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Estimation of body height based on the length of tibia in different stature groups

Reshma Fatteh[1], Jeyaseelan N[1], Pooja Shree Godaba[1], Narne Gayathri[1], P.S Sarath Kumar[1] Miranda Simone Roman[2], Reece Ranaldo De Buys[2], Lebogang Moatshe[2], Sahar Abdul-Rasool[2]

[1]Avalon *University School of Medicine, Curacao, Netherlands Antilles, Dutch Caribbean.*
[2]*Department of Medical Biosciences, Faculty of Natural Sciences, University of Western Cape Robert Sobukwe Road, Bellville, 7535, South Africa.*

Abstract
Estimation of stature is of major importance in the fields of anthropology and forensics for identification purposes. Numerous anthropological structures have been studied in order to determine whether overall height (standing height) can be estimated solely based on anatomical structures. The tibia is one of the structures utilized and the sole focus of this study. 400 random participants were selected to participate in this study where tibia length is measured in order to find a correlation between tibia length and the overall standing height of an individual. A comparison of means of standing height and tibia length between genders was performed using a t-test. A linear regression analysis was carried out to examine the extent to which tibia length can reliably predict standing height. The mean height of males 176.5 ± 4.87cm and have a mean tibia length 41.07 ± 3.69 cm, while the females are 161.05 ± 4.16 cm tall and have a tibia length 38.37 ± 2.97cm. The relationship between standing height and tibia length were determined using simple correlation coefficient at a ninety-five percent confidence interval. Definitive results were obtained and positive correlations were observed in both male and female populations. Tibia length positively correlated with body length in male and female groups (Males r =0.64, females r =0.38) The female population has a lower positive correlation compared to male population.

Key words*: Forensic Anthropology, Stature estimation, tibial length, body length.*

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I. Introduction

The estimation of body height in relation to various body parts proves to be of interest to forensic and biological anthropologists due to its function in identifying unknown remains and understanding body proportions. Body length is one of the important parameters of identification of unknown cadavers[1]. In cases where cadavers become skeletonized and no other bodily tissue is present, forensic anthropologists rely on anatomical methods for identification. The typical forensic anthropological analysis focuses on the determination of age, sex and stature of an unknown individual [2]. Identification becomes more challenging in cases where the full skeleton cannot be recovered.

Numerous Forensic Anthropological studies have been conducted in order to maximize successful identification in all cases, even in cases where the entire skeleton is not recovered. Many studies have shown that stature can be correctly estimated using morphometric structures, specifically long bones such as the tibia, femur, fibula and the humorous. A study conducted by Chandravadiya et al [3] reveals a highly significant correlation between stature and tibia length. However, not all research in this area has found a successful correlation. A German study conducted by Mall et al [4] calculated a high standard error estimate, yielding unsatisfactory results when focusing on humeral and ulnar length, even though other studies refute these findings whilst using the same morphometric structures. Stature estimation using arm span measurements in Turkish adults by Özlem et al[5] and estimation of stature from long bones of American whites and Negroes have been reported[6]. Total body height estimation using sacrum height has also been reported[7].The present anthropological study aims to find a correlation between tibia length and the stature of an individual.

II. Methods and Materials

A total of 400 participants 300 participants from the City of Cape Town, South Africa and 100 participants from Curacao were selected for the present study. Written consent was received from the participants. The parameters age, sex, height in centimeters of both tibia in centimeters were recorded.

Participants were asked to stand on an elevated stool with their right foot facing outward in order for the researcher to accurately access the tibia. The tibia was then measured using non-stretch measuring tape.

Standing height was measured to the nearest 0.1 cm using a stadiometer with the subject standing erect barefooted on a horizontal resting plane. It was measured as recommended by the International Biological Program[8]

III. Results

The observations recorded were analyzed using Microsoft Excel. The tibia length and body height were analyzed separately and standard deviations for both were determined (Table 1). Male and female results were also analyzed separately and mean height, standard deviation of standing height and tibia length were determined (Table 1). The correlation for tibia length and height were calculated for both male and female (Fig 1 and Fig 2) and the overall correlation coefficient for the entire sample size was calculated. The males indicating a strong positive correlation. The male gradient is steeper than that of the female gradient therefore implying that the males have a stronger positive correlation compared to that of the females. The females indicating a slight positive correlation regarding the steepness of the gradient.

Table 1: Tibia length versus body height**.**

	Male	Female
Total number	192	208
Height range	Range=Maximum-Minimum =194.0cm-145.5cm =48,5cm	Range=Maximum-Minimum =1795mm-100.3cm =79,2cm
Mean height	174.5cm	161.05cm
Standard deviation of standing height	84,14	80,80
Tibial length range	Range=Maximum-Minimum =55,0cm-28,5cm =26,5cm	Range=Maximum-Minimum =45,8cm-26,3cm =19,5cm
Mean tibial length	34.4cm	38,37cm
Standard deviation of tibia length	32,01	26,09
Correlation coefficient (Standing height and tibia length)	0.64	0.38
Overall Correlation coefficient of both male and female population	0,60 (standing height and tibia length)	

Fig. 1 Correlation Between Tibia Length and Overall Height in the Male Population

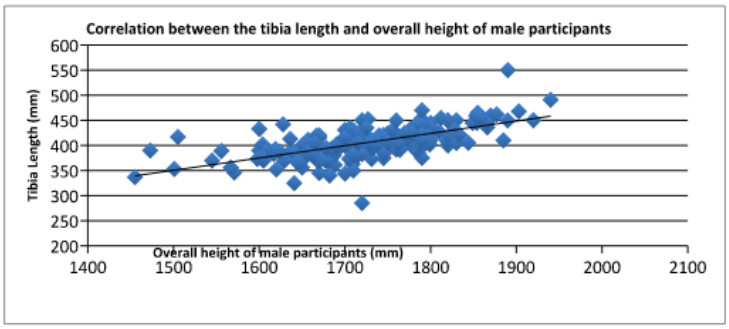
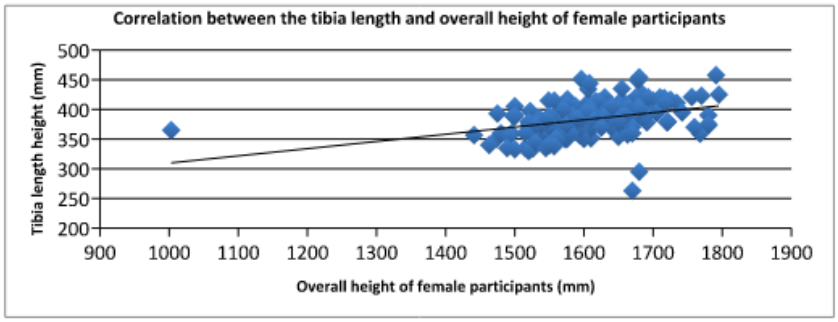


Fig 2: Correlation between Tibia Length and Overall Height in the Female Population



IV. Discussion

Within the Scientific discipline, researchers are often unsatisfied with limited amount of research due to the anthropologic perspective that there are a variety of sizes, shapes, colors, temperaments and other phenotypic characteristics present when observing the human body. Many articles based on tibia length versus body length were published [9] in order to better understand the topic from an anthropological perspective. It is however very important to note that the most reliable body indicator for estimation of standing height is the arm span by Mohanty et al[10,] Gardasevic[11]. Despite arm span being the most notable body indicator of the standing height of an individual, research suggests that the tibia is in fact a reliable body indicator of height estimation by Gardasevic [11] Khatun et al.[12]

Various Research supports the theory that high correlations exist between tibia length and overall body height comparatively. In this study a positive correlation was observed, however it was a weak positive correlation if the entire sample size is analyzed. Comparatively the male population had a significantly higher positive correlation than the female population observed. When analyzed, the male population showed a strong positive correlation with an r value of 0.95. The female population however, displayed a positive correlation with an r value of 0.54. When conducting a similar study, Agnihotri et al.[13] had different findings, observing an r value of 0.67 for the male population and an r value of 0.58 for the female population. Comparatively, similarities are present when analyzing both data sets. In the present study a higher positive correlation can be observed in male populations with lower positive correlation in the female population. The varying positive correlation in male and female population could be an indication of the differing anatomical bone structures in males and females. Brzobohata et al [14] reported a significant amount of sexual dimorphism when conducting a study on the human tibia. This supports the data collected when observing the difference in correlation between the male and female population where tibia length is of importance.

The present study reveals a higher positive correlation than normal in the case of tibia length and height of an individual in males. Arm span is presumably the most accurate method used to estimate overall height, however in a study carried out by Dev et al[15] where ulnar length was the sole focus, the correlation coefficient values are not significantly varied in comparison to this study with a computed correlation coefficient in males and females[16]. In this study however, the correlation coefficient for males is a significantly higher 'r value' and in females a slightly higher 'r value'. These discrepancies were statistically significant, when estimating height based on tibia length, the individual's general stature category should be taken into consideration, and group-specific formulae be used for short and tall subjects[17]

In addition to the claim by researchers that the arm span is the greatest estimator of human stature, research by Fongkete et al[18] claims that the upper breadth of the femur in males and the maximum anteroposterior diameter of the lateral condyle in females are the best estimators of stature. Despite claims, no data was found that proved to have the same correlation coefficient or higher for males in particular.

V. Conclusion

There is a significant positive correlation between the tibia length and the stature of an individual. Male and female populations show varying degrees of specific correlation coefficients; however, a positive correlation is evident. More research is required in order to fully understand the anthropological differences between male and female tibia, thereby providing more insight to the reasons for the comparative differences in the correlation coefficient when observing tibia length in relation to overall height of an individual.

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