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Stature Estimation from the Length of Phalanges of Little Fingers in Mangaluru Population

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Abstract

The aim of the study was to determine whether there is any correlation between the height and the different length of phalanges of little fingers in Mangaluru population and to determine sex using the formula found for this correlation. This study was conducted by taking 50 males and 50 females of Mangaluru population who were living in Mangaluru for the past 2 generations as participants. The height and different length of phalanges of little fingers were measured using stadiometer and vernier calipers. Regression formula was derived, and a significant correlation was found between different length of phalanges of little finger and stature of an individual.

Introduction

Forensic anthropology is the application of the anatomical science in a legal setting. In cases like plane crash, natural calamities anthropology helps to identify the bodies found by studying them. Anthropology determines the age, sex, ethnicity, height etc of an individual by using the structure of the body or by studying the skeleton found. Forensic anthropologists study and analyze the human remains in crime investigations. It is also known as study of humans. There are three sections in Forensic anthropology. They are Forensic Osteology, Forensic Archeology, and Forensic Taphonomy. Forensic Osteology is the study of the skeleton. Forensic Archeology involves the controlled collection of human remains. Forensic Taphonomy implicates the study of decomposition and environmental effects on changes to the body after death. Physical anthropology is sub discipline of anthropology which is the study of physical characteristics and the non-biological characteristics of human beings [1].

The examination of human skeletal remains may help in identifying the human remains and estimated time since death. One of the important factors in identifying an individual living or dead is stature estimation. When the whole body is present it is easy to identify the individual by stature estimation, whereas presence of only the part of body makes it difficult for forensic anthropologists. Forensic anthropologists apply standard scientific techniques developed in physical anthropology to identify human remains and to assist in the detection of crime. Forensic anthropologists work with law enforcement agencies and assist in processing skeletal evidence [2-5].

Stature is one of the most important parameters in the identification of an individual, living or dead. When intact bodies are to be examined, stature estimation does not pose any problem. But when dismembered human body parts are the materials to work with, it is of an even greater challenge for the forensic anthropologists. When dealing with human remain, estimating living stature can also help to identify an unknown individual because there is a close relationship between the body parts dimensions and height. The phalanges are digital bones in the hands and feet of most vertebrates. In primates, the thumbs and big toes have two phalanges while the other digits have three phalanges. They are, Distal, Intermediate, Proximal phalanges. The distal phalanges are the fingertips. Each intermediate phalanx connects to a proximal and distal phalanx. This middle phalanx has two joints and allows the finger to bend in two places. Proximal phalanges are the last phalanges which are attached to the palm [6].

Estimation of stature in living persons will help criminal justice system to solve cases. The present study was conducted

to obtain stature estimation from length of phalanges of little fingers in Mangaluru population.

Research Question

a. Is there a correlation between height of individuals and length of phalanges of little fingers?

b. Can sex be identified based on stature height and length of phalanges of little fingers?

Objectives of the study

I. To derive a formula for the estimation of stature from the length of phalanges of right and left little fingers.

II. To assess sex determination based on derivation of stature estimation from the length of phalanges of right and left little fingers [7-10].

Methodology

For the purpose of the study 50 male and 50 female participants were selected who has settled in Mangaluru from the past two generations. The study was conducted to estimate the stature from the length of phalanges of right and left little fingers. Age above 21 years was chosen for the reason that by this age nearly all secondary centers fuse with the respective shafts. Participants who are healthy individuals were taken for the study and exclusion criteria was the subjects having significant diseases, congenitally malformed limbs, metabolic disorders and developmental defects; deformities to reduce error in result. Cross sectional study design was employed for this study.

Stadiometer and Vernier Calipers were the main tools used for the study. Also, the participant information sheet with personal details like place, age, sex, name, height and phalanges of little finger measurements was used for data collection by the researcher for the purpose of collecting data from the participants along with consent forms [11-13].

Stature Measurement using Stadiometer

The vertical distance from the vertex to the foot was measured in centimeters. The participants were instructed to stand straight - bare footed on a horizontal resting plane of the stadiometer. They also initiated to turn both the palms of hand inward and fingers horizontally pointing downwards, and head oriented in Frankfurt Plane. The mobile phase of stadiometer was brought in contact with vertex in the mid sagittal plane. Measurement of Right and Left Little Finger Length using Vernier Caliper: To measure the length of phalanges of little finger, the participants were asked to place the hands on a flat table, palms of hand were turned outwards and fingers horizontally pointing downwards Figure 1.

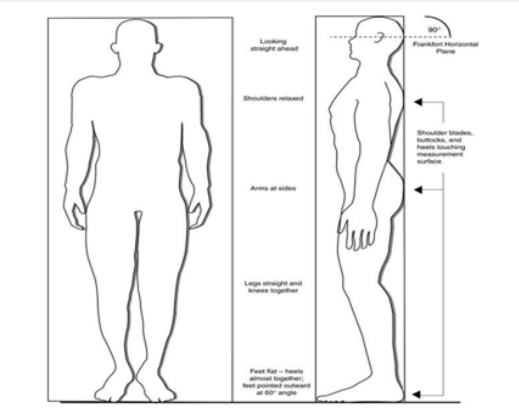

Figure 1: The movable rod of the stadiometer is brought in contact with vertex in the mid sagittal plane.

Measurement of Distal phalange length of little finger:

The distance between the tip of the little finger and the middle of distal phalangeal crease was recorded using a Vernier caliper.

Measurement of Intermediate phalange length of little finger

The distance between the middle of distal phalangeal crease and the proximal phalangeal crease was recorded using a Vernier caliper.

Measurement of Distal phalange length of little finger

The distance between the proximal phalangeal crease and the metacarpophalangeal crease was recorded using a Vernier caliper. Same procedure is followed for both the hands. Statistical techniques used for the research are:

1. Correlation (Pearson's Correlation)
2. Linear Regression (Stature Height using Length of phalanges of Right and Left Little Finger)
3. Discriminant Analysis for Sex Determination

Observation and Result

Here we observe that there is no significant difference between right and left phalanges - distal, intermediate and proximal with t (99) = -0.551, p=0.583, t (99) =-2.757, p=0.051 and t (99) = 0.292, p = 0.771 respectively.

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Here we observe that there is significant positive correlation between the height and length of phalanges with p<0.001. The R value represents the multiple correlation coefficients. R can be considered to be one measure of the quality of the prediction of the dependent variable; here R=0.860 indicates a good level of prediction Table 1. The R2 value (also called the coefficient of determination), which is the proportion of variance in the dependent variable that can be explained by the independent variables [14].

Table 1: Comparison of length of phalanges between right and left hand using paired t-test.

Length of Phalanges (cms)	Right	Left	Paired Samples Test	
			t statistic	p-value
Distal	2.21±0.19	2.19±0.20	T (99) =0.551	0.583
Intermediate	1.59±0.20	1.63±0.19	T (99)=-2.757	0.051
Proximal	1.78±0.23	1.77±0.20	T (99) =0.292	0.771

You can see from our value of 0.739 that our independent variables explain 73.9% of the variability of our dependent variable, height. The F-ratio in the ANOVA table tests whether the overall regression model is a good fit for the data. The Table 2 shows that the independent variables statistically significantly predict the dependent variable, F (4, 95) = 67.402, p <<0.001. i.e., the regression model is a good fit of the data. Estimated model coefficients for predicting height using length of phalanges and gender: Predicted Height = 126.755 +9.945*(length of distal) + 13.188 * (length of intermediate) - 0.931 * (length of proximal) - 10.386 * (Gender) Figure 2.

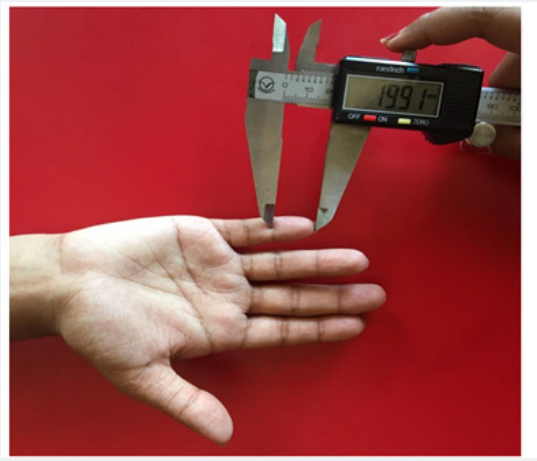

Figure 2: Vernier caliper used to measure the length of phalange of little finger; hand placed on the plane surface, palm of the hand facing upwards.

Table 2: Correlating height with length of phalanges using Pearson Correlation coefficient.

Pearson Correlation coefficient	Length of Distal(cms)	Length of Intermediate(cms)	Length of Proximal (cms)
r- value	0.701	0.634	0.452
p-value	<0.001	<0.001	<0.001

Here we observe that, independent variables like length of distal, length of intermediate and gender are significant (p<0.05) which indicates these independent variables added significantly to the prediction of height. Estimated model coefficients for predicting height using length of phalanges and gender: Predicted Height = 126.755 +9.945*(length of distal) + 13.188 * (length of intermediate) - 0.931 * (length of proximal) - 10.386 * (Gender) Here we observe that, independent variables like length of distal, length of intermediate and gender are significant (p<0.05) which indicates these independent variables added significantly to the prediction of height. This multivariate test is a goodness of fit statistic, since p <0.001, we can say that the model is a good fit for the data [15].

The standardized discriminant function coefficients in the Table 3 indicate the relative importance of the independent variables in predicting the dependent. They allow you to compare variables measured on different scales. Coefficients with large absolute values correspond to variables with greater discriminating ability. Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function.

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Table 3: Multiple linear Regression.

Model Summary[b]				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.860a	0.739	0.728	4.9944

a. Dependent Variable: Height (cms)

b. Predictors: (Constant), Right Proximal (cms)G

c. Right Intermediate (cms), Right Distal (cms)

Structure matrix represents the correlations between the observed variables and the dimensions created with the unobserved discriminant functions. Canonical Discriminant Function Coefficients are used to construct the actual prediction equation which can be used to classify new cases. Discriminant Function is DF= -28.956 + 0.156 * (height) + 2.028 * (length of distal) - 1.453 * (length of intermediate) + 0.739 * (length of proximal) Centroids are the mean discriminant scores for each group. This Table 4 is used to establish the cutting point for classifying cases. If the two groups are of equal size, the best cutting point is halfway between the values of the functions at group centroids

Table 4: ANOVA.

Model		Sum of Squares	df	Mean Square
1	Regression	6725.148	4	1681.287
	Residual	2369.712	95	24.944
	Total	9094.86	99	

a. Dependent Variable: Height (cms)

b. Predictors: (Constant), Right Proximal (cms), G

c. Right Intermediate (cms), Right Distal (cms)

Cut Score = (1.1372+ (-1.1372)) / 2 = 0.

If an individual person's score on the DF (calculated by plugging in their scores to the DF equation we wrote out above) is above 0, then they were probably the females. If their DF score is below 0, then they were probably the males. This Table 5 is used to assess how well the discriminant function works, and if it works equally well for each group of the dependent variable. Here it correctly classifies more than 94% of the cases in males and 90% in females. Overall, 92% of the cases are correctly classified. After cross validation (using leave one out method) overall accuracy is 90% Table 6.

Table 5: Estimated model coefficients for prediction.

Model B		Unstandardized Coefficients			t	p-value
		Std. Error	Beta			
1	(Constant)	126.755	8.339		15.201	<0.001
	G	-10.386	1.334	-0.545	-7.785	<0.001
	Right Distal(cms)	9.945	3.677	0.202	2.705	0.008
	Right Intermediate(cms)	13.188	3.532	0.276	3.734	<0.001
	Right Proximal(cms)	-0.931	2.796	-0.022	-0.333	0.74

Note: Gender: 0 is male and 1 is female.

Table 6: Residuals Statistics.

	Minimum	Maximum	Mean	Std. Deviation
Stature (cms)	146	182	162.92	9.5847
Predicted Stature (cms)	146.395	175.882	162.92	8.242

a. Dependent Variable: Height(cms)

Discussion

In the study 'Estimation of Stature from Finger Length' conducted by Pooja Ahuja et al in the year 2018, it was carried out on a cross sectional sample of 200 adult students out of which 100 were males and 100 were females of 18-25 age groups. The data collected from 100 males and 100 females were statistically analyzed using the SPSS software. The correlation between the stature and the fingers length was done along

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with the regression equation. In the present study we have undertaken 100 adult populations, out of which 50 were males and 50 were females. A positive correlation for both males and females was obtained for the estimation of the stature from the different length of phalanges of little finger Table 7.

Table 7: Comparison of length of phalanges between males and female using independent t-test

Group Statistics.

	G	N	Mean±SD	t- statistic	p-value
Height (cms)	Male	50	170.51±5.56	T (98) = 13.013	<0.001
	Female	50	155.33±6.09		
Length of Distal(cms)	Male	50	2.32±0.14	T (98) =8.359	<0.001
	Female	50	2.07±0.16		
Length of Intermediate(cms)	Male	50	1.69±0.16	T (98) =5.295	<0.001
	Female	50	1.50±0.19		

Another study conducted by Jaydip Sen et al on "Estimation of stature from lengths of index and ring fingers in a North-eastern Indian population" in the year 2013. Mean Stature, index finger length and ring finger lengths were found to be significantly longer in the males than the females. The present study also observed more mean stature and different phalange length in males than in females [16-17].

The study conducted by Renu Kamal & Praveen Kumar Yadav is 'Estimation of stature from different anthropometric measurements in Kori population of North India' in the year 2016. In totality, eight bone dimensions including stature, total arm length, length of the middle finger, knee length, foot length, foot breadth, maximum head length and maximum head breadth have been recorded. In the present study, different phalange length of both left and right little fingers were taken for estimating the stature of an individual Table 8.

"Estimation of sex from index and ring finger in a North Indian population" by Kewal Krishan et al. showed that significant sex differences exist in the length of index and ring finger ratio in an endogamous North Indian population. "Index and ring finger ratio -A new sex determinant in south Indian population" conducted by Tanuj Kanchan, Pradeep Kumar, Ritesh G. Menezes in the year 2008, investigated sexual dimorphism of the index and ring finger ratio. The index and ring finger ratio is found to be higher in females. The present study also showed that there is a significant sex difference exists in Mangaluru population Table 9.

Table 8: Discriminant Analysis.

Function	Eigen value	% of Variance	Cumulative %	Canonical Correlation
1	1.922a	100	100	0.811

a. First 1 canonical discriminant functions were used in the analysis.

Table 9: Standardized Canonical Discriminant Function Coefficients.

Wilks' Lambda					
Test of Function(s)		Wilks' Lambda	Chi-square	df	Sig.
1		0.342	102.926	4	<0.001
	Function				
	1				
Height(cms)	0.913				
Right Distal(cms)	0.303				
Right Intermediate(cms)	-0.258				
Right Proximal(cms)	0.157				

In the year 2015 a study 'Estimation of Sex from Index and Ring Finger Lengths in An Indigenous Population of Eastern India' was conducted by Jaydip Sen et al. The results indicate that Index Finger Length (IFL) and Ring Finger Length (RFL) of both hands were significantly longer in males as compared to females. The ring finger was longer than the index finger in both sexes. The study successfully highlights the existence of sex differences in IFL and RFL ($p<0.05$). In the current study the different length of phalanges of little finger in male was longer than in females, which says there is a major difference in male and female little fingers length Table 10.

Another study 'Estimation of stature from index and ring finger length in Davangere district' by G.M. Raju et al in the year 2014, A moderate correlation was observed between

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index and ring finger length of right hand and calculated height of an individual which is statistically highly significant. In this present study stature was estimated from the different length of phalanges of little finger was found to be statistically highly significant ($p<0.001$) Table 11.

Table 10: Structure Matrix.

	Function
	1
Height(cms)	0.948
Right Distal(cms)	0.609
Right Intermediate(cms)	0.386
Right Proximal(cms)	0.315

Table 11: Canonical Discriminant Function Coefficients.

	Function
	1
Height(cms)	0.156
Right Distal(cms)	2.028
Right Intermediate(cms)	-1.453
Right Proximal(cms)	0.739
(Constant)	-28.956

Unstandardized coefficients.

"Estimation of co-relation between middle finger length & stature of females in South Indian population" was conducted by Shivakumar AH, Vijaynath V, Raju G M in the year 2011. The study was an attempt to examine the relationship between the statures of middle finger length of 100 females of Karnataka, in south Indian population in age ranging from 17 to 19 years. In the current study we have taken both males and females aged above 21 years to get accurate result Table 12.

Table 12: Functions at Group Centroids.

G	Function
	1
Male	1.372
Female	-1.372

Unstandardized canonical discriminant functions evaluated at group means.

Conclusion

Significant correlation was found between the length of little finger and stature of an individual. A formula for estimating the approximate stature of a person through length of phalanges of little fingers and sex was derived which is as follows Predicted Height = 126.755 + 9.945 * (length of distal) + 13.188 * (length of intermediate) - 0.931 * (length of proximal) - 10.386 * (Gender) The Discriminant Function is: DF= -28.956 + 0.156 * (height) + 2.028 * (length of distal) - 1.453 * (length of intermediate) + 0.739 * (length of proximal) It correctly classifies more than 94% of the cases in males and 90% in females. Overall, 90% of the cases are correctly classified Table 13.

Table 13: Classification Results.

G MalFemale			Predicted Group Membership		Total
Original	Count	Male	47	3	50
		Female	5	45	50
	%	Male	94	6	100
		Female	10	90	100
Cross-validatedb	Count	Male	46	4	50
		Female	6	44	50
	%	Male	92	8	100
		Female	12	88	100

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a. 92% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c. 90% of cross-validated grouped cases correctly classified.

Suggestions

Various other parameters can be used for stature estimation like the arm and forearm length, foot and palm length etc. The study can be extended to people belonging to different races, particular community like fisherman community specially in coastal areas because of its Forensic importance, tribal community etc.

References

1. Aboul Hagag KE, Mohamed SA, Hilal MA, Mohamed EA (2011) Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians. Egyptian Journal of Forensic Sciences 1(2): 80-86.
2. Agrawal J, Raichandani L, Kataria SK, Raichandani S (2013) Estimation of stature from hand length and length of phalanges. Journal of Evolution of Medical and Dental Sciences 2(50): 9651-9656.
3. Ahuja P, Manve P, Christal G, Dahiya MS (2018) Estimation of Stature from Finger Length. Journal of Forensic Sciences and Criminal Investigation 7(2).
4. Buchner A (1985) The identification of Human remains. Int Dent J35(4): 307-311.
5. Didia BC, Nduka EC, Adele O (2009) Stature Estimation Formulae for Nigerians. J Forensic Sci 54(1): 20-21.
6. Habib SR, Kamal NN (2009) Stature estimation from hand and phalanges lengths of Egyptians. J Forensic Leg Med 17(3): 156-160.
7. Kamal R, Yadav PK (2016) Estimation of stature from different anthropometric measurements in Kori population of North India. J Forensic Leg Med 6(4): 468-477.
8. Kanchan T, Kumar GP, Menezes RG (2008) Index and ring finger ratio A new sex determinant in south Indian population. Forensic Sci Int 181(1-3): 1-53.
9. Komar DA, Buikstra JE (2008) Forensic Anthropology: Contemporary Theory and Practice. Oxford University Press, USA.
10. Krishan K, Kanchan T, Asha N (2012) Estimation of stature from index and ring finger length in a North Indian adolescent population. J Forensic Leg Med19(5): 285-290.
11. Raju GM, Shahina Dubey S, Vijayanath V (2014) Estimation of stature from index and ring finger length in Davangere district. International Journal of Clinical Trials 1(1): 18-21.
12. Rastogi P, Nagesh KR, Yoganarasimha K (2008) Estimation of stature from hand dimensions of north and south Indians. Leg Med 10(4): 185-189.
13. Sen J, Kanchan T, Ghosh A, Mondal N, Krishnan K (2014) Estimation of stature from lengths of index and ring fingers in a North-eastern Indian population. J Forensic Leg Med 22: 10-15.
14. Sen J, Kanchan T, Ghosh A, Mondal N, Krishan K (2015) Estimation of Sex from Index and Ring Finger Lengths in An Indigenous Population of Eastern India. J Clin Diagn Res 9(11): 1-5.
15. Shivakumar AH, Vijaynath V, Raju GM (2011) Estimation of co-relation between middle finger length & stature of females in South Indian population. Indian Journal of Forensic Medicine & Toxicology 5(1): 75-76.
16. Suseelamma D, Gayathri P, Deepthi S, Mohan CM, Kumar UM, Amarnath (2014) Study of Correlation between Stature and Length of Fingers. Scholars Journal of Applied Medical Sciences 2(2D): 773-784.
17. Verghese, Annie J, B MBalraj, GN Pramod Kumar (2010) A study of estimation of stature from length of fingers in Mysore, Indian Journal of Forensic Medicine Toxicology 4(2): 12-13.

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