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Estimation of Stature from the Length of the Right Index Finger in a Population in an Area in Dakshina Kannada and Sexual Dimorphism Exhibited

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Introduction

One of the most important aspects of forensic investigation is identification of the individual. Stature forms an important data in identification. Stature estimation becomes difficult when only some part of the body is available. Many factors like racial, ethnic and nutritional factors play an important role in the human development and growth. Estimation of stature from the length of fingers has been done by only very few anatomists and hence this study is quite useful [1]. Identification of human beings is mostly done by comparison with the accessible records. For this, osteological or dental examination can be used. Identification is done by assessment of age and sex of deceased in forensic examinations. In the study "Estimation of stature from lengths of index and ring fingers in a North Eastern Indian population", it has been explored how the index and ring finger lengths can be used to estimate stature [2-4].

Stature, age, sex, and ancestry will help to narrow down the pool of victim matches in forensic investigations. The relationship between different body parts can help a forensic scientist to calculate stature from mutilated and dismembered body parts in forensic examinations. This is important in events of murders, accidents or natural disasters. Stature can be estimated from feet or foot prints, imprints of the hand or from a shoe left at the scene of a crime. In putrefied, mutilated and extensively charred bodies it is impossible to get results with conventional indicators and routine methods of identification. In some cases, only mutilated and fragmentary remains are available due to mass disasters. Every body part has a more or less constant relationship with stature. The study "Estimation of stature from index and ring finger length in Davangere district" is helpful in conditions in which only hand or part of hand is available.

Anthropometry can help in identification of age, sex, ethnicity and stature of a person. There is an established relationship between stature and different parts of the body. Many studies have found a positive correlation between stature and hand dimensions. The formula for stature estimation has to be population specific [5]. Forensic pathologist aims at the identification of unknown cadavers by constructing a biological profile from their skeletal remains. The determination of sex from the measurement of long bones was focussed by many researchers. The aim of the study titled "A model for stature estimation and sex prediction using percutaneous ulnar and radial lengths in autopsied adult Egyptians" by Issa et al. was to formulate a model for stature construction and sex prediction from the maximal radial and ulnar lengths in adult Egyptians. Adult Egyptian cadavers were studied and statistically analyzed. 122 cadavers were used for analysis. The accuracy of both radial and ulnar measurements in sex determination was 98%, while it was 97.5% and 92.3% in case where radial and ulnar lengths were used alone [6].

Estimation of sex is an important aspect of forensic identification. The study "Estimation of Sex from Index and Ring Finger Lengths in An Indigenous Population of Eastern India" by Sen [2]. was conducted with an aim to estimate sex from index and ring finger lengths of adult individuals belonging to an indigenous population of eastern India. There were 500 participants belonging to the 'Rajbanshi' population in the study. The index and ring finger lengths of both hands were longer in males. This study proved that sex estimation from index and ring finger lengths can be useful when more reliable means are not available during medicolegal investigations [7].

Sex determination from human comingled remains was studied in "Sex determination from hand dimensions and index/ring finger length ratio in North Saudi population: Medico-legal view" by Marhrous. aimed at the determination of sex from hand dimensions which are human comingled remains. 600

volunteers were selected and hand length, hand breadth, hand index, index and ring finger lengths were estimated. The average hand length, hand breadth and index were 1.3, 0.96 and 2.93 cm greater in males than females respectively with no significant difference in both right and left hands. The index and ring finger ratios were found to be higher in females than males. Thus the anthropometric measurements of hand provide a reliable source of identification when a hand is detected at the scene of mass disaster and criminal situations [8].

The study "Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians" by Khaled. was done to find a method to determine sex by hand dimensions and index and ring finger length ratio in Upper Egyptians. Hand length breadth and index as well as index and ring finger ratio were estimated for 500 students. The average hand length was found to be 1.3 cm greater in males than females. Hand index less than or equal to 40.55 suggests females. Index and ring finger ratios were found to be higher in females. This study may prove useful in cases where an isolated hand is subjected for medicolegal examination [9]. "Estimation of sex from index and ring finger in a North Indian population" by Kewal. explores the possibility of estimation of sex from length of index and ring finger ratio in 140 individuals. The results of this study showed significant sex differences in Index Finger Length, Ring Finger Length and the index and ring finger ratio. Ring finger length is a better indicator of sex than index finger length. It was also understood from the study that index and ring ratio should not be employed in estimation of sex in forensic casework due to considerable overlap in male and female values [10].

"Determination of sex from Index and Ring finger ratio in neonates" by Manohar et al. aimed at evaluating sexual dimorphism of index and ring finger in neonates. 60 neonates were taken for the study. The 2D:4D ratios were found higher in female neonates than males and appear sexually dimorphic. A ratio of 0.93 or more suggests female neonate according to this study [11]. The study "Digit ratio (2D:4D)-An anthropometric marker for sexual dimorphism in J&K population" by Mudasir. Aimed at determining sex from the 2D:4D ratio of adult individuals of Jammu and Kashmir region. 200 medical students were selected for the study. It was found that males have longer index and ring finger length than females. 2D:4D ratio of more than 0.975 suggests female sex for both the hands. This study is useful when only the hand is available for medicolegal examination [12].

Research Question

The study was done to find a correlation between the length of right index finger and the height of an individual.

Objectives

The objectives of this study are

a) To derive a formula for the estimation of stature from the length of right index finger.

b) To find out whether there is sexual dimorphism in estimating stature from the length of right index finger.

Study Design and Methodology

The study subjects are males and females who were residents of an area in Dakshina Kannada. The present study is aimed at measuring the stature from the length of right index finger.

a) Method of Collection of data: Informed written consent will be obtained from the subjects.

b) Measurement of Stature Using Stadiometer: It is measured as vertical distance from the vertex to the foot. Measurement will be taken by making the subject to stand erect on a horizontal resting plane, on the stadiometer bare footed. Palms of hand turned inwards and fingers horizontally pointing downwards and head oriented in eye-ear-eye plane (Frankfurt Plane). The movable rod of the stadiometer is brought in contact with vertex in the mid sagittal plane (Figure 1).

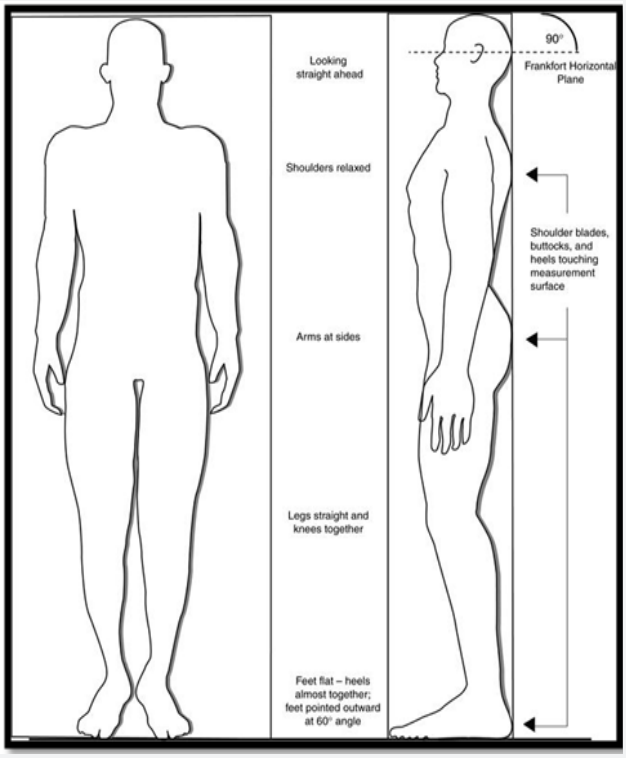

Figure 1: The movable rod of the stadiometer is brought in contact with vertex in the mid sagittal plane.

c) Measurement of Right Index Finger Length with Vernier Callipers: It is measured as straight distance from the midpoint of the proximal finger crease to the tip of the finger. Vernier caliper will be used to measure the finger length; hand placed on the plane surface, palm of the hand facing upwards (Figure 2).

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

d) Sample size: Considering the correlation between the height of the individual and length of index finger minimum sample size required is 60 for males and 60 for females with effect size 0.35, level of significance 5 percent and power 80 percent calculated using software G* Power 3.1.

e) Statistical analysis: For the first objective of estimating stature from the length of right index finger simple linear regression can be used for males and females. For the second objective of sexual dimorphism in estimating stature from the length of right index finger logistic regression can be used.

f) Source of data: Patients who visited various OPD departments of Yenepoya Medical College Hospital, Mangalore.

g) Inclusion criteria: Subjects aged between 18-60 years of Indian origin.

h) Exclusion criteria: Subjects having significant diseases, congenitally malformed limbs, metabolic disorders and developmental defects.

Observation and Results

(Tables 1-3).

This table provides the R, R2, adjusted R2, and the standard error of the estimate, which can be used to determine how well a regression model fits the data:

Table 1: Height (cm) * Right index finger length (cm).

Symmetric Measures					
		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.562	.090	7.378	.000[c]
Ordinal by Ordinal	Spearman Correlation	.659	.065	9.516	.000[c]
N of Valid Cases		120			

Table 2: Height (cm) * Age.

Symmetric Measures					
		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Interval by Interval	Pearson's R	.011	.093	.114	.909[c]
Ordinal by Ordinal	Spearman Correlation	.055	.093	.594	.554[c]
N of Valid Cases		120			

Table 3: Regression.

Descriptive Statistics			
	Mean	Std. Deviation	N
Height (cm)	165.43	10.330	120
Right index finger length (cm)	7.005	.5707	120
Age	35.38	12.028	120

Table 4.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.690[a]	.476	.462	7.576

a. Predictors: (Constant), Sex, Age, Right index finger length (cm).

Table 5.

ANOVA[a]					
Model	Sum of Squares	df	Mean Square	F	Sig.

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1	Regression	6038.819	3	2012.940	35.067	.000[b]
	Residual	6658.648	116	57.402		
	Total	12697.467	119			

a. Dependent Variable: Height (cm).
b. Predictors: (Constant), Sex, Age, Right index finger length (cm).

Table 6: Height (cm) =95.006+10.25Right index finger length (cm)-0.0359Age (years).

Coefficients[a]								
Model		Unstandardized Coefficients	Standardized Coefficients	Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	95.006	9.811		9.684	.000	75.576	114.436
	Age	-.039	.066	-.045	-.590	.556	-.169	.092
	Right index finger length (cm)	10.250	1.389	.566	7.380	.000	7.499	13.001

a. Dependent Variable: Height (cm).

Table 7.

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	152.73	177.62	165.43	7.124	120
Residual	-26.786	20.106	.000	7.480	120
Std. Predicted Value	-1.783	1.710	.000	1.000	120
Std. Residual	-3.536	2.654	.000	.987	120

a. Dependent Variable: Height (cm).

Table 8: Discriminate Analysis.

Group Statistics					
Sex		Mean	Std. Deviation	Valid N (listwise)	
				Unweighted	Weighted
Female	Age	32.646	10.9709	48	48.000
	Right index finger length (cm)	6.725	.4422	48	48.000
	Height (cm)	158.146	8.2797	48	48.000
Male	Age	37.194	12.4263	72	72.000
	Right index finger length (cm)	7.192	.5728	72	72.000
	Height (cm)	170.292	8.5801	72	72.000
Total	Age	35.375	12.0280	120	120.000
	Right index finger length (cm)	7.005	.5707	120	120.000
	Height (cm)	165.433	10.3296	120	120.000

Table 9: Summary of Canonical Discriminate Functions.

Eigen values				
Function	Eigen value	% of Variance	Cumulative %	Canonical Correlation
1	.593[a]	100.0	100.0	.610

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

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Table 10: Standardized Canonical Discriminate Function Coefficients.

Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**df**	**Sig.**
1	.628	54.277	3	.000

Table 11: From the above table, we get standard canonical discriminant function(DF):

Coefficients	
	Function
	1
Age	.349
Right index finger	
length (cm)	.170
Height (cm)	.888

DF=0.349×Age+0.170×Right index+0.888×Height.

Table 12: Pooled within-groups correlations between discriminating variables and standardized canonical discriminant functions. Variables ordered by absolute size of correlation within function. The above table gives you the correlation between each variable and discriminant function.

Structure Matrix	
	Function
	1
Height (cm)	.921
Right index finger length (cm)	.570
Age	.246

Table 13: Unstandardized canonical discriminant functions evaluated at group means.

Functions at Group Centroids	
Sex	**Function**
	1
Female	-.936
Male	.624

Cut score = (-0.936+0.624)/2= -0.156

Hence, classification will be based on cut score.

If DF> -0.156 that case will be classified as males and if DF<-0.156, that case will be classified as females.

Table 14.

Classification Results[a,c]					
		Sex	**Predicted Group Membership**		**Total**
			1	**2**	
Original	Count	Female	36	12	48
		Male	14	58	72
	%	Female	75.0	25.0	100.0
		Male	19.4	80.6	100.0
Cross-validated[b]	Count	Female	36	12	48
		Male	16	56	72
	%	Female	75.0	25.0	100.0
		Male	22.2	77.8	100.0

a. 78.3% 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. 76.7% of cross-validated grouped cases correctly classified.

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(Tables 4-14) and (Figure 3).

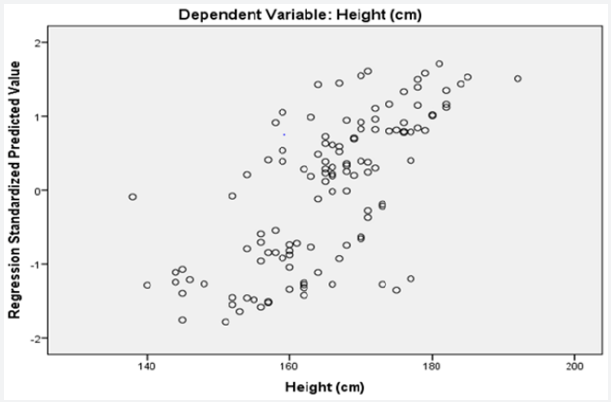

Figure 3: Scatterplot.

It was observed that there was a significant correlation between right index finger and Height of the individuals (Pearson correlation coefficient= 0.565). From the right index finger measurement a formula for calculating height of the individual was using regression coefficient is as follows:

Height (cm) =95.006+10.25Right index finger length (cm)-0.0359Age (years)

By calculating the discriminant function using the formula

DF=0.349×Age+0.170×Right index+0.888×Height

The gender of 78.3% of the original grouped cases was correctly predicted. After cross validation 76.7% of the cross validated grouped cases were correctly classified into males and females.

Discussion

In the study by Suseelamma. stature was estimated from the lengths of the fingers using the regression equation y = B0 + B1x where B0 is measuring height and B1 is calculated height. Among the five fingers middle finger gave the exact height [1]. In our present study stature was estimated from the length of right index finger using the formula:

Height (cm) = 95.006+10.25Right index finger length (cm)-0.0359Age(years)

From the study "Estimation of stature from lengths of index and ring fingers in a North Eastern Indian population" by Jaydip Sen. it was found that estimation of stature from index and ring finger measurements can be a useful approach when part of the hand with intact fingers is brought for examination in cases where other body parts are not available for medicolegal examination. This study was done among the widely distributed Rajbanshi population of North Bengal [2]. Our present study was done in a population in an area in Dakshina Kannada and stature was estimated using the length of right index finger.

The study by Amitava Pal [3]. showed how hand dimensions can be successfully used for estimating stature of adult Bengalee women in forensic practice by enforcement agencies and forensic scientists. Regression equations from hand dimensions were derived which are applicable only for Bengalee women [3]. In our study also, a formula for calculating stature has been derived. This may be applicable to people belonging to Dakshina Kannada area only. "Estimation of stature from index and ring finger length in Davangere district" by Raju et al. [4]. used the index and ring finger lengths to estimate stature using regression equation. Such studies can help in narrowing down the pool of possible victim matches in cases of identification from dismembered remains [4]. In our present study the sexual dimorphism shown in estimating stature from the length of right index finger has also been considered.

In the study by Numan et al. [5] "Prediction of Stature from Hand Anthropometry: A Comparative Study in the Three Major Ethnic Groups in Nigeria" estimation of stature using hand length was done for three major ethnic groups in Nigeria and the differences in the two sexes were also considered. Ethnic differences in anatomical dimensions and its relationship with stature have been examined [5]. This is similar to our present study. The study "A model for stature estimation and sex prediction using percutaneous ulnar and radial lengths in autopsied adult Egyptians" by Issa et al [6]. Stature estimation was determined using the calculated regression coefficient and constant values for each sex from measured bone lengths. "Estimation of Sex from Index and Ring Finger Lengths in An Indigenous Population of Eastern India" gives a description of how index and ring finger lengths can be used to estimate stature could be utilized to estimate sex of the individuals when more reliable methods of sex estimation are not available during medicolegal investigations [7]. In our present study, sexual dimorphism in estimating stature from dimensions of anterior mandibular teeth has been examined.

"Sex determination from hand dimensions and index/ring finger length ratio in North Saudi population" was a study done by Ibrahim et al. where the method to identify a person when only a separated hand is available has been explained. A hand index of less than or equal to 41.39 is indicative of female and an IFL/RFL ratio of ≥ 1.0321 and ≥ 1.0432 in right and left hand respectively are predictive of female sex [8]. "Determination of sex from hand dimensions and index/ring finger length ratio in Upper Egyptians" by Khaled. Concludes that hand dimensions and index/ring finger ratios prove useful to determine the sex of an isolated hand when it is subjected for medicolegal examination. A hand index of ≤40.55 is indicative of female and IFL/RFL ratio of ≤0.976 is indicative of male. Also sexual dimorphism in hand dimensions and IFL/RFL ratios is a constant feature in Upper Egyptian population [9].

"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. This study also showed

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that finger lengths are better predictor of sex than index and ring finger ratio. Estimation of sex narrows down the pool of possible victim matches as well as by aiding in a more accurate estimation of age since the age of epiphyseal fusion varies between males and females [10]. In our present study stature is estimated from the length of right index finger.

"Determination of Sex from Index and Ring Finger Ratio in Neonates" was a study done by Manohar et al. which found that second digit to fourth digit ratio were higher in female neonates and appeared sexually dimorphic. 2D:4D ratio less than 0.93 suggest a male neonate. This study can be useful in cases where only mutilated body or only remains are brought for forensic examination [11]. In the study "Digit ratio (2D:4D) - An anthropometric marker for sexual dimorphism in J&K population" by Khan et al. highlights the application of IFL and RFL ratios in determination of sex among individuals belonging to J & K region of India. This study also suggests that finger lengths are useful predictors of sex [12]. Our present study aims at estimating stature from the right index finger length and to determine the sexual dimorphism exhibited in this estimation.

Conclusion and Summary

A significant correlation was found between the length of right index finger and stature of an individual. A formula for estimating the approximate stature of a person through measurements of the dimensions of anterior mandibular teeth (right arch) was derived which is as follows.

Height (cm) =95.006+10.25Right index finger length (cm)-0.0359Age (years)

The discriminant function was calculated using the formula

DF=0.349×Age+0.170×Right index+0.888×Height

The gender of 78.3% of the original grouped cases was correctly predicted using this formula. After cross validation 76.7% of the cross validated grouped cases were correctly classified into males and females.

Recommendations

Various other parameters can be used for stature estimation like the arm and forearm length. The study can be extended to people belonging to different races and the values compared.

Limitations of the Study

a) The study is done in a population in an area in Dakshina Kannada. This may not be a good representative sample of a universal study group.

b) A single dimension i.e., length of right index finger is used to estimate stature which can reduce the accuracy.

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