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Efficacy of Digit Length in the Estimation of Stature: A Study on a Bengali-Speaking Hindu Adult Population of West Bengal

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Abstract

Estimation of stature from other body segments plays a crucial role in personal identification from the perspectives of forensic anthropology and medico-legal investigation. The present research aims to examine the efficacy of estimating stature using digit lengths of both hands. The study involved 470 Bengali-speaking Hindu young adults (234 males and 236 females). The participants represent students of some coeducational general degree colleges located across different sub-divisions of the North 24 Parganas district of West Bengal, India. We measured the digit lengths of both the hands and stature of the participants following standard protocol and derived the multiplication factor of each digit of both left and right hands. Linear regression analyses were applied to identify the efficacy of digital lengths in predicting stature.

The findings revealed that the combined lengths of all the digits of each hand of the participants have limitations in determining stature (Adjusted $R^2 < 0.4$ for both males and females) in both the sexes. Though digit 3 exhibited the highest R^2 values for both sexes, there has been little change in the overall impact. Compared to females, the combined digit length of males has a slightly higher predictive value (statistically not significant) for stature. We conclude from the study that the combined digit length of both males and females does not have any predictive value with regard to stature, even when it is significantly correlated with the latter.

Keywords: Digit Length, Stature Estimation, Personal Identification, Bengali Hindu Young Adults, Personal Identification.

Introduction

Determination of stature from mutilated body parts of a deceased individual can be achieved by applying mathematical and anatomical methods. The 'Fully's method' or the anatomical method is applied to reconstruct stature by aggregating measurements of the skeletal components that contribute to height, using correction factor for soft tissues. In contrast, the mathematical method employs regression formula and multiplication factor to estimate stature from specific bones or body components. This mathematical approach remains useful even when a portion of the body part is available, making it particularly valuable in medicolegal situations. Scholars argue for population-specific regression formulae and multiplication factors due to variations in body proportions (such as relative lengths of limbs and trunks) among different ethnic groups (Krogman and Iscan, 1986; Krishan, 2008; Varu et al., 2015; Dayal et al., 2016; Manjula and Kanchan, 2018; Gupta et al., 2019; Kanchan et al., 2019).

The relationship between the lengths of different body parts such as long bones, upper and lower extremities, foot dimensions and foot prints and overall stature, has garnered the interest of anthropologists, forensic scientists, and medical researchers for many years (Pearson, 1899; Trotter and Glesser, 1952; Rutishauser, 1968; Danborno et al., 2008; Agarwal et al., 2015).

An appreciable body of literature is available on Indian populations where estimation of stature has been made from measurements of various body parts (Athwale, 1963; Patel et al., 1964; Joshi et al., 1964; Lal and Lala, 1972; Kalte and Bansal, 1974; Qamra et al., 1980; Saxena, 1984, Bhatnagar et al., 1984; Thakur and Rai, 1987). Some of the studies have shown a positive association of varying degrees between stature and various body dimensions. For example, estimation of stature was made from the measurements of upper extremities (Kapoor et al., 2013; Moorthy and Zulkifly, 2014; Varu et al., 2015; Dayal et al., 2016; Pal et al., 2016; Mudasir et al., 2017; Manjula and Kanchan, 2018; Singh et al., 2018; Yadav and Pathak, 2018; Gupta et al., 2019; Kanchan et al., 2019; Singh et al., 2019), lower extremities (Patel et al., 2007; Sen and Ghosh, 2008; Babu et al., 2013; Meena et al., 2013; Pandey et al., 2014; Agarwal et al., 2015; Vardhan and Pandey, 2016; Yadav and Pathak, 2018; Singh et al., 2019), pelvic dimensions, facial dimensions (Krishan, 2007; Borkar et al., 2017), finger lengths, and phalange lengths (Wright and Vasquez, 2003; Danborno et al., 2008; Bardale et al., 2013;

Sen et al., 2013; Jee and Yun, 2015; Dayal et al., 2016; Hasan et al., 2017; Christal et al., 2018; Mutluay and Bozkir, 2019) across different populations.

Few scholars tried to establish the use of digit length in stature estimation (Pal et al.,2016; Kumar et al., 2016; Koulapur et al. 2017; Iddalgave et al., 2021; Venkatesan et al., 2024). However, it is found to be not as effective as traditional methods that utilize long bones and foot dimensions. These metrics of digit lengths can be effectively employed for stature estimation only when other reliable body dimensions are unavailable.

In this context, the present study aims to contribute by developing formulae to determine an individual's stature based on digit lengths. The specific objectives of this study were to examine bilateral asymmetry and sex difference in digit-lengths (1d to 5d) among Bengali-speaking Hindu young adults and to estimate the multiplication factor and develop linear regression equations based on digit lengths to estimate stature.

Materials and Methods

Study area

Some coeducational degree colleges located in the district of North 24 Parganas, West Bengal, India were identified as the field of studies. A total of 60 colleges were enlisted from the subdivisions of this district. Finally, six colleges, representing various subdivisions, were selected randomly for fieldwork. The selected study participants were the enrolled students of these six colleges and all of them belong to the Bengali speaking Hindu caste groups.

Study Participants and Sampling

This cross-sectional study was conducted on a total of 470 Bengali-speaking Hindu young adults (234 male students and 236 female students). Written consent was obtained from the study participants and college administration before proceeding with data collection. The participation in the study was voluntary in nature.

A total number of 108 individuals (57 males and 51 females) from Acharya Prafulla Chandra College (Barrackpore subdivision), 108 individuals (54 males and 54 females), each from Sree Chaitanya College, Habra, and Vivekananda College (Barasat subdivision), 67 participants (29 males and 38 females) from Saheed Nurul Islam Mahavidyalaya (Basirhat subdivision), 98 participants (49 males and 49 females) from Bidhannagar College (Bidhannagar subdivision), and 89 participants (45 males and 44

females) from P. R. Thakur Government College (Bongaon subdivision) were covered in this study.

All the participants were aged between 18 and 25 years, with no reported skeletal or other abnormalities or any specific health issue. Females who were on their family way or lactating were excluded from the study.

The research protocol was approved by the Institutional Ethics Committee of West Bengal State University (approval number WBSU/IEC/30/02, dated October 7, 2021).

Anthropometric Measurements

Stature and digit lengths (1d to 5d) of both the hands were measured using a Martin's anthropometer and a Martin's sliding calliper respectively. Each measurement was documented to the closest 0.1 centimetre. The measurements were made according to the protocols outlined by Lohman *et al.* (1988).

Each of the measurements was recorded twice to reduce the potential measurement error, and the mean was then worked out for further analysis.

Measurement Error and Reliability

The intra-observer technical error for all measurements was estimated using absolute Technical Error of Measurement (TEM), relative TEM (rTEM), and the coefficient of reliability (R). The values of TEM and rTEM were within the acceptable range (Ulijaszek and Kerr, 1999; Arroyo *et al.* 2010). A R coefficient value greater than 0.95 indicates that the data are reproducible enough without any significant measurement error.

Data Analysis

Data were analysed using the Statistical Software for the Social Sciences (SPSS, version 25.0). Mean ± SD values of the metric measurements were estimated. We used student's t-test, and paired sample t-test to compare for the intergroup and intragroup variations respectively.

Multiplication factors for estimating stature were derived from digit length by using an established standard formula:

$$\text{Multiplication factor} = \text{Stature (cm)} / \text{Digit length (cm)}$$

Regression equations for estimating stature were derived from the parameters by using the formula:

$$Y = a + bX$$

Where, Y = Stature, a = Value of constant, b = regression coefficient, X = parameters.

Results

All the anthropometric measures exhibit minimal error in terms of TEM (Table 1). Similarly, the percentage error for rTEM is also very low across all the measurements. The intra-observer standard error (TEM) for all the anthropometric measures is found to be within a minimal error range of 0.04 to 0.06 cm. Most of the measurements exhibit the lowest absolute TEM (0.04 cm), barring stature, which shows a slightly higher intra-observer TEM of 0.06 cm, less than the highest reference threshold value of 0.7 cm.

Table 1: Precision Estimation for all the Anthropometric Measurements

TEM estimation	St	RD1	LD1	RD2	LD2	RD3	LD3	RD4	LD4	RD5	LD5
Absolute TEM (cm)	0.06	0.05	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Relative TEM (%)	0.04	0.82	0.66	0.59	0.59	0.53	0.53	0.58	0.58	0.72	0.71
R Coefficient	1.000	0.993	0.994	0.994	0.995	0.994	0.995	0.996	0.996	0.995	0.994

*TEM= Technical Error of Measurement, R Coefficient= Reliability Coefficient, rTEM= Relative Technical Error of Measurement, St= Stature, RD1= Right Digit 1, LD1= Left Digit 1, RD2= Right Digit 2, LD2= Left Digit 2, RD3= Right Digit 3, LD3= left Digit 3, RD4= Right Digit 4, LD4= Left Digit 4, RD5= Right Digit 5, LD5= Left Digit 5.

The data reveal that the rTEM for all anthropometric parameters considered in this study range from 0.04% to 0.82%. This suggests a minimal error percentage, well below the acceptable threshold of 1.5% for intra-observer rTEM.

For each anthropometric measurement, the coefficient of reliability (R Coefficient) ranges from 0.993 to 1.000. Stature shows the lowest proportion of variance caused by measurement error, at <1%. The other measurements consistently demonstrate that the proportion of variance due to measurement error is less than 1% (table 1). The

data regarding the coefficients of reliability for each anthropometric parameter indicate a high level of reliability for intra-subject measurements.

The data also reveal that initially only a few variables of both the groups have a non-normal distribution. These variables are then transformed to a normal distribution using the inverse distribution function (IDF) to circumvent potential statistical complexities that might arise in subsequent analyses.

Table 2: Sex-specific Descriptive Statistics of all Anthropometric Variables with Normality Analysis among the Participants (n=470)

Variables (in cm.)	Male (n=234)				Female (n=236)			
	Mean± SD	Skewness	Kurtosis	Shapiro-Wilk	Mean± SD	Skewness	Kurtosis	Shapiro-Wilk
Stature	167.85± 7.01	0.25	0.53	0.992	154.71± 5.81	0.00	-0.24	0.998
RD1	6.35± 0.45	-0.11	-0.16	0.992	5.76± 0.43	0.15	0.48	0.988
LD1	6.33± 0.44	-0.09	-0.11	0.990	5.70± 0.43	0.31	0.34	0.988
RD2	7.00± 0.43	0.00	-0.35	0.994	6.44± 0.47	0.02	-0.17	0.997
LD2	7.00± 0.43	-0.04	-0.35	0.991	6.44± 0.46	0.00	-0.25	0.995
RD3	7.79± 0.44	0.22	-0.02	0.994	7.18± 0.47	0.04	-0.18	0.995
LD3	7.80± 0.44	0.16	-0.17	0.994	7.18± 0.48	0.02	-0.24	0.995
RD4	7.20± 0.46	0.05	0.19	0.995	6.56± 0.51	-0.05	-0.28	0.995
LD4	7.22± 0.46	-0.02	0.00	0.997	6.58± 0.51	0.00	-0.24	0.996
RD5	5.81± 0.39	-0.05	-0.28	0.990	5.32± 0.46	-0.04	-0.25	0.995
LD5	5.86± 0.40	-0.02	-0.28	0.994	5.34± 0.46	0.01	-0.27	0.995

*., Significant at the 0.05 level, $p<0.05$.

SD= Standard Deviation, RD1= Right Digit 1, LD1= Left Digit 1, RD2= Right Digit 2, LD2= Left Digit 2, RD3= Right Digit 3, LD3= left Digit 3, RD4= Right Digit 4, LD4= Left Digit 4, RD5= Right Digit 5, LD5= Left Digit 5.

Table 2 shows that the mean stature for male participants is higher (167.85 ± 7.01 cm) than the female participants (154.71 ± 5.81 cm). Similar trend is observed for the other anthropometric variables, including digit lengths. However, digit lengths from either side in both the sexes demonstrate closer mean values to the mean of their counterparts. Additionally, the Shapiro-Wilk test results confirm that the variables follow a normal distribution pattern.

Table 3: Sex Differences and Bilateral Asymmetry of all the Anthropometric Variables among the Participants

Anthropometric variables	Sex differences				Bilateral asymmetry		
	Mean ± SD (Male) (n=234)	Mean ± SD (Female) (n=236)	t-value	p-value	Mean ± SD (n=470)	t-value	p-value
Stature	167.85± 7.01	154.71± 5.81	22.113	0.001	-	-	-
RD1	6.35± 0.45	5.76± 0.43	14.344	0.001	6.05±0.53	4.747	0.001
LD1	6.33± 0.44	5.70± 0.43	15.682	0.001	6.01±0.54		
RD2	7.00± 0.43	6.44± 0.47	13.356	0.001	6.72±0.53	-0.090	0.928
LD2	7.00± 0.43	6.44± 0.46	13.812	0.001	6.72±0.53		
RD3	7.79± 0.44	7.18± 0.47	14.675	0.001	7.49±0.54	-0.151	0.880
LD3	7.80± 0.44	7.18± 0.48	14.398	0.001	7.49±0.56		
RD4	7.20± 0.46	6.56± 0.51	14.110	0.001	6.88±0.58	-2.275	0.023
LD4	7.22± 0.46	6.58± 0.51	14.247	0.001	6.90±0.58		
RD5	5.81± 0.39	5.32± 0.46	12.426	0.001	5.56±0.49	-4.533	0.001
LD5	5.86± 0.40	5.34± 0.46	12.996	0.001	5.60±0.50		

SD= Standard Deviation, p-value= Probability value, RD1= Right Digit 1, LD1= Left Digit 1, RD2= Right Digit 2, LD2= Left Digit 2, RD3= Right Digit 3, LD3= left Digit 3, RD4= Right Digit 4, LD4= Left Digit 4, RD5= Right Digit 5, LD5= Left Digit 5.

Table 3 shows a significant difference between the sexes for all the anthropometric variables. The table further shows significant bilateral asymmetry for digit 1, digit 4 and digit 5 ($p<0.05$).

Table 4: Estimation of Multiplication Factor of the Digital Lengths with Respect to the Estimation of Stature among the Participants (n=470)

Multiplication Factor of anthropometric variables for stature	Mean± SD	
	Male (n=234)	Female (n=236)
MF-RD1	26.55± 1.79	26.95± 1.73
MF-LD1	26.62± 1.81	27.27± 1.74
MF-RD2	24.05± 1.30	24.10± 1.52
MF-LD2	24.02± 1.30	24.12± 1.49
MF-RD3	21.57± 0.97	21.60± 1.18
MF-LD3	21.56± 0.98	21.61± 1.27
MF-RD4	23.37± 1.26	23.68± 1.60
MF-LD4	23.30± 1.27	23.61± 1.55
MF-RD5	29.00± 1.81	29.27± 2.26
MF-LD5	28.76± 1.86	29.14± 2.19

* Multiplication Factor = Stature / Anthropometric parameter

SD= Standard Deviation, MF-RD1= Multiplication Factor of Right Digit 1, MF-LD1= Multiplication Factor of Left Digit 1, MF-RD2= Multiplication Factor of Right Digit 2, MF-LD2= Multiplication Factor of Left Digit 2, MF-RD3= Multiplication Factor of Right Digit 3, MF-LD3= Multiplication Factor of Left Digit 3, MF-RD4= Multiplication Factor of Right Digit 4, MF-LD4= Multiplication Factor of Left Digit 4, MF-RD5= Multiplication Factor of Right Digit 5, MF-LD5= Multiplication Factor of Left Digit 5.

Table 4 presents the sex-specific mean multiplication factors along with their standard deviations. Notably, the standard deviation values of most of the variables in both the groups are moderate to low. Using the mean multiplication factors for different digit lengths, stature can be estimated using the following formula:

Stature= Mean multiplication factor of the variable × value of the digit length

Table 5: Simple Linear Regression Coefficient between Stature as Dependent and Individual Digit Length as Independent Variables among the Participants (n=470)

IV	Constant (a)	b-value	R	R^2	Adjusted R^2	t-value	F-value
Male participants (n=234)							
RD1	125.861	6.617	0.422**	0.178	0.174	7.085***	50.191***
LD1	129.216	6.104	0.384**	0.147	0.144	6.331***	40.079***
RD2	107.685	8.599	0.528**	0.279	0.276	9.479***	89.844***
LD2	108.169	8.521	0.518**	0.268	0.265	9.221***	85.020***
RD3	91.641	9.778	0.607**	0.369	0.366	11.638***	135.443***
LD3	91.571	9.782	0.618**	0.382	0.379	11.973***	143.348***
RD4	104.488	8.796	0.583**	0.340	0.337	10.930***	119.467***
LD4	106.047	8.556	0.567**	0.322	0.319	10.497***	110.194***
RD5	122.154	7.869	0.441**	0.194	0.191	7.481***	55.963***
LD5	125.393	7.249	0.418**	0.175	0.171	7.014***	49.202***
Female participants (n=236)							
RD1	113.424	7.164	0.533**	0.284	0.281	9.639***	92.907***
LD1	113.781	7.184	0.534**	0.285	0.282	9.668***	93.476***
RD2	113.599	6.380	0.511**	0.262	0.258	9.104***	82.875***
LD2	111.891	6.651	0.528**	0.279	0.276	9.521***	90.647***
RD3	104.557	6.982	0.560**	0.314	0.311	10.348***	107.089***
LD3	109.265	6.328	0.526**	0.276	0.273	9.453***	89.351***
RD4	115.063	6.040	0.535**	0.286	0.283	9.684***	93.774***
LD4	113.264	6.297	0.552**	0.305	0.302	10.134***	102.702***
RD5	122.168	6.120	0.483**	0.233	0.230	8.433***	71.121***
LD5	119.579	6.580	0.517**	0.267	0.264	9.238***	85.349***

***. Significant at the 0.001 level, $p<0.001$; **. Significant at the 0.01 level, $p<0.01$.

IV= Independent Variables; RD1= Right Digit 1; LD1= Left Digit 1; RD2= Right Digit 2; LD2= Left Digit 2; RD3= Right Digit 3; LD3= Left Digit 3; RD4= Right Digit 4; LD4= Left Digit 4; RD5= Right Digit 5; LD5= Left Digit 5; a= value of constant; b= regression coefficient; R^2= Coefficient of determination.

It appears from Table 5 that the lengths of all the digits of both the hands (both male and female) have significant association with stature, but the proportion of variance explained in the dependent variable is graded. Lengths of D3 and D4 of both the hands could explain the highest proportion of variance in stature for males; and RD3 and LD4 for females.

The regression equations showing highest reliability in estimating stature in terms of adjusted R^2 values and standard error of estimates (S.E.E.) are as follows:

For the male participants:

1. Y (Stature) = 91.641 + 9.778 × Right Digit 3 with S.E.E. of ±5.58
2. Y (Stature) = 91.571 + 9.782 × Left Digit 3 with S.E.E. of ±5.52

For the female participants:

1. Y (Stature) = 104.557 + 6.982 × Right Digit 3 with S.E.E. of ±4.82
2. Y (Stature) = 113.264 + 6.297 × Left Digit 4 with S.E.E. of ±4.85

Figures 1 to 4 explains the scatter diagram of the relationship between the digit length and stature for males and females.

Figure 1: Stature with Right Digit 3, Male

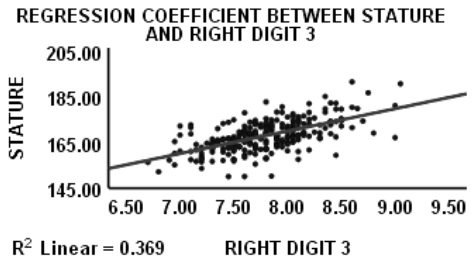


Figure 2: Stature with Left Digit 3, Male

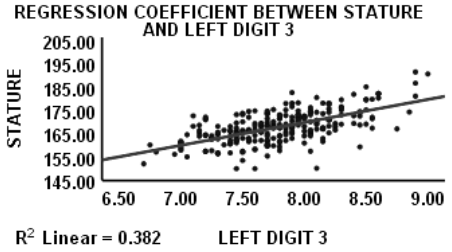


Figure 3: Stature with Right Digit 3, Female

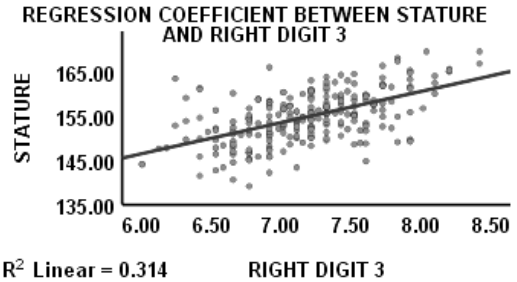


Figure 4: Stature with Left Digit 4, Female

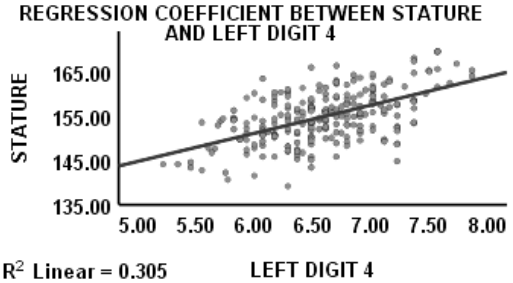


Table 6: Multiple Linear Regression Coefficient between Stature as Dependent and Combined Digit Length of Left and Right Hands Separately as Independent Variables among the Participants (n=470)

IV	Constant (a)	b-value	Adjusted R^2	t-value	p-value	F-value	collinearity	VIF
Male participants (n=234)								
RD 1	89.341	1.253	0.376	1.196	0.233	29.044***	0.601	1.664
RD 2		-0.150		-0.092	0.927		0.267	3.743
RD 3		6.294		3.244***	0.001		0.185	5.417
RD 4		3.384		2.093*	0.037		0.233	4.287
RD 5		-0.314		-0.231	0.817		0.462	2.163
LD 1	88.652	1.111	0.381	1.085	0.279	29.723***	0.641	1.559
LD 2		-0.028		-0.019	0.985		0.316	3.168
LD 3		7.354		4.270***	<0.001		0.224	4.459
LD 4		2.500		1.552	0.122		0.233	4.300
LD 5		-0.518		-0.392	0.696		0.456	2.194

IV	Constant (a)	b-value	Adjusted R^2	t-value	p-value	F-value	collinearity	VIF
Female participants (n=236)								
RD 1	99.653	3.455	0.355	3.313**	0.001	26.829***	0.456	2.194
RD 2		-0.475		-0.364	0.716		0.250	3.994
RD 3		3.583		2.625**	0.009		0.229	4.371
RD 4		1.026		0.809	0.419		0.218	4.587
RD 5		1.079		1.017	0.310		0.392	2.549
LD 1	101.139	3.332	0.360	3.214**	0.001	27.422***	0.458	2.182
LD 2		0.858		0.688	0.492		0.277	3.605
LD 3		1.162		0.875	0.382		0.224	4.465
LD 4		2.011		1.526	0.128		0.204	4.901
LD 5		1.402		1.255	0.211		0.353	2.830

***, Significant at the 0.001 level, $p<0.001$; **., Significant at the 0.01 level, $p<0.01$; *., Significant at the 0.05 level, $p<0.05$.

IV= Independent Variables; RD1= Right Digit 1; LD1= Left Digit 1; RD2= Right Digit 2; LD2= Left Digit 2; RD3= Right Digit 3; LD3= Left Digit 3; RD4= Right Digit 4; LD4= Left Digit 4; RD5= Right Digit 5; LD5= Left Digit 5; a= value of constant; b= regression coefficient; R^2= Coefficient of determination, VIF= Variance Inflation Factor.

Table 6 shows that the combined digit length of left and right hands for males significantly predict around 37% and 38 % of the variance of stature respectively. In case of females, the combined digit length of left and right hands significantly predicts around 35% and 36 % of the variance of stature respectively.

Using the aforementioned standard formula, the estimated multiple regression equations for both the sex-specific participants' groups derived from each set of their digit lengths are stated below:

For the male participants:

1. Y (Stature) = 89.341 + 1.253 × Right Digit 1– 0.150 × Right Digit 2 + 6.294 × Right Digit 3 + 3.384 × Right Digit 4 – 0.314 × Right Digit 5 with S.E.E. of ± 5.54
2. Y (Stature) = 88.652 + 1.111 × Left Digit 1 – 0.028 × Left Digit 2 + 7.354 × Left Digit 3 + 2.500 × Left Digit 4 – 0.518 × Left Digit 5 with S.E.E. of ± 5.51

For the female participants:

1. Y (Stature) = 99.653 + 3.455 × Right Digit 1– 0.475 × Right Digit 2 + 3.583 × Right Digit 3 + 1.026 × Right Digit 4 + 1.079 × Right Digit 5 with S.E.E. of ± 4.67
2. Y (Stature) = 101.139 + 3.332 × Left Digit 1 + 0.858 × Left Digit 2 + 1.162 × Left Digit 3 + 2.011 × Left Digit 4 + 1.402 × Left Digit 5 with S.E.E. of ± 4.65

Figures 5 to 8 explain the scatter diagram of the relationship between stature and the combined digit lengths from each side for males and females.

Figure 5: Stature with Right Digits (all), Male

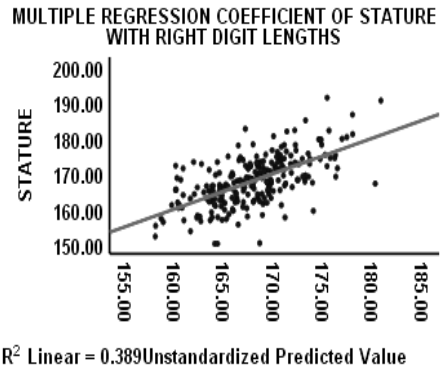


Figure 6: Stature with Left Digits (all), Male

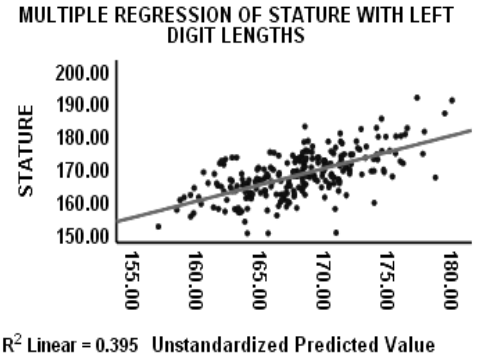
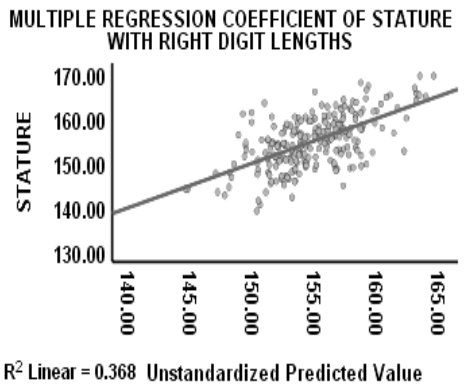


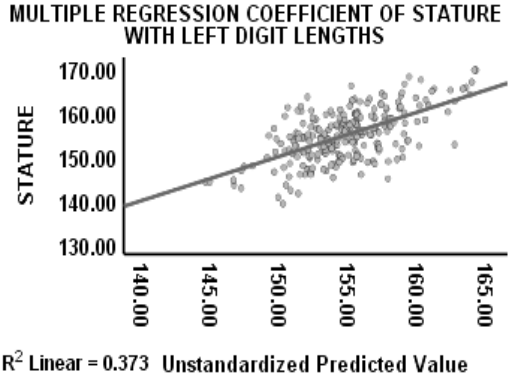
Figure 7: Stature with Right Digits

Figure 8: Stature with Left Digits (all),

(all), Female



Female



Discussion

This study revealed clear sex differences across all the anthropometric variables, with males exhibiting significantly higher digit lengths than females. These findings are consistent with previous researches (Mutluay and Bozkir, 2019; Rhiu and Kim, 2019), that reported pronounced sex-based differences in hand and digit measurements across diverse populations. Such dimorphism is well-documented in forensic anthropological literature, which plays a significant role in biological profiling during human identification (Krishan et al., 2012; Agnihotri et al., 2007).

Sex differences in limb and digit proportions reflect not only genetic and hormonal influences but also population-specific morphological variation, necessitating the development of sex-specific regression models for accurate stature estimation (Kanchan et al., 2008; Ozaslan et al., 2003). The use of pooled sex data in regression analyses can reduce the predictive accuracy, potentially compromising the utility of such models in forensic contexts (Krishan and Sharma, 2007; Rao et al., 2009). Therefore, as affirmed by this study and existing literature, tailoring regression equations to sex and ethnicity is essential to enhance the precision and applicability of stature estimation models in forensic investigations, especially within demographically diverse populations.

Additionally, this study identified statistically significant bilateral asymmetry in most digit lengths, consistent with the findings by Akhlaghi et al. (2019), Mutluay and Bozkir (2019), and Talukdar et al. (2022), but contrary to the symmetry significantly reported by Asadujjaman et al. (2019). Such asymmetry highlights the potential limitation of using unilateral measurements interchangeably in stature estimation, as side-specific variation may reduce predictive accuracy in forensic applications (Krishan et al.,

2012; Kanchan and Krishan, 2011). However, bilateral asymmetry in body dimensions is a natural occurrence and can result from various factors such as gestational stress, developmental instability, occupational activities, environmental pressures, and compensatory adaptations to injuries (Palmer & Strobeck, 2003; Van Valen, 1962; Ozener, 2010). To reduce the potential influence of such variables, this study included only participants without major pathological conditions or reported musculoskeletal injuries.

This study's initial observations indicate that males show a stronger association between stature and digit lengths compared to females, as reflected in both the Pearson correlation coefficient (R) and the regression coefficient (R^2). Notably, digit 3 demonstrates the highest degree of correlation with stature in both male and female groups. This finding aligns with the results of some previous studies (Mutluay and Bozkir,2019; Rhiu and Kim, 2019; Bakirci and Cay, 2022; Srinivasulu et al., 2022), which differ from the conclusions of Asadujjaman et al. (2019), reporting weaker or inconsistent correlations.

This study also found that while digit lengths from either hand are significantly correlated with stature, their ability to predict stature is limited. None of the digit lengths can reliably predict stature with moderate to high accuracy for both male and female individuals within this specific religious ethnic community. However, the length of digit 3 of both hands showed stronger predictive potential for males compared to other digit lengths. For females, the lengths of the right digit 3 and left digit 4 demonstrated greater predictive capacity than the other digits. These results align with some of the previous findings (Asadujjaman et al., 2019; Mutluay and Bozkir, 2019), but differ from those reporting higher predictive values (Talukdar et al., 2022; Srinivasulu et al., 2022).

This study also found that the cumulative predictive capacity of digit lengths from each hand was relatively poor, with adjusted R^2 values consistently below 0.4 for both males and females. This trend persisted even when individual digit lengths were analyzed, indicating that digital anthropometry alone may not provide sufficient accuracy for reliable stature estimation. These findings align with those reported by Asadujjaman et al. (2019), who also observed low coefficients of determination in similar population-based studies. Additionally, Krishan and Sharma (2007) and Ozaslan et al. (2005) also emphasized that while hand and digit measurements may show statistically significant correlations with stature, their standalone predictive capacity is often limited. However, the analysis did derive univariate model equations from such digit lengths, having the highest predictive value among all. Additionally, multivariate model equations were

developed from the bilateral set of all five digits for both sex-specific groups in order to estimate stature, along with multiplication factors for all digit parameters.

This study, however, acknowledge several limitations concerning the use of digit lengths for stature estimation in forensic contexts. Primarily, the findings are constrained by the narrow demographic scope, focusing solely on young Hindu adults from a specific district in West Bengal. Consequently, the results lack generalizability in the context of broader populations. Moreover, the predictive accuracy of the method was found to be relatively low, thereby limiting its practical utility in forensic casework.

An additional limitation arises from the fact that the measurements were obtained from living individuals under controlled conditions. These measurements may not accurately reflect the characteristics of postmortem or decomposed remains, which are typically encountered in forensic scenarios. Therefore, caution is warranted when extrapolating these findings to real-world forensic investigations.

Despite these limitations, the study underscores a potential, albeit limited, forensic application. In circumstances where only hand remains are recovered, digit lengths—particularly those of the third and fourth digits—may serve as a rough supplementary tool for stature estimation. However, their use should be strictly confined to scenarios where more reliable skeletal indicators, such as long bones, are unavailable.

Importantly, this study contributes to the theoretical understanding of stature estimation using hand anthropometry within forensic anthropology, particularly for underrepresented populations such as Hindu young adults in West Bengal. Future research involving larger, more diverse samples across broader geographic regions is recommended to validate and enhance the applicability of this method.

Conclusion

This study concludes that individual digit lengths, whether considered unilaterally or bilaterally, are poor predictors of stature in both male and female groups within the studied population. While statistically significant correlations exist – particularly for digit 3 – their practical application in stature estimation is limited due to weak predictive strength.

It has been found that incorporating all the five digit lengths of each hand into multivariate models could not substantially improve estimation accuracy. The adjusted R^2 values remained below 0.4, reaffirming that digit anthropometry alone is insufficient for developing robust stature prediction models in this context.

Overall, the findings underscore the necessity of using more comprehensive anthropometric parameters—potentially in combination with other body dimensions—to improve stature estimation accuracy, especially in ethnically and religiously diverse populations. While this study introduced multiplication factor analysis based on digit lengths as an auxiliary tool besides regression models, its use would remain supplementary rather than definitive. Future research in this field should explore combined anthropometric modeling to enhance predictive accuracy in stature estimation within specific demographic groups. Additionally, cross-validation with independent samples and inclusion of broader age ranges could further refine its applicability.

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Conflict of Interest

The author declares no conflict of interest in this study.

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