Prediction of Stature from Metacarpal Length and Hand Length: A Digital Radiographic Study

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ABSTRACT

Introduction: Personal identification means establishment of individuality of a person. Stature estimation is one of the most important biological profiles used in identification of an individual. The dimensions of long bones, skull, foot, hand etc. have been successfully used for the determination of stature. The objective of this study was to assess the reliability of Metacarpal length and Hand length in determination of Stature**.**

Material and methods: A cross sectional sample of 100 patients belonging to south Indian population was randomly selected from patients who visited the Department of Oral Medicine and Radiology, M.R. Ambedkar Dental College after obtaining informed consent. Stature of the subjects was measured using a height chart ruler. Hand wrist radiographs of the left hand were obtained. 2nd, 3rd Metacarpal length and hand length were measured. The collected Data was subjected to logistic regression analysis.

Results: In males the mean value of 2nd,3rd Metacarpal length and hand length was 78.15mm, 75.56mm, 224.63mm respectively.The observed mean difference was statistically significant *P*<0.001.In females the mean values of 2nd,3rd Metacarpal length, Hand length was 74.10, 71.12, 210.23, respectively. The observed mean difference was statistically significant *P*< 0.001.

Conclusion: In the present study we found that 2nd, 3rd Metacarpal length and Hand length were reliable in prediction of Stature. We can there-fore recommend the radiographic measurements of 2nd, 3rd Metacarpal length and Hand length in the determination of Stature for personal identification in forensic science.

Keywords: Prediction of Stature, Metacarpal Length and Hand Length, Digital Radiographic Study

INTRODUCTION

Anthropometry is the branch of physical anthropology that studies the quantitative variations of human features such as Stature. In a forensic context, among the information potentially collected from human remains, estimated stature can be an important feature to be added to the criteria, helping to narrow the search from missing persons data. Personal identification is defined as establishing the identity of an individual. The need for personal identification arises in natural mass disasters like earth quakes, bomb blasts mass murders, and in cases when the body is highly decomposed or dismembered to deliberately conceal the identity of the individual.[1] The main attributes of biological identity are sex, age, Stature and ethnic background of the individual which are also called the 'Big four' in forensic context. Stature estimation is also an important part of personal identification.[2] Due to the allometric relationship of the body parts with one another, stature can be estimated from almost all the bones of the skeleton. Stature reconstruction from skeletal remains forms part of the forensic anthropological analysis for the purpose of identification of the individual. Stature has a definite and proportional biological relationship with each and every part of the human body, i.e. extremities, vertebral column, head, face, trunk. Human stature is a quantitative trait affected by genetics and environmental factors. Stature (height) estimation plays an important role in the identification of deceased persons from a few body parts, such as feet, hands, and arms, especially when stature cannot be measured directly due to body parts being dismembered. This relationship can help to calculate Stature from dismembered and mutilated body parts in forensic examination. The dimensions of long bones, skull, foot, hand etc. have been successfully used for determination of Stature.[2]

Dentomaxillofacial radiology plays a important role in dentistry to reveal craniofacial growth of an individual. Growth prediction can be assessed using physiological parameters such as peak growth velocity in standing height, pubertal markers, dental development, and radiological analysis of skeletal maturation. While physiological markers do not allow precise growth prediction, evaluation of skeletal maturity with the help of radiographs is considered to be more reliable approach. Fishman introduced the skeletal maturation index for the assessment of skeletal growth based on the maturation of hand and wrist bones. The hand wrist area is made up of numerous small bones. These bones show predictable and scheduled pattern of appearance, ossification and union from birth to maturity. The hand wrist bones are one part of skeleton that resists all environmental insult for maximum time and thus, can be a valuable tool in personal identification. Hand wrist radiography is commonly used for determination of skeletal

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maturation due to the presence of various bones in this area.[5]

With this background the present research was done to study the correlation between the Metacarpal length, Hand length, and stature using Hand Wrist Radiograph with the objectives to measure the Stature of the subjects, to measure the Metacarpal length, Hand length on hand wrist radiographs, to establish correlation between Stature and 2nd, 3rd Metacarpal length, Hand length on hand wrist radiographs and to assess the reliability of Metacarpal length and Hand length in determination of Stature.

MATERIAL AND METHODS

In this study a cross sectional sample of 100 individuals consisting of 50 males and 50 females in the age group of 18-25years belonging to the South Indian population were selected from patients who reported to the Department of Oral Medicine and Radiology, M.R. Ambedkar Dental College and Hospital, Bangalore.

A detailed case history was recorded and informed consent was obtained.

Inclusion Criteria

100 healthy individuals in the age range of 18-25 years of both the genders

Exclusion Criteria

1. Patients with developmental disorders or syndromes.
2. Patient with bone related disorders, injury, amputation or previous history of surgery of left hand.

Methodology

Stature Measurement

The subjects were made to stand in an erect posture against a wall without any head wear and foot wear. The feet axis was parallel or slightly divergent and head was in Frankfort Horizontal plane with a ruler placed on the point vertex and stature was measured using a height chart ruler.

Metacarpal length and Hand length Measurement

Hand wrist radiographs of the left hand were obtained using KODAK - 8000C Panoramic and Cephalometric System following radiation protection protocol.

Radiographic measurement of 2nd and 3rd Metacarpal length were measured from most protuberant point of 2nd and 3rd Metacarpal to the midpoint of line in the carpo-metacarpal space.

- Radiographic measurement of Hand length was measured from distance between the midpoint of the line connecting the distal styloid points of radius, ulna and foremost point of the middle finger. Measurements on hand wrist radiographs were done using Windows Trophy Dicom Software

STATISTICAL ANALYSIS

The data collected was subjected to linear regression analysis and multiple linear regression analysis.

RESULTS

2nd, 3rd Metacarpal length and Hand length was found to be a significant predictor of Height in males and females (P<0.001) and is able to explain 39.0%, 56.0% and 19.9% of the variation in Stature (R^2=0.086, 0.183, 0.152) respectively. Correlation was observed between Stature and 2nd, 3rd Metacarpal length, Hand length in the total sample, which was statistically significant (P-value < 0.001) (table-1).

2nd, 3rd Metacarpal length and Hand length was found to be a highly significant predictor of Stature (P<0.001) and is able to explain 46.1%, 48.7%, 22.4%, of the variation in

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	133.590	0.390	0.128	0.003*	0.136	0.644	0.086
3rd Metacarpal (mm)	122.224	0.560	0.120	<0.001*	0.322	0.798	0.183
Length of Hand (mm)	120.013	0.199	0.047	<0.001*	0.107	0.291	0.157
* Denotes significant parameter.							

Table-1: Prediction of Stature using Metacarpal Length, Hand length in the Total sample -(linear regression)

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	163.578	0.040	0.210	0.849	-0.382	0.462	0.041
3rd Metacarpal (mm)	140.240	0.350	0.201	0.087	-0.053	0.754	0.060
Length of Hand (mm)	145.929	0.093	0.074	0.218	-0.056	0.241	0.031
Does not denote significant parameter.							

Table-2: Prediction of Stature using Metacarpal Length, Hand length in males

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	123.462	0.461	0.111	<0.001*	0.269	0.741	0.291
3rd Metacarpal (mm)	125.216	0.487	0.114	<0.001*	0.258	0.717	0.275
Length of Hand (mm)	112.797	0.224	0.059	<0.001*	0.105	0.343	
*Denotes significant correlation.							

Table-3: Prediction of Stature using Metacarpal Length, Hand length in females

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2 (Adj)
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	121.781	-0.757	0.287	0.010*	-1.327	-0.187	0.217
3rd Metacarpal (mm)		0.808	0.269	0.003*	0.273	1.343	
Length of Hand (mm)		0.183	0.100	0.070	-0.015	0.382	
Denotes significant parameter							

Table-4: Prediction of Stature from Metacarpal Length, Hand length in the total sample- (Multiple linear regression)

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2 (Adj)
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	150.970	-1.930	0.490	<0.001*	-2.917	-0.943	0.255
3rd Metacarpal (mm)		1.525	0.441	0.001*	0.636	2.413	
Length of Hand (mm)		0.229	0.154	0.144	-0.081	0.538	
Denotes a significant parameter							

Table-5: Prediction of Stature from Metacarpal Length, Hand length in MALES

Parameter	Constant	β	SE of β	P-Value	95% CI for β		R^2 (Adj)
					Lower Bound	Upper Bound	
2nd Metacarpal (mm)	119.417	0.292	0.217	0.186	-0.146	0.729	0.270
3rd Metacarpal (mm)		0.229	0.204	0.267	-0.181	0.640	
Length of Hand (mm)		0.012	0.106	0.910	-0.201	0.225	
Does not denote any significant parameter							

Table-6: Prediction of Stature from Metacarpal Length, Hand length in Females

length (R^2=0.291, 0.275,0.230) respectively. Correlation was observed in females between Stature and 2nd, 3rd Metacarpal and Hand length, which was highly significant statistically (*P*-value <0.001) (table 2,3).

2nd and 3rd Metacarpal length was found to be a significant predictor of Height in males and females (*P*<0.001) and is able to explain 75.7% and, 80.8% of the variation in length (R^2=0.217) respectively. Correlation was observed between Stature and 2nd, 3rd Metacarpal length in the total sample, which was highly significant statistically (*P*-value < 0.001). No correlation was observed between Stature and Hand length (table-4).

Correlation was observed between Stature and 2nd, 3rd Metacarpal length, which was highly significant statistically(*P*-value < 0.001) (table-5).

Formula for total sample using metacarpals and hand length

In total sample using individual parameter
(Statistical Method: Linear Regression)

HEIGHT=133.590+0.390 X 2nd Metacarpal
HEIGHT=122.224+0.560X 3rd Metacarpal
HEIGHT=120.013+0.199 X Hand length

In total sample using all three parameters:
(Statistical Method: Multiple Linear Regression)

HEIGHT=121.781-0.757 X 2nd Metacarpal length+ 0.808 x 3rd Metacarpal+0.183 x Hand Length.

DISCUSSION

In forensic practice, accurate determination of stature is important and frequently used parameter in the identification of unknown and comingled human remains. Along with sex, age and race, stature is one of the biological entities that can be estimated from skeleton long bones after death of the individual. Studies have shown that stature can be estimated from length of long bones, bone fragments, spine, hand foot dimensions, metacarpal and metatarsal length, scapula and skull. Estimation of living stature from various body parts is considered as an important tool in personal identification. There are various ways to estimate stature from long bones but the easiest and the reliable method is regression analysis. The obvious advantage of this method is that a single bone can be used to estimate the stature of individual, whereas the main disadvantage is that regression formulae are required for different populations, different bone and also separately for sex. This is because variation in body proportions exists, making these formulae population and stature specific.[6-10]

Stature estimation equations are most accurate when derived from one population and then applied to the same population. This is because proportions from one population are not

necessarily the same as those from another.[11-14]

Owing to the paucity of literatures concerning this point in south Indians, the present study was undertaken to estimate stature from metacarpal and hand length using hand wrist radiographs.

In the present study mean stature values in males 166.71cms where as in females is 159.88 cms. Higher mean stature value was recorded in males compared to females. The difference was found to be statistically significant (P<0.001). This finding was in agreement with the study conducted by Patil and Mody et.al, Krishna K et.al, where the authors found stature values to be higher in males when compared with females.[2,15] Stature is an inherent characteristic and males are constitutionally taller than females. An association of Y chromosome with stature has been documented. In addition, age of puberty being 2 years later in males as compared to females gives them extra time for growth. Besides less estrogen from testosterone permits them to grow for longer period of time in males when compared to females

Significant Correlation was observed between Stature and 2nd, 3rd Metacarpal length and Hand length in total sample and in females using *Linear regression analysis*. Significant Correlation was observed between Stature and 2nd, 3rd Metacarpal length in total sample and in males using *Multiple linear regression analysis.*

This finding was in accordance with the study conducted by Musgrave et al (1978) in England male population which showed the estimation of Stature from Metacarpal length and Hand length clinically.[7]

A similar study was conducted by Kimura K(1991) who found a significant correlation between Stature, and 2nd Metacarpal length and Hand length in left hand which showed higher significance for 2nd metacarpal than Hand length with larger significance in males than females clinically.[11,12]

This finding was in concordance with the study conducted by Ozaslan et al. who established a regression formula and estimated height from 2nd Metacarpal length in 184 males `1`and had a positive as well as a statistically significant correlation with the stature radiographically.[8] In our present study we derived a separate regression equation to estimate Stature from 2nd, 3rd Metacarpal length and Hand length radiographically for South Indian population in both males and females.

This could be due to the proportion of the human hand, i.e., the length relationships between metacarpals and stature is known to differ between males and females. It has been historically known that males tends to have shorter second but longer four digits than females.[16] The precision of Stature determination can be increased if other variables can be added. Since variations in Stature prevail in various ethnic groups, individual population based formulae must be deduced for application in different races.

CONCLUSION

Skeletal bones are hard stable structures not easily decomposed as other body structures and survive even disastrous environmental conditions and make good material in living and non living population for forensic investigations. In the present study we found that 2nd, 3rd Metacarpal length and Hand length were reliable in prediction of Stature. We can there-fore recommend the radiographic measurements of 2nd, 3rd Metacarpal length and Hand length in the determination of Stature for personal identification in forensic science.

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