ORIGINAL RESEARCH PAPER | Forensic Medicine | Volume - 7 | Issue - 3 | March - 2017 | ISSN - 2249-555X | IF : 4.894 | IC Value : 79.96

# STATURE ESTIMATION MEASURING LEFT FOOT BREADTH IN INDIAN CADAVERS

KEYWORDS: Anthropometry, Identification, Left foot length and Supine length.

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**ABSTRACT** Forensic medicine have multiple discipline among them Identification is very important aspect. Identification means to explore identify of an individual which required in this civilized world. Measurements of different body parts is an age old process it can be applied with precision to estimate stature of a person living or dead hence delineating identity if previous records on the basis of either recall method or documentary evidences present. Anthropometry is a simple and easy to use tool. A fair attempt has been made through this study with aim & objectives to find out correlation between stature and left foot breadth, derivation of regression equations and multiplication factors and also to find out bisexual variation if any. This was hospital based analytical cross sectional study involving 200 cadavers. It was observed that left foot breadth showed significant positive correlation with supine length with significant bisexual variation ($p<0.001$). Regression equations derived found to give better estimation of stature in comparison to multiplication factors.

## INTRODUCTION

According to an age old truth which tells a forensic expert that although there is only one way in which to be born, there are many ways in which to die. Criminals mutilate cadavers as they want to destroy all traces of identity. In a country like India, even animals and vultures may attack a dead body and mutilate it in a very short time, when exposed in an open field.[1] Duty of a forensic expert starts when human remains are discovered that cannot be recognized.[2]

Forensic Medicine which is a diverse branch of medical science encompasses a lot of attributes; amongst all identification is one of the major attribute. Identification means the determination of the individuality of a living or dead person. **Living as well as dead person** must be identified in different legal and medico legal situations like murder, rape, inter-change of newborn babies, disputed paternity,in case of impersonation, insurance, disputed sex and in case of mass disasters, etc[3].

Anthropometry is highly objective and reliable in the hands of trained anthropometrists. A subset of anthropometry i.e. 'forensic anthropometry' display significance and importance of somatometry, cephalometry, craniometry and osteometry in the identification of human remains.[4]

A forensic expert calculate the stature of a deceased by using the regression equation from the available skeleton material, isolated long bones or after reconstructing lengths of long bone when fragments found, for establishing the identity of a dead person.[5]

The research of Trotter and Gleser (1952), of Dupertuis and Hadden (1951) is basic, not only for American Whites and Blacks, but for the whole problem of statural reconstruction, as well. Dupertuis and Hadeen suggested that stature be calculated, where possible, from a combination of two or more long bones. There have been a number of new important studies on various populations which includes work of Allbrook on east African Blacks, of Lundy on South African blacks, of Yung-hao, Shulin, Fangwu and Shitai on Chinese, of Breitinger on Germans, of Telkka on Finns, of Mendes-Correa on Portuguese. However new studies on European and Asiatic whites have been few, including those by Jit and Singh, Oliver, and cerny and Komenda. Broca, Stewart, Krogman and Iscan have considered stature as a parameter of human biodemography.[6]

## AIM AND OBJECTIVES

**AIM:** Determination of correlation between supine length and percutaneous measurements of left foot breadth in corpse.

**OBJECTIVES:**

1. Correlation between supine length and percutaneous measurements of lower limb i.e. foot breadth in male and female independently.
2. Subsequent determination of supine length in dead bodies after derivation of regression equation and multiplication factor.
3. To find bisexual variation.

## MATERIAL AND METHODS

Total number of 200 (100 Males and 100 Females) dead bodies brought to the mortuary of GTB hospital were be studied for taking the various measurements.

**INCLUSION CRITERIA:**

- Adult cases brought to mortuary for medico legal autopsy.
- Individuals in whom there was no anatomical distortion of the portion of body in relation to stature.

**EXCLUSION CRITERIA:**

- Cases with disease or defect affecting the growth in general or of bones.
- Cases with deformity and disease affecting the bones of lower extremity.

**STUDY DESIGN:** Analytical cross sectional study.

**EQUIPMENTS USED:**

- Autopsy equipments.
- Scientifically standardized graduated Anthropometer.

**METHODS OF COLLECTING THE DATA:**

- The necessary informed consent taken before taking the measurements.
- Rigor mortis was broken before taking measurements.
- All the measurements were taken with dead body lying in supine

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position.
- Mean value was used for computation of data.

**SUPINE LENGTH**
Supine length was measured from vertex of head to heel of foot, after placing dead body on autopsy table 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.[7]

**OBSERVATION AND RESULTS**
Anthropometric measurements of 200 (100 males and 100 females) adult cadavers were taken. For statistical computation & understanding and also for uniform & fair comparisons total number of cases, both males and females were divided in to four age groups of 10 year intervals with 25 individuals in each age group. Linear regression equations and multiplication factors were formulated independently for male & female and separately for each age group in relation with parameters included in the present study.

The age and sex wise distribution of cases is shown in Table – 1.

**TABLE – 1: DISTRIBUTION OF CASES**

| Age groups | Males ($n_1$ = 100) | Females ($n_2$ = 100) | Total(N = 200) |
|---|---|---|---|
| 18-28 years | 25 | 25 | 50 |
| 29-38 years | 25 | 25 | 50 |
| 39-48 years | 25 | 25 | 50 |
| >48 years | 25 | 25 | 50 |

**SUPINE LENGTH**
The supine length of the dead body was measured while body was lying in supine position on standardized graduated autopsy table from vertex of skull to heel of foot. The average supine lengths were more in males as shown in Table – 2 below.

**TABLE – 2: SUPINE LENGTH MEASUREMENTS**

| 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 of 150 cm observed 29-38yr and more than 48 yr age groups and maximum supine length found in 29-38 yr age group as 191cm as shown in Table – 3.

**TABLE – 3: MEASUREMENTS OF SUPINE LENGTH 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:** 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:** In males mean value of left foot breadth found to be 8.331 cm and standard deviation as 0.2939 cm. Similarly in case of females, standard deviation being 0.5126 and mean value of 7.692 cm as depicted in Table – 5.

**TABLE –5: COMPARISON OF FOOT BREADTH**

| Sex | Side | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| Male (n=100) | L | 7.8 | 9.4 | 8.331 | 0.2939 |
| Female(n=100) | L | 6.8 | 8.5 | 7.692 | 0.5126 |

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

**LEFT FOOT BREADTH IN MALES:** The left foot breadth in males showed minimum value in 39-48 yr and more than 48 yr age groups i.e. older groups while the maximum value in 18-28yr and 29-38 yr age groups i.e. the younger ones. The mean value of left foot breadth 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: LEFT FOOT BREADTH MEASUREMENTS**

| Age groups | No. of cases | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| 18 – 28 years | 25 | 7.9 | 9.4 | 8.465 | 0.3203 |
| 29 – 38 years | 25 | 8.1 | 9.4 | 8.376 | 0.3086 |
| 39 – 48 years | 25 | 7.8 | 8.9 | 8.336 | 0.2737 |
| >48 years | 25 | 7.8 | 8.6 | 8.156 | 0.1828 |

Linear regression equations derived are depicted in Table – 7. (Figure 1)

**TABLE – 7: REGRESSION EQUATION IN MALES**

| Age groups | Regression equation | SEE(+/-) cms | 'r' value | p-value |
|---|---|---|---|---|
| 18-28 years | 54.059+13.382×LFtB | 4.9087 | 0.666 | 0.001 |
| 29-38 years | 20.970×LFtB-9.761 | 6.0131 | 0.740 | 0.001 |
| 39-48 years | 63.174+12.445×LFtB | 5.5459 | 0.531 | 0.006 |
| >48 years | 101.637+7.595×LFtB | 5.5701 | 0.247 | 0.235 |
| Combined | 45.414+14.462×LFtB | 5.5258 | 0.612 | 0.001 |

Linear regression equation derived from left foot breadth for estimation of supine length in males show significantly positive 'r' value with 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

**LEFT FOOT BREADTH IN FEMALES:** The minimum value observed in 39-48 yr and more than 48 yr age groups and maximum value was similar in all age groups. The mean value of left foot breath was least in more than 48 yr age group. The standard deviation observed minimum in 29-38 yr age group and maximum in 39-48 yr age group as shown in Table – 8.

**TABLE – 8: MEASUREMNTS OF LEFT FOOT BREADTH IN FEMALES**

| Age groups | No. of cases | Min | Max | Mean | SD |
|---|---|---|---|---|---|
| 18 – 28 years | 25 | 7.0 | 8.5 | 7.804 | 0.4886 |
| 29 – 38 years | 25 | 6.9 | 8.5 | 7.788 | 0.4475 |
| 39 – 48 years | 25 | 6.8 | 8.5 | 7.752 | 0.5425 |
| >48 years | 25 | 6.8 | 8.5 | 7.424 | 0.4994 |

Linear regression equations derived are depicted in Table – 9.(Figure 2)

**TABLE – 9: REGRESSION EQUATION IN FEMALES**

| Age groups | Regression equation | SEE(+/-) cms | 'r' value | p-value |
|---|---|---|---|---|
| 18-28 years | 132.525+2.711×LFtB | 7.7721 | 0.172 | 0.412 |
| 29-38 years | 155.376-0.197×LFtB | 6.2386 | 0.014 | 0.945 |
| 39-48 years | 120.463+4.306×LFtB | 7.4380 | 0.305 | 0.138 |
| >48 years | 145.867+1.008×LFtB | 6.0691 | 0.084 | 0.688 |
| Combined | 137.774+2.068×LFtB | 6.7582 | 0.156 | 0.122 |

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 left foot breadth in females from this study does not

Volume - 7 | Issue - 3 | March - 2017 | ISSN - 2249-555X | IF : 4.894 | IC Value : 79.96

provide better correlation of stature.

Figure – 1: Correlation between supine length and left foot breadth in males

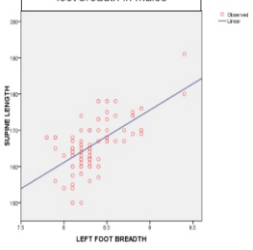
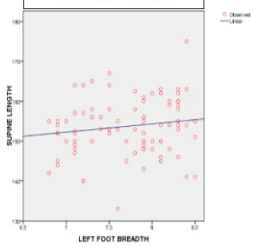



Figure – 2: Correlation between supine length and left foot breadth in females

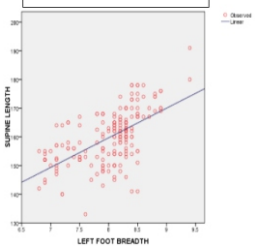



Linear regression equation derived from foot breadth for estimation of supine length in combined cases (males + females)-

SL= 77.038+10.329 × LFtB, (SEE = 7.4430), (r =0.590) (Figure 3)

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 for left foot length when total cases were combined together (p =0.001).

Figure – 3: Correlation between supine length and left foot breadth in total cases




Multiplication factors were derived for each parameter included in the study and is shown in Table – 10.

**TABLE – 10: MULTIPLICATION FACTORS FOR DIFFERENT PARAMETERS**

| Parameter | Multiplication factor for males | Multiplication factor for females |
|---|---|---|
| Left foot breadth | 19.909 | 19.986 |

**DISCUSSION**

The distinct advantage of mathematical method over anatomical method is that a single body part can be used to estimate the living stature of an individual. Standard error of estimate needs to be considered giving a possible range of stature from a given bone/body part.

According to Roche (1986), genetically stature at 18 years is accepted as adult, although there are small increments in stature after this. In the present study the average age of an individual ranges from 18 years and above which has been done on the cosmopolitan population of Delhi region of India.

**STATURE:**

The mean stature for males in the present study is 165.90 cm and for females is 153.68 cm. Minimum and maximum stature in males is 150 cm and 191 cm, while in females it is 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.

**FOOT BREADTH:**

The mean left foot breadth in males is 8.331 cm and in females it is 7.692 cm.

Significant bisexual differences seen with greater foot breadth among males this is consistent with the other studies too. The measured mean foot breadth are similar with study of Rani et al, while there is slight variations left 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[8] | Turkey (203M,108F) | Percutaneous | M | | 6.3 | 11.1 | 9.31 |
| | | | F | | 7.0 | 9.8 | 8.56 |
| Zeybek et al[9] | Turkey (136M,113F) | Percutaneous | M | L | 8.362 | 10.863 | 9.573 |
| | | | F | L | 7.582 | 9.578 | 8.557 |
| Rani et al[10] | Delhi (150M,150F) | Percutaneous | M | L | 7.1 | 10.3 | 8.666 |
| | | | F | L | 6.1 | 9.6 | 7.902 |
| Krishan,Sharma A[11] | Himachal Pradesh (123M,123F) | Percutaneous | M | L | 8 | 10.8 | 9.50 |
| | | | F | L | 7.2 | 10 | 8.53 |
| Krishan et al[12] | Himachal Pradesh (123M,123F) | Percutaneous | M | L | 8.1 | 10.9 | 9.5 |
| | | | F | L | 7.3 | 9.8 | 8.5 |
| Kanchan et al[13] | Punjab (100M.100F) | Percutaneous | M | L | 8.6 | 12 | 10.1 |
| | | | F | L | 8.2 | 10.4 | 9.1 |
| Sen J, Ghosh S[14] | North Bengal (225M,225F) | Percutaneous | M | L | 8.80 | 11.90 | 9.91 |
| | | | F | L | 5.50 | 10.50 | 8.99 |
| Bhavna,NathS[15] | Delhi (503 M) | Percutaneous | M | | | | 10.11 |
| Chikhalker et al[16] | Maharashtra (147M,153F) | Percutaneous | M + F | | 7.10 | 10.05 | 8.895 |
| Present Study | Delhi (100M,100F) | Percutaneous | M | L | 7.8 | 9.4 | 8.331 |
| | | | F | L | 6.8 | 8.5 | 7.692 |

In the present study foot breadth shows reverse results on comparing it with foot length. The correlation coefficient in males is 0.644 for right 0.612 for left foot breadth. The highest value seen in 29-28 year age group (0.779 for right and 0.740 for left side) followed by in youngest age group i. e. 18-28 years. In females it is less 0.143 and 0.156 for right and left respectively. 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. (Table-12)

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: COMPARISON OF REGRESSION EQUATIONS DERIVED**

| Authors | Sex | Regression equation | SEE (+/-) cms | r value |
|---|---|---|---|---|
| Zeybek et al[9] (Turkey) | Both | | | 0.692 |
| | | | | 0.697 |
| | M | | | 0.352 |
| | | | | 0.365 |
| | F | | | 0.266 |
| | | | | 0.225 |
| Rani et al[10] (Delhi) | M | 161.761+0.898×LFtB | 6.557 | 0.413 |
| | F | 138.526+2.669×LFtB | 5.488 | 0.358 |
| Krishan,Sharma A 11(Himachal Pradesh) | M | 135.33+3.46×LFtB | 6.17 | 0.324 |
| | F | 134.83+2.45×LFtB | 4.92 | 0.323 |
| Krishan et al[12] (Himachal Pradesh) | M | 124.336+4.616×FtB | | |
| | F | 111.232+5.224×FtB | | |

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| | | | | |
|---|---|---|---|---|
| Kanchan et al[13] (Punjab) | Both | 106.123+5.971×LFtB | 4.847 | 0.701 |
| | M | 131.134+3.576×LFtB | 5.440 | 0.406 |
| | F | 95.390+7.072×LFtB | 3.714 | 0.688 |
| Bhavna, Nath S15 (Delhi) | M | 132.61+3.46×FtB | 5.26 | 0.383 |
| Chikhalker et al [16](Maharashtra) | M+F | 114.828119+5.906901× FtB | | 0.488 6 |
| Sen J, Ghosh S14 (North Bengal) | Both | 72.996+8.761×LFtB | | 0.721 |
| | M | 106.004+5.674×LFtB | | 0.532 |
| | F | 113.675+3.979×LFtB | | 0.387 |
| Present study(Delhi) | Both | 77.038+10.329×LFtB | 7.4430 | 0.590 |
| | M | 45.414+14.462×LFtB | 5.5258 | 0.612 |
| | F | 137.774+2.068×LFtB | 6.7582 | 0.156 |

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 |
|---|---|---|---|---|
| Left foot breadth | 0.6390 | 10.814 | < 0.001 | Highly significant |

**TABLE 14: COMPARISON OF DIFFERENT PARAMETERS IN TOTAL MALES**

| Parameter | Side | Regression equation | SEE (+/-) cms | r value |
|---|---|---|---|---|
| Foot breadth | L | 45.414+14.462×LFtB | 5.5258 | 0.612 |

**TABLE 15: COMPARISON OF DIFFERENT PARAMETERS IN TOTAL FEMALES**

| Parameter | Side | Regression equation | SEE (+/-) cms | r value |
|---|---|---|---|---|
| Foot breadth | L | 137.774+2.068×LFtB | 6.7582 | 0.156 |

**TABLE 16: COMPARISON OF DIFFERENT PARAMETERS IN TOTAL NUMBER OF CASES**

| Parameter | Side | Regression equation | SEE (+/-) cms | r value |
|---|---|---|---|---|
| Foot breadth | L | 77.038+10.329 × LFtB | 7.4430 | 0.590 |

**TABLE – 17: MULTIPLICATION FACTORS FOR DIFFERENT PARAMETERS**

| Parameter | Multiplication factor for males | Multiplication factor for females |
|---|---|---|
| Left foot breadth | 19.909 | 19.986 |

**CONCLUSIONS AND SUMMARY**

1) The mean value of supine length /average height in male is about 12 cm more as compared to female.

2) The left foot breadth showed positive correlation with supine length.

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

4) Correlation of stature gives better estimate for stature in males with foot breadth.

5) Multiplication factors were derived for both genders in the present study but are less accurate than regression equations.

6) Regression equations derived in this study can be used for the population all over the country as present study done in cosmopolitan population.

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