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Estimation of height from percutaneous length of fibula in adult Bengalee population

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Abstract: *Background:* Morphology and morphometry of lengths of bones with respect of the height of the person vary from country to country and from place to place. *Objective:* objective was to study relationship between the percutaneous length of fibula & height of that individual in adult bengalee population. *Methods:* In a cross sectional descriptive study, 400 (200male & 200 female) adult bengalee person were studied and the percutaneous length of fibula & their height were measured and analysed. *Results:* Positive correlation was found between the height of the person and the length of both right and left fibula separately both in case of male and female subjects. Also correlation between the right and left fibula was statistically significant both in male and female subjects. *Conclusion:* In the present study the results showed that length of fibula is important for estimating height in respect of specific racial, geographical and gender specific population group (here adult Bengalee population). Separate and independent linear regression equation derived for the specific population group & it demonstrates that the length of fibula (long bone) can be used to estimate the stature of adult Bengalee population in Burdwan District.
Keywords: Fibula, Bone Length, Body Height, Percutaneous Length, Body Stature.

Introduction

Personal identification is one of the fundamental birth right which refers to determination of individuality of a person. Age, sex and stature are the primary characteristic of identification [1]. Establishment of identity of unknown human remains is a challenging task in medico-legal cases, especially if the remains are partial, mutilated or dismembered. Such situations usually arise in cases of natural disasters, war situation, rail, road or aircraft accident or terrorist explosions.

Therefore, in medico-legal cases of unidentified body or body parts, estimation of height plays an important role in the identification. It is well known that there is definite relationship between the height of the person and various body parts like head, trunk and length of the upper and lower limbs. The bone length forms the basis for stature estimation. The lengths of long bones of lower limbs provide better estimates of stature as compared to the bones of upper limbs [2]. Anthropometry, which deals with expressing human form in numbers, has been widely used in forensic identification of sex, age, race and stature of a person. Among these, the sex and stature are the most important [3].

Calculation of accurate estimation of height from bones has been obtained in past researches by many regression formulae. However, it must be taken into consideration, that these regression equations can vary depending upon the population, race and region. Thus, it is of utmost importance to study a particular population thoroughly before formulating regression equations for that specific population.

In 1888, Rollet [4] was first to conduct a research in this field, using measurements from 50 male and 50 female corpses to determine the relationship between measurements of various body parts and the stature. In 1899, Pearson, a mathematician, used this data to derive the regression equations, which he suggested were population specific. Since then numerous advancements [5-6] have been made in this field, which are being efficiently applied in the identification process. Using stature estimation, a forensic scientist can narrow down the pool of possible victim matches in any ongoing investigation [7].

The stature is directly proportional to different body parts and hence, shows a definite biological and genetic relation with each other. In forensic cases, stature (or body height) is usually estimated using 'anatomical' and 'mathematical' techniques [8]. Researchers have established a relationship between stature and measurements of different body parts which are often represented using linear regression equation derived from them [9]. As these measurements vary from population to population, race to race, it is of highest importance to collect data from as many population subgroups as possible and make a comprehensive database.

In absence of documental skeletal material, the researcher has focused their attention forward living population groups of India and has taken relevant bone length over the skin and co-related them with the stature to find out the degree of relationship between them and subsequently formulated multiplication factors and regression formulae from long bones reconstruction of stature. Human height or stature is measured as the distance from the top of the head to the bottom of the feet in a human body, standing erect. It is measured by stadiometer [10], usually in centimeter when using the metric system [11-12] or feet and inches when using the imperial system [13-14]. A particular genetic profile, called Y haplotype I-M170 is correlated with height in men.

Fibula is a long bone (Compact) situated at the lateral side of the leg (medial bone of leg is Tibia). Among the leg bones fibula is much more slender than the tibia. The Fibula has a proximal head, a narrow neck, a long shaft and a distal lateral malleolus. The shaft varies in form, being variably moulded by attached muscles [15]. The head of the fibula is irregular in shape and projects anteriorly, posteriorly and laterally. A round facet on its proximomedial aspect articulates with a corresponding facet on the inferolateral surface of the lateral tibial condoyle. It faces proximally and anteromedially, and has an inclination that may vary among individuals from almost horizontal to an angle of upto 45 degree. A blunt apex projects proximally from the posterolateral aspect of the head and is often palpable approximately 2cm distal to the knee joint [15].

The lower limb length has the greatest contribution to the standing height of a person. The most predictive equation are on the length of the long bones of lower limb like femur, tibia and fibula in living individual. Percutaneous measurement of length of fibula can be done, as both ends of fibula are subcutaneous. So the length of fibula may be an ideal application for estimating the height of a living person.

Estimation of height of an individual from the length of fibula is well documented parameter in anthropological research and medico-legal purpose. But there is lack of population specific data and background for this study to carryout in this setting among Bengalee population. Many factors like age, gender, race, genetic factors, nutrition, climate etc influence bony length and thus height of an individual. It is known fact that the different population groups exhibit variation in their body proportions as result of which correlation of length of one bone to height not only varies from population to population but also in between sexes.

As the correlation factors of different population groups and different geographic areas are different, this necessitates the researches to be done in selected population group of a selected geographic area. In view of the above context this study was planned to find the relation of height with the percutaneous length of fibula and it has been carried out amongst adult Bengalee Population of Burdawan District, West Bengal. No such study has been done so far for estimation of height in Bengalee population. So, this study will provide a base line data and specific regression formula to estimate the stature in this particular population group.

Material and Methods

The present study is a cross sectional observational study conducted in adult Bengalee population of East Burdwan District of West Bengal. The objectives are to measure percutaneous length of fibula, to estimate height of the body, to establish relation between the length of fibula and height and finally to formulate regression formula for estimation of height from the length of fibula in adult Bengalee population. All method and procedures applied within this study are approved by Ethicsl Committee of Burdwan Medical College, Burdwan, West Bengal.

Random sample of 400 subjects (200 males and 200 females) were taken from the General Medicine Out Patient Department (OPD), staff, Medical and Dental Students of Burdwan Medical College, Anatomy Department. Subjects with any obvious congenital or acquired deformity of spine or extremities were not included in the study. The study population was chosen in the age group of 18-65 years to eliminate physiological developmental error and also to keep multiplication factor more or less similar in this age group. The subjects gave their written consent for this study in the appropriate consent form.

The measurements were taken by standard anthropometric instruments in centimeters, according to the technique described by Vallois [16]. All the measurements were taken by same observer and with the same instruments, to avoid any technical and or inter-observer and to maintain reproducibility. To eliminate discrepancy due to diurnal variations, the measurements were taken between 10 am to 2 pm. The measurements were taken three times and their mean value was noted for estimation of height.

Height of the subject was measured in standing position on a standard stadiometer (Figure- 1) from vertex to floor with standing bare footed, erect on an even floor, both feet close in contact with each other, the trunk braced along the vertical board, and head adjusted in Frankfurt plane, and then head was tilted slightly upwards by applying gentle force to the mastoid process and zygomatic bone. The measurement was taken in centimeters by bringing horizontal slide bar to the vertex and with the help of measuring tape in standing erect anatomical position, vertex to heel with bare foot.

Fig-1: Measurement of height of subject using Stadiometer.

The Fibular length was taken as the distance between the highest points on the head of fibula to the most distal point on the lateral melleolus. The subject, in a standing position, was instructed to keep one leg on a low table. The required landmarks are easier to locate in this position. Cross pieces of the rod compass of the anthropometer were applied to the highest point on the head of fibula and the most distal point on the lateral melleolus to take the measurement (Figure-2).

This measurement was taken on the right side of each individual and the same technique repeated on the left side in the same way in case of each subject. Afterwards the data had been analyzed statistically and results were assessed.

Fig-2: Percutaneous length of fibula is being measured with the help of a spreading caliper.

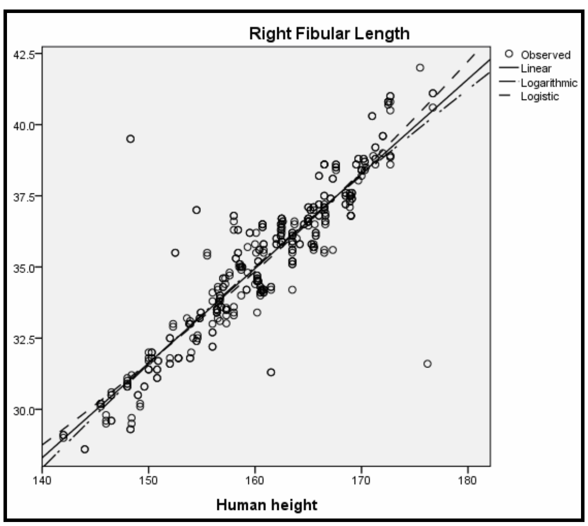
Results

All the variables like height, fibular length were normally distributed, so Pearson correlation was used. The positive correlation was found between total sample of Human height vs both Right & left Fibular Length and correlation coefficient (r) was 0.900 & 0.896 respectively. Both of them were statistically significant (p<0.0001). There was positive correlation between Left Fibular Length vs Right Fibular Length and correlation coefficient (r) was 0.997. It was statistically significant (p<0.0001) (Table-1 & Fig-3).

Table-1: Correlation between Human length subjects Vs Fibular length

	Right Fibular lentgh	Left Fibular length	P value (<0.05 significant)
Total Human Subjects	correlation coefficient (r) 0.900	correlation coefficient (r) 0.896	p<0.0001
Male Subjects	correlation coefficient (r) 0.811	correlation coefficient (r) 0.802	p<0.0001
Female Subjects	correlation coefficient (r) 0.949	correlation coefficient (r) 0.948	p<0.0001

Fig-3: Correlation between Total Human (both Male+ Female) height Vs Right Fibular length.



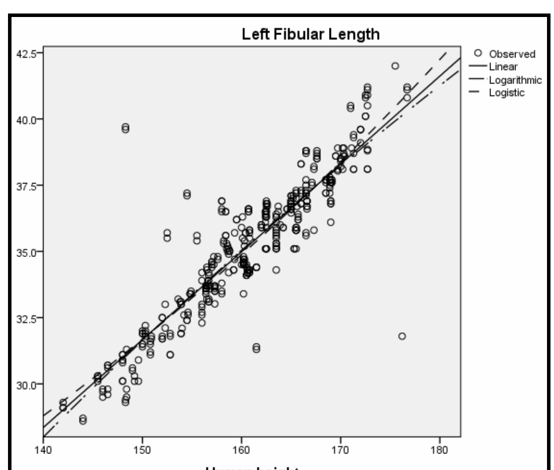
While analyzing data of the male subjects, positive correlation was found between male Human height vs Right Fibular Length and correlation coefficient (r) was .811. In case of left fibula, there was positive correlation with correlation coefficient (r) of .802. Both of these correlations in male subjects were statistically significant (p<0.0001). While analyzing correlations between Right Fibular Length vs Left Fibular Length it showed statistically significant (p<0.0001) positive correlation, with correlation coefficient (r) being 0.995 in case of male subjects (Table-2).

Table-2: Correlation between Right & Left Fibular length

	Correlation coefficient between Right Fibular length & Left Fibular length	P value (<0.05 significant)
Total Human Subjects	correlation coefficient (r) 0.997	p<0.0001
Male Subjects	correlation coefficient (r) 0.995	p<0.0001
Female Subjects	correlation coefficient (r) 0.998	p<0.0001

Similarly among the female subjects, positive correlation was found between Human height vs both Right & Left Fibular Length and correlation coefficient (r) recorded were 0.949 & 0.948 respectively, both of which were statistically significant (p<0.0001). Among the female subjects statistically significant (p<0.0001) positive correlation was found between Right Fibular Length vs Left Fibular Length and correlation coefficient (r) was 0.998 (Fig-4)

Fig-4: Correlation between Total Human (both Male+ Female) height Vs Right Fibular length



After analyzing the data by suitable statistical software, the following multiplication factors with regression formulae were obtained:

For total subjects:

Human Height = 75.134+2.433XRightFibularLength ±2.096 ($p<0.0001$)
Human Height = 74.829+2.439XleftFibularLength ±2.132 ($p<0.0001$)

In Male Subjects:

Human Height = 86.830+2.119XRightFibularLength ±3.980($p<0.0001$)
Human Height = 85.699+2.148XLeft Fibular Length ±4.078 ($p<0.0001$)

In Female Subjects:

Human Height = 68.723+2.609XRightFibularLength ± 2.119($p<0.0001$).
Human Height = 69.042+2.597XLeft Fibular Length ± 2.130($p<0.0001$).

Discussion

Accurate stature estimation is important in forensic medicine. To date, several researchers have proposed formulae for estimating stature based on measurements of different long bones (Humerus Radius, Ulna, Femur, Tibia, Fibula etc. the skull, and various short bones. Many times, dismembered, mutilated and comingled bodily parts of deceased persons are brought for forensic examination. In such situations stature estimation from available body parts can prove vital to narrow down the investigation to a limited number of individuals.

The present research hypothesized that the heights of Bengalee population of East Burdwan District are significantly correlated to the right sided as well as left sided fibular length. Many of the previous studies of the relationships between stature and bone measurements have involved simple populations drive from a single country. Genetic and environmental components influence skeletal development; therefore, formulae derived from a certain population will not be suitable for stature estimation in population from different nations or continents. In addition the majority of the earlier studies were carried out on cadavers or skeleton collections. As the different population groups of different geographic area exhibit different correlation for prediction of their height from a specific long bones, the present study was carried out in a specific population group and specific geographical area (Bengalee community of East Burdwan District).

To test this hypothesis data were collected on height, left fibula and right fibula and prediction models are developed. The average height and fibular length (both left and right side) have measured and there was a positive correlation between the height and fibular length. Out of the Anatomical and mathematical methods, the latter method has been most commonly used by forensic scientist for stature estimation due to non availability of complete skeletons in most medico-legal cases. The mathematical method holds and 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 with stature.

Several studies have provided height predictions equations for different population groups using length of fibula. A study was conducted by Nath et al, (2007) in Indian population almost in similar age groups as this study reported average height and length of fibula [17]. In 2009, Auyeung et al, conducted almost similar study and they included the length of fibula and length of Ulna to establish a regression equation to predict the height of the elderly Chinese population along with age comparison [18].

In this study mean age was 33.8775± 9.9163 Years. Chi-square value: 2.5048; p-value: 0.4744. Association of Age vs Sex was not statistically significant. In case female mean height 160.0435 and standard deviation 20.6893 of height and p value 0.0252 and in case of male mean height 163.4865 and standard deviation 6.4555 and p value 0.0252. So according to the statistical analysis mean human height according to sex was statistically significant.

In case of female, the mean length, SD, and p value of left fibular were 34.4160, 2.6806 and <0.0001 respectively. In case of male, mean, SD and p value of left fibula were 36.2076, 2.4504 and <0.0001 respectively. In the same way female right fibular length mean, SD and p value are 34.3830, 2.6650 and <0.0001 respectively. In male, right fibular length mean, SD and p value were 36.1710, 2.4565 and <0.0001 respectively.

In total subjects in case of right fibula r value .900 and p value <0.0001 which was positive correlation significantly. In total subjects in case of left fibula r value .896 and p value <0.0001 which was positive correlation significantly.

After calculating the data collected and analysis them by putting on SPSS software, the following regression equations have obtained. These equation will be used to calculated one's approximate height from percutaneous length of his/her fibula (both right and or left sided)

Male and female:

Human Height = 75.134+2.433XRightFibularLength ±2.096 (p<0.0001)
Human Height = 74.829+2.439XLeftFibularLength ±2.132 (p<0.0001)

Male:

Human Height = 86.830+2.119XRightFibularLength ±3.980(p<0.0001)
Human Height = 85.699+2.148XLeft FibularLength ±4.078(p<0.0001)

Female

Human Height = 69.042+2.597XLeft FibularLength ± 2.130(p<0.0001)
Human Height = 68.723+2.609XRightFibularLength ± 2.119(p<0.0001)

The results of the present study validate and support the hypothesis that there exist a strong relationship between stature and dimensions of different body parts, particularly bone length. The results of the present study also clearly demonstrate that the percutaneous length of both right and left fibula can be used for estimation of stature, (irrespective of sex). Though data from living populations may not be an ideal solution to establish a proper regression equation to find out the height but, at least, it provides population specific formulae which to some extend, can overcome the imprecision in medico-legal cases that may result by using formulae developed for a totally alien population.

Furthermore, there is a need to develop population specific regression formulae because populations vary in their size and stature and in the proportions of the body parts to stature. 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 population. As early as 1929 Stevenson had observed that the regression formulae developed one race when used for another race give unsatisfactory results.

Several recent studies also stressed upon the better reliability of population – specific regression formulae for estimation stature in forensic cases. Thus, it is advisable to developed population- specific regression formulae.

Conclusions

In the present study the height, length of right fibula and length of left fibula of each subject have measured accurately. Total subjects in the study included 400 adult Bengalee populations. The study carried out in the General Medicine OPD and in Department of Anatomy, Burdwan Medical Collage. The age group of the study covered 18 – 65 years and out of 400 subjects 50% male and another 50% belonging to female population (400=200+200).

Height of each individual is measured using stadiometers and the fibular length is measured using spreading calipers. And the relation between the height and fibular length is established after proper statistical analysis. Regression lines were drawn with 95% confidence limits for direct estimation of stature from the given percutaneous length of fibula. The regression coefficients and difference between those of males and females were significant at $p \leq 0.05$ hence justifying the equations suggested. Applicability of the present equations and their differences with those of both Indian and western authors were critically discussed.

Thus the present study showed that length of fibula is important for estimating height in respect of specific racial, geographical and gender specific population group(here adult Bengalee population). Separate and independent linear regression equation derived for the specific population group. Results also concluded that the present study demonstrates that the length of fibula (long bone) can be used to estimate the stature of adult Bengalee population in East Burdwan District.

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