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Estimation of Stature from Bilateral Hand Length among Medical Students of North Indian Medical College: A Cross-Sectional Study

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ABSTRACT

Background: Accurate assessment of height plays a critical role in clinical practice, nutrition, sports science, and forensic investigations. In situations where height cannot be measured directly, hand length and other anthropometric measurements serve as practical alternatives for estimating stature.

Methods: This cross-sectional study included 150 healthy medical students (90 males and 60 females) within the age range of 18–25 years. Stature, right-hand length, and left-hand length were recorded following standard anthropometric procedures. Pearson's correlation analysis and linear regression modeling were applied to evaluate the relationship between height and hand dimensions.

Results: In males, height correlated significantly with right-hand length ($r=0.43$, $p<0.001$) and left-hand length ($r=0.43$, $p<0.001$). In females, correlations were stronger, with $r=0.50$ ($p<0.001$) for right-hand length and $r=0.50$ ($p<0.001$) for left-hand length. Regression models further confirmed that hand length is a significant predictor of stature in both sexes, explaining approximately 19% variability of height in males and 26% in females.

Conclusion: Bilateral hand length demonstrates a moderate and statistically significant correlation with stature, with predictive strength slightly higher in females than in males. The sex-specific regression equations derived in this study can help estimate height when direct measurement is not feasible, particularly in clinical and forensic settings.

Key-words: Anthropometry, Correlation, Forensic identification, Hand length, Height, India, Stature estimation

INTRODUCTION

Stature is an important anthropometric indicator used in clinical, forensic, sports, and nutritional evaluations. It serves multiple purposes, including monitoring growth patterns, determining appropriate drug dosage, assessing nutritional status and interpreting physiological parameters. However, in individuals with spinal deformities, lower-limb loss, severe illness, immobility, or in postmortem and mass-disaster scenarios, accurate standing height may not be measurable, making indirect estimation from other body segments essential. [1,2]

Hand length—defined as the linear distance from the distal wrist crease to the tip of the middle finger—has been widely explored as such a surrogate. Multiple population-based studies have demonstrated that both right- and left-hand length show moderate to strong positive correlations with stature and can be used to construct reliable regression models. Recent Indian work among young adults and medical students has reported statistically significant correlations and practical

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regression equations linking bilateral hand length with height, underscoring the value of hand length in situations where direct stature measurement is not feasible. [3-5]

International data further support this relationship. Research conducted in Saudi Arabia, Western Australia, and other multinational populations has reported that hand length frequently demonstrates stronger correlations with stature compared with other hand parameters, and that regression models based on hand measurements can estimate height with accuracy typically within a few centimeters across varied ethnic groups.[6,7] A large Central Indian series also confirmed robust correlations for bilateral hand length and breadth, along with stature, in both males and females, reinforcing the forensic and epidemiological utility of hand-based equations.[8]

More recent analytical and multicentric studies have highlighted the importance of developing **population- and sex-specific models**. Studies conducted in Ethiopia and other African populations have reported strong correlations between height and bilateral hand length, with left-hand length frequently identified as the most reliable single linear predictor.[9] Contemporary Indian and South Asian work has similarly emphasized that while the direction of the hand–stature relationship is consistent, the slope and intercept of regression equations differ by region and demographic group, necessitating locally derived formulae for accurate application.[3-5]

In parallel, studies using handprints and individual digit measurements have shown that even partial hand data (such as finger lengths) can be exploited for stature estimation, expanding the relevance of hand anthropometry to fragmented or decomposed remains in medico-legal practice.[10,11] Collectively, these findings indicate that bilateral hand length is a simple, quick, and non-invasive parameter with considerable potential in clinical screening, sports selection, ergonomics, and forensic identification.

Against this backdrop, the present study examines the association between standing height and bilateral hand length among medical students in a North Indian medical college. The objectives were to measure bilateral hand length among medical students, assess its correlation with stature, and derive regression equations to estimate stature.

MATERIALS AND METHODS

Research Design- This cross-sectional observational study was carried out in the Department of Forensic Medicine at a North Indian medical college to assess the correlation between standing height and bilateral hand length (right and left). The study population included medical students aged 18–25 years who were available during the study period and consented to participate.

Inclusion Criteria

- ✓ Healthy medical students aged 18–25 years
- ✓ Willingness to provide written informed consent

Exclusion Criteria

- ✓ Congenital or acquired deformities of the upper limbs
- ✓ History of fractures, trauma, or surgeries affecting the hand
- ✓ Musculoskeletal or chronic systemic conditions influencing limb growth or proportions
- ✓ Any condition that could interfere with accurate anthropometric measurements

Sample Size- A total of 150 students participated in the study. Eligible volunteers who provided informed consent were selected through simple random sampling from the list of available medical students.

Data Collection- All anthropometric measurements were obtained using standard procedures and calibrated instruments. Standing height was measured using a stadiometer, with participants barefoot, heels together, body upright, and head aligned in the Frankfurt horizontal plane. Hand length was measured with a non-stretchable measuring tape from the distal wrist crease to the tip of the middle finger. Measurements were taken with the participant seated comfortably, forearm supinated, and the hand placed flat on a firm surface with fingers fully extended. Right- and left-hand lengths were recorded separately. To minimize inter-observer variability, a single trained examiner performed all measurements. All instruments were inspected and calibrated before each session to ensure accuracy and consistency.

Statistical Analysis- Data were analyzed using Microsoft Excel and Jamovi 2.6.44. Descriptive statistics (mean and SD) were calculated for height and bilateral hand length. Pearson's

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correlation was used to assess the relationship between height and hand length, and separate linear regression models were developed for each side to estimate stature. A two-tailed $p<0.05$ was considered statistically significant, and 95% confidence intervals were reported.

Ethical Considerations- The study received approval from the Institutional Ethics Committee, and written informed consent was obtained from all participants. Confidentiality and anonymity were ensured throughout, with no personal identifiers recorded or used during data collection, data entry, analysis, or reporting.

RESULTS

A total of 150 medical students participated in the study, comprising 90 males and 60 females. The mean height of males was 171.86±5.97 cm, with a range of 157.8 cm to 184.9 cm. The mean right-hand length was 18.95±1 cm, while the mean left-hand length was 18.93±1 cm. The ranges for right- and left-hand lengths were 5.0 cm and 5.1 cm, respectively, demonstrating comparable variability between both sides. Overall, male participants exhibited higher mean values for height and hand length than females (Table 1).

Table 1: Height and Hand Length Measurements in Male Participants

Variables	N	Mean	SD	Range	Minimum	Maximum
Height	90	171.86	5.97	27.1	157.8	184.9
Right Hand Length	90	18.95	1.00	5.0	16.5	21.5
Left Hand Length	90	18.93	1.00	5.1	16.4	21.5

The mean height of females was 156.35±5.88 cm, with a range of 28 cm (143.1–171.1 cm). The mean right-hand length measured 17.46±0.90 cm, while the left-hand length measured 17.44±0.89 cm, with similar ranges for both sides. Compared to males, females exhibited both lower stature and smaller hand dimensions, consistent with expected sexual dimorphism in anthropometric characteristics (Table 2).

Table 2: Height and Hand Length Measurements in Female Participants

Variables	N	Mean	SD	Range	Minimum	Maximum
Height	60	156.35	5.88	28	143.1	171.1
Right Hand Length	60	17.46	0.90	4.6	15.7	20.3
Left Hand Length	60	17.44	0.89	4.5	15.7	20.2

As presented in Table 3, height showed a statistically significant positive correlation with hand length in both males and females. Among females, right-hand length demonstrated a correlation coefficient of $r=0.50$ ($p<0.001$), while left-hand length showed a nearly identical correlation ($r=0.50$, $p<0.001$). This indicates a moderate linear relationship, with both hands contributing equally to stature estimation.

In males, the strength of association was slightly lower compared to females. Right-hand length showed a correlation of $r=0.43$ ($p<0.001$), and left-hand length demonstrated $r=0.43$ ($p<0.001$). Although somewhat weaker, both correlations remained statistically significant, confirming that hand length remains a meaningful predictor of height in both sexes.

Table 3: Pearson's Correlation Coefficient (r) Between Height and Hand Length

Group	Variable	r-value	p-value
Male	Right Hand Length	0.50	<0.001
Male	Left Hand Length	0.50	<0.001
Female	Right Hand Length	0.43	<0.001
Female	Left Hand Length	0.43	<0.001

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Table 4 presents the regression parameters for estimating stature from bilateral hand length. In males, the right-hand length model showed a slope of 2.61 and an intercept of 122.38 (R^2 = 0.256), yielding the equation:

$$H = 122.38 + 2.61 \times RHL.$$

A similar predictive pattern was observed for left-hand length, with a slope of 2.59, an intercept of 122.74, and an R^2 of 0.255.

In females, right-hand length produced a slope of 3.30 and an intercept of 98.74 (R^2 = 0.191), resulting in the equation:

$$H = 98.74 + 3.30 \times RHL.$$

The left-hand model demonstrated comparable parameters, with a slope of 3.35, an intercept of 97.87, and an R^2 of 0.18.

Overall, hand length showed a moderate positive ability to predict stature in both sexes. Predictive strength was slightly higher in males, indicating sex-related variation in body proportions and reinforcing the need for sex-specific regression equations in anthropometric and forensic applications.

Table 4: Regression Coefficients, R^2 Values, and Regression Equations

Groups	Predictor	Slope (b)	Intercept (a)	R^2	Regression Equation
Male	Right Hand Length	2.61	122.38	0.25	H=122.38 + 2.61×RHL
Male	Left Hand Length	2.59	122.74	0.25	H=122.74 + 2.59×LHL
Female	Right Hand Length	3.30	98.74	0.19	H=98.74 + 3.30×RHL
Female	Left Hand Length	3.35	97.87	0.18	H=97.87 + 3.35×LHL

Fig. 1 shows the scatter plot between height and right-hand length in females, demonstrating a clear positive linear trend. The regression line and R^2 value indicate that right-hand length moderately predicts female stature.

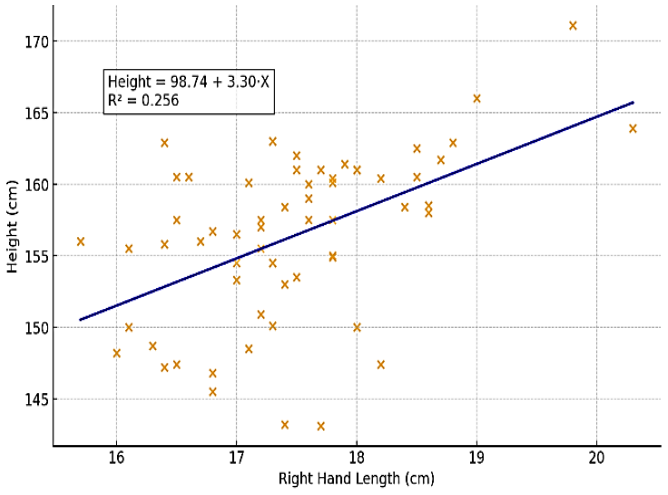

Fig. 1: Height vs Right Hand Length (Females)

Fig. 2 illustrates the relationship between height and left-hand length in females. A similar upward trend is observed, with the regression line showing comparable predictive strength to the right-hand.

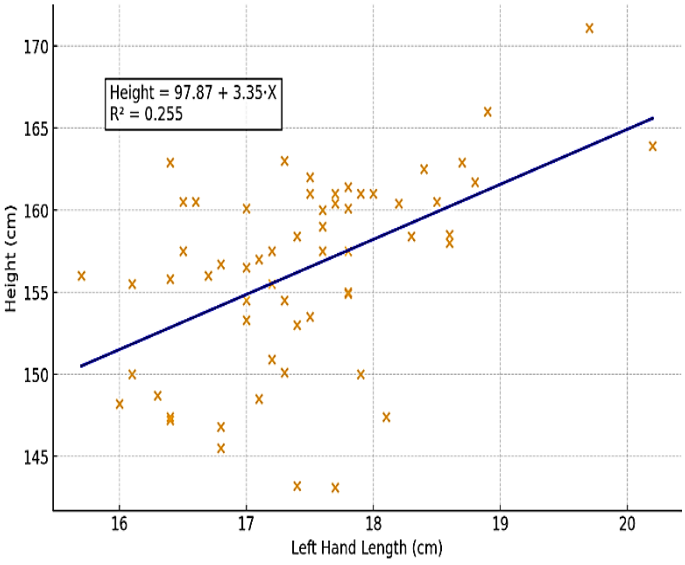

Fig. 2: Height vs Left Hand Length (Females)

Fig. 3 presents height versus right-hand length in males. Although the data points are more scattered than in females, the regression line shows a moderate positive association with stature.

Fig. 4 displays the scatter plot of height against left-hand length in males. The positive linear pattern and regression outputs indicate that left-hand length also serves as a moderate predictor of male stature.

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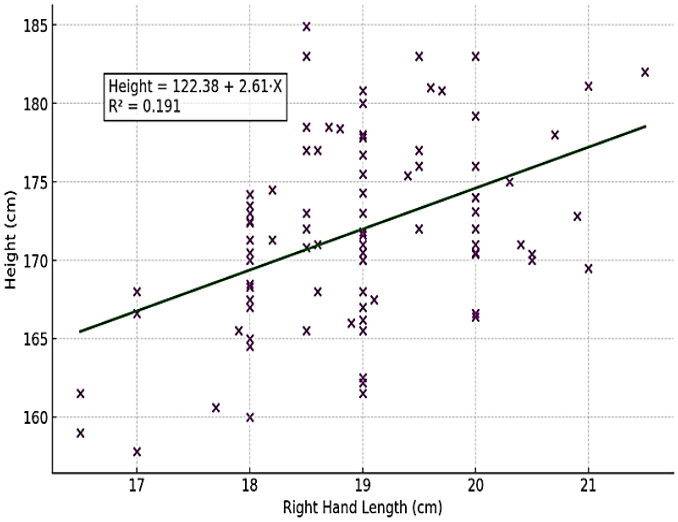

Fig. 3: Height vs Right Hand Length (Males)

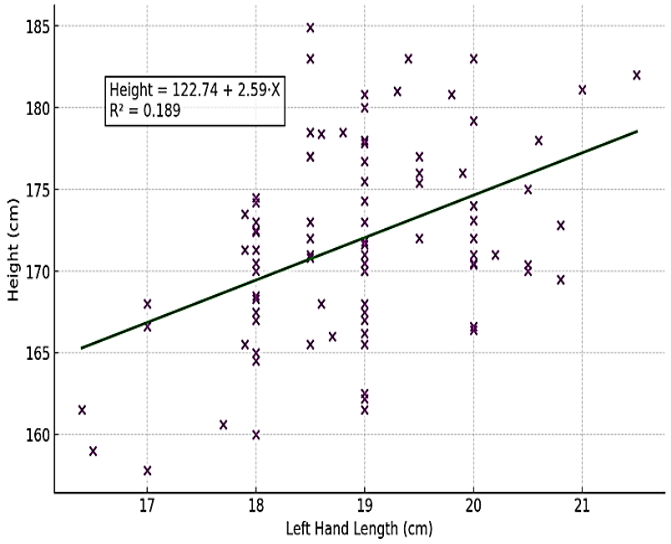

Fig. 4: Height vs Left Hand Length (Males)

DISCUSSION

The present study evaluated the relationship between stature and bilateral hand length among young adults aged 18–25 years. Both males and females demonstrated statistically significant positive correlations between height and hand length. Interestingly, the strength of association was slightly higher in females, with hand length explaining about one-fourth of height variability, compared to approximately one-fifth in males. Although moderate in magnitude, these correlations confirm that hand length remains a useful and practical surrogate for stature estimation when direct height measurement is not feasible, particularly when sex-specific predictive models are applied.[1,3,9,12]

The present study revealed moderate and statistically significant correlations between stature and bilateral hand length, with females exhibiting slightly stronger associations than males, as reflected by the Pearson coefficients (females: r ≈ 0.50; males: r ≈ 0.43; both p<0.001). These observations are consistent with existing anthropometric research, which indicates that hand length serves as a meaningful, albeit moderate, predictor of stature. Prior Indian studies by Anand *et al.* [3] and Kavyashree *et al.* [12] have reported comparable correlation strengths among young adults. Similarly, Tiruneh *et al.* [9] observed moderate correlations between hand dimensions and height in Ethiopian college students, supporting cross-population consistency in the proportional relationship between hand size and overall stature.

Correlation strengths in the present study were lower than those reported in several earlier Indian and international studies. For instance, Bandyopadhyay *et al.* [4] and Akhtar *et al.* [5] reported stronger associations (r>0.60). At the same time, studies conducted in Western Australia and the Middle East—such as those by Hussein *et al.* [6] and Ishak *et al.* [7] demonstrated even higher predictive reliability. These differences may stem from several factors: (i) population specificity, as the current sample consisted exclusively of medical students with comparatively reduced anthropometric variability; (ii) restricted age range (18–25 years), limiting natural variation in body proportions; (iii) sample size differences, since many previous studies included broader, more diverse cohorts; and (iv) measurement methodology, as some studies employed digital calipers or 3D anthropometric systems, which enhance precision and reduce random error.

Notably, some Indian studies-such as those by Pandey *et al.* [10] and Charmode *et al.* [8], included additional hand dimensions (hand breadth, phalangeal lengths), which tend to yield stronger correlations than hand length alone. Consequently, the moderate r and R^2 values observed in this study are expected when relying on a single linear measurement. Additionally, regional differences in ethnicity, nutritional status, physical activity, and secular growth patterns can influence overall body proportions, which may in turn affect the regression slopes and intercepts derived across different populations.

The regression slopes observed in this study (approximately 3.30 for females and 2.60 for males) are consistent with values reported in both Indian and

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international research, where slope estimates commonly fall between 2.5 and 3.5.[1,3,9] This suggests that although correlation strengths vary, the rate of increase in height per unit increase in hand length remains broadly comparable across populations. The R^2 values (≈25.6% in females and ≈19.1% in males) indicate that hand length alone explains a moderate proportion of variability in stature. While this predictive capacity is lower than that of indicators such as arm span or lower-limb dimensions, hand length remains a valuable parameter when those measurements are not available.

Overall, the present findings reinforce the utility of bilateral hand length as a practical proxy for stature estimation. Differences in correlation strength and predictive accuracy across populations underscore the need for population-specific regression equations, especially in forensic and clinical contexts where small deviations in height estimation may influence decision-making.[1,3] The consistency of regression slopes across multiple studies suggests a stable proportional relationship. Still, intercepts and R^2 values remain sensitive to population characteristics, further supporting the development of localized models like those presented in this study.[9,12]

The regression equations proposed in this study have value across multiple fields. In clinical practice, they can aid in estimating stature in bedridden, immobilised, or critically ill patients where direct measurement of standing height is not feasible. In forensic medicine, hand length offers a reliable parameter for stature reconstruction when only partial remains, severed hands, or identifiable handprints are available. Additionally, in sports science, physiotherapy, and ergonomics, hand measurements may serve as preliminary screening tools for anthropometric profiling, equipment sizing, and physical performance analyses [13,14].

LIMITATIONS

This study has several limitations. It was conducted within a single medical college, which may limit the generalizability of the findings to broader populations. Although the sample size (n=150) was adequate for statistical analysis, it remains modest compared to large-scale anthropometric surveys. The participants belonged to a narrow age range (18–25 years) and a relatively homogenous academic and socioeconomic background, which may not capture wider population variability. Additionally, despite standardized techniques, manual measurement methods may introduce minor observer-dependent variations

CONCLUSIONS

The present study establishes that bilateral hand length shows a statistically significant positive correlation with standing height in young adults. Although predictive strength varies slightly between sexes, the regression equations derived offer a practical approach to estimating stature when direct measurement is not feasible, highlighting the usefulness of hand length in clinical, forensic, sports, and ergonomic settings.

However, the findings should be interpreted cautiously due to the single-center design, modest sample size, and narrow age range. Broader validation is required to enhance external applicability. Future research should include larger, multicentric cohorts representing diverse ethnic, regional, and socioeconomic groups, as well as wider age ranges. Incorporating digital, laser-based, or 3D anthropometric assessment tools and establishing regional or national anthropometric databases will further strengthen predictive models and improve their reliability for routine practical use.

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