

## Prediction of Stature from Foot Length

Palimar Vikram\*, Gupta Chandni\*\*, Neena Priyadarshini A V\*\*\*

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### Abstract

In medico-legal autopsies, establishing identity of dead is frequently essential. Estimation of stature from extremities could play a vital role in identification of dead bodies in forensic investigations. The measurements of foot have been used for determination of stature of an individual. The present study examines the association between stature and foot dimensions in post-mortem individual during autopsy. Foot length of 50 males and 50 females were taken independently on left and right side of each individual during the autopsy. The data were statistically analysed in order to evaluate the correlation between stature and foot length. Statistical analysis showed that in males and females were varied 16.9 % and 15% respectively in length of body. It can be explained by right foot length. Left foot length and stature relation was statistically insignificant.

**Key words:** Foot length; Stature; Estimation.

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### Introduction

Stature provides perception into several features of a population including nutrition, health and genetics. Stature is considered as one of the factors for individual identification and one of the 'big fours' of forensic anthropology. The stature of individual is an integral characteristic and its estimation considered to be a vital assessment in identification of unidentified human remains [1].

Adult height may be achieved any time in life from early teens to early twenties. However, it is usually reached during mid-teens for females and late-teens for males. For better precision, stature assessment may be attempted only after maturity [1]. There is a well-known

connection between stature and different body parts like head, trunk, upper and lower extremities. This permits a forensic expert to estimate stature from different parts of body. With increasing occurrence of mass catastrophes, homicides, air plane crashes, train and road accidents etc., there is constant need of such studies which aid in recognizing the deceased from fragmentary and mutilated human remains. In such conditions, dimensions of hands and feet could provide good estimate about the height of a person [1].

The assessment of stature from extremities forms a vital part in identification process of dead persons. It has been perceived that measurements from lower extremity of the body have better association with body stature than those from the upper extremity. Assessment of stature from the foot measurements has significant forensic importance in developing descriptions of suspects from evidences at the scene of the crime and in corroborating height estimates from witnesses [2].

Ossification and maturation in foot occurs prior than long bones and therefore, during puberty age, stature could be more precisely

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**Authors affiliation:** \*Associate Professor, Department of Forensic Medicine, \*\* Assistant Professor Department of Anatomy, Kasturba Medical College, Manipal, Karnataka, (A Constituent College of Manipal University, Manipal), \*\*\*Assistant Professor, Department of Forensic Medicine, Malabar Medical College, Calicut, Kerala

**Reprints requests:** Dr. Vikram Palimar, Associate Professor, Department of Forensic Medicine, Kasturba Medical College, Manipal, India 576104. E-mail: vpalimar@gmail.com

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anticipated from foot dimensions as compared to long bones [3].

The purpose of present study is to evaluate anthropometric association between measurements of feet with stature and to develop formulae to estimate stature from these measurements.

## Materials and methods

In this study 50 males and 50 females bodies were studied who came for autopsy. Measurements of stature (S) of an individual and foot length (FL) in both right and left foot were taken using Vernier callipers. The data were statistically analysed in order to assess the relationship between stature and foot measurements and formulae were designed so that by measuring at the foot length it may be possible to predict the stature of the individual.

Landmarks involved in taking anthropometric measurements:

### Stature

It is distance between vertex and heel of an individual.

### Foot length

It is distance from most prominent part of back heel to most distal part of longest toe (2nd or 1st).

## Results

The mean of all parameters for males and females was showed in table 1 and 2.

For Males 16.9% of variation in length of body could be explained by right foot length.

### Prediction Equation:

Length of the body =  $130.2 + 1.62 \times$  right foot length

Based on results of current investigations, only right foot length was significant with 0.003 regression coefficient for prediction regarding

**Table 1: Mean of parameters for males**

Parameters	Mean (cm)	Range
Stature	168	160-180
Right foot length	23.38	20.5-27
Left foot length	23.43	20-27

**Table 2: Mean of parameters for females**

Parameters	Mean (cm)	Range
Stature	153.86	137-161
Right foot length	20.61	19.5-24
Left foot length	20.67	19.5-24.5

**Table 3: Comparison of our parameters in males with other studies**

Authors	Right foot length		Left foot length		Stature	
	Mean	Range	Mean	Range	Mean	Range
Hilmi Ozden <sup>(6)</sup>	26.0 ± 1.34	22.50-30.0	26.04 ± 1.36	23.0-30.0	174.39 ± 7.21	153.0-197.0
Gulsah Zeybeka <sup>(7)</sup>	25.6	23.3- 29.1	25.57	23.3- 29.0	174.19	159.0- 191.0
Jaydip Sen <sup>(2)</sup>	23.96	21.10-27.30	24.01	21.20-27.40	162.23	145.50-178.50
Mukta Rani <sup>(4)</sup>	23.348	19-26.5	23.46	19.9- 26.9	169.5	150.1-184.5
Jitender Kumar Jakhar <sup>(3)</sup>	25.445±1.286	22.72-28.33	25.442±1.232	22.6-28.4	173.485 ±6.206	161-186.2
Kewal Krishan <sup>(1)</sup>	24.72	21.8-28.0	24.70	21.7-28.6	168.24	147.6-183.6
Tanuj Kanchan <sup>(5)</sup>	26.3	21.5- 30.0	26.3	23.2- 29.8	167.4	151.4- 180.6
Present study	23.38	20.5-27	23.43	20-27	168	160-180

**Table 4: Comparison of our parameters in females with other studies**

Authors	Right foot length		Left foot length		Stature	
	Mean	Range	Mean	Range	Mean	Range
Hilmi Ozden <sup>(8)</sup>	23.26 ± 1.07	20.50-26.50	23.30 ± 1.07	20.50-26.80	160.94± 6.31	142-179
Gulsah Zeybeka <sup>(7)</sup>	23.046	20.0- 25.6	23.07	19.2- 25.6	161.69	148- 176
Jaydip Sen <sup>(2)</sup>	22.23	19.70-24.90	22.27	19.80-25.10	149.53	133.50-169.60
Mukta Rani <sup>(4)</sup>	20.599	17.7-24.5	20.691	17.8-24.6	159.519	148.0-173.0
Jitender Kumar Jakhar <sup>(3)</sup>	23.089 ± 948	20.80-25.35	21.400 ± 927	20.58-22.22	159.045±5.067	146.5-166.7
Kewal Krishan <sup>(1)</sup>	22.65	20.4-25.4	22.60	20.4-24.9	155.72	140.7-169.5
Tanuj Kanchan <sup>(5)</sup>	23.8	21.1- 28.1	23.8	21.3 - 28.1	159.5	143.1- 171.0
Present study	20.61	19.5-24	20.67	19.5-24.5	153.86	137-161

stature of an individual. However, left foot length was not show the relation with stature of an individual.

For Females 15% of variation in the length of body could be explained by right foot length.

### Prediction Equation

Length of the body = 104.6+2.4 × right foot length

According to results of current study only right foot length was significant with 0.005 regression coefficient for prediction of stature of an individual. However, left foot length was not show the relation with stature of an individual.

### Discussion

In medico-legal autopsies, establishing individual identity of victims is frequently required. Assessment of stature from extremities and their parts could play a vital role in recognizing dead in forensic investigations.

In present study, mean value and range of all parameters for males were similar to Kewal Krishan & Sharma (2007) [1], Jitender Kumar Jakhar [3], Mukta Rani et al (2011) [4] studies which studied living individuals. However, current investigations were performed in dead bodies during autopsy. In present study the mean value and range of all parameters for females were not similar to the study done by others may be due to racial differences.

Bilateral differences in foot dimensions (cm) among males and females in present study -

were 0.05cm and -0.06, respectively. However, Tanuj Kanchan [5] and Kewal Krishan [1] studies were showed, it was -0.028, 0.029 (male) and 0.016, 0.042 (female).

Based on results of current study it could conclude that only right foot length is significant for prediction of stature of an individual. The regression coefficient was 0.005. Left foot length showed no relation with the stature of an individual. And the formula to find the stature from foot length.

#### Males

Length of the body = 130.2+1.62 × right foot length

#### Females

Length of the body = 104.6+2.4 × right foot length

While Tanuj Kanchan [5] created the formulae as

#### Males

Stature- 93.269 + 2.819(RFL), Stature- 90.275 + 2.930(LFL)

#### Females

Stature- 103.270 + 2.365(RFL), Stature- 105.200 + 2.287(LFL)

Kewal Krishan [1] created the formula as

#### Males

S = 68.085 + 4.054 FL, Females -S = 71.941 + 3.703 FL

Jitender Kumar *et al* [3] created the formula as

*Males*

$S=82.597+ 3.572FL$ , Female-  $S= 65.406+4.057 FL$

Mukta Rani *et al* (2011) [4] created the formula as

*Males*

Stature:  $98.320 + 3.050 FLRT$ , Stature:  $97.279 + 3.080 FLLT$

*Females*

Stature:  $90.207 + 3.374 FLRT$ , Stature =  $91.109 + 3.309 FLLT$

Jaydip Sen [2] created the formula as

*Males*

Stature

$83.518 + 3.282(FL)$ , Female stature-  $67.009 + 3.707(FL)$

Agnihotri [6] reported that right foot length could explain about 77% variations in stature. In contrast, current findings showed that, for males, 16.9% variation in length of body could be explained by right foot length while for females 15% variation in length of body explained by right foot length. On the other hand, Jakhar [3] conclude in their study that best correlation with stature was left foot length in all subjects.

Krishan [1] was observed that highest correlation coefficient between stature and foot length with lowest SEE (standard error of estimate). This indicated that foot length were able to provide highest reliability and accuracy in estimating stature of an unknown individual. This may be attributed to the fact that foot is anatomically involved in stature of a person [1]. Other workers also found that foot length was a good parameter for predicting stature compared to foot breadth in both genders [2, 4, 7].

## Conclusions

Statures are abundant and their importance lies in simplicity of measurement, applicability and precision in prediction [5]. In forensic analysis problems are being experienced in stature and gender assessment of bodies mutilated in mass devastation. Thus, to overcome these problems, new means are being developed. This study was devoted to the derivation of formulae for assessing stature from fragmentary remnants of foot whenever such a thing is recovered.

In present study, males were showed higher mean values in each anthropometric dimension than among females. Similar results were also observed in other studies [1,3,7]. Statistically significant differences may be attributed to the early maturity of girls than boys. Consequently, boys have also two more years of physical growth. Present investigations showed that stature was a significant parameter in determining partial identity of unidentified bodies and mutilated remnants.

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