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FOOT LENGTH RATIOS COMPARED TO STATURE IN A MIXED GENDER, NON PATHOLOGICAL SAMPLE

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ABSTRACT

Studies have established sexual dimorphisms in long bones. This study is a prospective cross sectional study based on the measurement of height and foot length of 351 students between 18-27 years of age. The left foot was selected for measurements as per recommendation of the international agreement for paired measurements at Geneva in 1912. The data obtained was analyzed stature foot length ratio was calculated for each age group and a correlation and regression formula was derived between the height and foot length of the individual from which height may be calculated if the foot length is known. Within the same age range, males were found to be taller with longer foot length than the females while the females had higher stature ratio. This proves that when height is the standard of comparison women tend to have longer feet than men of the same height. Hence, the regression equation for male $y = 84.45 + 3.559(x)$; $for\ female\ y = 139.95 + 1.071(x)$ this proves that though foot length can be used to predict height. It may only predict sex with great reservation; only when the age range of the individual can be estimated.

Keywords: Foot Length, Stature Ratio, Height

INTRODUCTION

In the past scientist have used several bones of the human skeleton in the estimation of stature and they all agree that stature can be estimated with relative accuracy even from small bones such as metatarsals (1) . in extreme conditions fragments of long bones have been used in the determination of stature[2],[3]; even though it is generally agreed that long bones provide better accuracy, ascertaining sex and estimation of stature from incomplete skeletal decomposing bodies is a recurring theme in physical anthropology and forensic science and the use of known parameters to estimate stature an indispensable tool within the field of forensic identification. In recent times the use of the foot for identification has been the focus of attention. Working amongst a

north Indian population Krishan et al., found that foot length measurements estimates stature with greater accuracy compared to foot breadth measurements[4]. Working among same population they also introduced the heel ball index which they found though larger in women than men in both feet, the difference found was only statistically significant on the right feet[5]. This index was also discovered to be independent of stature and weight of an individual whereas foot dimensions showed a positive correlation. Other body parts that has been used successfully to estimate stature include inter-anterior superior iliac spinous distance[6,7] here researchers found that foot length was a more reliable tool for estimating stature than inter-anterior superior iliac spinous distance though the latter showed some sexual dimorphism.

One of the foremost and most cited studies on estimation of stature from long bones of American whites is by Trotter and Glesser 1952[8] who was one of the first to create a regression formula for calculating stature from long bones using American causalities in the Korean War and collections of 1,728 human remains created by Robert J. Terry between 1899-1941 when he was head and professor of anatomy at the Washington medical school. These remains are presently in the national museum of natural history of the Smithsonian institution, Washington USA. Since then various works have been done all over the world to establish these relationships. Krishna and Sharma (2006) gave linear multiple regression equation for estimation of stature from dimensions of hands and feet in north Indian Ragputs[9]. This study aims to establish a relationship between height and foot length and to derive a new regression formula for estimating height/ stature of an individual using the foot length while taking into account the sex of the individual and probable age related changes.

MATERIAL AND METHOD

The study was carried out on a cross sectional sample of 351 students age range between 18-27 years. Samples were drawn randomly across the student population, after giving informed consent to participate in the study. All subjects who took part had no known foot pathologies.

Anthropometry

The left foot was selected for measurements in accordance with the recommendation of the Geneva international agreement for paired measurements[10]. Foot length was measured as a direct distance from the most prominent point of the back of the heel (pternion) to the tip of the longest toe (Acropodion)[10]. For the estimation of stature each individual was asked to

remove his/her shoes, the subject was then measured in the erect anatomical position with a standing height measuring instrument. The statistical method used in analyzing results are mean, range, standard deviation, - correlation coefficient (height and foot length).

RESULTS:

TABLE I: Age Group and Measured Anthropometric Characteristics of Male Students

Age Group	No of Male	Average Foot Length	Average Measured Height	Stature Ratio
18-19	56	23.35	167.71	7.18
20-21	60	24.51	171.29	6.99
22-23	42	25.11	173.86	6.92
24-25	31	24.59	174.65	7.1
26-27	11	24.86	172.60	6.94
Total	**200**			
Mean		**24.48**	**172.02**	**7.03**
S.D		**0.60**	**2.439**	

Age group 22-23 had the longest foot length while age groups 24-25 were tallest of all the age ranges.

TABLE II: Age Group and Measured Anthropometric Characteristics of Female Students

Age group	No of Female	Average Foot Length(cm)	Average Measured Height(cm)	Stature Ratio
18-19	40	22.51	163.71	7.27
20-21	45	22.66	164.30	7.25
22-23	30	23.06	164.22	7.12
24-25	20	23.05	165.49	7.18
26-27	16	23.10	166.50	7.21
Total	**151**			
Mean		**22.87**	**164.24**	**7.18**
S.D		**0.243**	**1.013**	

Age group 26-27 had the longest foot length while age groups 24-25 were tallest of all the age ranges.

TABLE III: Height, Foot Length, Correlation Coefficient®, Regression Coefficient (b) and Value of Constant (a) in Males and Females.

	Male	Female
Total Number	200	151
Height Range(cm)	154.5-195.0	154-174.0
Mean Height(cm)	172.02	164.84
S.d of Height	2.439	1.013
Foot Length of Range(cm)	22.5-29.0	21.7-25.0
Mean Foot Length	24.48	22.87
S.d of Foot Length	0.60	0.243
Correlation Coefficient (r) Height and Foot Length	0.779	0.796
Regression Coefficient (b)	3.559	1.071
Value of Constant (a)	84.87	139.95

Regression equation
For male Y=84.45+3.559(x)
For female y=139.95+1.071(x)

In this study it was discovered that average foot length increased with age up to age group 22-23 where it was maximum after which it decreased and remained constant for both males and females. The highest measurements for height were recorded between the age range 24-25 years for males and 26-27 years for females. Our analysis of the different age group though revealing a clear pattern of sexual dimorphism with male consistently being taller with longer feet compared to females, however the stature ratio (height /foot length) was higher in females in each age group. This contrasted with the study done by Ashizawa et al., 1997[11] who working among Urban Japanese concluded proportionate to stature women have smaller feet. Baba (1975)[12] who examining individuals of the same homogenous population as Ashizawa had earlier concluded the opposite. This controversy regarding the direction of sexual dimorphism in foot length stature ratio was explained by fessler et al.,[13] in an extensive work analyzing data from four different studies suggested a possible reason for this discrepancy as being that some of the authors substituted the ratio of the mean for the mean of the ratios.

That particular error was avoided in this study. The reason for females of the same age group as males having a higher stature ratio (stature/foot length) is easily explained by the fact that women of a given foot length are shorter than men having the same size feet. The above result though agreeing with the study provided by Robin (1986)[14] who collected traced foot outlines and foot print

from the left and right feet of 527 US subjects age 14 and over and found that males are larger in both foot length than females. Anderson et al.,[15] on the basis of a longitudinal study they carried out on 20 US children found that at age 18 foot length as a ratio is slightly larger in girls than in boys. With regards with the estimation of height from foot length much data is not available since most authors instead used the alternative of dividing the foot length with the height (foot length/height) we however chose to do the reverse because we believe it to be less clumsy if in forensic a detailed identification of a foot is needed, this method we believe will reduce the error in statistical derivation in such a case. Quamra et al.,[16] derived a regression equation allowing the estimation of stature from foot length in a North West Indian population. The correlation coefficient between foot length and height was 0.69 in males and 0.70 in females; this is similar to this present study of 0.779 in males and o-796 in females. Patel et al.,[17] also derived a correlation coefficient for males 0.65 and females 0.80. Danborno et al.,[18] used multiple linear regression analysis to predict stature from foot length and hand length. The regression equation derived in this study proved effective in predicting height for both males and females.

In revising this work we discovered that when foot length was divided by stature, the ratio derived was almost a constant across the age groups and sexes. Since about 80% of the student population is made up of the Urhobo and Isoko ethnic group we wonder if it is a case to prove the ethno specificity of this parameter. However Chockalingam et al., noticed such consistency in various foot dimension taken among non clinical males[19] and a mixed gender population.[20] And went on to suggestfurther studies being required to chart and map foot ratios in different ethnic, gender and pathological foot types, which will be useful in forensic medicine, research and in the shoe manufacturing industry.[20]

CONCLUSION

The study proves that though foot length can be used to predict height it may only predict sex with great reservation only if the age range of the individual can be estimated.

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