Original Article

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Human Stature Estimation from Foot Length: A Preliminary Study

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Abstract

Aim: In this study an attempt has been made to derive a linear regression equation for estimation of stature from the length of foot. *Background:* Estimation of stature from foot length is considered as an important parameter in medico-legal and forensic examinations. When highly decomposed and mutilated dead bodies with fragmentary remains are brought for postmortem examination, it becomes difficult to identify the deceased. *Material Methods:* The present study is conducted on 506 medical students 255 male and 251 female of age group between 18 - 25 years, was conducted at Index medical college hospital and research center Indore. The measurements were taken by using standard anthropometric instruments are the - I. Standard flexible steel tape. II. Spreading caliper (0-300 mm). *Results:* The observed data was subjected to statistical analysis like 't' test for correlation coefficient. The value of 't' was found to be statistically significant. Simple linear regression equation derived has been used for estimation of height. *Conclusion:* It is concluded that the foot length provides good reliability in estimation of stature in forensic examinations & in medico legal cases and the correlation between present parameters can be helpful in medico-legal cases for identification of individuals. Regression equation derived can be of help in artificial limb centers for construction of prosthesis required in cases of amputations following gangrene, trauma, frostbite etc.

Keywords: Height; Foot length; prosthesis; stature.

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Introduction

The stature prediction is a relatively a central position in the anthropological research & in identification of the person by the medico-legal experts. Estimation of stature from individual skeletal material, amputated limbs, mutilated, and parts of limb has obvious significance in personal identification of murders, accidents or natural disasters mainly concerning with forensic identification analysis [1].

Whenever the body is recovered in mutilated or fragmented state, the problem of identification of the person and this is difficult for the most experienced forensic expert.

The mutilation of dead body is done by a criminal who wants to destroy all traces of identity and thus facilitate the disposal of the dead. The correlation between stature & foot length and breadth is done after linear regression equation and multiple regression equations that will help in estimating stature, whenever the mutilated or fragmentary remains of feet are recovered [2]. Maturation & Ossification in the foot occurs in earlier than the long bones and height could be more accurately estimated from foot length [3].

Material and Method

The present study was conducted on 506 Medical students 255 males and 251 females, Age group

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between 18 - 25 years old, at Index Medical College Hospital & Research Center Indore.

Methods

a) Length of foot

b) Height - Height from the vertex of subject to the standing surface, of the foot.

Vertex is the highest point of the head in Anatomical position which is obtained by joining the infra orbital margin to the upper margin of the external auditory meatus (Frankfurt's plane).

Instrument

I. Standard flexible steel tape.

II. Spreading caliper (0-300 mm).

Fig. 1: Standard flexible steel tape

Fig. 2: Photograph Show's Height Measurement

Foot length is measured with spreading caliper (0-300 mm). Foot length is measured from the most prominent point of back of the heel to the tip of the hallux or to the second toe, if second toe is longer than the hallux, when foot is rested over a flat hard surface with the help of spreading caliper

Fig. 3: Showing the technique used for the foot length

Calculation formula

The calculations were done using regression formula.

Regression: It is used to express the functional relationship between two variables. In the most basic form of this technique (simple linear regression), the value of one variable (X) eg. Age or diameter is used to predict the value of the other variable (Y) eg. diameter. In simple linear regression equation X is an independent variant and y is a dependent variant. It is particularly useful in generating curves for various diameter parameters.

Simple Linear Regression

The relationship between two variables may be one of functional dependence of one on the other. That is, the magnitude of one of the variables (the dependent variable) is assumed to be determined by i.e., is a function of the magnitude of the second variable (the independent variable). The independent variable is also called the "predictor" or "regressor" variable and dependent variable the "response" or "criterion" variable. The term "dependent" does not imply a cause-and-effect relationship between the two variables.

The simple linear regression equation follows as under

Y = a + bX

X = Independent variable [Aortic diameter above celiac trunk or Age]

Y = Dependent variable [Aortic diameter below superior mesenteric artery, celiac trunk diameter, superior mesenteric artery diameter]

Where

a = Intercept

b = Slope

Such a dependent relationship (Y = a + bX) is termed a regression, the term simple regression refers to the fact that only two variables are being considered. The regression coefficient intercept (a), generally represent the background value of the dependent variable (Y) and thus, intercept has the same units as of Y, the dependent variable. The regression coefficient (b), generally called slope, expresses what change in Y is associated, on the average, with a unit change in X. The units of b are the units of Y divided by the units of X.

Results

Total 506 medical students including 255 males and 251 females of age group between 18-25 years old were included in this study.

The various observations and results are arranged in tables and presented graphically as follows:-

Table 1: Total Foot length V/s Height in Male and Female population

S.No.	Parameter	Sex	Mean ± SD
1.	Rt. Foot length	Male	252.40 ± 11.54
		Female	227.40 ± 12.21
2.	Lt. foot length	Male	250.38 ± 11.90
		Female	227.73 ± 11.99
3.	Total height	Male	1709.05± 113.39
		Female	1533.74 ± 205.44

Table 2: Regression analysis of various parameters in male & female

Parameter	Sex	Coefficient	SE coefficient	T	P
Constant	Male	508.4	158.3	3.21	0.001
	Female	726.01	95.48	7.60	0.000
Right foot length (mm)	Male	1.998	2.050	0.97	0.331
	Female	1.835	1.134	1.62	0.107
Left foot length (mm)	Male	1.882	1.901	0.99	0.323
	Female	0.106	1.143	0.09	0.926

Table 3: Regression analysis of total height (mm) versus Right foot and Left foot length (mm) in male & female

Parameter		Sex	Coefficient	SE coefficient	T	P
Constant	Male	Rt. foot length	573.6	138.7	4.13	0.000
		Lt. foot length	631.1	131.3	4.81	0.000
	Female	Rt. foot length	907.35	56.69	16.01	0.000
		Lt. foot length	907.18	58.42	15.53	0.000
Right foot length (mm)		Male	4.4989	0.5491	8.19	0.000
Female			2.8782	0.2489	11.56	0.000
Left foot length (mm)		Male	4.2593	0.5183	8.22	0.000
Female			2.8748	0.2562	11.22	0.000

Table 4: Correlation of total height in relation to other parameter in male & Female

S.No.	Parameter	Sex	Pearson correlation	P value
1.	Right foot length & total height	Male	0.737	0.000
		Female	0.591	0.000
2.	Left foot length & total height	Male	0.750	0.000
		Female	0.580	0.000

Table 5: Total result (male & female) Regression analysis of total height versus Rt. Foot & Lt. Foot Length in combined gender males and females

Parameter	Co-efficient	SE - Coefficient	T	P	Significance	
Consent	252.40	43.33	5.83	0.000	P<.001	High significance
Right Foot length	1.4295	0.7176	1.99	0.047	P<.05	Significance
Length foot length	1.8206	0.7012	2.60	0.010	P<.05	Significane

Discussion

The estimation of Stature (height) from foot length has been attempt by many workers & in present study are compared with the study of other researchers The present study deal with the observation of total correlation of total standing height with foot length.

Table no. 1 show the mean height and mean right foot length & left foot length of male & female student in the age group in between 18 - 25 year.

Regression-equation formula in Male

Height (Y) = Constant (a) + (slope (b) X right foot length)

Y = a + (b x foot length)

(Y) = 573.6 + (4.498 X right foot length)

Height (Y) = Constant (a) + (slope (b) X left foot length)

(Y) = 631.1 + (4.2593 x lt. foot length)

Table 6: Showing comparison of foot length of present study in male and with that of the Indranil Manna, Hilmi Ozden, Anitha Oommen and Kewal Krishan's study

S. No	Researh Worker	Sex	Sample size	Side	Mean±SD
1.	Indranil Mann(4)	Male	200	Right	24.47±1.25
				Left	24.38±1.21
2.	Hilmi Ozden(5)	Male	294	Right	26.00±1.34
				Left	26.04±1.36
3.	Anitha Oommen(6)	Male	50	Right	26.21±1.27
				Left	26.00±1.56
4.	Kewal krishan(7)	Male	1040	Right	25.43±3.25
				Left	25.82±3.23
5.	Present study	Male	255	Right	25.24±1.15
				Left	25.03±1.19

The above table 6 shows that in the present study the mean value of the right foot length is 25.24±1.15 and left foot length is 25.03±1.19 and Our finding correlates with various studies in males.

Table 7: Showing comparison of foot length of present study in female and study of Hilmi Ozden, Patel S M, Devesh V Oberoi & Indranil Manna.

S. No	Research Work	Sex	Sample Size	Side	Mean±SD
1.	Hilmi Ozden [5])	Female	275	Right	23.26±1.07
				Left	23.30±1.07
2.	Patel SM [3]	Female	224	Right	22.34±1.12
				Left	22.34±1.17
3.	Devesh V. Oberoi [8]	Female	50	Right	22.43±1.17
4.	Indranil Manna [4]	Female	100	Right	22.98**±1.44**
				Left	22.14±1.05
5.	Present Study	Female	255	Right	22.74±1.22
				Left	22.77±1.19

The above table 7 shows that in the present study the mean value of the right foot length is 22.74±1.22 and left foot length is 22.77±1.19 and Our finding correlates with Patel SM [7], Oberoi DV and Manna I study, while slightly differ from Ozden H study in females.

Regression-equation formula in Female

Height (Y) = Constant (a) + (slope (b) X right foot length)

(Y) = 907.35 + (2.8782 X right foot length)

Height (Y) = Constant (a) + (slope (b) X left foot length)

(Y) = 907.18 + (2.8748 x left foot length)

Where Y = Total height

X = Foot length, Correlation coefficient (r)

Correlation coefficient (r), (height & foot length) between height and foot length is

Conclusion

The present study has established definite correlation between stature and foot-length and also regression equations have been established. It will help in medico - legal cases in establishing identity of an individual. when body are found as in mass disasters, bomb explosions, accidents etc. If either of the measurement (foot length or total height) is known, the other can be calculated and this would be useful for Anthropologists and Forensic Medicine experts. Regression equation derived can be of help in artificial limb centers for construction of prosthesis required in cases of amputations following gangrene, trauma, frostbite etc.

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