6898	.8539	.408	.4573
	Total	Mean	170.00	24.725	25.000	9.44	9.500
		N	8	8	8	8	8
		S.D	10.637	1.5210	1.5033	.563	.6392
Total	0	Mean	171.74	26.051	35.230	9.46	9.482
		N	99	99	99	99	99
		S.D	6.555	1.2422	90.4887	.793	1.2062
	1	Mean	158.69	23.836	23.816	8.81	8.930

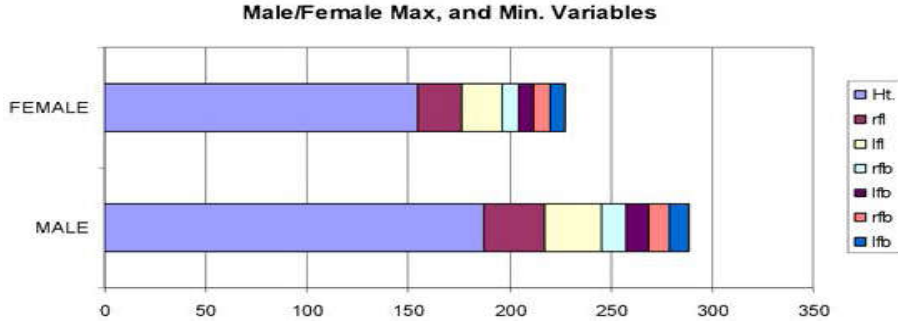

Fig. 2: Chart showing the mean value of the data obtained. Male and Female population are shown separately color coded

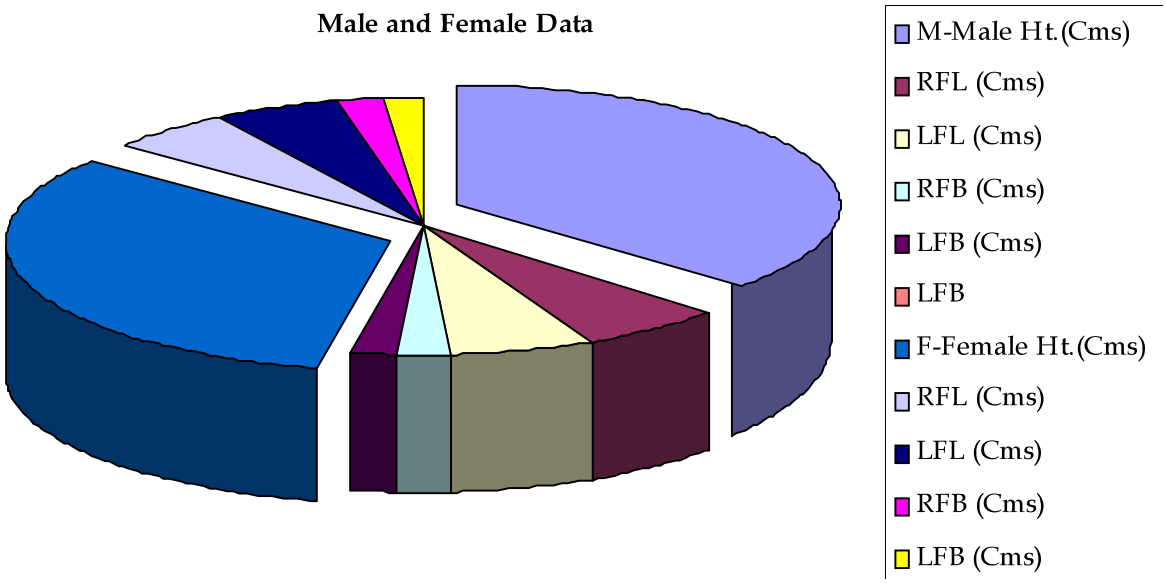

Fig. 2: Chart showing the data collected. Male and Female population are shown separately color coded.

Male and Female Data

M-Male Ht.(Cms)

RFL (Cms)

LFL (Cms)

RFB (Cms)

LFB (Cms)

LFB

F-Female Ht.(Cms)

RFL (Cms)

LFL (Cms)

RFB (Cms)

LFB (Cms)

Discussion

In our study we studied 200 sample size (100 males and 100 females) from region of South India, mainly from eastern districts. In our study a significant correlation was obtained for male individuals 0.771 height and rfl, whereas in females it showed significance of 0.700 for height with lfl. for gender estimation our did not show any significance with foot dimensions. Among male population the findings were (r) value of 0.771, (a) value of 58.544, (b) value of 4.476 and the S.D. for height was 6.555. Among the females, it was "lfl" which showed the higher significance with (r) value of 0.700, (a) value of 78.398, (b) value of 3.371 and the s.d for height was 6.533.

The derived formula with the above values:

$y = 58.544 + 4.276 * (x)$. {males}

$y = 78.398 + 3.371 * (x)$. {females}

Substituting the values of either the height and/or foot length (if gender is known in case of selection of foot to the above formulae the required value may be calculated with +/- SD of the height.

The above formulae tried and tested is applicable to all the age groups with near accurate results.

another advantage of the results obtained is that if the age group is known, applying the linear regression formula, after calculating the regression coefficient (r) and constant value (a), the human remains can be isolated according to the individual's age at the time of death.

Conclusion

1. Stature/height of the individual was correlating well with the foot length than foot breadth.
2. That stature varies in a single day in a single individual.
3. Right foot length showed statistically highly significant correlation with the height in males.
4. Left length showed statistically highly significant correlation with the height in females.
5. Deduced a formula to estimate either height or rfl (males), lfl (females).

The formulae are:

y = 58.544 + 4.276 * (x). {males}

y = 78.398 + 3.371 * (x). {females}

References

1. PekkaSaukko, Bernard Knight. The establishment of identity of human remains, Knights Forensic Pathology. Third edition, pg-123.
2. Jeremy Rich. Forensic Medicine of lower extremity. 2005.p.380-383, 74, 75.
3. Dikshit PC. Textbook of Forensic Medicine and Toxicology. 2nd edition, 2007;
4. Modi's Medical Jurisprudence and Toxicology. Edited by Mathiharan, Student edition, 2009.
5. Mukhejee's Textbook of Forensic Medicine and Toxicology. Edited by Karmakar R N, 3rd edition.
6. KrishanVij, Textbook of Forensic Medicine and Toxicology, priniciples and practices, 4th edition. 2008.
7. Narayan Reddy KS, The Essentials of Forensic Medicine and Toxicology, 28th edition, 2009.