ORIGINAL ARTICLE

Estimating stature from hand and foot anthropometry: A pilot study

Muhammad Maqsood[1], Muhammad Kashif Butt[1], Laiba Saher[1], Samiullah Asif[1]

Department of Forensic Medicine, Shalamar Medical and Dental College, Lahore, Pakistan[1]

ABSTRACT

Background: Stature estimation is a critical component of forensic identification, particularly when dealing with incomplete human remains. While global anthropometric models exist, population-specific data for Pakistan remain scarce.

Objective: To determine the correlation of hand and foot length with stature in medical students and to derive sex-specific regression equations for stature prediction, using hand and foot lengths.

Methods: A pilot cross-sectional study was conducted from August 21 to September 20, 2025, in the Forensic Department of Shalamar Medical & Dental College, Lahore, Pakistan. Both male and female MBBS students (n=100), aged 20 to 25 years from a medical college, were included in the study. Standardized anthropometric techniques were used to measure hand and foot lengths and stature. Pearson's correlation test and multiple linear regression were employed to develop predictive models.

Results: Significant positive correlations were found between stature and both hand and foot lengths of both sides (r = 0.688–0.773, $p < 0.001$), with left foot length showing the strongest correlation ($p<0.001$). Gender-specific regression analyses revealed that, for males, the model with left-hand and foot length explained 36.0% of the variance in stature, with foot length as the significant predictor. For females, the similar model explained 33.2% of variance, with both hand and foot length as significant predictors.

Conclusion: Stature was significantly correlated with hand and foot lengths, with left foot length showing the strongest association. Sex-specific regression analyses indicated that left foot length was the main predictor in males, while left hand and left foot lengths significantly predicted stature in females.

Key Words: Stature, Hand, Foot, Anthropometry, Forensic Anthropology

DOI: https://doi.org/10.53685/jshmdc.v6i2.399

Corresponding Author:
Muhammad Kashif Butt
Assistant Professor
Department of Forensic Medicine, Shalamar Medical and Dental College, Lahore, Pakistan.
Email address: drkashifpak@yahoo.com
Received: 23.10.25, 1st Revision: 29.11.25
2st Revision: 10.12.25, Accepted: 15.12.25

…………………………………………………………………………
…………………………………………………………………………
…………………………………………………………………………
…………………………………………………………………………

How to cite this article: Maqsood M, Butt MK, Saher L, Asif S. Estimating stature from hand and foot anthropometry: A pilot study. J Shalamar Med Dent Coll. 2025; 6(2): 77-82. doi: https://doi.org/10.53685/jshmdc.v6i2.399

INTRODUCTION

Establishing individual identity is of paramount importance in forensic science.[1] Stature estimation is considered one of the "big four" parameters—along with age, ancestry, and sex- essential for assisting in human identification.[2] Considering increasing mass disasters such as floods, earthquakes, homicides, bomb blasts, aviation disasters, train collisions, and traffic accidents, are the circumstances indicating a persistent need to identify deceased individuals from fragmented and dismembered remains.[3] Consequently, developing accurate methods for estimating stature is imperative. Stature is defined as the length of the individual in the standing position.[4]

In recent decades, forensic anthropology has emphasized the need to develop region-specific regression equations for stature estimation. This is important because anthropometric relationships vary significantly across populations due to differences in genetics, nutritional habits, climate, socioeconomic status, and physical activity levels. A method validated in one country may therefore not apply to another, highlighting the necessity of indigenous data collection.[5]

Global studies have determined stature from the combined lengths of the skull, vertebrae, pelvis, and lower limbs.[6,7] Traditionally, the stature has been estimated using bones such as the metatarsals, feet, tibia, femur, ulna, humerus, hand digits, and phalanges, with established correlations between estimated stature and the lengths of these bones.[7,8] Stature estimation formulae for White and African American males and females were introduced in 1952.[9] A recent study from Pakistan reported significant positive correlations between stature and hand length, suggesting that regression equations can accurately estimate one measurement from the other.[10]

Although relationships between stature and bone lengths are well documented, these relationships vary across populations and ethnic groups due to genetic, nutritional, and physical activity factors. Stature estimation can provide crucial assistance in forensic investigations within both civil and criminal contexts. Data on stature estimation from hand and foot measurements in the Pakistani population are limited. This pilot study aimed to address this gap by establishing the correlation between hand and foot length and stature in medical students and by deriving sex-specific regression equations for stature prediction using hand and foot lengths.

METHODS

A cross-sectional study was conducted in the Forensic Medicine Department of Shalamar Medical & Dental College, Lahore, Pakistan, from August 21 to September 20, 2025. To account for the possibility of lateral asymmetry, all participants self-reported as right-handed.

A sample size of 21 males and 18 females was calculated using MedCalc statistical software version 23.4.5, Correlation coefficients between stature and foot length of 0.58 and 0.62 for males and females, respectively, were used, with 80% power of the study, and 95% confidence interval.[11]

Simple, convenient sampling was done, and participation was voluntary after informed consent. Both male and female 3rd-year MBBS students (n=100), aged 20-25 years, were included in the study. Subjects with a history of any surgical procedure on the limbs and with any skeletal deformity, conditions such as scoliosis, limb length discrepancy, amputations, and fractures were excluded. Subjects with any injuries in the past six months that could affect limb measurement and alignment (e.g., fractures, sprains, amputations) were also excluded from the study, as these might alter measurements.

A proforma was designed to record the socio-demographic characteristics, physical examination findings, and anthropometric measurements. Written informed consent was obtained from all participants to take their measurements after a comprehensive explanation of the study's purpose and procedures.

Each participant's hand length, foot length, and stature (height) were measured. Anatomical landmarks used for the hand length included the tip of the third digit to the distal wrist crease, and for foot length (heel to tip of hallux). Participants' stature (height) was measured using a wall-mounted stadiometer. Participants were instructed to stand erect, barefoot, with the head in the natural, neutral plane (Frankfort Horizontal Plane). The height was then measured as the distance from the vertex of the skull to the floor. The distance between the dactylion (the terminal point of the third digit) and the most distal palmar crease of the wrist (the stylion landmark) was measured and defined as hand length. The length of the foot was recorded as the distance between the most posterior point of the heel (akropodion) and the most anterior point of the hallux in a straight line. Hand and foot lengths were measured directly using digital sliding callipers, with the participant's foot resting on a flat surface and the hand in a full weight-bearing position. To minimize inter-observer error, all measurements were taken twice, and the mean value was calculated to ensure accuracy.

Ethical Approval

The ethical approval to conduct the study was obtained from the Institutional Ethical Review Board of Shalamar Medical and Dental College, Lahore, Pakistan (IRB# SMDC-IRB/AL/2025-042) dated, 21st August 2024.

Statistical Analysis

Data was analysed using SPSS version 24. Descriptive statistics were computed for means, minimum and maximum values, and standard deviations. Pearson's correlation coefficient was used to assess the correlation between stature and hand and foot length.

The mean differences in hand length, foot length, and stature across genders were compared using an independent-samples t-test. Regression analysis was conducted on the entire sample and separately for both genders. Regression models were

adjusted for multiple variables after assessing multicollinearity. A p-value <0.05 was considered statistically significant.

RESULTS

The mean age of participants was 21.53±1.04 years. Descriptive characteristics of the study population (n=100) are presented in Table 1. The sample comprised 58 female and 42 male participants. There was a statistically significant difference in stature between genders (p <0.001), with males exhibiting a higher mean height than females (Table 1). Correlation analysis demonstrated that all limb measurements were significantly and positively correlated with height (p < 0.001). The strongest correlations were observed with the left foot (Table 2).

Multiple linear regression analysis was used to develop predictive models for stature. The most parsimonious and robust models utilized one hand and one foot measurement to derive sex-specific prediction equations (Tables 3 and 4). Right foot length is a significant predictor of stature in both sexes. Right hand length did not reach statistical significance in either model. The models explain 35.3% (males) and 26.4% (females) of stature variability (Table 3).

Table 4 presents gender-specific multiple linear regression models for predicting stature from left-hand and left-foot lengths. In males, the regression model was statistically significant (R^2 = 0.360, p < 0.001), explaining 36.0% of the variance in stature. Left foot length emerged as an important predictor of stature (B = 1.687, p = 0.003), whereas left hand length was not statistically significant (B = 1.159, p = 0.132). In females, the regression model was also statistically significant (R^2=0.323, p< 0.001), accounting for 32.3% of the variance in stature. Both left-hand length (B=1.949, p=0.003) and left-foot length (B=1.510, p=0.016) were significant predictors of stature (Table 4).

The models revealed that foot length was a consistently significant predictor of stature for both sexes (p < 0.05). For males, only foot length contributed significantly, whereas hand length did not contribute significantly in either model.

The regression models incorporating left-side measurements (Table 4) demonstrated marginally higher predictive power, with coefficients of determination of 0.36 in males and 0.32 in females, compared with the corresponding right-side models (Table 3).

Table 1: Anthropometric measurements of the study participants

Anthropometric measurements	Males (mean ± SD)	Females (mean ± SD)	p-value
Height (cm)	173.82 ± 5.62	160.09 ± 6.06	0.000[a]*
Right Hand (cm)	20.55 ± 1.140	18.76 ± 1.170	0.000[a]*
Left Hand (cm)	20.48 ± 1.090	18.75 ± 1.170	0.000[a]*
Right Foot (cm)	26.55 ± 1.520	23.83 ± 1.270	0.000[a]*
Left Foot (cm)	26.58 ± 1.530	23.80 ± 1.220	0.000[a]*

[a]*Independent samples t-test was applied. *p<0.05 was considered statistically significant.*

Table 2: Correlation between stature and bilateral hand and foot measurements

Variable	r	p-value
Right Hand Length-stature	0.688	< .001[a]*
Left Hand Length-stature	0.708	< .001[a]*
Right Foot Length-stature	0.765	< .001[a]*
Left Foot Length-stature	0.773	< .001[a]*

[a]*Independent samples t-test was applied.*p<0.05 was considered statistically significant.*

Table 3: Gender-specific multiple linear regression models for stature prediction using right hand and right foot lengths					
Sex	**Predictor**	**Unstandardized Regression Coefficients**		**R^2**	**p-value**
		B	**Std. Error**		
Male	**Constant**	105.66	15.113		0.000*
	Right Hand length	1.189	0.715	0.353	0.104
	Right Foot length	1.647	0.534		0.004*
Female	**Constant**	97.726	14.079		0.000*
	Right Hand length	1.304	0.712	0.264	0.073
	Right Foot length	1.59	0.655		0.018*

R^2 = coefficient of determination. ***p-value <0.001 was taken as statistically significant.*

Regression Equation for Males (right side):

"Height (cm)" = 105.656 + (1.189 × "Right Hand Length (cm)") + (1.647 × "Right Foot Length (cm)")

Regression Equation for Females (right side):

"Height (cm)" = 97.726 + (1.304 × "Right Hand Length (cm)") + (1.590 × "Right Foot Length (cm)")

Table 4: Gender-specific multiple linear regression models for stature prediction using left hand and left foot lengths					
Sex	**Predictor**	**Unstandardized Regression Coefficients**		**R^2**	**p-value**
		B	Std. Error		
	Constant	105.25	15.165		0.000*
Male	**Left Hand length**	1.159	0.753	0.360	0.132
	Left Foot length	1.687	0.539		0.003*
	Constant	87.601	14.228		0.000*
Female	**Left Hand length**	1.949	0.628	0.323	0.003*
	Left Foot length	1.51	0.605		0.016*

R^2 = coefficient of determination. ***p-value <0.01 was taken as statistically significant.*

Regression Equation for Males (left side):

"Height (cm)" = 105.248 + (1.159 × "Left Hand Length (cm)") + (1.687 × "Left Foot Length (cm)")

Regression Equation for Females (left side):

"Height (cm)" = 87.601 + (1.949 × "Left Hand Length (cm)") + (1.510 × "Left Foot Length (cm)")

DISCUSSION

Accurate estimation of stature is a fundamental component of forensic identification, particularly in heterogeneous populations with marked variation in anthropometric characteristics. Population-specific predictive models are therefore essential to enhance the accuracy and reliability of forensic assessments. In this regard, population-specific predictive models are imperative to improve the validity and trustworthiness of forensic judgments. In Pakistan, the availability of indigenous anthropometric data remains limited, necessitating locally relevant research in this domain. Accordingly, the present pilot study was undertaken to examine the relationship between stature and hand and foot measurements in a Pakistani population. By deriving sex-specific regression equations, this study seeks to contribute contextually appropriate forensic standards that may improve stature estimation within the local population.

The results of the present study indicated that stature and both hand and foot length were significantly correlated; left foot length showed the strongest correlation, and significant predictive equations were derived from the two limb measurements. In our study, regression models incorporating bilateral measurements (hand and foot lengths) explained up to 35% and 36% of the variance in stature for the right and left sides, respectively, among males. Furthermore, among females, the bilateral measurements explained 26% and 32% of the variance in stature for the right and left sides, respectively. The left foot length was identified as the

stronger predictor of stature, and the regression model using left hand and left foot measurements provided a strong prediction of stature. The findings of this study strongly support the hypothesis that appendicular measurements, specifically hand and foot lengths, are significant anthropometric predictors of stature, with a robust linear relationship consistent with studies across diverse populations.[12-14] Foot length showed a slightly stronger correlation with height than hand length, consistent with recent research indicating that pedal dimensions are marginally superior estimators of stature.[15-17] This finding may be physiologically explained by the role of the feet in weight-bearing and stability, which may necessitate a more deterministic scaling relationship with overall body height than that for the hands.

These results contrast with a previous study of Iranian and Pakistani medical students, which found that regression models were not statistically significant for Pakistani male foot length and Iranian female hand length[18]. These differences may be attributable to anthropometric variability and methodological differences. The regression analyses in our study refined this relationship by incorporating measurements of one hand and one foot, stratified by sex. These findings are consistent with an Indian study and a study of adult Turks, which developed multiple regression models using left- and right-hand and foot measurements as strong predictors of height.[19,20] Some studies have found that hand length is a stronger predictor of stature than foot length in specific populations, as seen in an Indian study that reported that hand length had the highest correlation with stature (and regression analysis identified hand length as the single best predictor of height in their sample, outperforming foot length).[21] Another study in the Kolhapur population found that right-hand length had a slightly stronger correlation with stature than right-foot length, suggesting that hand length is a better predictor.[22] In our study, foot length was a stronger predictor than hand length, contrasting these studies.

Sex-stratified analysis revealed important predictive patterns. In males, left foot length emerged as a statistically significant predictor in the regression model, whereas in females, both left hand length and left foot length were significant predictors. The sex-specific models provide more precise and tailored equations when the sex of an individual is known—a frequent scenario in forensic examinations. This reduction in explanatory power within sex groups indicates that other factors, such as genetic background, nutritional history, or individual variation in limb-to-torso ratios, play a more substantial role in determining height within each sex.[23] This finding aligns with the work conducted in Northeastern Thailand, which noted that population-specific formulae often yield the highest accuracy, and further suggests that sex-specific formulae may be necessary for precise forensic applications.[5]

CONCLUSION

This pilot study demonstrates a significant association between stature and anthropometric measurements of the hand and foot in medical students. Gender-specific regression models indicated that foot length is a more consistent predictor of stature than hand length. Models incorporating left-side measurements showed marginally higher predictive performance than those incorporating right-side measurements. These findings suggest that hand and foot dimensions, particularly foot length, may be helpful for stature estimation; however, larger studies across diverse populations are needed to validate and refine these regression equations.

Limitations and future recommendations

This study's relatively small sample size and unequal sex distribution may limit the generalizability and precision of the regression models. Additionally, as measurements were obtained from living subjects under controlled conditions, caution is warranted when applying these findings to post-mortem contexts. Future studies should validate these equations in larger, more diverse populations and explore integrating anthropometric data with additional biological markers to enhance predictive accuracy.

Acknowledgements

The authors extend their sincere gratitude to all participants who volunteered for this study.

We are also deeply thankful to Mr. Shujat Ali, Mr. Yasir Hameed, and Mr. Usman for their invaluable assistance and diligent efforts during the data collection phase. Their commitment and teamwork were essential to the successful completion of this project. Finally, we acknowledge the support and facilities provided by the Department of Forensic Medicine at Shalamar Medical and Dental College, Lahore, Pakistan.

REFERENCES

1. Morgan RM. Forensic science. The importance of identity in theory and practice. Forensic Sci Int: Synergy. 2019; 1: 239-242. doi: 10.1016/j.fsisyn.2019.09.001.

2. Kira K, Chiba F, Makino Y, Torimitsu S, Yamaguchi R, Tsuneya S, et al. Stature estimation by semi-automatic measurements of 3D CT images of the femur. Int J Legal Med. 2023; 137(2): 359-377. doi:10.1007/s00414-022-02921-y.
3. de Boer HH, Roberts J, Delabarde T, Mundorff AZ, Blau S. Disaster victim identification operations with fragmented, burnt, or commingled remains: experience-based recommendations. Forensic Sci Res. 2020; 5(3): 191-201. doi: 10.1080/20961790.2020.1751385.
4. Moorthy TN. Regression analysis to determine stature from hand anthropometry among Ilocano population in Philippines for person identification. Indones J Legal Forensic Sci. 2021; 11(1). doi:10.24843/IJLFS.2021.v11 .i01.p03.
5. Boonthai W, Srisen K, Poodendaen C, Phetnui P, Unsri S, Iamsaard S, et al. Population-specific equations for stature estimation using forearm bones: insights from Northeastern Thailands diverse ethnic landscape. Anthropol Anz. 2024; 81(2): 225-232. doi: 10.1127/anthranz/2024/1854.
6. Imai N, Funayama K, Suzuki H, Tsuchiya K, Minato I, Endo N. Formulas for estimating living stature based on bony pelvic measurements reconstructed from computed tomography images. Homo. 2021; 72(1): 1-9. doi: 10.1127 /homo/2021/ 1239.
7. Park J, Lee M, Kim D, Kwon H, Choi Y, Park K, et al. Estimating adult stature using metatarsal length in the Korean population: a cadaveric study. Int J Environ Res Public Health. 2022; 19(22): 15124. doi: 10.3390/ijerph192215124.
8. Parash M, Rahman M, Naushaba H, Haque S, Shimmi SC. Simple linear regression approach for evaluating models to estimate stature based on upper limb dimensions of adult Bangladeshi males. Egypt J Forensic Sci. 2022; 12(1): 12. doi: 10.1186/s41935-022-002773.
9. Trotter M, Gleser GC. Estimation of stature from long bones of American Whites and Negroes. Am J Phys Anthropol. 1952;10(4):463–514. doi: 10.1002/ajpa.1330100407.
10. Asif MAM, Manzoor S, Butt U, Alam Tanoli A, Khan A, Adil M. Correlation between hand length and stature. Esculapio J Services Inst Med Sci. 2023; 19(01): 78–81. doi:10.51273/esc 23.2519116.
11. Malik AR, Akhter N, Ali R, Farrukh R, Aziz K. A study on estimation of stature from foot length. Professional Med J. 2015; 22(5): 632639. doi:10.29309/TPMJ/2015.22.05.1304.
12. Methepatil S, Dethe V. Prediction of height using hand and foot parameters in Maharashtrian population. Natl J Clin Anat. 2022; 11(3): 143-147. doi: 10.4103/NJCA.NJCA _52_22.
13. Kataria S, Dechalwal S, Shedge R, Devi N, Sachdeva M, Jain S. Stature estimation using hand and foot metrics among the Meena tribal population of the north-western Indian region. J Forensic Sci Med. 2024; 10(2). doi: 10.4103/jfsm.jfsm _92_23.
14. Igbigbi PS, Ominde BS, Adibeli CF. Anthropometric dimensions of hand and foot as predictors of stature: A study of two ethnic groups in Nigeria. Alex J Med. 2018; 54(4): 611–617. doi:10.1016/j.ajme.2018.11.002.
15. Moustafa S. Estimation of stature from anthropometric dimensions of hand and foot in Egyptian sample. Ain Shams J Forensic Med Clin Toxicol. 2017; 29(2): 19-25. doi: 10.21608 /ajfm.2017.18206.
16. Tiruneh C, Teshome D, Geberemeskel T, Derso M, Necho M, Teshome Y, et al. Prediction of body height using hand length and hand breadth in pharmacy and nursing students at Misrake Ghion college, northeast Ethiopia: an anthropometry study. Acad Forensic Pathol. 2024; 14(1): 10-20. doi: 10.1177/1925 3621231225259.
17. Kanchan T, Kotian MS, Menezes RG, Garg RK, Moudgil R, Kaur R. Stature estimation from foot length using universal regression formula in a north Indian population. J Forensic Sci. 2010; 55(1): 163-166. doi: 10.1111/j.1556-4029.2009.012 36.x.
18. Jouzdani A, Madadi S, Abbas M, Razavi H, Alizamir T. The comparison stature estimation from forearm, hand length and foot length between Iranian and Pakistani medical students. AIMS Med Sci. 2022; 9(3): 332-343. doi: 10.3934/medsci. 2022027.
19. Sanli SG, Kizilkanat ED, Boyan N, Ozsahin ET, Bozkir MG, Soames R, et al. Stature estimation based on hand length and foot length. Clin Anat. 2005; 18(8): 589-596. doi: 10.1002/ ca.20146.
20. Karmalkar A, Nikam V. Prediction of stature from long bones versus hand and foot measurements: a comparative study of the Kolhapur population. Natl Med J India. 2021; 34(3): 154-157. doi: 10.25259/NMJI_79_20.
21. Yellapurkar S, Pundir S, Kaul A. Role of hand and foot print dimensions in stature identification among Indian population. Indian J Forensic Med Toxicol. 2020; 14(3): 584-589. doi: 10.37506/ijfmt.v14i3.10404.
22. Patel P, Tanna J, Kalele S. Correlation between hand length and various anthropometric parameters. Int J Med Toxicol Forensic Med. 2012; 2(2): 61-63. doi: 10.22037/ijmtfm.v2i2 (spring).3254.
23. Joshi A, Thorat S. Gender differences in the relationship between forearm length and height across different age groups: a correlation and regression analysis. Adv Hum Biol. 2024; 14(3): 207-2010. doi: 10.4103/aihb.aihb_96_24.

AUTHOR'S CONTRIBUTIONS:

MM: Data acquisition, data analysis, manuscript drafting.

MKB: Study design, interpretation of data, critical revision of the manuscript.

LS: Data analysis, critical review of the manuscript, manuscript drafting.

SA: Data collection, interpretation of data, manuscript drafting.

All authors approved the final version to be published and agreed to be accountable for all aspects of the work, ensuring that any questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved

CONFLICT OF INTEREST:

None

GRANT SUPPORT AND FINANCIAL DISCLOSURE:

Authors declared no specific grant for this research from any funding agency in the public, commercial or non-profit sectors

DATA SHARING STATEMENT:

The data are available from the corresponding author upon request.

………..…………………………………………………