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IN DIFFERENT STATURE GROUPS: BODY HEIGHT ESTIMATION BASED ON TIBIAL LENGTH IN SOUTH INDIAN POPULATION

Anatomy

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ABSTRACT

Long bone length is one of the best-known indicators of human stature. Although the long bone length/height ratio differs in tall and short individuals, no detailed study has investigated whether specific formulae should be used to calculate height in different stature groups. Stature estimation is an important part of the identification process of human skeletal remains or body parts to establish individuality of an unidentified dead, body or any mutilated part of such body by the Medico-legal expert. The present study made an attempt to estimate the stature from percutaneous tibial length (PCTL) by formulating simple regression equation and multiplication factor for people.This study proposes a new height estimation method. Body height and tibia length were measured in 150 male subjects aged 18.0 –34.6 years. Three subgroups were established according to body height (short, medium, or tall), using the 15th and 85th percentiles as cutoff levels. The general formula and a group-specific regression formula were used to estimate height in each subgroup. A control group with the same properties as the study group was analyzed in the same manner. Particularly with "short" and "tall" subjects, the difference between true height and the height predicted by the groupspecific formulae was smaller than the difference observed when the general formula was used. These discrepancies were statistically significant. When estimating height based on tibia length, the individual's general stature category should be taken into consideration, and groupspecific formulae should be used for short and tall subjects. The regression formulae reported here have important applications in forensic science for identification of unknown human remains, particularly partial, mutilated and dismembered ones

KEYWORDS

Tibia length; stature estimation; body proportions; Percutaneous Tibial Length , Height Estimation.

INTRODUCTION:

A challenging task in medico-legal cases, especially when the remains are partial, mutilated or dismembered. Such situations usually arise in cases of natural disasters, rail and aircraft accidents, wars and terrorist explosions. Many times, only parts of human body, such as limbs, are available for identification. Being an individual characteristic, stature is one of the important parameters for personal identification. Estimation of stature, therefore, plays an important role in medico-legal cases in the identification of unknown bodies, parts of bodies or even skeletal remains. There exists a strong relationship between stature and dimensions of different body parts, particularly bone lengths, which forms the basis for stature estimation [1]. Out of various body parts, long bones play an important role for stature estimation in forensic investigations [2-8]. The lengths of long bones of lower limbprovide better estimates of stature as compared to the bones of upper limb.(9).

Long bone length isknownto bethe bestindicator of stature. However, it is known that the long bone length/height ratio does vary to some degree with differences in stature (10-11). The tibia is one of the commonly used long bones for stature estimation. The tibia length/body height ratio has been shown to vary among populations, and evenamongindividuals. Bone and stature of an individual are influenced by numerous factors as age, gender, race, geographical climate, nutrition and genetic factors (12-13). Hence, the correlation factors of one region will not hold good for the other, as this necessitates the researches to be done on a regional basis(12-14). There are various ways to estimate stature from bones, but the most easiest and reliable method is by regression analysis (15-16). Regression formulae derived from the major long bones are generally considered to be more accurate. However the formulae derived cannot be generalized to all population groups, hence it is necessary to derive regression equations which are region wise and population specific (13) which can be applied to estimate stature of a population from its skeletal remains. Based on this our study aim is to test the hypothesis that estimations of stature are more accurate if different regression formulae are used for specific stature groups.

MATERIALAND METHODS:

The study involved 250 randomly selected Turkish males, ranging in age from 18.0 –34.6 years. The subjects were from various cities and socioeconomic backgrounds. A sample of 150 individuals was randomly selected from this larger group, and was identified as the study group. The other 150 subjects formed the control group. When stature was analyzed in each group, both showed a Gaussian distribution . The respective coefficients of skewness and kurtosis were 0.082 and 0.028 for the study group, and 0.083 and 0.326 for the control group. The Kolmogorov-Smirnov test of normality also verified these findings (P 0.001 for both groups). Each subject's body height and tibia length were measured using a Martin anthropometer. Body height was measured with the subject standing in bare feet with his back to anthropometer. The person's head was adjusted to the Frankfurt horizontal, and then the head was tilted slightly upwards by applying gentle force to the mastoid processes and zygomatic bones (13). For tibia length, the distance between the medial condyle and the most distal point of the medial malleous was for each of these height categories. The general formula and the group-specific formulae derived from the study group were used in the control group in order to test the accuracy of the formulae.

RESULTS:

Table.1. General Characteristics of study and control groups

Variable	Study Group (N= 150)	Control Group (N=150)	T	P Value
	Mean ± SD	Mean ± SD		
Age (yrs)	20.86 ± 4	21.70 ± 2.52	1.89	0.058
Stature (mm)	1746.38 ± 91.3	1745.53 ± 88.28	0.02	0.980
Tibia length (cm)	389.62 ± 30.02	390.40 ± 28.09	0.11	0.900

Table.2. General height estimation formula and group-specific formulae based on tibia length for different stature categories in study group (mm)

Stature category	Regression equation	SE	R^2	F	P
Short	Stature = 950.86 ± 1.833 Tibia length	31.90	0.441	12.76	0.004
Medium	Stature = 942.80 ± 2.052 Tibia length	36.10	0.542	101.18	0.000
Tall	Stature = 1224.11 ± 1.528 Tibia length	35.02	0.640	10.65	0.005
General formula	Stature = 678.63 ± 2.735 Tibia length	39.24	0.812	528.32	0.000

Table.3. Differences between estimated height based on general formula and true height in control group (mm)

Stature category	N	Mean ± SD	Minimum	Maximum
Short	25	35.11 ± 34.12	-10.74	103.01
Medium	99	1.58 ± 30.15	-51.80	93.32

Tall	26	-34.08 ± 35.70	-113.86	20.80
All Controls	150	0.92 ± 36.29	-113.86	103.01

*Negative values indicate under estimates; Positive values indicate over estimates

Table.4. Differences between estimated height based on group specific formulae and true height in control group (mm)

Stature category	N	Mean ± SD	Minimum	Maximum
Short	25	10.78 ± 31.62	-33.42	82.86
Medium	99	1.11 ± 28.08	-42.60	72.79
Tall	26	-4.37 ± 20.02	-43.49	27.38
All Controls	150	1.62 ± 27.62	-43.49	82.83

*Negative values indicate under estimates; Positive values indicate over estimates

DISCUSSION:

Stature estimation from different body parts is significant in medico-legal cases. It provides an important parameter for personal identification. Many times, dismembered, mutilated and comingled bodily parts of deceased persons are brought for forensic examination. In such situations, estimated stature from available body parts can prove vital to narrow down the investigation to a limited number of individuals. Out of the anatomical and mathematical methods, the latter method has been more commonly used by forensic scientists for stature estimation due to non-availability of complete skeletons in most medico-legal cases (14-17). The mathematical method holds an advantage because it can be used even if a single limb/partial limb or single long bone is available to the examiner, given the proportional relationship that various body parts have with stature . The results of the present study validate and support the hypothesis that there exists a strong relationship between stature and dimensions of different body parts, particularly bone lengths. The results of the present study also clearly demonstrate that the percutaneous lengths of tibia and fibula can be used for the estimation of stature (18).

The earlier studies established that the means of stature reconstruction, i.e. M.F or regression formulae are both population and gender specific and thus it is important to first identify the recovered remains and then relevant measurements should be taken to reconstruct the stature. Though both the methods may be used, but regression equations provide greater reliability in estimated stature (19-20). We have also derived regression formula and M.F. both. Previous study (21) reported that the Regression formulae are more dependable than multiplication factor for estimation of stature. They suggested that the regression formula derived by Allbrook (22) for estimating the stature in the British population is not suitable to estimate the stature in Indian population (21). Regarding estimation of height from long bones, femur and tibia lengths are more closely related to stature than the lengths of other long bones. Essentially, it is possible to explain variations in stature based on differences in the dimensions of these long bones, however, it is not clear whether the femur or tibia has more impact on changes in body proportions. Previous study (23) found the relationship between femur length and stature to be virtually constant in adults, regardless of gender or ethnicity. Because the tibia and fibula are known to be more strongly positively allometric than the femur body proportions have also been studied from the perspective of growth and nutrition. Still, no detailed investigation has examined the effects of such proportional changes on stature estimation. However, they did not mention proportional changes in relation to stature differences among individuals. Previous studies (24) discussed the potential for error in stature estimation, particularly in tall and short subjects, and stated that the major axis regression technique is more reliable for individuals in extreme height categories. Our results indicate that group-specific formulae give more accurate height estimates for individual sinextremeheightcategories.

Furthermore, there is a need to develop population specific regression formulae because populations vary in their size and stature (25) and in the proportions of the body parts to stature (26). Limb length to stature proportions also differ between human populations. Therefore, the use of regression formulae for stature estimation across populations could be problematic due to differences in body proportions in different populations (27). Previous studies author Stevenson had observed that the regression formulae developed on one race when used for another race give unsatisfactory results (28). On the other hand, in some forensic cases, the available bones or body parts are isolated. In such cases, the isolated bones or body parts should be evaluated according to their own dimensions in order to decide which stature group-specific formula would be applied. In the present study, tibiae were classified according to their lengths into three groups as short, medium, and long. As in the classification of body height, 15th and 85th percentiles were used as cutoff points; tibiae with a length of 360 mm or less were determined as short, 361–420 mm as medium, and 421 mm and above as long. In addition to stature grouping, another grouping was established based on tibia length. Short, medium, and tall groups constructed by these two methods were compared with each other, and no statistically significant difference was observed. In other words, long tibiae mostly belonged to the tall, and short tibiae to short individuals. Present study findings indicate that grouping depending on tibia length could be used to identify the stature group to which a specimen belongs. In order to verify this suggestion, the previously calculated stature group specific regression formulae were applied to the groups established based on tibia length.

CONCLUSION:

It is possible to determine the stature of a deceased person whose only body part available is a mutilated leg, by using the data and formula derived from the present study fairly accurately to some extent. However the formulae derived cannot be generalized to all population groups, hence it is necessary to derive regression equations which are region wise and population specific. The stature group specific formulae to the groups based on body height and tibia length were closely similar with each other. Overall, the procedure we present in this paper is appropriate for use in predicting stature grouping. It appears that group specific formulae may be more reliable for forensic cases in which height estimates for individuals are important. We conclude that the regression equations presented here can be used to estimate ante-mortem stature, with reasonable accuracy, of unknown mutilated or dismembered human lower limb remains from percutaneous lengths of tibia and fibula in medico-legal cases. Thus the data of this study are recommended in anthropological studies for stature estimation amongst the ethnic group under study.

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