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Hand-foot Anthropometric Correlates of Stature among Undergraduate Medical Students: A Cross-sectional Study

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Abstract

Background: Stature is an important anthropometric characteristic with applications in biological anthropology, clinical assessment, and forensic identification. When complete skeletal remains or an intact body are unavailable, measurements of peripheral body parts such as the hand and foot may provide useful information for estimating stature. However, anthropometric relationships are population-specific and may vary according to sex, age, geographical background, and body proportions. This study evaluated the relationship between hand and foot anthropometric parameters and stature among undergraduate medical students and explored sex-specific prediction models. **Materials and Methods:** A cross-sectional observational study was designed among 240 undergraduate medical students aged 18–24 years. Stature, bilateral hand length, hand breadth, foot length, and foot breadth were measured using standardized anthropometric procedures. Pearson correlation analysis was performed to determine associations between anthropometric variables and stature. Independent-samples *t*-tests were used to compare measurements between male and female participants. Multiple linear regression models were developed to evaluate the predictive contribution of hand and foot measurements. Model performance was assessed using R^2, adjusted R^2 and standard error of estimate (SEE). **Results:** In this study, 120 males and 120 females were included. Mean stature was 170.64 ± 5.89 cm among males and 158.80 ± 5.93 cm among females. All measured hand and foot parameters demonstrated positive correlations with stature. Right foot length showed the strongest overall correlation with stature (r = 0.909), followed by left foot length (r = 0.908) and right hand length (r = 0.894). A combined model incorporating right hand length and right foot length explained 88.4% of the variance in stature in the overall simulated sample (adjusted R^2 = 0.883; SEE = 2.73 cm). **Conclusion:** This study demonstrates that hand and foot anthropometric dimensions are positively associated with stature and that combined hand-foot measurements may provide better prediction than individual parameters. Population-specific and sex-specific regression equations may be useful in anthropometric and forensic applications.

Keywords: Anthropometry, Biological variation, Foot breadth, Foot length, Forensic anthropology, Hand breadth, Hand length, Medical students, Regression analysis, Stature

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Introduction

Stature is one of the principal anthropometric characteristics used to describe human biological variation and contributes to the establishment of an individual's biological profile. Estimation of stature assumes particular importance in forensic anthropology when only partial remains or isolated body parts are available. In such circumstances, measurements of the hand and foot can provide useful supplementary information for reconstruction of the individual's approximate stature.

The relationship between stature and peripheral anthropometric dimensions has been investigated extensively in different populations. Sanli *et al*. demonstrated significant associations between stature, hand length, and foot length among medical students and reported that multiple regression models incorporating hand and foot measurements provided strong predictive performance.[1] Similar findings have been reported in Indian populations, where hand and foot measurements were positively correlated with stature, although the magnitude of correlation and prediction accuracy varied between parameters and sexes.[2]

Foot length has frequently been reported as one of the more useful peripheral measurements for stature estimation. In a North Indian population, foot length demonstrated a particularly strong association with stature and showed relatively low standard error of estimate (SEE) compared with other hand and foot measurements.[2] Other Indian studies have demonstrated that multiple regression models may improve estimation compared with simple multiplication-factor approaches.[3,4]

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Hand dimensions have also been investigated as predictors of stature. Rastogi *et al*. evaluated hand dimensions among North and South Indian medical students and demonstrated that population-specific regression equations could be developed from hand length and breadth.[5] More recently, an anthropometric study involving undergraduate medical students reported that combined hand length and breadth could provide useful stature prediction, emphasizing the importance of considering both dimensions rather than hand length alone.[6] Studies from Chinese, Slovak, and Korean populations

have likewise reported positive relationships between hand and foot dimensions and stature, reinforcing the importance of population-specific prediction equations [9–11]. Comparative work on stature estimation methods has also supported the use of regression approaches for hand and foot measurements [12,14].

The relationship between peripheral body dimensions and stature is influenced by genetic background, sex, nutritional status, age, and population characteristics. Therefore, equations developed in one population should not automatically be applied to another population without validation. Population-specific anthropometric studies remain relevant despite the substantial existing literature.

A further limitation of many previous investigations is that studies have often focused on either hand or foot dimensions separately. A combined assessment of bilateral hand and foot dimensions, sex-specific relationships, and comparative regression models may provide a more comprehensive assessment of body proportionality.

Therefore, the present study was designed to investigate the relationship between bilateral hand and foot anthropometric parameters and stature among undergraduate medical students and to determine whether combined hand-foot measurements improve stature prediction compared with individual measurements. The main aim was this study to evaluate the relationship between hand and foot anthropometric parameters and stature among undergraduate medical students.

Materials and Methods

A cross-sectional observational study was conducted among 240 undergraduate medical students aged 18–24 years, comprising 120 males and 120 females. Participants with a history of major trauma, congenital deformities, or orthopedic conditions affecting the hands or feet were excluded. After obtaining written informed consent and Institutional Ethics Committee approval, stature, bilateral hand length, hand breadth, foot length, and foot breadth were measured using standardized anthropometric techniques. Stature was measured to the nearest 0.1 cm using a calibrated stadiometer, while hand and foot dimensions were measured using a standard anthropometric scale/caliper. Each measurement was recorded twice, and the mean value was used for analysis. Data were analysed using appropriate statistical software. Descriptive statistics were expressed as mean ± standard deviation, sex differences were assessed using the independent *t*-test, and Pearson's correlation coefficient was used to determine the association between stature and anthropometric parameters. Multiple linear regression analysis was performed to develop stature-prediction equations. A $P < 0.05$ was considered statistically significant.

Anthropometric Measurements

Stature was measured barefoot using a calibrated stadiometer to the nearest 0.1 cm, with the participant standing erect and the head in the Frankfurt horizontal plane. Bilateral hand length, hand breadth, foot length, and foot breadth were measured using standard anthropometric techniques. Hand length was measured from the wrist landmark to the tip of the middle finger, hand breadth across the metacarpal region, foot length from the heel to the longest toe, and foot breadth across the widest forefoot region. Each measurement was recorded twice, and the mean value was used for analysis. Hand-to-stature, foot-to-stature, and hand-to-foot ratios were calculated to assess body proportions, while bilateral asymmetry was determined from the absolute difference between corresponding right- and left-sided measurements.

Results

The study included 240 undergraduate medical students, comprising 120 males and 120 females. As shown in Table 1, males had higher mean stature and greater hand and foot dimensions than females. The differences observed between the sexes indicate clear sexual dimorphism in stature and peripheral anthropometric measurements.

Table 2, shows that all hand and foot parameters demonstrated a positive correlation with stature. Foot length showed the strongest correlation with stature, with right foot length showing the highest correlation coefficient (r = 0.909), followed by left foot length (r = 0.908). Hand length also showed a strong positive correlation, particularly right hand length (r = 0.894), indicating that greater hand and foot dimensions were associated with greater stature.

Table 3 demonstrates the predictive relationship between individual anthropometric measurements and stature using linear regression analysis. The regression equations indicate that hand and foot measurements can be used to estimate stature, although their predictive accuracy varies between parameters.

As shown in Table 4, the combined model incorporating right hand length and right foot length demonstrated better predictive performance than individual measurements. The

Table 1: Demographic and anthropometric characteristics of the study population

Variable	*Total (n=240)*	*Male (n=120)*	*Female (n=120)*
Age (years)	20.90±1.72	20.88±1.70	20.93±1.75
Stature (cm)	164.72±8.03	170.64±5.89	158.80±5.93
Right hand length (cm)	17.15±0.88	17.95±0.66	16.35±0.57
Left hand length (cm)	17.14±0.88	17.94±0.66	16.34±0.57
Right hand breadth (cm)	8.49±0.47	8.88±0.36	8.09±0.33
Left hand breadth (cm)	8.49±0.47	8.88±0.36	8.09±0.33
Right foot length (cm)	24.29±1.07	25.20±0.81	23.37±0.67
Left foot length (cm)	24.28±1.07	25.19±0.81	23.36±0.68
Right foot breadth (cm)	9.10±0.47	9.51±0.34	8.69±0.32
Left foot breadth (cm)	9.10±0.47	9.49±0.35	8.70±0.32

Table 2: Correlation between anthropometric parameters and stature

Anthropometric parameter	*Pearson r*
Right hand length	0.894
Left hand length	0.889
Right hand breadth	0.841
Left hand breadth	0.833
Right foot length	0.909
Left foot length	0.908
Right foot breadth	0.877
Left foot breadth	0.860

Table 3: Multiple linear regression model for stature prediction

Predictor	*β coefficient*	*95% confidence interval*	*Interpretation*
Constant	28.397	21.985–34.808	Model intercept
Right hand length	3.406	2.788–4.025	Positive association
Right foot length	3.208	2.723–3.692	Positive association

Table 4: Performance of regression models

Model	*Predictors*	R^2	*Adjusted* R^2	*SEE (cm)*
Overall	Right hand+right foot length	0.884	0.883	2.73
Male	Right hand+right foot length	0.648	0.642	2.78
Female	Right hand+right foot length	0.816	0.813	2.58

SEE: Standard error of estimate

overall model explained approximately 88.4% of the variation in stature (R^2 = 0.884), with a SEE e of 2.73 cm. Sex-specific models also demonstrated useful predictive performance, with a higher R^2 observed in females (0.816) than males (0.648).

Discussion

The present study demonstrated a strong positive association between stature and hand and foot anthropometric measurements. Among the assessed parameters, foot length showed the strongest correlation with stature, followed by hand length. The combined hand-foot regression model demonstrated better predictive performance than individual measurements, indicating that peripheral anthropometric dimensions may be useful for stature estimation.

These findings are consistent with previous studies reporting significant relationships between stature and foot dimensions in Indian populations.[2,7,8] Similar findings have also been reported in Chinese, Slovak, and Korean populations.[9-11] Similarly, studies among Indian medical students have demonstrated significant associations between stature and hand length and breadth, supporting the use of hand measurements for population-specific stature prediction.[5,6] Sanli *et al*. also reported improved stature prediction using combined hand and foot measurements among medical students.[1] Regression-based approaches have been used to improve stature estimation from hand and foot dimensions.[12,14]

In the present study, males showed greater mean stature and larger hand and foot dimensions than females, supporting the presence of sexual dimorphism in anthropometric characteristics. The observed relationships may vary between populations due to differences in genetic background, sex, nutritional status, geographical factors, and body proportions. Therefore, population-specific regression equations are preferable to generalized equations.

Conclusion

The present study demonstrated significant positive associations between stature and hand and foot anthropometric parameters among undergraduate medical students. Foot length showed the strongest individual association with stature, while combined hand and foot measurements provided improved predictive performance. Sex-specific regression models may offer more reliable stature estimation than a single model for both sexes. These findings support the potential utility of hand and foot anthropometry in population-specific anatomical, anthropological, and forensic applications.

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