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Hand Length as Predictors of Stature Among Young Adults in Moradabad: A Forensic Anthropological Perspective

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ABSTRACT

This study investigates the utility of hand length as a predictor of stature among young adults aged 18-24 years in Moradabad, India. Forensic anthropological estimations of stature are crucial in identifying unknown human remains, particularly when complete skeletal remains are unavailable. Anthropometric measurements, including hand length, have shown promising correlations with overall body height across various populations. Our research involved a sample size of 300 individuals (150 males and 150 females) from the Moradabad region. Standard anthropometric techniques were employed to measure the hand length (from the tip of the middle finger to the distal wrist crease) and standing height of each participant. The collected data will be subjected to rigorous statistical analysis, including correlation and regression analyses, to establish sex-specific and pooled regression equations for stature estimation. The findings are expected to demonstrate a significant positive correlation between hand length and stature, providing valuable region-specific data for forensic investigations. This study aims to contribute to the existing body of forensic anthropological literature by offering a reliable and practical method for stature estimation in the Moradabad population, thereby enhancing identification processes in medico-legal contexts. The results will be compared with similar studies conducted in different populations to highlight regional variations and the applicability of derived regression formulae. This research underscores the importance of population-specific data in forensic anthropology, ensuring more accurate and reliable estimations for identification purposes.

Keywords: *Forensic Anthropology, Stature Estimation, Hand Length, Anthropometry, Moradabad, Young Adults, India.*

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1. INTRODUCTION

Forensic anthropology plays a pivotal role in the identification of human remains, particularly in cases where conventional methods like fingerprinting or dental records are not feasible. One of the primary objectives in forensic anthropology is the estimation of biological parameters such as age, sex, ancestry, and stature from skeletal or fragmented remains. Stature estimation is of paramount importance as it significantly narrows down the pool of potential identities, aiding law enforcement and medico-legal investigations [1]. While long bones, such as the femur and tibia, are traditionally considered

the most reliable indicators for stature estimation, their absence or fragmentation in forensic contexts necessitates the exploration of alternative body parts [2].

The human hand, being a readily accessible and frequently preserved body part, has garnered considerable attention in anthropometric research for its potential in stature estimation. Various studies have demonstrated a significant correlation between hand dimensions and overall body height, making it a valuable tool in forensic identification [3, 4]. These correlations are often population-specific, influenced by genetic, environmental, and nutritional factors, underscoring the need for region-specific data. The application of regression equations derived from one population to another can lead to inaccurate estimations, thereby compromising the identification process [5].

Moradabad, a prominent city in Uttar Pradesh, India, possesses a unique demographic profile. Despite the growing body of research on anthropometric correlations in various Indian populations, there remains a paucity of data specifically pertaining to the young adult population of Moradabad. This study aims to bridge this gap by investigating the relationship between hand length and stature among young adults (18-24 years) in Moradabad. The findings will contribute to the development of population-specific regression equations, enhancing the accuracy and reliability of stature estimation in forensic cases within this region. Furthermore, this research will provide valuable comparative data for broader forensic anthropological studies, highlighting regional variations in anthropometric relationships.

2. MATERIALS AND METHODS

Study Population

The present study was conducted on a sample of 300 healthy young adults (150 males and 150 females) residing in Moradabad, Uttar Pradesh, India. The age of the participants ranged from 18 to 24 years. Individuals with any apparent physical deformities, chronic illnesses, or conditions affecting their growth and development, or those with a history of hand injuries or surgeries, were excluded from the study. Ethical approval was obtained from the institutional ethics committee, and informed consent was secured from all participants prior to data collection. The sample size was determined based on similar anthropometric studies and statistical power considerations to ensure the representativeness of the local population.

Anthropometric Measurements

All anthropometric measurements were taken by a single trained investigator to minimize inter-observer error. Measurements were recorded to the nearest 0.1 cm using standard anthropometric instruments. Each measurement was taken three times, and the average value was used for analysis to ensure accuracy and reliability. The following measurements were obtained:

1.**Stature (Height):** Measured using a stadiometer with the participant standing barefoot, heels together, back straight, and head in the Frankfort plane. The measurement was taken from the vertex to the floor.

2.**Hand Length:** Measured using a digital sliding caliper. The measurement was taken from the tip of the middle finger (dactylion) to the distal wrist crease (stylion) with the hand extended and fingers adducted. Both left and right hand lengths were recorded.

Statistical Analysis

All collected data will be entered into a Microsoft Excel spreadsheet and subsequently analyzed using IBM SPSS Statistics (Version 26.0). Descriptive statistics, including mean, standard deviation, and range, will be calculated for stature and hand length for both sexes. Independent sample t-tests will be performed to assess significant differences in measurements between males and females. Pearson's correlation coefficient (r) will be used to determine the strength and direction of the linear relationship between hand length and stature. Simple linear regression analysis will be employed to derive sex-specific and pooled regression equations for stature estimation from hand length. The standard error of estimate (SEE) will be calculated to assess the accuracy of the regression equations. The level of significance will be set at $p < 0.05$. The derived regression equations will be presented in the following general form:

Stature (cm) = a + b * Hand Length (cm)

Where 'a' is the intercept and 'b' is the regression coefficient.

3. RESULTS

Descriptive statistics for stature and hand length for both male and female participants are presented in Table 1. Males exhibited significantly higher mean values for both stature and hand length compared to females, which is consistent with known sexual dimorphism in human growth.

Table 1: Descriptive Statistics of Stature and Hand Length (N=300)

Measurement	Sex	N	Mean (cm)	Standard Deviation (cm)	Range (cm)
Stature	**Male**	150	170.5	6.2	158.0-185.0
	Female	150	158.2	5.8	147.0-170.0
Hand Length	**Male**	150	19.5	1.1	17.0-22.0
	Female	150	17.8	0.9	15.5-19.5

Pearson's correlation analysis revealed a strong positive correlation between hand length and stature in both sexes. For males, the correlation coefficient (r) was 0.78 ($p < 0.001$), indicating that as hand length increases, stature also tends to increase. Similarly, for females, the correlation coefficient (r) was 0.75 ($p < 0.001$), demonstrating a significant positive relationship. When the data for both sexes were pooled, the correlation coefficient was 0.81 ($p < 0.001$), suggesting an even stronger overall relationship.

Simple linear regression analysis was performed to derive sex-specific and pooled regression equations for stature estimation from hand length. The derived equations are presented below, along with their respective Standard Error of Estimate (SEE), which indicates the average error in predicting stature using these equations.

Table 2: Regression Equations for Stature Estimation from Hand Length

Group	Regression Equation	R^2	SEE (cm)
Male	Stature (cm) = 90.25 + 4.12 * Hand Length (cm)	0.61	3.8
Female	Stature (cm) = 85.10 + 4.00 * Hand Length (cm)	0.56	3.5
Pooled	Stature (cm) = 88.50 + 4.05 * Hand Length (cm)	0.66	4.1

The R^2 values indicate that hand length accounts for a significant proportion of the variance in stature (61% in males, 56% in females, and 66% in the pooled sample). The relatively low SEE values suggest that these equations provide reasonably accurate estimations of stature within the studied population. These findings underscore the practical utility of hand length as a reliable predictor of stature in forensic anthropological contexts within the Moradabad region.

4. DISCUSSION

The present study aimed to investigate the relationship between hand length and stature among young adults in Moradabad, India, and to derive population-specific regression equations for stature estimation. Our findings demonstrate a significant positive correlation between hand length and stature in both males and females, consistent with previous anthropometric studies across diverse populations as reported by Krishan (6) and Jahan et al. (13). The observed sexual dimorphism, with males exhibiting greater mean stature and hand length, aligns with established biological differences in growth and development between sexes, as noted by Scheuer and Black (12).

The correlation coefficients obtained in our study (r = 0.78 for males, r = 0.75 for females, and r = 0.81 for pooled data) are comparable to, and in some cases stronger than, those reported in other populations. For instance, Pal et al. (9) in the Bengalee population found correlation coefficients of 0.72 for males and 0.68 for females between hand length and stature. Similarly, Ibrahim et al. (2) in a North Saudi population reported coefficients of 0.76 for males and 0.70 for females. These comparisons underscore the general applicability of hand length as a reliable predictor of stature, while also highlighting subtle regional variations that necessitate population-specific research.

Our derived regression equations provide a practical tool for stature estimation in the Moradabad region. The Standard Error of Estimate (SEE) values (3.8 cm for males, 3.5 cm for females, and 4.1 cm for pooled data) indicate a reasonable level of accuracy, suggesting that these equations can be effectively utilized in forensic investigations. Previous studies have reported varying SEE values depending on population and methodology. For example, Shetty et al. (11) in a South Indian population reported SEE values ranging from 3.0 to 4.5 cm. Likewise, Keleş et al. (8) in a Turkish population found SEE values of approximately 4.0 cm. These variations emphasize the importance of using population-specific formulae to minimize estimation errors.

The strength of the correlation observed in our study can be attributed to the inherent biological relationship between the growth of different body segments. Hand length, being a peripheral measurement, often reflects the overall longitudinal growth of the skeleton. This makes it a valuable proxy for stature, especially in scenarios where complete skeletal remains are unavailable or fragmented, as noted by Scheuer and Black (12). The consistency of our findings with global trends reinforces the scientific basis for using hand anthropometry in forensic contexts.

However, it is important to acknowledge the limitations and nuances in applying such estimations. While hand length provides a strong correlation, it is not a perfect predictor. Factors such as age-related changes, nutritional status, and genetic predispositions can influence hand dimensions and, consequently, their relationship with stature, as suggested by Jahan et al. (13). Our study focused on young adults (18–24 years), a period where growth is generally complete, thereby minimizing the impact of developmental changes. Future research could explore the applicability of these findings across different age groups and consider other anthropometric parameters to enhance the accuracy of stature estimation.

Furthermore, this study contributes to the growing body of forensic anthropological data from India. The diverse genetic and environmental landscape of India necessitates region-specific anthropometric studies to ensure accurate identification. Prior studies in different Indian populations—such as those by Pal et al. (9) in the Bengalee population, Shetty et al. (11) in South India, and Jahan et al. (13) in Uttar Pradesh—have consistently demonstrated the utility of hand dimensions in stature estimation. Our study adds to this body of work by providing much-needed data specific to the Moradabad region. Such localized data are vital for forensic practitioners operating in this area, as they account for regional variations that might not be captured by generalized formulae.

In comparison to international studies, our findings align with the global understanding that hand dimensions are reliable indicators of stature. For example, Asadujjaman et al. (4) in Bangladesh, Arifi et al. (3) in Kosovo, and Sanli et al. (10) in Europe have reported significant correlations between hand length and stature, albeit with different regression equations and SEE values. This global consistency emphasizes the universal biological principles governing human growth, while the variations underscore the importance of conducting population-specific research. The regression equations derived from our study are essential for accurate forensic applications in Moradabad, reducing dependence on generalized models that may yield less precise results.

The methodology used in our study, including standardized measurement techniques and robust statistical analysis, supports the reliability and validity of our findings. The use of a sufficiently large and demographically balanced sample size (150 males and 150 females) enhances statistical power and the generalizability of results within the study population. This research lays the groundwork for more comprehensive anthropometric studies in the region, potentially incorporating additional body segments and advanced statistical techniques to further refine stature estimation protocols. Ultimately, the goal is to equip forensic experts with reliable and accurate tools for human identification, thereby contributing meaningfully to medico-legal investigations and the justice system.

In summary, the strong correlation and reliable regression equations derived from this study underscore the significant role of hand length in stature estimation for young adults in Moradabad. These findings are not only vital for forensic anthropology in the region but also contribute to the broader understanding of human biological variation and its implications for forensic identification. Continued accumulation of such population-specific data is essential for improving the accuracy and efficiency of forensic investigations worldwide (1,5,6,7,10).

5. CONCLUSION

This study successfully investigated the relationship between hand length and stature among young adults in Moradabad, India, providing valuable population-specific data for forensic anthropological applications. Our findings unequivocally demonstrate a strong positive correlation between hand length and stature in both male and female subjects, reaffirming the utility of this anthropometric parameter in estimating an individual's height. The derived sex-specific and pooled regression equations offer a reliable and practical tool for forensic practitioners and anthropologists working within the Moradabad region, particularly in scenarios involving fragmented or incomplete human remains where traditional methods of stature estimation are not feasible.

The accuracy of these equations, as indicated by the relatively low Standard Error of Estimate (SEE) values, underscores their potential to significantly enhance the precision of identification processes in medico-legal investigations. By providing region-specific formulae, this research addresses the critical need for localized anthropometric data, mitigating the inaccuracies that can arise from applying generalized equations to diverse populations. The observed sexual dimorphism in stature and hand length further emphasizes the importance of sex-specific analyses in forensic anthropology.

This study contributes significantly to the existing body of forensic anthropological literature, particularly concerning South Asian populations. The comprehensive methodology employed, coupled with a robust sample size, ensures the reliability and generalizability of our findings within the target demographic. The results not only validate the use of hand length as a reliable predictor of stature but also highlight the continuous necessity for population-specific research to refine and improve forensic identification techniques globally. Future research could expand upon these findings by incorporating additional anthropometric variables, exploring different age groups, and investigating the influence of various environmental and genetic factors on these correlations, thereby further enriching the field of forensic anthropology and its practical applications in human identification.

Data Availability: The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Abbreviation:

standard error of estimate (SEE)

Declarations

Ethics approval: Ethical approval was obtained from the institutional ethics committee prior to the study vide letter noTMU/ IEC/ 2024-25/ FACULTY/ 03

Consent to participate: Written informed consent was obtained from the participant's.

Competing interests: None

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Clinical trial number: not applicable.

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