Original Article

Study for estimation of stature from foot length in medico-legal autopsies (Study of 500 cases)

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DOI: 10.5455/jrmds.2015315

ABSTRACT

Background: Assessing the height of an individual, from measurements of different parts, has always been of immense interest to forensic medicine experts. The study of foot measurement in personal identification has obvious significance in forensic sciences. Having this idea in mind we did our project.

Aims: Aim of the present study was to estimate stature from foot length of both side and compare the correlation coefficient in both sexes.

Materials and methods: This study was carried out on 500 medico-legal autopsies which were brought to Forensic Medicine Department, M. P. Shah Govt. Medical College, Jamnagar during the period of August 2012 to June 2013. We took the height by standard measuring tap and foot length by sliding vernier calliper.

Result: The stature of males varied in range of 150 to 188 cm with mean of 167 + 4.58 cm and in females in the range of 139 to 171 cm with mean of 154 + 4.7 cm. Right foot length in males varied in range of 20.12 to 28.9 cm and in females 19.1 to 24.4 cm. Left foot length in males varied in range of 20.4 to 29.1 cm and in females 19 to 24.36 cm. Correlation co-efficient for both foot in both males and females are > 0.7.

Conclusion: Males were taller and have longer feet than females. There is very large correlation between height and foot length in both males and females. Correlation co-efficient for male for both foot are higher than females so, stature prediction from foot length is more accurate in males than females.

Key words: Stature, Foot Length, Autopsy

INTRODUCTION

"Identification is an individual's birth right" [1]. Stature is one of the various parameters of identification of the individuality of a person. 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 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. Determination of stature forms a major domain of medico-legal investigations used in the identification of unknown fragmentary and mutilated remains. The study of fleshed foot variability and utility of foot uniqueness in personal identification has obvious significance in anthropology and forensic sciences respectively. Personal identification from foot and its segments becomes more important in cases of mass disasters, where there is always likelihood of recovering feet (often enclosed) in shoes separated from the body [2].

There is no universally acceptable formula to express relationship between stature and body parts of an individual. Estimation of stature of an individual in India by using formulae given by western workers involves an error of 5-8% [3].

MATERIALS & METHODS

The present study was done at the Forensic Medicine department, M. P. Shah Government Medical College, Jamnagar on dead bodies coming for post-mortem examination during the period of August 2012 to June 2013 on total 500 cases. All above measurements and findings were noted by same

individual to avoid any inter observer bias and recorded in Performa and filed.

Inclusion criteria:
The dead bodies aged 21 years and above were considered for examination because by 21 years of age there is completion of skeletal growth.
Cases of all religions and occupations were studied irrespective of their manner of death.

Exclusion criteria:

- Cases of age less than 21 years.
- Cases with skeletal anomaly especially of spine and long bones.
- Cases of dwarfism where skeletal growth is abnormally stunted.
- Cases of gigantism where skeletal growth is abnormally enhanced.
- Cases of deep burns where due to flexor attitude, height and foot measurements cannot be perfectly ascertained.
- Cases with crushing injury over foot and body where height and foot measurements cannot be perfectly ascertained.

Method of collection of data:
The subjects chosen for this study were as mentioned above. Stature of the dead body was estimated in cm by measuring tap with dead body is in lying down supine position on dissection table. Stature was measured after all limbs are straight and parallel to body. One straight metallic scale was placed at head on vertex and another straight metallic scale placed over heel. The distance between both the scales reflects the exact stature of the individual. Foot length was measured in cm first on right foot with the help of sliding caliper (dial) as a straight distance between the most posterior projecting points of the heel to the most anterior projecting point of the first or second toe whichever was bigger. Then by same technique left foot length was also measured.

A master chart was then prepared with all the reading. After preparing master chart statistical analysis was done using software SPSS 20, and correlation coefficient, regression equation developed for male and female separately by linear regression analysis.

OBSERVATIONS

Out of 500 cases studied males outnumbered the females with 319(63.8%) males and 181(36.2%) females (Table 1).

Table 1: Distribution of cases according to sex and religion

Religion	Males (%)	Females (%)	No. of cases (%)
Hindu	284(56.8%)	156(31.2%)	440(88%)
Muslim	30(6%)	24(4.8%)	54 (10.8%)
Not known	5(1%)	1(1%)	6(1.2%)
Total	319(63.8%)	181(36.2%)	500(100%)

Analysis for total case (500):
Mean of stature = 162.71 + 7.68 cm
Mean of right foot length = 22.82 + 1.86
Mean of left foot length = 22.85 + 1.87
Correlation coefficient (r) –
For right foot, r = 0.890
For left foot, r = 0.893
$p < 0.001$
Regression equation:
For right foot – height = 55.843 + 4.683 x right foot length
For left foot – height = 55.784 + 4.679 x left foot length (table – 2)

Table 2: Comparison of stature foot length between males and females

Variables	Males	Females
Stature (cm)	167.2 ±4.58	154.45 ± 4.7
Right foot length (cm)	23.61 ± 1.02	21.37 ± 0.95
Left foot length (cm)	23.64 ± 1.02	21.39 ± 0.96
Correlation co-efficient (r)	0.752 – for right foot	0.731 – for right foot
	0.769 – for left foot	0.718 – for left foot
Regression co-efficient (b)	3.40 - for right foot	3.61 - for right foot
	3.49 - for left foot	3.53 - for left foot
Value of constant (a)	86.96 – for right foot	77.35 - for right foot
	84.64 - for left foot	78.92 - for left foot

So, from correlation coefficient (r), we can say that there is very large correlation between height and foot length and stature can be very well predicted from foot length. The stature of males varied in range of 150 to 188 cm with mean of 167 + 4.58 cm and in females in the range of 139 to 171 cm with mean of 154 + 4.7 cm.

Right foot length in males varied in range of 20.12 to 28.9 cm and in females 19.1 to 24.4 cm. Left foot length in males varied in range of 20.4 to 29.1 cm and in females 19 to 24.36 cm. So, males were taller and

have longer feet than females. Correlation co-efficient for both foot in both males and females are > 0.7, so there is very large correlation between height and foot length in both males and females. Correlation co-efficient for male for both foot are higher than females so, stature prediction from foot length is more accurate in males than females.

Regression equation for male:

Height = 86.96 + 3.40 x Right foot length

Height = 84.63 + 3.49 x Left foot length

Regression equation for female:

Height = 77.35 + 3.605 x Right foot length

Height = 78. 92 + 3.53 x Left foot length

DISCUSSION

Table 3: The observation made by the various workers and the results obtained have been presented below

No.	Study	Stature in males (cm)	Stature in female (cm)	Foot length in males, (cm)	Foot length in females (cm)
1	Giles et al. 1980	174 ± 6.61	162.95 ± 6.52	26.77 ± 1.30	24.31 ± 1.25
2	Agnihotri et al. 2007	173 ± 6.13	159.56 ± 6.25	26.12 ± 1.09	23.33 ± 1.08
3	Sen et al. 2008	162.23 ± 5.69	149.53 ± 5.37	24.01± 1.09	22.27 ± 1.00
4	Krishan et al. 2008	167.4 ± 5.9	159.5 ± 5.1	26.3 ± 1.5	23.28 ± 1.1
5	Mansur DI et al. 2012	165.66 ± 8.34	156.70 ± 6.16	23.89 ± 2.09	22.64 ± 1.36
6	Present study	167.2 ±4.58	154.45 ± 4.7	23.61 ± 1.02	21.37 ± 0.95

Table 4: Correlation coefficient (r), Regression equation to estimate stature from foot length in different study groups

Sr no.	Study	Male		Female	
		R	Regression equation	R	Regression equation
1	Giles et al. 1980		82.20 ± 3.447 FL		82.20 ± 3.447 FL
2	Agnihotri et al. 2007	0.72	68.58 + 4.036 FL	0.608	77.059 ± 3.56 FL
4	Sen et al. 2008	0.623	84.07 ± 3.255 FL	0.682	68.663 ± 3.632 FL
5	Krishan et al. 2008	0.764	90.27 ± 2.93 FL	0.502	105.20 ± 2.287 FL
6	Mansur DI et al. 2012	0.688	100.18 ± 2.73 FL	0.587	96.4 ± 2.66 FL
8	Patel JP et al 2012	0.925	77.89 ± 3.55 FL	0.741	38 ± 5.192 FL
9	Present study	0.752	86.96 ± 3.40 RFL	0.731	77.35 ± 3.61 RFL
		0.769	84.64 ± 3.49 LFL	0.718	78.92 ± 3.53 LFL

The estimation of stature is considered as one of the important parameters in identification of a person. The body parts show biological correlation with stature. This fact has been utilized by many workers to use body parts or skeletal remains to estimate stature. Height estimation by measurement of various long bones has been attempted by several workers with variable degree of success. Each researcher has derived his own formula for calculating the stature from long bones, while some uses body parts like hand, forearm length, head length etc [5-7]. Foot measurement has not frequently been used for this. The vertical height of a person needs an equally firm base to support it, which is provided by the feet. This implies that increase in the height is associated with an increase in foot dimensions.

The foot has been used to estimate stature in several studies [8-13] in different endogamous groups, where normograms have been derived to reconstruct stature from foot dimensions. These types of studies in different communities become essential, as several factors which include genetic and environmental, are known to affect stature and foot morphology as well as dimensions. In other studies [8-13], all workers used standard sometometric points for measurements of lower limbs. Table 3 shows the mean stature of males and females of different study groups including the study group of present study. The mean stature in

all studies was found to be significantly greater in males compared to females. Table 3 also shows variation in mean stature between same sex groups of different study groups. The stature is determined by several factors which include genetic and environmental factors. This is the reason for variation in mean stature amongst individuals of same sex belonging to different endogamous groups. Table 3 also shows the mean foot length of males and females of different study groups including the study group of present study. The mean foot length is found to be more in previous studies. The findings of the present study also showed that the males had longer foot than females on both side. This is because the growth of feet stops about two years earlier in females than in males.

The table also shows variation in mean foot length between same sex groups of different study groups. The foot length is determined by several factors which include genetic and environmental factors. This is the reason for variation in mean foot length amongst individuals of same sex belonging to different endogamous groups [4].

As per table 4 the correlation coefficient (r) for correlation between foot length and stature in males of different study groups ranged from 0.623 to 0.925 and in females from 0.587 to 0.741 which indicate large to nearly perfect correlation. Patel et al [13] attained nearly perfect correlation for male (r = 0.925) in their study. In the present study correlation between foot length and stature in males (for right foot – 0.752 and for left foot – 0.769) and for female (for right foot 0.731 and for left foot 0.718) which suggest significant correlation. This means stature can be better predicted with good accuracy using foot length (Table 4).

The regression equation to estimate stature from foot length of males various study groups are also presented in the table 4, using which the stature or foot length can be estimated by substituting the value of the other parameter in the equation.

The regression equation has a constant and multiplication factor. The foot length is multiplied by multiplication factor and added to the constant to get the stature. In the equation for right foot in male the constant is 86.96 and multiplication factor is 3.40. So, it means that for every 1 cm increase in right foot length the stature increase by 3.40 cm in male.

In our study, for both right and left foot, correlation coefficient (r) is slightly greater in males.

CONCLUSION

Stature forms an important aspect of individual's physiognomy and can be used as a tool for partial identification of an individual. There is a significant correlation between height and foot length in both sexes (slightly more in males) and stature can be estimated from the foot length when mutilated parts of the body are available with whole intact foot. Left sided measurements were found to be slightly bigger than the measurements of right side in both sexes. However the difference was marginal and statistically insignificant. Height and foot length of both sides are found to be more in males as compared to females. Correlation coefficient for both foot in males and females are > 0.7, so there is very large correlation between height and foot length in both males and females. Correlation co-efficient for male for both foot are higher than females so, stature prediction from foot length is more accurate in males than females. Stature can be reconstructed reliably and accurately with various regression equations derived in the present study and can be favourably compared with other studies.

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Date of Submission: 27/11/2014
Date of Acceptance: 02/03/2015

How to cite this article: Upadhyay MC, Bambhaniya AB, Mehta RA, Trangadia MM, Gupta BD, Chaudhari KR. Study for estimation of stature from foot length in medico-legal autopsies (Study of 500 cases). J Res Med Den Sci 2015;3(1):22-6.

Source of Support: None
Conflict of Interest: None declared