

UNLOCKING ANTHROPOMETRIC INSIGHTS: THE ASSOCIATION BETWEEN FOOT LENGTH AND STATURE IN THE PASHTUN POPULATION

Anwar Ul Haq¹, Rizwan Ul Haq², Ghulam Muhayudin³, Anwar Ali⁴, Syeda Hina zehra⁵, Sumbul Javed⁶.

¹Department of Forensic Medicine and Toxicology, Khyber Girls Medical College, Peshawar.

²Department of Forensic Medicine and Toxicology, Jinnah Medical College, Peshawar.

³Departments of Forensic Medicine and Toxicology, Women Medical College Abbottabad.

⁴Department of Forensic Medicine and Toxicology, Muhammad College of Medicine, Peshawar.

⁵Post Graduate Scholar, Khyber Girls Medical College, Peshawar.

⁶Department of Forensic Medicine and Toxicology, Khyber Girls Medical College, Peshawar.

Correspondence:

Dr. Anwar Ul Haq

Email: dranwarulhaq23@gmail.com

Abstract:

Background: Stature is vital for identifying individuals, and estimating height through hand and foot dimensions has long intrigued anatomists, scientists, and forensic experts.

Objective: This research aimed to determine correlation among length of foot and height in the Pashtun community.

Material and Methods: It was cross-sectional observational study carried out with 135 students both male and female aged 18 to 23 at Jinnah Medical College, Peshawar, from December 1, 2023, to March 31, 2024. The study used complete enumeration probability sampling and excluded individuals with foot deformities, spinal irregularities, atypical statures, and those under 18. Research conducted after approval from Institutional Ethical Committee. Data included measurements of height and foot length in centimeters. The obtained data were statistically analyzed.

Results: it was observed that average height of males was 173.50 cm and females had 159.56 cm, with mean left and right foot lengths of 26.5 cm and 24.19 cm for males and females respectively. A significant relationship between length of foot and height was found for both genders ($r=0.602$ for males and $r=0.629$ for females, $p<0.01$). The regression coefficient (b) for height prediction was 2.13 for males and 2.96 for females. Regression equations for stature estimation was developed, showing more accurate results for females, with Standard Errors of Estimate (SEE) of ± 4.22 for males and ± 4.41 for females.

Conclusion: This research aimed to determine the height and length of foot of pashtun population and establish a predictive equation for stature based on foot length in adults. The study suggests that foot length could be a key parameter for determining stature across various ethnic groups. Further research among diverse populations is needed to validate stature measurement as a reliable identifier.

Keywords: Stature, Foot length, Height, Gender, Forensic anthropologist, Anthropometric parameters

Cite this article: Ul Haq A, Ul Haq R, Muhayudin G, Ali A, Hina Zehra S, Javed S. Unlocking Anthropometric Insights: The Association between Foot Length and Stature in the Pashtun Population. BMC J Med Sci. 2025; 6(1): 80-83. <https://doi.org/10.70905/bmcj.06.01.0501>

Introduction:

The practice of identifying offenders based on anthropometric measurements emerged as a tactical method in forensic science in the year 1882¹. Subsequently, it has been extensively employed as effective technique for forensic identification; however, limited focus has been placed on studying human

footprints and feet within this domain². In 1968, Rutishauser initially illustrated that accuracy of predicting height from length of foot in humans seem to be notably superior to that from long bones. Various techniques are employed for the identification of individuals for legal or humanitarian purposes, with

Authorship Contribution: ^{1,6}Substantial contributions to the conception or design of the work; or the acquisition, Data analysis, Literature review, ²Drafting the work or revising it critically for important intellectual content, ^{3,4,5,6}Final approval of the version to be published, Topic Selection & Supervision

Funding Source: none

Conflict of Interest: none

Received: Feb, 06, 2025

Accepted: April, 26, 2025

Published: July 30, 2025

stature playing a crucial role, especially in cases involving mutilated, decomposed, or severed body parts due to disastrous incidents such as explosions, earth quakes, terrorist attacks and mass-casualties, etc., demonstrating the significant importance of the foot and its components in personal identification during mass calamities³.

One aspect of forensic examination for individual identification involves Anthropometry. Essential parameters utilized for identification include assessing age, gender, ethnicity, and so forth⁴. Determining the height of an individual from skeletal remains or dismembered limbs holds crucial implications in personal identification in scenarios like homicides, accidents, or natural calamities, as necessitated in forensic identification procedures⁵. Various countries such as India⁶, Egypt⁷ and Nigeria⁸ have conducted studies using hand and foot measurements for estimating height. The size of the foot, in conjunction with other anatomical features like head, torso, and upper and lower limbs lengths, is believed to play a role in establishing a definitive biological relationship with stature^{6,7,8}. Scarce research has been conducted utilizing similar parameters in Pakistan, highlighting the urgent need to investigate the association between foot length and body height to determine ethnic characteristics within this specific population⁹. This investigation would also contribute to formulating a regression equation for estimation of stature based on foot length and its relationship with height¹⁰.

Material and Method:

Study Population:

The study included male and female students aged 18–23 years, enrolled at Jinnah Medical College.

Sampling Technique and Sample Size:

The sample comprised 135 participants, determined using the complete enumeration sampling technique, including all eligible individuals in the defined population during the study period.

Inclusion and Exclusion Criteria:

•**Inclusion Criteria:** Participants aged 18–23 years who consented to participate.

•**Exclusion Criteria:**

1. Individuals with foot injuries or deformities.
2. Those with spinal irregularities.
3. Participants with atypical statures (e.g., dwarfism, gigantism).
4. Individuals under 18 years of age.

Ethical Approval:

Approval for the study was obtained from the Institutional Ethical Committee prior to data collection.

Data Collection Procedures:

Height Measurement: Participants' body height was measured using an anthropometer or stadiometer.

Subjects stood barefoot in an anatomical position, and height was recorded in centimeters from the top of the head to the ground.

Foot Length Measurement: Participants placed their foot on a blank sheet of paper, and the foot outline was traced with a fine-point pencil. The foot length was measured in centimeters, extending from the most prominent point at the heel to the tip of the great toe (or second toe, if longer).

Data Analysis:

- All measurements were recorded in centimeters and analyzed using SPSS version 26.0.
- Descriptive statistics, including the Mean $\pm$ Standard Deviation, were calculated for quantitative variables following normal distribution.
- The normality of the data was assessed using the One-sample Kolmogorov–Smirnov (K–S) test.
- A Pearson correlation coefficient was computed to evaluate the relationship between foot length and Height.
- Linear regression analysis was performed to assess the predictive relationship between the variables.
- A p-value < 0.05 was considered statistically Significant.

Study Design and Setting:

This cross-sectional observational study was conducted at Jinnah Medical College, Peshawar, over a period of four months, from December 1, 2023, to March 31, 2024.

Results:

In current investigation, as illustrated in Table 1, average height of male population was 174.50 cm, while for the female population it was 159.56 cm. The left foot mean length was 27.5 cm for males and 24.29 cm for females, whereas the right foot length was 27.5 cm for males and 24.29 cm for females. The mean foot length of males was observed to exceed that of females. Within our research, detailed in Table 2, a robust and statistically significant association ($r = 0.603$, $p < 0.01$) was identified between body height and foot length of males. Similar relationship observed between stature of female and length of foot ($r = 0.630$, $p < 0.01$). The calculated regression coefficient (b) for height and foot length was 2.14 for males, 2.97 for females.

Table 3 within our investigation outlines the regression equation utilized for predicting stature based on foot measurements for both genders. Globally, regression formulas are widely recognized as crucial tools for estimating stature from diverse anthropometric measures. Through computer evaluation, regression coefficients 'a' and 'b' computed, with 'a' representing the regression coefficient for the stature, dependent variable, and 'b' for length of foot, the independent

variable. Therefore, stature = a + box; in it x = foot length. The Standard Error of Estimate (SEE) indicates coefficient of determination (R²) were determined to be more accurate for females compared to males. among the parameters, signifying that foot length is highly reliable and accurate in estimating the stature of an unidentified individual¹². In India, a study conducted on individuals aged 14 to 25 founded that height can be estimated fairly accurately using regression equations for both males and females¹³. A research focusing on humans created a regression equation that is capable of predicting an individual's height based on their foot length, indicating that foot length increases in

Table 1: Anthropometric measurements of the study subjects			
Subject	Body height range cms (mean±SD)	Left Foot length range cms (mean±SD)	Right Foot length range cms (mean±SD)
Male	160-185 (174.50±5.25)	20.0-29.5 (26.50±1.35)	20.0-29.0 (26.50±1.42)
Female	146-169 (159.56±5.45)	21-27 (24.19±1.13)	21.6-26.8 (24.19±1.17)
Both Gender	146-185 (168.35±8.74)	20.0-29.5 (24.50±1.70)	20.5-29.0 (25.00±1.84)

Table 2: Descriptive statistics of parameters in both male and female			
Parameter	Male	Female	Both
Correlation coefficient (r) height & foot length	0.60	0.63	0.81
Regression coefficient (b) Height & foot length	2.14	2.97	3.71
Value of constant (a) height & foot length	116.70	89.00	74.29

Table 3: Linear regression formula for stature (cm) from foot length					
Sex	Regression equation	SEE	Co-efficient of determination (R ²)	Adjusted (R ²)	P-value
Male	BH=116.75+2.14 x FL	4.26	0.36	0.35	0.05
Female	BH=89.00+2.97 x FL	4.40	0.40	0.37	0.04
Both	BH=74.29+3.71 x FL	4.47	0.38	0.35	0.02

BH-Body height; FL-Foot length; SEE-Standard Error of Estimate.

the variance between estimated stature and actual stature, with values ranging for males between ±4.22 correspondence with height for both males and females¹⁴. Bindurani et al. noted correlation coefficients between foot width and length of foot of 0.41 and 0.71 for males, and 0.68 and 0.71 for females¹⁵. A research on Turkish population revealed average heights of 172.4 cm for males and 162.0 cm for females, with corresponding foot lengths of 25.0 cm for males and 22.8 cm for females, showing significant correlation coefficients (r) of 0.696 for males and 0.496 for females¹⁶. A study in the Slovakian population found mean heights of 180 cm for males and 168.3 cm for females, with foot lengths of 37.9 cm for males and 38.4 cm for females, showing significant correlation coefficients (r) of 0.759 for males and 0.722 for females¹⁷. Acikgoz et al. found a connection between length of hand, foot length, and height using multiple linear regression analysis, involving a sample of 154 adults (80 male, 74 female) from Turkey¹⁸. Their findings indicated that a multiple linear regression model encompassing both sexes was best, with a multiple correlation coefficient R of 0.927.

Discussion:

An individual's height is an intrinsic trait that differs depending on the ethnicity and race. Ossification and development take place sooner in the feet than in the long bones, allowing for a more precise determination of stature during adolescence through foot measurements as opposed to long bone measurements¹¹. Statistical analysis revealed significant differences in these measurements (Table-1) across both sexes, aligning with previous research findings. Mishra A et al. conducted a study on length of foot and the height, reporting heights of male and female study subjects ranging from 153-181 cm and 139-173 cm, respectively, showing a notable correlation in between the two. The length of left foot ranged from 22-26 cm in males and 20-26 cm in females, while the length of right foot ranged from 22-27 cm in males and 21-26 cm in females.

These results demonstrate positive correlation coefficients. Hence, precision of height prediction is enhanced in instance of females with resemblances to investigation conducted by Saco-Ledo G¹⁹. The distinct regression formulas obtained from various studies indicate that these equations are only suitable for the specific population from which the data was gathered, owing to the inherent variability within this population in terms of these measurements. This variability can be linked to the impact of genetic and environmental elements such as dietary habits and weather patterns, etc. Varied regression equations from diverse research have illustrated that formulas are exclusively relevant to specific populace from which data was obtained, due

to the implicit diversity within this population in these measurements, which can be linked to both genetic influences and environmental conditions, such as weather patterns and dietary habits. Gupta and Thallaur²⁰ advised against utilizing same formulas for height estimation in various population subgroups. Thus, height can be estimated with good accuracy using linear regression formulas based on available body parts. Moreover, these regression equations vary between genders due to differences in stature and foot length, with both measurements typically being greater in males. This discrepancy requires the use of distinct regression formulas for each gender. The most suitable approach to develop a regression equation applicable to all populations must be community-oriented. Additionally, these equations are not suitable for individuals at extreme ends of the height spectrum, such as titans or pygmies.

Conclusion:

The focus of research was to determine the height and length of foot of the Pashtun population, aiming to establish a correlative equation for predicting stature based on foot length in adults. This study posits that foot length has the potential to be a key parameter in determining stature across various ethnic groups. Consequently, there is a need for further research among diverse populations to solidify stature measurement as a reliable identifier for individuals.

References:

1. Gupta R, Nayyar AK, Gupta MK, Bhagat OL. Forensic tool for sex prediction-hand dimensions. *African Health Sciences*. 2022 Dec 23;22(4):408-12.
2. Moorthy TN, Baskaran M. Footprint-based gait analysis in a homicide case-identified the culprit as wife of the deceased, also the complainant: challenging forensic podiatry crime scene report. *Sch Int J Law Crime Justice*. 2021;4(3):166-9.
3. Ghaffar UB, Shaik RA, Faraz A, Sami W, Hussain S, Khan N. Correlation between height and foot length in Saudi population in majmaah, Saudi Arabia. *Int. J. Curr. Res. Rev*. 2020 Nov;12:6-9.
4. Paul P, Mukhopadhyay A, Biswas S. Stature determination from different body dimensions: a systematic review appraisal. *Int J Exp Res Rev*. 2020;21:19-24. doi: 10.52756/ijerr.2020.v21.003.
5. Rai P, Das A, Agrawal AK, Arora D. Physical anthropometry in estimation of stature: A systematic review. *Int. J. Curr. Res. Rev*. 2020 Dec;12:75-9.
6. Shetty B, Deepak M, Monteiro FN, Castelino KP, Xavier AP. Estimation of stature from dimensions of hands and feet in a South Indian Population. *IP Int J Forensic Med Toxicol sci*. 2020;5(1):14-9.
7. Ghaleb S, Adly M, Hassan DA, Fouad M. Estimation of stature from dimensions of hand and foot in Egyptian population at greater Cairo. *The Egyptian Journal of Forensic Sciences and Applied Toxicology*. 2019 Mar 1;19(1):71-86.
8. Igbigbi PS, Ominde BS, Adibeli CF. Anthropometric dimensions of hand and foot as predictors of stature: A study of two ethnic groups in Nigeria. *Alexandria journal of medicine*. 2018;54(4):611-7.
9. Jouzdani AF, Madadi S, Abbas MA, Razavi H, Alizamir T. The comparison stature estimation from forearm, hand length and foot length between Iranian and Pakistani medical students. *AIMS Medical Science*. 2022;9(4):496-511.
10. Vukotic M. Body height and its estimation utilizing foot length measurements in Montenegrin adolescents: a national survey. *Nutrición hospitalaria: Órgano oficial de la Sociedad Española de Nutrición Clínica y Metabolismo (SENPE)*. 2020;37(4):794-8.
11. Biswas SO, Mitra DE, Basu RI, Datta M. Estimation of stature using lower limb dimensions among adolescent population of Kolkata: A cross-sectional study. *International Journal of Anatomy Radiology and Surgery*. cm. <https://doi.org/10.7860/ijars/2022/55108.2820>. 2022.
12. Mishra A, Kakkar D, Kaur G, Chauhan T, Gondhali U, Kushwaha KP. Stature and its estimation utilizing hand and foot measurements in North Indian population. *Indian Journal of Forensic Medicine and Pathology*. 2023;16(1):35-43.
13. Yadav S, Nayak VC, Palimar V, Gupta C, Chetal JR. An Estimation of Stature and Sex using Various Anthropometric Parameters in South Indian Population. *Journal of Forensic Science and Medicine*. 2023 Apr 1;9(2):130-6.
14. Vukotic M. Body height and its estimation utilizing foot length measurements in Montenegrin adolescents: a national survey. *Nutrición hospitalaria: Órgano oficial de la Sociedad Española de Nutrición Clínica y Metabolismo (SENPE)*. 2020;37(4):794-8.
15. Bindurani MK, Kavyashree AN, Asha KR, Subhash L. Determination of sex from foot dimensions. *Int J Anat Res*. 2017;5(4.3):4702-6.
16. Al-Kharaz AA, Chong A. Gender differences in foot morphology of Middle Eastern adults using close-range photogrammetry technique. In: 2021 IEEE 11th IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE) 2021 Apr 3 (pp. 301-306). IEEE.
17. Uhrova P, Beňuš R, Masnicová S. Stature estimation from various foot dimensions among Slovak population. *Journal of forensic sciences*. 2013 Mar;58(2):448-51.
18. Acikgöz AK, Erkman AC, Binokay F, Göker P, Bozkir MG. Estimación de la Estatura a Partir de Mediciones Radiográficas en una Población Adulta de Anatolia. *International Journal of Morphology*. 2021 Jun;39(3):809-15.
19. Saco-Ledo G, Porta J, Monson TA, Brasil MF, Atamtürk D, Duyar I. Piecewise regression equations for estimating stature: an anthropometric study in Spanish females. *International Journal of Legal Medicine*. 2020 Nov;134(6):2289-96.
20. Gupta K, Thallaur S, Singh R, Barwa J, Das S. Stature estimation from finger length by regression equation. *Int J Curr Sci Res Rev*. 2023;6(2):1537-1541. doi: 10.47191/ijcsrr/V6-i2-73