Original Research

A STUDY OF ESTIMATION OF STATURE FROM HAND MEASUREMENTS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Stature estimation from partial remains is a critical component of forensic identification and disaster victim management. Hand dimensions, particularly hand length and breadth, have emerged as practical predictors of stature in diverse populations.

Objective: To determine the relationship between stature and hand dimensions among young Indian adults and to derive regression equations for stature estimation from hand length and selected finger measurements.

Methods: A cross-sectional study was conducted among a mixed-sex sample of medical students aged 18–25 years at a Government Medical College in Andhra Pradesh, India. Anthropometric measurements included stature, weight, BMI, right- and left-hand length, right- and left-hand breadth, and the lengths of individual fingers on both hands, recorded using standard anthropometric instruments. After cleaning biologically implausible entries, descriptive statistics, Pearson correlation, and simple linear regression were performed. The results were interpreted in conjunction with recent international literature on hand-based stature estimation.

Results: A total of 308 participants (approximately equal proportions of males and females) were analyzed. Mean stature was 164.07 ± 9.14 cm, and mean BMI was 22.53 ± 4.31 kg/m². Mean right- and left-hand lengths were 17.79 ± 1.19 cm and 17.81 ± 1.19 cm, respectively. Stature showed a strong positive correlation with left-hand length ($r = 0.817$, $p < 0.001$) and right-hand length ($r = 0.811$, $p < 0.001$). Among finger measurements, left ring finger length ($r = 0.712$) and left middle finger length ($r = 0.705$) showed the strongest associations with stature. The best single-predictor regression model for stature was based on left hand length, Height (cm) = 55.98 + 6.03 × Left hand length (cm), with $R^2 = 0.668$ and mean absolute error (MAE) 4.07 cm; right hand length yielded a similar model with $R^2 = 0.657$.

Conclusion: Hand length is a robust predictor of stature in young Indian adults from Andhra Pradesh, with left- and right-hand lengths providing practical regression equations suitable for forensic casework. These findings align with recent Asian and international studies and underscore the necessity of population-specific algorithms for forensic stature estimation. However, these findings are based on a single-centre sample of young medical students and a restricted age range of 18–25 years, which may limit generalizability to other age groups and populations. Future studies in broader, community-based cohorts are needed to validate and refine these regression equations.

Keywords: Forensic Anthropology, Anthropometry, Stature estimation, Hand Dimensions, Regression Analysis, Indian Population.

INTRODUCTION

Stature is a fundamental biological characteristic and one of the most useful parameters in personal identification, particularly when dealing with fragmented, mutilated, or decomposed human remains.[1,2] In medico-legal investigations and mass disasters, estimation of stature from partial remains such as hands, feet, or long bones helps narrow the pool of possible matches and supports linkage with dental, DNA, or circumstantial evidence.1

Among body segments used for anthropometric reconstruction, the hand has practical forensic value because hands and handprints are frequently encountered in crime scenes, accidents, and mass disasters.3,4 Anthropometric studies have therefore focused increasingly on hand dimensions—hand

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length, hand breadth, palm measurements, and phalangeal lengths—as candidate predictors of stature.1,5-6 Multiple studies across populations have shown that hand length is often the single most informative hand-based predictor of stature, although the magnitude of association and optimal regression algorithms show marked regional and ethnic variation.1,4,7

In Indian populations, stature estimation has been attempted from upper limb segments, hand dimensions, and foot measurements, with several reports emphasizing sex-specific and region-specific differences.1,2,8 Ahemad and colleagues reported that hand length was the most important predictor of stature among North Indian males.9 Krishan and collaborators have demonstrated significant correlations between stature and hand and foot dimensions in North Indian adults, with stronger predictive power for combined models than for single predictors.10 More recently, Tanvir et al. showed that hand length demonstrated the strongest correlation with stature among young adults from Delhi, and that multiple regression models using hand and foot measurements provided lower standard errors than simple linear models.2

Despite these advances, there remains a paucity of contemporary data from Southern Indian populations—particularly Andhra Pradesh—on stature estimation from hand dimensions. Given the known influence of genetic, nutritional, and environmental factors on body proportions, extrapolating regression equations across regions may lead to substantial estimation error and misinterpretation in forensic practice.1,2,11

The present cross-sectional study was conducted to determine the relationship between stature and hand dimensions among young Indian adults in Andhra Pradesh and to derive population-specific regression equations for stature estimation from hand length and selected finger measurements. The study also aims to contextualize these findings within the broader international literature on hand-based stature estimation.

METHODS

Study design and setting

This was a cross-sectional anthropometric study conducted in the Department of Forensic Medicine and Toxicology at a Government Medical College in Kadapa, Andhra Pradesh, India, over a period of one year. The study population comprised undergraduate mixed-sex MBBS students aged 18–25 years, representing a young adult group commonly included in stature estimation research.

Participants and sampling

Participants were recruited through consecutive sampling from among eligible, apparently healthy MBBS students of Government Medical College, Kadapa, who provided written informed consent during the study period, with normal skeletal growth, of both sexes, and predominantly residents of the Telugu-speaking states. Students with a history of chronic disease, orthopaedic deformity, skeletal dysplasia, or any condition affecting growth or stature were excluded based on clinical history and self-report. The planned sample size was 300, based on logistical feasibility and comparability with previous regional studies. This sample size was also considered adequate to detect at least a moderate correlation between hand dimensions and stature with high statistical power at the 5% significance level. A total of 308 participants were included in the final analyzable dataset after data cleaning. No substantial non-response was observed among eligible students approached for participation.

Ethical considerations

Ethical approval for this study (IEC No. 015/GMC/KDP/2024) was provided by the Institutional Ethics Committee, Government Medical College Hospital, Kadapa, on 16 December 2024. Written informed consent was obtained from all participants after providing information about the study objectives, procedures, potential risks and benefits, confidentiality safeguards, and the possible publication of anonymized data and images without revealing individual identities. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and complied with the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants.

Anthropometric measurements

Weight was measured in minimal clothing and without footwear using a calibrated SECA 813 digital weighing scale, and recorded in kilograms. Stature was measured using a SECA 213 portable stadiometer with participants standing erect, barefoot, heels together, and the head positioned in the Frankfurt horizontal plane16; height was recorded in centimeters. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and classified using South Asian cut-offs. Underweight, less than 18.5 kg/m²; normal, 18.5–22.9 kg/m²; overweight, 23.0–24.9 kg/m²; and obesity, 25.0 kg/m² or higher. 17

Figure 1. Measurement of hand and finger dimensions using a digital Vernier caliper.

(A) Hand length, (B) hand breadth, (C) ring finger length, (D) index finger length and (E) little finger length.

Hand measurements included right and left-hand length (from the distal crease of the wrist to the tip of the middle finger) and hand breadth (maximum transverse breadth at the metacarpal heads), measured using sliding calipers and anthropometric scale, again recorded to the nearest 0.1 cm.5,8 Additional measurements included the lengths of individual fingers (index, middle, ring, and little) on both hands, from the fingertip to the metacarpophalangeal crease.6,8

To minimize diurnal variation, all measurements were taken between 14:00 and 16:00 hours. The measurement procedures for hand length, hand breadth, and selected finger lengths using a digital Vernier calliper are illustrated in Figure 1.

A single trained investigator performed all measurements to minimize inter-observer variability, with periodic instrument calibration to maintain measurement accuracy.

Operational definitions

Stature was defined as the participant's vertical height, measured in the standing position without footwear, with the head maintained in the Frankfurt horizontal plane. Hand length was defined as the linear distance from the distal wrist crease to the tip of the middle finger. Hand breadth was defined as the maximum transverse breadth across the metacarpal heads. Finger length was defined as the distance from the fingertip to the metacarpophalangeal crease for the respective finger. BMI was defined as body weight in kilograms divided by the square of height in metres.18

Data management and cleaning

Data was recorded on a structured proforma, and data entry was done with Windows Excel 2019 (Windows Corporation, Redmond, WA). All the entries were double-checked for any possible errors. Initial descriptive exploration revealed a small number of biologically implausible anthropometric values—extreme entries in finger-length fields that were inconsistent with human hand dimensions and almost certainly attributable to data-entry errors.

Predefined plausibility limits were applied before analysis. Stature values below 120 cm or above 220 cm were considered implausible. Hand length and hand breadth values outside 13–22 cm, and finger-length values outside 3–12 cm, were reviewed against the original data sheet and treated as missing if confirmed to be erroneous or biologically implausible. Weight and BMI values were also screened for internal consistency with recorded height and anthropometric measurements.

A small number of implausible entries were identified, predominantly in finger-length variables, and these observations were recoded as missing rather than deleted from the dataset. Thus, all 308 participants were retained for overall descriptive analysis, while variable-specific correlation and regression analyses were performed using available-case denominators. This explains the minor variation in sample size across individual hand and finger measurements reported in the Results tables, such as 294 observations for right hand length, 293 for left hand length, and 307 for right ring finger length.

Statistical analysis

Statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) 26 version software (IBM Corp., Somers, NY, USA). Descriptive statistics (mean, standard deviation, minimum, and maximum) were computed for stature, weight, BMI, and all hand and finger measurements. The level of statistical significance was set at $p < 0.05$ (two-tailed).

Pearson correlation coefficients were calculated to examine the linear relationship between stature and

each hand and finger measurement. Simple linear regression models were fitted with stature as the dependent variable and individual hand measurements as predictors, with particular emphasis on left- and right-hand length based on prior evidence that hand length is the most informative single hand-based predictor of stature. Regression performance was evaluated using the coefficient of determination (R^2), standard error of estimate (SEE), and mean absolute error (MAE).

To enhance forensic applicability, sex-stratified correlation and regression analyses were additionally performed, and the corresponding results are presented in the supplementary tables. Multiple linear regression models were also constructed to assess whether combinations of hand dimensions improved explanatory power compared with single-predictor models, as reflected by changes in R^2 and SEE.

Assumptions of linear regression were examined by inspection of residual-versus-fitted plots (linearity and homoscedasticity) and normal probability plots of standardized residuals (normality). No major deviations from these assumptions were observed, and all reported models were retained.

RESULTS

A total of 308 participants were included in the analysis, comprising 152 males and 156 females. Descriptive statistics, bilateral comparisons, sex-wise comparisons, correlation analyses, and simple linear regression analyses were performed for stature and all recorded hand variables.

Participant and hand measurement profile

The mean values, standard deviations, and ranges of stature and hand measurements in males and females are shown in Table 1. All measured variables were significantly greater in males than females, including stature, bilateral hand length and hand width, and all bilateral finger lengths (all $p < 0.001$).

Table 1. Descriptive statistics for stature and hand measurements in males and females

Measurements	Total N	Males Mean	Males SD	Males Min-max	Females Mean	Females SD	Females Min-max	T-value	P
Stature (cm)	308	171.07	6.28	142.00–186.00	157.24	5.65	145.00–173.00	20.31	<0.001
Weight (kg)	308	67.86	14.53	42.00–137.00	54.26	10.40	34.00–87.00	9.66	<0.001
BMI (kg/m²)	308	23.17	4.66	16.25–42.28	21.91	3.86	15.14–38.65	2.59	0.010
RHL (cm)	308	18.67	0.75	16.80–19.95	16.99	0.92	14.44–19.30	17.26	<0.001
LHL (cm)	308	18.72	0.69	16.90–19.94	17.00	0.93	14.10–19.10	18.03	<0.001
RHW (cm)	308	8.17	0.52	6.84–10.15	7.20	0.43	6.04–8.24	17.81	<0.001
LHW (cm)	308	8.05	0.53	6.59–9.92	7.02	0.47	5.74–8.20	18.10	<0.001
RIFL (cm)	308	7.10	0.48	5.90–8.49	6.57	0.46	5.35–7.84	9.89	<0.001
LIFL (cm)	308	7.25	0.51	5.98–8.64	6.62	0.46	5.23–7.89	11.36	<0.001
RMFL (cm)	308	7.91	0.51	6.48–9.28	7.23	0.49	5.97–8.62	11.85	<0.001
LMFL (cm)	308	7.99	0.52	6.53–9.53	7.29	0.51	5.88–8.65	11.98	<0.001
RRFL (cm)	308	7.32	0.50	5.94–8.69	6.63	0.49	5.17–8.05	12.21	<0.001
LRFL (cm)	308	7.27	0.51	5.98–8.87	6.55	0.49	5.11–7.89	12.63	<0.001
RLFL (cm)	308	5.91	0.48	4.60–7.12	5.35	0.48	3.71–6.80	10.14	<0.001
LLFL (cm)	308	5.91	0.46	4.66–7.14	5.31	0.46	3.72–6.55	11.43	<0.001

RHL, right hand length; LHL, left hand length; RHW, right hand width; LHW, left hand width; RIFL, right index finger length; LIFL, left index finger length; RMFL, right middle finger length; LMFL, left middle finger length; RRFL, right ring finger length; LRFL, left ring finger length; RLFL, right little finger length; LLFL, left little finger length; SD, standard deviation. Note: Minor variations in Total N reflect exclusion of implausible measurements.

Bilateral differences

Right-left comparisons are shown in Table 2. In males, right hand width and right ring finger length were significantly greater than left-sided values, whereas left index and middle finger lengths were significantly greater than right-sided values. In females, right hand width and right ring finger length were also significantly greater, while left index and middle finger lengths were significantly greater. No statistically significant bilateral difference was observed for hand length in either sex, and little finger length was also bilaterally similar in both sexes.

Table 2. Bilateral differences in hand dimensions of males and females

Variable	Males Mean diff (R-L)	SD	T-value	P-value	Females Mean diff (R-L)	SD	T-value	P-value
HL	-0.050	0.323	-1.794	0.075	-0.011	0.276	-0.515	0.607
HW	0.117	0.241	5.952	<0.001	0.184	0.255	8.991	<0.001
IFL	-0.150	0.243	-7.601	<0.001	-0.048	0.205	-2.947	0.004
MFL	-0.084	0.225	-4.607	<0.001	-0.058	0.225	-3.224	0.002
RFL	0.052	0.222	2.910	0.004	0.086	0.223	4.830	<0.001
LFL	-0.010	0.269	-0.441	0.660	0.033	0.276	1.475	0.142

HL, hand length; HW, hand width; IFL, index finger length; MFL, middle finger length; RFL, ring finger length; LFL, little finger length; SD, standard deviation.

Correlation with stature

All hand variables showed positive and statistically significant correlations with stature in both sexes, as shown in Table 3. Among males, the strongest correlations were observed for left hand length and right hand length. Among females, the strongest correlations were observed for left hand length, right hand length, left middle finger length, and right ring finger length.

Table 3. Correlation between stature and hand dimensions in males, females, and overall (combined)

Variable	Males Right	Males Left	Females Right	Females Left	Combined Right	Combined Left
HL	0.568	0.580	0.634	0.637	0.811	0.817
HW	0.257	0.222	0.394	0.382	-	-
IFL	0.444	0.435	0.556	0.565	-	-
MFL	0.457	0.438	0.574	0.600	-	-
RFL	0.431	0.447	0.585	0.575	-	-
LFL	0.325	0.417	0.515	0.569	-	-

HL, hand length; HW, hand width; IFL, index finger length; MFL, middle finger length; RFL, ring finger length; LFL, little finger length. All correlations were statistically significant at $p < 0.01$.

Regression equations for stature estimation

Simple linear regression equations derived from each hand variable are shown in Table 4. In males, the best single predictor was left hand length, followed by right hand length. In females, the best predictor was left hand length, closely followed by right hand length. In the combined sample of 308 subjects, left hand length produced the strongest overall model, followed by right hand length.

Table 4. Linear regression equations for stature prediction from hand dimensions

Variable	Males Regression equation	±SEE	R^2	Females Regression equation	±SEE	R^2	Both Regression equation	±SEE	R^2
RHL	Height = 84.93 + 4.584 × RHL	5.00	0.322	Height = 91.00 + 3.900 × RHL	4.40	0.401	Height = 56.51 + 6.017 × RHL	5.18	0.657
LHL	Height = 75.92 + 5.047 × LHL	4.91	0.336	Height = 91.29 + 3.879 × LHL	4.38	0.406	Height = 55.98 + 6.033 × LHL	5.07	0.668
RHW	Height = 145.54 + 3.127 × RHW	6.09	0.066	Height = 120.17 + 5.148 × RHW	5.21	0.155	Height = 93.11 + 9.242 × RHW	6.66	0.470
LHW	Height = 150.02 + 2.615 × LHW	6.14	0.049	Height = 124.82 + 4.620 × LHW	5.24	0.146	Height = 99.24 + 8.612 × LHW	6.72	0.460
RIFL	Height =	5.64	0.197	Height =	4.71	0.309	Height =	6.91	0.429

Variable	Males Regression equation	±SEE	R^2	Females Regression equation	±SEE	R^2	Both Regression equation	±SEE	R^2
	129.97 + 5.787 × RIFL			112.79 + 6.767 × RIFL			88.69 + 11.032 × RIFL		
LIFL	Height = 132.27 + 5.352 × LIFL	5.69	0.189	Height = 111.66 + 6.887 × LIFL	4.68	0.320	Height = 89.51 + 10.757 × LIFL	6.68	0.468
RMFL	Height = 126.97 + 5.577 × RMFL	5.60	0.209	Height = 109.63 + 6.588 × RMFL	4.64	0.330	Height = 84.22 + 10.558 × RMFL	6.52	0.492
LMFL	Height = 128.96 + 5.270 × LMFL	5.66	0.192	Height = 109.06 + 6.614 × LMFL	4.53	0.360	Height = 85.48 + 10.295 × LMFL	6.49	0.497
RRFL	Height = 131.31 + 5.433 × RRFL	5.69	0.185	Height = 112.26 + 6.779 × RRFL	4.60	0.342	Height = 89.27 + 10.731 × RRFL	6.51	0.495
LRFL	Height = 131.23 + 5.484 × LRFL	5.63	0.200	Height = 113.43 + 6.692 × LRFL	4.64	0.331	Height = 90.99 + 10.588 × LRFL	6.43	0.507
RLFL	Height = 146.11 + 4.223 × RLFL	5.98	0.105	Height = 124.97 + 6.038 × RLFL	4.86	0.265	Height = 107.34 + 10.082 × RLFL	7.21	0.379
LLFL	Height = 137.05 + 5.751 × LLFL	5.73	0.174	Height = 120.27 + 6.960 × LLFL	4.66	0.324	Height = 100.27 + 11.371 × LLFL	6.68	0.465

RHL, right hand length; LHL, left hand length; RHW, right hand width; LHW, left hand width; RIFL, right index finger length; LIFL, left index finger length; RMFL, right middle finger length; LMFL, left middle finger length; RRFL, right ring finger length; LRFL, left ring finger length; RLFL, right little finger length; LLFL, left little finger length; SEE, standard error of estimate; R^2, coefficient of determination.

Interpretation of findings

Overall, hand length was the most informative hand-based predictor of stature in this population, while hand width and little finger length showed lower predictive strength. Finger lengths, particularly middle and ring finger lengths, demonstrated moderate predictive value and may be useful when full hand length measurement is not available. The consistent superiority of hand length in males, females, and the pooled sample supports its use as the primary anthropometric variable for stature estimation in this cohort.

DISCUSSION

Principal findings

This cross-sectional anthropometric study demonstrates that hand length is a strong predictor of stature in young Indian adults from Andhra Pradesh. Left- and right-hand lengths showed strong positive correlations with stature ($r \approx 0.81$) and generated simple linear regression equations with R^2 values of approximately 0.66, indicating that about two-thirds of the variance in stature could be explained by hand length alone.

Finger dimensions, particularly ring and middle finger lengths, also correlated significantly with stature, but the predictive performance of finger-based models was lower than that of hand-length models. The derived regression equations based on hand length achieved mean absolute errors of approximately 4 cm, which is comparable to or better than several previously published hand-based stature models in similar age groups 1,2,6.

From a forensic perspective, these results indicate that hand length provides a practical single-predictor measure for approximate stature estimation when only the hand remains or handprints are available.

However, the observed error metrics underscore that estimates are inherently approximate and should be interpreted with caution at the individual level.

Comparison with previous studies

The present findings are broadly aligned with both Indian and international literature that identifies hand length as the most informative hand anthropometric variable for stature estimation. In a Korean population, diversified hand anthropometric dimensions were used to estimate stature, and hand length emerged as the most important single predictor; estimation accuracy was reported to be higher in females than in males.1 Ahemad, working on Indian male subjects, also found hand length to be the most important predictor of stature.9

In an Iban population in Malaysia, hand and handprint measurements showed significant associations with stature, with larger hand dimensions in males, and population-specific regression models were recommended for forensic practice.4,7 Studies from Bangladeshi and Indian populations similarly reported strong correlations between stature and various handprint measurements, with simple and multiple regression models offering useful estimation tools. 3,8

Within India, Krishan and colleagues have repeatedly emphasized the utility of hand and foot dimensions in stature estimation, and recent work from Delhi young adults demonstrated that hand length and foot length showed the strongest correlations with stature, with multiple regression models outperforming simple linear models.2 The present study's hand-length R^2 values (≈0.66) in a mixed-sex Southern Indian sample compare favourably with the hand-length R^2 reported in some East Asian and North Indian cohorts, underscoring the robustness of hand length as a predictor1,2,10.

The growing body of literature on forearm-hand length also shows strong correlations with stature, further supporting the concept that upper limb segments can provide reliable anthropometric clues in forensic contexts.11 By focusing specifically on hand length and finger measurements, this study adds region-specific evidence from Andhra Pradesh to the existing anthropometric literature and reinforces the consistent role of hand length as a robust predictor of stature.

Forensic and public health implications

From a forensic standpoint, the derived regression equations provide practical tools for preliminary stature estimation when only a hand remains or when handprints are available, such as in fire accidents, explosions, dismemberment cases, or advanced decomposition.1-3,9 Because hand dimensions can be measured relatively quickly and non-invasively, these models may also be useful in field investigations and disaster victim identification.

However, the literature consistently emphasises that stature estimation algorithms should be population-specific and used with awareness of their confidence intervals and standard errors of estimate.1,4,12 Applying regression equations derived from one population to another—especially across ethnic or regional boundaries—can produce substantial bias. The present study addresses this issue by providing algorithms tailored to young adults from Andhra Pradesh, though further validation in broader Southern Indian cohorts would strengthen external validity.

From a public health and ergonomic perspective, the hand anthropometric data provide contemporary regional reference values for young adults, which can inform the design of tools, instruments, and workspaces. Such region-specific norms are relevant for healthcare and industrial environments where hand-intensive tasks are common and where inappropriate sizing can contribute to discomfort or occupational injury.

Strengths and limitations

Key strengths of this study include a relatively large sample of young adults, systematic measurement of both hand length and individual finger lengths, and the use of standardized protocols. Measurements were collected within fixed afternoon time windows to minimize diurnal variation and were performed by a single trained observer, reducing inter-observer variability and random measurement error. In addition, biologically implausible values were identified and treated as missing, which likely improved the stability of correlation and regression coefficients by preventing distortion from obvious data-entry errors.

Several limitations should be acknowledged. The sample was drawn from medical students at a single government medical college, which may not reflect the wider Southern Indian population in terms of socioeconomic, nutritional, and occupational characteristics. The narrow age range (predominantly 18–25 years) further limits extrapolation to older adults, in whom age-related changes in stature and limb proportions may alter the underlying relationships.

Methodologically, the analysis relies primarily on simple linear regression models and does not include multi-variable or non-linear approaches, nor validation in an independent dataset; external validation and more complex modelling could improve predictive accuracy and clarify generalisability. Although sex-stratified analyses were undertaken and sex-specific regression equations are presented in detail, their external validation remains an important area for refinement in future work.

Future directions

Future research should prioritize external validation of these hand-based stature equations in independent Southern Indian cohorts, including non-medical populations and a wider age range. The development of sex-specific and multi-variable regression models

incorporating combinations of hand, foot, and forearm–hand measurements may further reduce error and enhance forensic utility, particularly when model performance is evaluated using R2, standard error of estimate, and mean absolute error. Where data support it, exploration of non-linear relationships or machine-learning methods could be considered, provided that gains in accuracy are balanced against the need for interpretability and practical applicability in forensic casework. Longitudinal and multi-centre studies would also help characterise secular trends in body proportions and support the creation of updated, population-specific anthropometric standards for stature estimation.

CONCLUSION

Hand length is a strong and reliable predictor of stature in young Indian adults from Andhra Pradesh, with left- and right-hand lengths yielding practical regression equations explaining approximately two-thirds of the variance in height. The study's findings align with recent international and Indian literature and reinforce the utility of hand dimensions in forensic identification, particularly when only partial remains are available.

Population-specific regression models, such as those presented in this manuscript, should be incorporated into regional forensic protocols, with ongoing validation and refinement to improve accuracy across diverse demographic groups.

Declarations

Conflict of Interest: The authors declare that they have no conflicts of interest related to this work.

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Use of Generative AI: No generative AI or AI-assisted tools were used in the conception, data collection, analysis, or writing of this manuscript.

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