

DETERMINING ADULT HEIGHT FROM CLAVICLE LENGTH

Suryakanta Pati¹, Dilip Kumar Mallick², Chaman Kumar Bisoyi³ and Praveen Kumar Pradhan⁴

¹Associate Professor, Department of Forensic Medicine and Toxicology, J.K.M.C.H., Jajpur, Odisha, India

²Assistant Professor, Department of Forensic Medicine and Toxicology, S.J.M.C.H., Puri, Odisha, India

³Assistant Professor, Department of Forensic Medicine and Toxicology, S.L.N.M.C.H., Koraput, India

⁴Assistant Professor, Department of Forensic Medicine and Toxicology, Government Medical College and Hospital, Sundargarh, Odisha, India

Corresponding Author: Praveen Kumar Pradhan

Abstract

Background: Determining adult height from clavicle length is an interdisciplinary endeavor intersecting forensic anthropology, medicine, and bioarchaeology. This method is pivotal in forensic investigations and anthropological research, offering insights into individuals' biological characteristics across various populations.

Methods: A cross-sectional observational study was conducted over three years at SCB Medical College, Cuttack, Odisha, involving 100 healthy adult volunteers. Clavicle length and stature were measured, and demographic data including age, sex, and ethnicity were recorded. Statistical analyses, including correlation and multiple regression, were performed to explore the relationship between clavicle length and stature while adjusting for potential confounders.

Results: The study found a significant positive correlation between clavicle length and stature ($r = 0.62$), with males exhibiting a slightly stronger correlation than females. Multiple regression analysis revealed clavicle length as a significant predictor of stature ($\beta = 0.61$, $p < 0.001$), with sex also contributing significantly to the model ($\beta = 0.24$, $p = 0.003$). Ethnicity and age did not significantly affect the relationship between clavicle length and stature within the sample.

Conclusion: Clavicle length serves as a reliable indicator for estimating adult height, with implications for forensic identification and anthropological research. The study underscores the importance of population-specific equations for improving accuracy in height estimations.

Recommendation: Further research should explore additional factors influencing the relationship between clavicle length and stature, such as nutritional status and geographical variations. Population-specific studies are warranted to enhance the applicability of clavicle-based stature estimation methods.

Keywords: Clavicle length, stature estimation, forensic anthropology, multiple regression analysis.

INTRODUCTION

Determining adult height from clavicle length is a fascinating area of study that intersects the fields of forensic anthropology, medicine, and bioarchaeology. This method of estimation plays a crucial role in forensic investigations and anthropological research, providing valuable insights into the biological characteristics of individuals from past and present populations. The relationship between clavicle length and overall body height is grounded in the principles of human growth and development, suggesting a proportional growth pattern that can be analyzed and applied in various contexts [1,2].

Research has shown that the clavicle, or collarbone, is one of the last bones to complete ossification, which typically concludes around the age of 25 [3]. This late ossification makes the clavicle a reliable indicator for estimating adult height, as its length remains relatively stable after full growth is achieved. Studies by Franklin et al. [4] have developed regression formulas for estimating stature from the measurements of long bones, including the clavicle, highlighting the bone's significance in forensic and archaeological applications.

Moreover, the use of clavicle length in determining adult height has been validated across different populations, indicating its universal applicability despite variations in genetic and environmental factors [6]. These findings underscore the importance of creating population-specific equations to improve the accuracy of height estimations, as demonstrated by various researchers who have explored the relationship between clavicle length and height in specific demographic groups [6].

The determination of adult height from clavicle length is a critical tool in the forensic and anthropological sciences, offering a window into the lives of individuals and populations through the study of human remains. The ongoing development of more refined and population-specific estimation methods continues to enhance the accuracy and reliability of this approach [7].

The study aims to establish a correlation between the length of the clavicle and the overall height of an adult individual. This research seeks to develop a reliable method for estimating an adult's stature based on measurements of the clavicle. This can be particularly useful in forensic and anthropological contexts, where complete remains are not always available. By achieving this objective, the study aims to contribute to the fields of forensic science, anthropology, and related disciplines by providing a scientific basis for stature estimation, which can aid in the identification of individuals and the analysis of human remains.

MATERIALS AND METHODS

Study Design and Setting

The investigation was structured as a cross-sectional observational study aimed at examining the relationship between the clavicle length and the stature of adults. This research was

conducted over three years, from December 2019 to December 2022, within the Department of Forensic Medicine and Toxicology (FMT) at SCB Medical College, located in Cuttack, Odisha.

Participants

A total of 100 volunteers—comprising both males and females—were enrolled in the study from the pool of adults visiting the hospital. The inclusion criteria specified healthy individuals aged 18 years and older, without any history of surgical interventions or congenital anomalies affecting the clavicle or overall stature.

Bias Minimization

To reduce potential biases, the study ensured a broad representation of participants across various demographics, including different ages, sexes, and ethnic backgrounds. This approach aimed to enhance the generalizability of the findings.

Variables

The study focused on two primary variables: the length of the clavicle (measured in centimeters) and the stature of the individual (also in centimeters). Secondary variables included age, sex, and ethnicity to assess their influence on the primary relationship of interest.

Data Collection

Data collection involved precise physical measurements conducted by trained personnel. Stature was measured with the participant standing, ensuring an erect posture and eyes facing forward. Clavicle length was measured from the sternal end to the acromial end while the participant was in a supine position, using a standard anthropometric measuring tape for accuracy.

Procedure

The procedural aspect of the study required participants to first have their stature measured, followed by the clavicle length. These measurements were meticulously taken to maintain consistency across all participants, ensuring the reliability of the collected data.

Statistical Analysis

The collected data were analyzed using the SPSS software package. Descriptive statistics provided a comprehensive overview of the participant demographics and measurements. Pearson's correlation coefficient was employed to explore the relationship between clavicle length and stature. Further, multiple regression analysis was utilized to ascertain the predictive capability of clavicle length on stature, adjusting for possible confounders such as age, sex, and ethnicity. Statistical significance was determined at a p-value of less than 0.05.

RESULTS

Participant Demographics

The study encompassed a total of 100 participants, with an equal gender distribution (50 males and 50 females). The age of participants ranged from 18 to 65 years, with a median age of 35 years. The demographic diversity of the sample allowed for a comprehensive analysis across different age groups and both genders.

Measurements and Descriptive Statistics

The average stature of the participants was found to be 168 cm, with a standard deviation of 9 cm, ranging from 150 cm to 186 cm. The mean length of the clavicle was 15.2 cm for males and 14.1 cm for females, with standard deviations of 1.2 cm and 1.0 cm, respectively. These measurements indicated a noticeable difference in clavicle length between genders.

Correlation Analysis

Pearson's correlation analysis revealed a significant positive correlation between clavicle length and stature. The correlation coefficient (r) was 0.62, indicating a moderately strong relationship. This suggests that as the clavicle length increases, there is a tendency for stature to also increase.

Gender-based Analysis

When analyzing the data separately for males and females, the correlation between clavicle length and stature remained significant for both groups. However, the correlation was slightly stronger in males ($r = 0.65$) compared to females ($r = 0.59$), suggesting a gender difference in the relationship between clavicle length and stature.

Multiple Regression Analysis

A multiple regression analysis was conducted to predict stature based on clavicle length, adjusting for age, sex, and ethnicity. The model was statistically significant ($F(4, 95) = 27.3$, $p < 0.001$), explaining approximately 53% of the variance in stature ($R^2 = 0.53$). Clavicle length emerged as a significant predictor of stature ($\beta = 0.61$, $p < 0.001$), with sex also contributing significantly to the model ($\beta = 0.24$, $p = 0.003$), indicating that males tended to be taller at any given clavicle length compared to females.

Ethnicity and Age Considerations

Although ethnicity and age were included as variables in the regression model, their contributions were not statistically significant in predicting stature, suggesting that the relationship between clavicle length and stature is relatively consistent across different ethnicities and age groups within this study's sample.

Table 1: Comprehensive overview of the study's participants, including the total number of participants, their age range, gender distribution, and the average range of both stature and clavicle length measurements.

Characteristic	Total	Mean (SD)
Total Participants	100	-
Age (years)	-	35 (\pm 12)
Age range (years)	18-65	-
Male	50	-
Female	50	-
Average Stature (cm)	168	-
Stature Range (cm)	150-186	-
Average Clavicle Length - Male (cm)	15.2	15.2 (\pm 1.2)
Average Clavicle Length - Female (cm)	14.1	14.1 (\pm 1.0)

DISCUSSION

This study of 100 participants, evenly split between males and females and spanning ages 18 to 65, provided a detailed look into the relationship between clavicle length and stature. The findings showed an average stature of 168 cm, with clavicle lengths averaging 15.2 cm for males and 14.1 cm for females, highlighting a gender disparity [8]. A significant positive correlation ($r = 0.62$) was observed, suggesting that taller individuals tend to have longer clavicles. This correlation was slightly stronger in males ($r = 0.65$) than in females ($r = 0.59$), indicating a gender-specific pattern. The multiple regression analysis further confirmed clavicle length as a significant predictor of stature, accounting for about 53% of stature variance, with males typically taller for a given clavicle length. Despite including age and ethnicity in the analysis, these factors did not significantly affect the stature estimation, underscoring the primary importance of clavicle length and gender. This study thus affirms the utility of clavicle measurements in forensic and anthropological contexts for estimating adult stature, with notable implications for identifying remains and understanding human physical diversity [9,10].

In recent years, several studies have emerged from India, focusing on the estimation of adult height from skeletal measurements, including the clavicle, which offers valuable insights into anthropometric research within the region. A notable study conducted in Tamil Nadu aimed to determine adult stature from the length of the clavicle using skeletal remains, highlighting the potential of clavicular measurements in forensic and anthropological applications [11]. Similarly, research from Central India established a positive correlation between the length of the clavicle and stature in the female population, developing a regression equation for stature estimation based on clavicle length, underscoring the bone's relevance in stature estimation [12]. Another study in North India focused on the morphometric and topographic analysis of the nutrient foramen in human clavicles, providing anatomical data that could be pertinent not only for surgical procedures but also for anthropometric research [13]. Additionally, an

autopsy-based study in Central India explored the use of clavicle length for sex estimation, demonstrating the multifaceted applications of clavicular measurements in forensic science [14]. Lastly, research from the Saurashtra region of Gujarat specifically addressed stature estimation from clavicle length in adults, contributing to the regional understanding of anthropometric relationships and the development of accurate estimation methods [15]. These studies collectively enhance the body of knowledge on anthropometry in India, offering regional perspectives on the estimation of stature from skeletal measurements.

Conclusion

The study establishes a significant positive correlation between clavicle length and stature, reinforcing the utility of clavicle-based stature estimation in forensic and anthropological contexts. The findings underscore the importance of population-specific equations for enhancing accuracy in height estimations, while also highlighting the influence of sex on the relationship between clavicle length and stature. This research contributes to the ongoing development of reliable methods for estimating adult height, thereby facilitating the identification of individuals and the analysis of human remains in diverse populations. Further investigations into additional factors affecting clavicle-based stature estimation are recommended to refine and broaden the applicability of this method in forensic and anthropological sciences.

REFERENCES

1. Mediavilla ER, Pérez BP, González EL, Sánchez JA, Fernández ED, Sáez AS. Determining sex with the clavicle in a contemporary Spanish reference collection: A study on 3D images. *Forensic Science International*. 2016 Apr 1; 261:163-e1.
2. Kralík M, Urbanová P, Wagenknechtová M. Sex assessment using clavicle measurements: Inter-and intra-population comparisons. *Forensic Science International*. 2014 Jan 1; 234:181-e1.
3. Franklin, D., Oxnard, C. E., O'Higgins, P., & Dadour, I. (2008). Estimation of stature from the length of the clavicle in a South African population. *Journal of Forensic Sciences*, 53(3), 557-562.
4. Introna, F., Di Vella, G., & Campobasso, C. P. (1997). Determination of height in life using multiple regression of skull and long bone measurements. *Forensic Science International*, 90(1-2), 111-124.
5. Kimura, K. (1991). Anthropological analysis of body height based on skeletal remains. *Journal of Anthropological Society of Nippon*, 99(3), 233-248.
6. Schaefer, M., Black, S., & Scheuer, L. (2009). *Juvenile Osteology: A Laboratory and Field Manual*. Academic Press.
7. Varsha P, Swapnil P, Bharat P. Correlation between Stature and Length of Clavicle in Female Population of Central India. *Indian Journal of Forensic Medicine & Toxicology*. 2020 Jul 1;14(3).
8. Rajitha V, Anitha MR, Rekha G, Nathan SS. Determination of Sex and Age from Human Clavicles and its Radiographic Images. *Indian Journal of Anatomy*. 2016 Jan;5(1):93.

9. Popovic S, Bjelica D, Molnar S, Jaksic D, Akpinar S. Body height and its estimation utilizing arm span measurements in Serbian adults. *International Journal of Morphology*. 2013 Mar 1;31(1):271-9.
10. Shirley NR. Age and sex estimation from the human clavicle an investigation of traditional and novel methods.
11. "Prospective Study on Estimation of Stature of Adult from Length of Clavicle in a Tertiary Care Hospital in Tamilnadu," 2024 (<https://doi.org/10.37506/eyсны530>)
12. "Correlation between Stature and Length of Clavicle in Female Population of Central India," 2020. (<https://doi.org/10.37506/ijfmt.v14i3.10414>)
13. "Morphometric and Topographic Study of Nutrient Foramen in Human Clavicle in North India," 2023 (<https://doi.org/10.52403/ijrr.20230183>).
14. "Sex estimation using discriminant function analysis of the maximum length of the clavicle: An autopsy-based study in Central India," 2021. (<https://doi.org/10.5958/0974-0848.2021.00006.3>)
15. "Estimation of stature from the length of the clavicle in adult (post-fusion age) in Saurashtra region of Gujarat," 2020 (<https://doi.org/10.5958/0974-4568.2020.00003.4>)