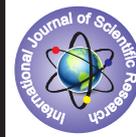


STUDY OF ESTIMATION OF SUPINE LENGTH AND ITS CORRELATION WITH RIGHT FOOT BREADTH



Forensic Science

KEYWORDS: Anthropometry, Identification, Right foot breadth, Supine length.

Dr. Deepak Chaturvedi

Department Of Forensic Medicine & Toxicology, University College Of Medical Sciences And Guru Teg Bahadur Hospital, New Delhi India 100095

Dr. Priyanka

Department Of Pediatrics, Rajendra Institute Of Medical Sciences Ranchi Jharkhand India 834009

Dr. Vishwajeet Singh

Department Of Forensic Medicine & Toxicology, University College Of Medical Sciences And Guru Teg Bahadur Hospital, New Delhi India 100095

Dr. Navneet Ateriya

Department Of Forensic Medicine & Toxicology, All India Institute Of Medical Sciences Jodhpur, Rajasthan India 342005

ABSTRACT

This research work was done by anthropometric measurements of 200 cadavers among them 100 were males & 100 were females. The Aim & objective were to estimate correlation of supine length with right foot breadth and so help in identification of an individual. Identity of an individual is of paramount importance in civil as well as criminal cases. Previously multiple efforts had been done but due to significant genetic, environmental variation data of foreign countries cannot be applied in India. Establishing the supine length of a person from skeletal remains or bones is a routine practice in forensic anthropology, by which derivation of the regression equations and multiplication factors done. The right foot breadth showed significant positive correlation with spine length (especially in males). Multiplication factors were less accurate than regression equations.

INTRODUCTION

The type of death which taxes the resources of most experienced forensic expert is when the body is recovered in mutilated state and problem of identification of person is involved. The mutilation of dead body is also done by a criminal who wants to destroy all traces of identity and thus facilitate the disposal of the dead. Unclaimed dead bodies of lunatics, fakirs and pilgrims lying along roadside or in remote spots may also mutilate easily.¹ When human remains are discovered that cannot be recognized or identified by any other means, the forensic anthropologist is called upon to reconstruct the biologic nature of the individual.² The establishment of identity needed in living persons, intact fresh corpses, decomposed corpses, mutilated and dismembered corpses, and for cremains.³ Identification is difficult but also important for mutilated & commingled remains and hence requires special attention in these settings.⁴

Anthropometry is a series of systematized measuring techniques that express quantitatively the dimensions of the human body and skeleton. It includes age, sex, race, and stature by which a person can be identified. Other methods are identification through DNA analysis, dactylography, religion, podography, superimposition techniques, and tooth analysis etc. Anthropometry is awarding when comparing DNA fingerprinting in developing countries where facilities and infrastructure is lacking.

It is a fact especially familiar to Anatomists that trunk and limbs exhibit consistent ratios among themselves. This relationship is very useful anthropologically to find racial differences and medico legally, when only parts of the deceased body are available. Accurate stature estimation from skeletal remains can foster useful information on health and micro evolutionary trends in past human populations. Stature can be estimated through the anatomical method and the mathematical method,⁵ FORDISC 3 and revised Fully method.⁶

Krogman states that the identification of human skeletal remains is a critical matter. There is long historical background of anthropological measurements like in 1888 Rollet published the earliest formal statural tables, using the humerus, radius, ulna, femur, tibia, and fibula of 50 male and 50 female French cadavera. Which were reassessed in 1892-93 by Manouvrier. In 1899 Pearson, using Rollets data, developed regression formulae based on bones from the right side only. In 1898-1902 Hardlicka measured long bones of American Whites and Blacks.⁷ This study done with the aim of measurement of the foot breadth among cadavers and delineates its correlation with

supine length and also deduce best multiplication factors and regression equations.

AIM AND OBJECTIVES

AIM: Determination of correlation between supine length and percutaneous measurements of a lower limb parameter i.e. right foot breadth in cadavers.

OBJECTIVES:

1. Correlation between supine length and measurements of right foot breadth in male and female independently.
2. Derivation of multiplication factor and regression equation to be subsequently used for determination of supine length.
3. To find bisexual variation.

MATERIAL AND METHODS

Measurements of the 200 dead bodies 100 males and 100 females brought for postmortem examination to the Mortuary of the Department of Forensic Medicine, University College of Medical Sciences and Guru Teg Bahadur Hospital, Delhi. The inclusion criteria for present study were 1) the adult cases brought to mortuary for medico legal autopsy and 2) individuals in whom there was no anatomical distortion of body. While cases with disease or defect affecting the growth and with disease affecting the bones of lower extremity were excluded.

STUDY DESIGN: This was Analytical cross sectional study which included all adult cases. The cases were divided into four age groups as shown below in Table-1.

TABLE 1: SHOWING DISTRIBUTION OF BOTH SEXES IN VARIOUS AGE GROUPS.

Age group (years)	Males (n1 = 100)	Females (n2 = 100)	Total (N = 200)
18-28	25	25	50
29-38	25	25	50
39-48	25	25	50
>48	25	25	50

MATERIALS USED:

The following instruments and documents were used for the study:

- Standard Autopsy equipments.
- Scientifically standardized graduated Anthropometer for supine length and foot breadth.
- Documentary evidence, information from relative etc. for assessment of accurate or near accurate age.

METHODS OF COLLECTING THE DATA:

- The necessary informed consent obtained from next of kin/relative.
- Rigor mortis was broken by standard technique of treating the dead body thoroughly with warm water and then breaking it manually if required.
- All the measurements were taken three times in centimeters and mean value was used for computation of data.

SUPINE LENGTH

Dead body was placed in supine position on the flat hard surfaced autopsy table, with the knee and hip joints extended, and the neck and feet in a same plane and thus supine length was measured from vertex of head to heel of foot using graduations on side of autopsy table.

FOOT BREADTH

Foot breadth was taken as the distance between the medial margin of the head of the first metatarsal and the lateral margin of the head of the fifth metatarsal.⁸ (Figure-1)

Figure-1 showing right foot breadth measurement



All the above measurements were tabulated and statistical computation of data was done for each group in both the genders to find out the correlation between supine length and percutaneous measurement of lower limb parameters and to derive independent linear regression equations and independent multiplication factor for each parameter.

OBSERVATION AND RESULTS

This study conducted for derivation of the linear regression equations and multiplication factors to determine the correlation between supine length and percutaneous measurements of right foot length so the identification of a person made possible.

This was done with the intention to find out whether a single equation can be used effectively for both genders in all the age groups or an independent equation will be required separately for an individual age group for best prediction of stature.

SUPINE LENGTH

Table - 2 suggest that average supine length was more in males as compared to females.

TABLE – 2: SUPINE LENGTH MRASUREMENTS

Sex	Min	Max	Mean	SD
Male (n = 100)	150	191	165.90	6.9497
Female (n = 100)	133	175	153.68	6.8071

SUPINE LENGTH IN MALES: The minimum supine length observed in two age groups i.e. 29-38yr and more than 48 yr age groups and maximum supine length also found in 29-38 yr age group as shown in Table – 3.

TABLE – 3: SUPINE LENGTH MEASUREMENTS IN MALES

Age groups	No. of cases	Min	Max	Mean	SD
18 –28 years	25	157	180	167.220	6.4389
29– 38 years	25	150	191	165.880	8.7480
39 – 48 years	25	154	178	166.920	6.4091
>48 years	25	150	174	163.580	5.6267

SUPINE LENGTH IN FEMALES: Among females minimum value of supine length as 133 cm observed in 39-48 yr age group and maximum value of 175 cm seen in 18-28 age group as described in Table – 4.

TABLE – 4: SUPINE LENGTH MEASUREMENTS IN FEMALES

Age groups	No. of cases	Min	Max	Mean	SD
18 –28 years	25	140	175	153.680	7.7229
29– 38 years	25	141	165	153.840	6.1079
39 – 48 years	25	133	164	153.840	7.6468
>48 years	25	141	165	153.360	5.9626

FOOT BREADTH: Foot breadth measured as distance between the medial margin of the head of the first metatarsal and the lateral margin of the head of the fifth metatarsal (Table – 5).

TABLE – 5: COMPARISON OF FOOT BREADTH

Sex	Side	Min	Max	Mean	SD
Male (n=100)	R	7.8	9.4	8.345	0.3030
Female(n=100)	R	6.8	8.5	7.680	0.5137

Significant bisexual differences were seen in foot breadth. The foot breadth is observed to be less in females as compared to males.

RIGHT FOOT BREADTH IN MALES: The minimum value was observed in 39-48 yr and more than 48 yr age groups i.e. older groups while the maximum value was observed in 18-28yr and 29-38 yr age groups i.e. the younger ones. The mean value was least in more than 48 yr age group which also showed minimum value of the standard deviation as illustrated in Table – 6.

TABLE – 6: RIGHT FOOT BREADTH MEASUREMENTS

Age groups	No. of cases	Min	Max	Mean	SD
18 – 28 years	25	8.0	9.4	8.464	0.3239
29 – 38 years	25	8.1	9.4	8.396	0.3372
39 – 48 years	25	7.8	8.9	8.336	0.2644
>48 years	25	7.8	8.7	8.184	0.2135

Linear regression equation derived from foot breadth for estimation of supine length in males in each age group is depicted in Table – 7. (Figure-2)

TABLE – 7: REGRESSION EQUATION IN MALES

Age groups	Regression equation	SEE(+/-) cms	'r' value	p-value
18 – 28 years	56.955+13.027×RFtB	4.9684	0.655	0.001
29 – 38 years	20.218×RFtB-3.873	5.5983	0.779	0.001
39 – 48 years	57.244+13.157×RFtB	5.4988	0.543	0.005
>48 years	80.647+10.134×RFtB	5.3060	0.384	0.058
Combined	42.711+14.762×RFtB	5.3463	0.644	0.001

Linear regression equation derived from foot breadth for estimation of supine length in males show significantly positive 'r' value however the 'r' value was highest among 29-38 yr age groups thus gives better result as for estimation of supine length in males from foot length.

But equally good prediction can be made using equation derived from combined age group.

RIGHT FOOT BREADTH IN FEMALES: Among females right foot breadth minimum value observed in 39-48 yr age group and more than 48 yr age group while the maximum value was also observed in middle and older age groups but the mean value was least in more than 48 yr age group. The standard deviation was minimum in 29-38 yr age group and maximum in 39-48 yr age group as described in Table -8.

TABLE - 8: RIGHT FOOT BREADTH MEASUREMENTS IN FEMALES

Age groups	No. of cases	Min	Max	Mean	SD
18 – 28 years	25	7.0	8.4	7.784	0.4947
29 – 38 years	25	6.9	8.5	7.772	0.4496
39 – 48 years	25	6.8	8.5	7.744	0.5370
>48 years	25	6.8	8.5	7.420	0.5083

Linear regression equations derived the highest 'r' value in 39-48 yr age group as depicted in Table -9.(Figure-3)

TABLE - 9: REGRESSION EQUATION IN FEMALES

Age groups	Regression equation	SEE(+/-) cms	r' value	p-value
18 – 28 years	135.164+2.379×RFtB	7.7969	0.152	0.467
29 – 38 years	156.583-0.353×RFtB	6.2372	0.026	0.902
39 – 48 years	120.638+4.287×RFtB	7.4487	0.301	0.144
>48 years	147.651+0.769×RFtB	6.0777	0.066	0.755
Combined	139.152+1.892×RFtB	6.7716	0.143	0.157

Linear regression equation derived from foot breadth for estimation of supine length in females show positive 'r' value for all age groups with highest in 39-48 yr age groups. But the p- value in all age groups is >0.05. So right foot breadth in females from this study do not provide better correlation of stature.

Figure - 2: Correlation between supine length and right foot breadth in males

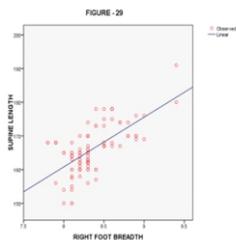
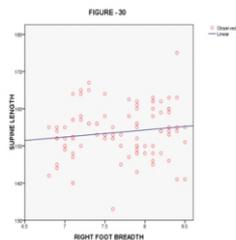


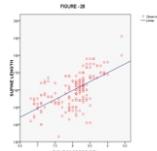
Figure - 3: Correlation between supine length and right foot breadth in females



Linear regression equation derived from foot breadth for estimation of supine length in combined cases (males + females)-

SL= 77.332+10.291 × RFtB, (SEE =7.3734), (r = 0.600) (Figure-4)
 On comparing it was observed that foot breadth provide better correlation of supine length in males. While for females this study does not provide better correlation of stature. However correlation was significantly positive and highest when total cases were combined together (p=0.001).

Figure - 4: Correlation between supine length and right foot breadth in total cases



Multiplication factors were derived in the study is shown in Table - 10.

TABLE - 10: MULTIPLICATION FACTORS FOR DIFFERENT PARAMETERS

Parameter	Multiplication factor for males	Multiplication factor for females
Right foot breadth	19.880	20.017

DISCUSSION

Different formulae are required for different population groups, different bones or body parts. Mathematical methods employed in stature estimation include multiplication factor and regression analysis. Forensic significance of these mathematical methods is based on the principle that there is a high linear correlation between an individual's stature and the body part or bone length⁹.

As individual stops growing in height on completion of union of the epiphysis and the diaphysis, which is usually by the age of 18-20 years. In this study the average age of an individual ranges from 18 years and above. This may also be attributed to the fact that the average adult length of foot is attained by the age of 16 years in males (M. Anderson et al. 1956, M.M. Blais et al. 1956).

In the present study the average age of an individual ranges from 18 years and above which has been done on the adult population of Delhi region of India. The study was aimed at and concentrated on finding the correlation between supine length and anthropometric measurements of right foot length of both males and females for subsequent determination of stature.

STATURE:

The mean stature for males in the present study was 165.90 cm and for females it was 153.68 cm. Minimum and maximum stature in males was 150 cm and 191 cm, while in females it was 133cm and 175cm respectively. In the present study mean stature was less in females than males, which is consistent on comparing with other studies so it can be inferred that females are smaller than males. This was seen even true when in this study age group wise comparisons made among females and males as described in Table - 3 and ⁴.

Common finding to all the studies is that the mean height is more in males as compare to females. The results of present study are suggestive of similar pattern. However the average height in both males and females among European populations is more as compared to present study.

FOOT BREADTH:

The mean right foot breadth in males in the present study was 8.345 cm and in females it was 7.680 cm. Significant bisexual differences seen with greater foot breadth among males this is consistent with the other mentioned studies. The measured mean foot breadth are similar with study of Rani et al, while there is slight variations in right foot breadth in both genders with the other study. This might be attributed to different geographical areas covered along with different nutritional patterns in the study group.(Table-11)

TABLE - 11: FOOT BREADTH COMPARISON

Authors	Population studied	Condition in which bone studied	Sex	Side	Min	Max	Mean
Ozaslan et al ¹⁰	Turkey (203M,108F)	Percutaneous	M		6.3	11.1	9.31
			F		7.0	9.8	8.56
Zeybek et al ¹¹	Turkey (136M,113F)	Percutaneous	M	R	8.330	11.042	9.772
			F	R	7.696	9.944	8.718
Rani et al ¹²	Delhi (150M,150F)	Percutaneous	M	R	6.8	10.8	8.524
			F	R	6.2	9.6	7.816
Krishan, Sharma ¹³	Himachal Pradesh (123M,123F)	Percutaneous	M	R	8	10.9	9.52

			F	R	7.2	10	8.56
Kanchan et al ¹⁴	Punjab (100M,100F)	Percutaneous	M	R	8.5	11.9	9.9
			F	R	8	10.4	9.1
Sen J, Ghosh S ¹⁵	North Bengal (225M,225F)	Percutaneous	M	R	8.60	12.10	9.89
			F	R	5.80	10.50	8.98
Bhavna, Nath S ¹⁶	Delhi (503 M)	Percutaneous	M				10.11
Chikhalkar et al ¹⁷	Maharashtra (147M,153F)	Percutaneous	M +		7.10	10.05	8.895
			F				
Present Study	Delhi (100M,100F)	Percutaneous	M	R	7.8	9.4	8.345
			F	R	6.8	8.5	7.680

The correlation coefficient in males was 0.644 for right foot breadth. The highest value seen in 29-28 year age group (0.779) followed by in youngest age group i. e. 18-28 years. In females it was less i.e.0.143. Thus males give better results than females for foot breadth. The value of 'r' is 0.600 and 0.590 when both males and females were combined. So, if the age of a person is known, then better results can be obtained by using independent linear regression equations.

The regression equation derived from present study give best estimation of stature among males with similar standard error as given by Kanchan et al and Bhavna et al. Present study provide better correlation coefficient.(Table-12)

TABLE 12: COMPARISON OF REGRESSION EQUATIONS DERIVED

Authors	Sex	Regression equation	SEE (+/-) cms	r value
Zeybek et al ¹¹ (Turkey)	Both			0.692
				0.697
	M			0.352
				0.365
	F			0.266
				0.225
Rani et al ¹² (Delhi)	M	158.170+1.334×RFtB	6.523	0.345
	F	139.111+2.263×RFtB	5.517	0.345
Krishan, Sharma A ¹³ (Himachal Pradesh)	M	136.39+3.35×RFtB	6.19	0.315
	F	136.47+2.25×RFtB	4.97	0.294
Krishan et al ⁶ (Himachal Pradesh)	M	124.336+4.616×FtB		
	F	111.232+5.224×FtB		
Kanchan et al ¹⁴ (Punjab)	Both	101.879+6.457×RFtB	4.777	0.711
	M	132.130+3.530×RFtB	5.426	0.411
	F	84.186+8.289×RFtB	3.077	0.799
Bhavna, Nath S ¹⁶ (Delhi)	M	132.61+3.46×FtB	5.26	0.383
Chikhalkar et al ¹⁷ (Maharashtra)	M+F	114.828119+5.906901×FtB		0.4886
Sen J, Ghosh S ¹⁵ (North Bengal)	Both	74.517+8.617×RFtB		0.706
	M	108.874+5.394×RFtB		0.506
	F	116.860+3.633×RFtB		0.349
Present study (Delhi)	Both	77.332+10.291×RFtB	7.3734	0.600
	M	42.711+14.762×RFtB	5.3463	0.644
	F	139.152+1.892×RFtB	6.7716	0.143

Table-13 depicts the bisexual variations. By using unpaired t-test the Mean differences, t- value and p- value of various measurements in

both males and females were derived. Sex differences are statistically significant (p<0.01) for all the measurements as shown below.

TABLE - 13: BISEXUAL VARIATIONS IN VARIOUS MEASUREMENTS AMONG MALES AND FEMALES.

Variable	Mean difference	t - value	p - value	Inference
Right foot breadth	0.6650	11.151	< 0.001	Highly significant

TABLE 14: REGRESSION EQUATIONS DERIVED

Sex	Side	Regression equation	SEE (+/-) cms	r value
Male	R	42.711+14.762×RFtB	5.3463	0.644
Female	R	139.152+1.892×RFtB	6.7716	0.143
Combined	R	77.332+10.291×RFtB	7.3734	0.600

TABLE - 15: MULTIPLICATION FACTORS DERIVED

Parameter	Males	Females
Right foot breadth	19.880	20.017

CONCLUSIONS AND SUMMARY

- 1) The mean value of supine length /average height in male is about 12 cm more as compared to female.
- 2) Right foot breadth showed positive correlation with supine length.
- 3) Supine length averages about one centimeter more than the measurement of standing height.
- 4) Regression equations derived for combined cases too show significantly positive correlation and so can be applied irrespective of sex and age.
- 5) Significant bisexual differences are seen in foot breadth. The foot breadth is observed to be less in females as compared to males.
- 6) Correlation of stature gives better estimate for stature in males with foot breadth.
- 7) Multiplication factors were derived for each parameter in both genders in the present study but are less accurate than regression equations.

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