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Original Research Paper

Estimation of Adult Human Stature from Measurements of Inter-Acromial Length in Gujarati Population of India

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Abstract

Stature is one of the biological characteristics often used in Forensic Anthropology, both to help build profiles for unidentified individuals and to support putative identifications. Frequently fragmentary remnants are brought to a Forensic expert for investigation purpose. It is, therefore, necessary to have different formulae for the determination of stature using measurement of different body parts. The aim of this study was to estimate the stature from anthropometric measurement of inter-acromial length and derive a linear regression equation. A total of 300 subjects (150 males and 150 females) of SBKS Medical Institute & Research Center, Sumandeep Vidyapeeth, Vadodara, Gujarat belonging to the age group 22 – 44 years were selected for the study. The stature and inter-acromial length of each subject were measured with the help of a stadiometer, spreading caliper and self-retracting tape measure. There exists a positive correlation between the stature and the inter-acromial length in both males and females combined ($p < 0.001$), which was highly significant. Our study also showed low degree of positive correlation in case of males & females measured separately. P- Value is highly significant ($p < 0.001$) in all the cases.

Key Words: Stature estimation; Inter-acromial length; Forensic anthropology; Regression equation

Introduction:

Establishment of individuality of an individual carries an immense importance in medico legal investigation in living as well as in dead. Identification is determination of the individuality of a person based on physical properties. [1] When the whole set of skeleton is available, the task is easy; but it becomes challenging when incomplete set of skeleton or only part of the body is available.

Such incomplete bodies are encountered in homicides [to conceal evidence], in railway accidents, plane crashes, bomb explosions, various mass disasters, etc. The estimation of sex, age and stature from the available material helps in identifying an individual. [2]

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The points usually noted for the purpose of identification are race, sex, age, complexion and features, hair, anthropometry, dactylography, foot prints, deformities, scars, tattoo marks, occupation marks, handwriting, clothes and personal articles, speech, voice, gait, ticks, manner, habit, mental power, memory, education, DNA profile and miscellaneous methods of identification. [3]

The branch of Forensic science that uses the data obtained from body parts and skeletons from the living or dead people for Forensic purposes are called “Forensic Anthropology”. [4] Height of a person increases progressively and becomes maximum at the age between 21-25 years. Later, for every 25 years, it is shortened by 2.5 cm due to thinning of intervertebral discs and some stooping posture as a result of decreased tone of muscles. [5]

Human stature has always been a symbol of an authority, physical prowess and dominance over other living beings. Stature or body height is an important factor in establishing the identity of a person especially in the skeletonized remains. The calculation of stature is based on the relative proportions of different body parts, both in relation to each other and in relation to the overall height of the individual.

In ancient times, physicians & surgeons like Charak & Sushruta were well acquainted with the relation of different parts of body with

height. According to Charak, the height of an average man should be 84 - *anguls*, thigh - 21 *anguls*, forearm - 15 *anguls* & arm -16 *anguls*. [6] "*Angul*" is a Sanskrit terminology for width of a finger except thumb, which was an easy and common way to get approximate measurement of lengths of various objects.

Although many formulae for stature estimation from long bones have been proposed, there is concern regarding the accuracy of the use of population specific formulae to people of different geographical regions. It is obvious that there are no universally applicable formulae for stature estimation from the length of long bones as the relationship between them is influenced by the race, sex and age of an individual. Thus, the need for race, age and sex specific stature estimation formulae is proved beyond doubt. [7]

There are two ways by which we can determine the height of an individual i.e. from cadaveric bones and in living subjects. The cadaveric estimation of height shows marked difference in findings when compared to the studies estimating heights in living subjects.

However, the studies estimating heights in cadavers do not represent a population. Also, cadavers are likely to have been lying in abnormal postures for long durations and it may not be possible to straighten the body to get accurate stature measurement. According to Mildred Trotter & Goldine C. Glesser there is an increase in height of 2.5 cm after death when measurement is taken in recumbent position. [8]

The height of an individual has changed from earlier times to the present. Pliny believed that mortals grow smaller and smaller, generation by generation. [9] This belief which derived apparently from old heroic mythology persisted tenaciously.

However, the contrary is the view of Krogman; who explicitly expressed in the introductory paragraph to 'Calculation of Stature' that "We are taller today than ever before". [10]

It is also necessary to have different formulae for the determination of stature from the measurement of different body parts, like cases in which only the fragmentary remnants are available (without even a single long bone) for identification.

Literature search revealed that only few studies have been published to find out formulae for estimation of stature without long bones. [11]

With this background a need was felt to conduct a study which can enlighten if there exists any correlation between stature and IAL and if so then any sexual variation in correlation of stature and IAL. This study also aim to derive linear regression formulae from correlation of stature and IAL and then to compare the correlation between stature and IAL with previous studies.

Material and Methods:

An observational study was conducted from Mar 2012-Feb 2013 in the Department of Forensic Medicine, Sumandeep Vidyapeeth, Vadodara, Gujarat, among the students and staff members after obtaining approval from institutional ethical committee.

A total of 300 subjects (150 males and 150 females) belonging to the age group 22 - 44 years were selected for the study.

The rationale behind selecting this age limit is that, by 22 years, all the epiphysis of shoulder joint including clavicles are fused; and normally no further growth is expected.

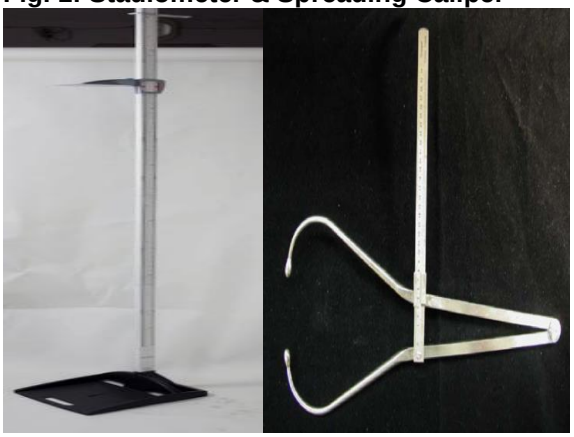
Furthermore, by 44 years the decrease in growth due to degenerative changes is not significant enough to affect the regression equation. [5] Apparently healthy Gujarati individuals in the age range of 22 - 44 years (Verified by School Leaving Certificate / Birth Certificate) and are willing to participate by giving valid consent were included in the study.

Those whose ethnicity is other than Gujarati and also those having grossly visible or previous history of injury leading to skeletal abnormality of spine long bones and upper trunk were excluded from the study.

Methodology:

Volunteers were explained the need and purpose of the study and were shared the relevant details of this research prior to participation. The stature and inter-acromial length of each subject were measured in centimeter with the help of a stadiometer (Fig.1), spreading caliper (Fig. 2) and self-retracting measuring tape.

Fig. 1: Stadiometer & Spreading Caliper

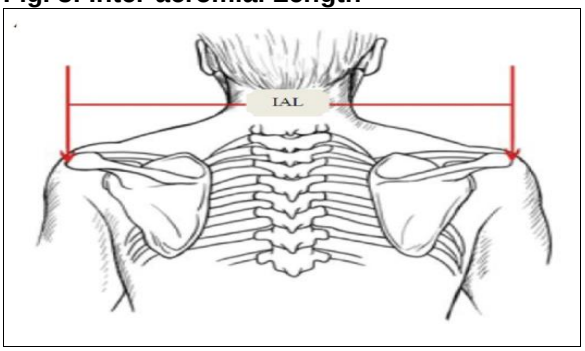


After taking consent and recording general particulars, the stature was measured

by making the subject stand straight on a horizontal resting plane bare footed with the head in the Frankfort plane, buttocks and heels pressed against the upright position of the instrument and the palms of the hands turned inwards and the fingers pointing downwards. Then the movable piece of the anthropometer was brought in contact with the vertex in the mid sagittal plane.

Similarly, inter-acromial length was measured with the person sitting in the erect position. Inter-acromial length is the distance between two bony landmarks, i.e. acromial process of scapula on each side. (Fig. 3)

Fig. 3: Inter-acromial Length



The participant was asked to sit erect with the arms hanging freely at the sides. The posture of the participant was checked from behind making sure that the shoulders are neither too far back nor forward, and that there is a noticeable curvature in the lower back.

Then the participant was requested to hold the breath for few seconds so that the lateral border of acromial process can be located by following the scapula out to the arm until it makes a sharp turn and marked on each shoulder. A blunt ended spreading caliper (pelvimeter) was gently placed between the thumb and forefinger, which allowed palpating the bony ridges with other fingers.

The arms of the spreading caliper were then placed directly on the skin next to the lateral border of each acromial process and pressure was applied to compress the soft tissue over the acromial processes without hurting the participant. The measurement was taken twice i.e., once with a spreading caliper and once with a self-retracting measuring tape.

Both the measurements were taken at a fixed time between 14:00 - 16:30 hours to eliminate discrepancies due to diurnal variation.

The linear regression equation formulae were evolved using statistical methods for the relationship between statures and inter-acromial lengths. The results were analyzed using statistical package SPSS version 20.0.

Results:

The maximum, minimum and average statures of different sexes along with their maximum, minimum and average inter-acromial lengths were calculated and tabulated. The linear regression formulae, standard errors and coefficient of co-relations of the above data were computed using statistical methods by presuming X as an independent variable and Y as dependent variable. "p" value is the probability role at 0.05 level of significance. For the purpose of the present study, a 'p' < 0.05 is considered significant; and 'p' > 0.05 is considered not-significant.

Regression equation:

$\Sigma y = Na + b\Sigma x$

$\Sigma xy = a \Sigma x + b \Sigma x^2$

Where Σ= Sum value,

y= Value of stature

N= Number of cases studied

x= Value of inter-acromial length

a= Unit greater than x value by y value

b= Regression coefficient

The maximum inter-acromial length in case if males and females combined was 48.9 cm; minimum was 30.0 cm, with a mean of 39.1 cm. (Table 1)

From the above equations, linear regression formulae, standard errors and co-efficient of correlations were developed to fulfill the aims and objectives of the study. After statistical analysis of the results, three linear regression equation formulae were obtained. (Table 2)

Discussion:

Male and female skeletons require different formulae, due to the difference in bodily proportions between the two sexes. For this reason, if an individual skeleton cannot be sexed, it is difficult to allocate an estimated height. A lot of researches had been done on stature estimation from long bones of extremities, but a little is known about stature from other body measurements.

Obviously, a little work has been reported from India on the use of statistical methods to calculate the stature from the inter-acromial length. The present study showed high degree of positive correlation in case of males and females combined (unknown sex) while it shows low degree of positive correlation in case of males & females separately. P- value is highly significant (i.e. p <0.001).

The males had longer inter-acromial lengths. Males tend to develop broader shoulder from puberty compared to the females, and this may be a reason for the higher inter-acromial

length. In this study, the standard errors came out to be ± 6 cm in males and ± 5 cm in females.

Therefore, there is no difference in the standard errors in case of males but there is difference of +1 cm in case of females as compared to the study conducted by Koulapur VV et al. [11] However, for females the standard error can be comparable to studies by Momonchand A et al, [12] but in case of males, the difference in standard errors is 2 cm.

In a study conducted by Koulapur VV et al the standard errors came out to be ± 6 cm (males) and ± 4 cm (females). [11] While in a study done by Momonchand A and Meera Devi T to determine the stature from inter-acromial length, the standard errors were ± 8 cm (males) and ± 5 cm (females). [12] There was a standard error of 6-8 cm for males and 4-5 cm for females between different regression equation formulae.

Ozaslan A. et al**,** conducted a study to estimate stature from bi-acromial and bi-iliocristal measurements on Turkish Population and concluded that the best correlation was observed in males for Bi-Acromial Breadth (r=0.42) and for females (r=0.26), but for Bi-Ilio-Cristal Breadth there was a very weak correlation in both males (r=0.21) and females (r=0.19).

When both variables were used together, it was detected that a small increase observed in stature of males (r=0.43). Standard error in males for Bi-Acromial Breadth (BAB) was ± 6.2 cm while for Bi-IlioCristal Breadth (BICB) it was ± 6.6 cm. In case of females standard errors came out to be ± 6.3 cm and ± 6.4 cm for BAB and BICB respectively. [13]

In present study, co-efficient of correlation r=0.59 in cases of males and females combined, in case of males r =0.31and in females r=0.23. Therefore, a similar coefficient of correlation has been found in case of females and standard errors in case of males of Indian Population and Turkish Population.

Stature varies at different times of the day by 1.5- 2 cm. It is less in the afternoon and evening due to reduced elasticity of the intervertebral discs and the longitudinal vertebral muscles. On an average the body lengthens after death by about 2 cm, due to complete loss of muscle tone, relaxation of large joints and loss of tensioning effect of para-spinal muscles on intervertebral discs. [5]

Therefore; in this study all the measurements were taken at a fixed time to avoid diurnal variations.

Conclusion:

This study will provide baseline information for stature estimation from inter-acromial length in Gujarati population of India. It could lead to the development of a standard data on various groups of population. In context of anthropology, comparison made with other population could contribute to understanding of the relative ethnic composition of our population. From a forensic point of view, the approximate height of an individual can be estimated if upper portion of the trunk is available without the long bones.

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Table 1: Sex-wise and combined Distribution of statures and inter-acromial Lengths (cm)

Characters	Males	Females	Combined (M+F)
Maximum Stature	186.0	171.2	186.3
Minimum Stature	141.0	139.5	139.5
Average Stature	169.3	155.9	162.6
Max. inter-acromial length	48.9	46.0	48.9
Mini. inter-acromial length	35.0	30.0	30.0
Avg. inter-acromial length	41.2	37.0	39.1

Table 2: Correlation between Stature (y) and Inter-acromial length (x)

Characters	Linear Regression Formulae	Standard Error	Coefficient of Correlation R / r	p-value
Males and Females combined	y=102.27+1.54x	± 7 cm	0.59	0.000
Males only	y= 140.01+ 0.71x	± 6 cm	0.31	0.000
Females only	y=137.31+ 0.50x	± 5 cm	0.23	0.000