

Research Article

Height Estimation Based on Radius Bone Length in Tamil Adults in Medan City

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Abstract. Background: Height is an important component in the preparation of biological profiling for forensic identification, especially when bodies are found in an incomplete condition. Regression equations need to be developed specifically according to sex and population because body proportions are not the same in each group. Objective: This study compiled an equation of height estimation based on the length of the right and left radius in Tamil adults in Medan City. Methods: Cross-sectional analytical research involved 100 respondents aged 21-30 years who were selected through purposive sampling, consisting of 50 males and 50 females. Height was measured using microtoise, while bilateral radius length was measured using sliding calipers. Normality was assessed through the Kolmogorov-Smirnov test. Interverniable relationships were analyzed using Pearson correlation and simple linear regression by sex and body side. Results: The average height of males was 168.440 cm and females were 155.267 cm. The length of the right and left radii was positively correlated with height in males ($r=0.507$ and $r=0.564$; $p<0.001$) and females ($r=0.548$ and $r=0.546$; $p<0.001$). The lowest Standard Error of the Estimate was obtained from the left radius of males of 4.203 cm and the right radius of females of 2.636 cm. Conclusions: Radius length can be used as a predictor of height in Tamil adults in Medan City by taking into account gender, bone sides, and population characteristics.

Keywords: Forensic Anthropology; Forensic Identification; Radius Length; Regression Equations; Tamils.

1. Introduction

Personal identification is an important part of forensic medicine. This process becomes more difficult when the body is decomposed, burned, mutilated, or only found in the form of bone fragments. In these circumstances, the examiner compiles a biological profile that includes gender, age, population affinity, and height. Height cannot establish a singular identity. However, this information is able to narrow down the possibility of identity and support matching with antemortem data [1]-[3].

Forensic anthropology applies the biological science of the human skeleton to assist with the legal process. Long bones play an important role because their size is related to height and can survive when soft tissue has been damaged. The femur and tibia often provide good estimates, but both bones are not always available. Radius can be used as an option because it is easy to measure in living subjects and has shown a positive association with height in a number of populations in Indonesia [1], [2], [4], [5].

Height estimation can be done through both anatomical and mathematical methods. The anatomical method sums the skeletal components and corrects the soft tissues. The mathematical method uses regression equations formed from reference samples. Regression is more practical when only one bone is available. Its accuracy depends on the fit between the examined individual and the population that forms the equation. Gender, age, genetic background, nutrition, disease, environment, and intergenerational changes can affect body proportions [6]-[8].

The city of Medan has a population with diverse ethnic backgrounds, including communities of Indian descent who have long settled. The Tamil group became an important part of the history of migration and social life in Medan [9]. Although population-specific anthropometric standards are required in identification, Indonesian research focuses more on

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Lampung, Javanese, Minahasa, Batak, Bugis, and Toraja groups [1], [2], [4], [10]-[12]. Data on Tamil adults in Medan are still limited.

The magnitude of the relationship between radius length and height is not always the same between populations. Wulan and Indharaswari found a moderate correlation in adult male Lampung and Javanese tribes [1]. Marthing and colleagues reported a stronger bilateral relationship in the Minahasa population [2]. Studies in the Batak group also showed a meaningful correlation with different coefficients [4]. These variations reinforce the need for equations developed from the target population.

This study measured the height and length of the right and left radius in Tamil men and women aged 21-30 years in Medan City. The goal was to describe anthropometric characteristics, analyze the relationship between radius length and height, and produce regression equations according to sex and body side. The research hypothesis states that an increase in radius length is related to an increase in height.

2. Literature Review

Height in Forensic Identification

Forensic identification combines primary and secondary identifiers. Fingerprints, dental examinations, and DNA are commonly used as primary identifiers. Personal descriptions, victims' objects, scars, and anthropometric characteristics provide additional support [3], [13]. Biological profiles help investigators select relevant antemortem data and rule out unsuitable candidates. Height information is often available on identity cards, medical records, employment documents, or family statements.

The accuracy of the estimate is influenced by the condition of the carcass and the quality of the comparator's standard standards. A complete skeleton allows for anatomical reconstruction. A single bone requires mathematical prediction. The regression equation expresses height as a function of a bone size plus constants. The Standard Error of the Estimate describes the actual height distribution of the predicted value. Smaller SEE values indicate better precision in model-forming samples, but do not guarantee the same results in other populations [6], [14].

Radius Length and Population Specificity

The radius extends from the elbow to the wrist. Its proximal landmark includes the head of the radius, while the distal part includes the styloid process. The determination of the landmark must be consistent as minor errors can change the regression results. Bilateral measurements are also required. Hand dominance, physical activity, trauma, development, and examination errors can cause right and left differences.

Body growth reflects the interaction of genetic potential with nutrition, hormones, disease, activity, and the environment [7], [15]. Sexual dimorphism affects the height and size of adult bones. On average, males have larger long bone dimensions than females, although their distributions may overlap. Therefore, sex-separated equations are more appropriate when sex can be reliably estimated.

Population specificity does not mean that one ethnic group is uniform. This principle confirms that the regression coefficient depends on the characteristics of the sample. Migration, intermarriage, socioeconomic circumstances, nutrition, and secular trends can alter anthropometric distributions. Similarities from young adults of Tamil ethnicity in Medan need to be validated before being used in other age groups, other regions, or different populations.

3. Research Methods

Research Design and Location

This study used a cross-sectional analytical design. Data collection was conducted at Bodhi Gaya Temple, Medan Polonia, Medan City, from September to October 2024. All variables were measured once in a series of examinations. The target population included Tamil adults in Medan City, while the affordable population came from the Tamil community in the study area.

Sampling and Sampling Techniques

The sample was selected through non-probability purposive sampling. The study involved 100 respondents with a balanced composition, namely 50 males and 50 females. The inclusion criteria included the age of 21-30 years, domiciled in Medan City, from the Tamil tribe without mixed marriage up to two generations before, and willing to sign an informed

consent. Respondents were excluded if they had congenital abnormalities, spinal deformities, history of fractures, trauma, surgery, or other conditions that could affect height or radius length.

Anthropometric Measurements

Height was measured in centimeters using a microtoise on a flat surface. Respondents stood barefoot, both legs together, arms relaxed, body straight, and head facing straight forward. The measuring part was lowered until it touched the vertex. Body position was kept consistent to reduce variation due to footwear, hunched posture, or inappropriate head position [17], [18].

The length of the right and left radii is measured in centimeters using a sliding caliper. The examiner determines the radius head on the proximal part and the styloid process on the distal part. The caliper is placed between the two landmarks without applying excessive pressure to the soft tissue. Both sides are recorded separately, then the measurement sheet is checked to reduce recording errors.

Statistical Analysis

Height is set as a bound variable. The length of the right and left radii becomes an independent variable. Categorical data are presented as frequency and percentage, while numerical data are presented as mean and standard deviation. The Kolmogorov-Smirnov test is used to assess the distribution of data. Pearson correlation measures the direction and strength of the relationship. Simple linear regression is arranged separately by sex and side with the formula $y = a + bx$. A $p < 0.05$ value is judged meaningful. The accuracy of the model is compared via SEE.

Research Ethics

The research protocol was obtained through the Faculty of Medicine, HKBP Nommensen University. Institutional permission was obtained prior to recruitment. Each respondent received an explanation of the research objectives and procedures and signed a written agreement. Measurement data and questionnaires were used for research purposes.

4. Results and Discussion

Characteristics of Respondents and Anthropometry

All 100 respondents met the study criteria. Men and women amounted to 50 people each. The age groups of 21-25 years and 26-30 years also consisted of 50 respondents each. This young adult age range reduces variation due to unfinished skeletal growth or decline in height in old age.

Table 1. Distribution of respondents by gender and age group.

Variabel	Category	Frequency	Percentage(%)
Gender	Male	50	50%
	Women	50	50%
Age	21-25	50	50%
	26-30	50	50%

Males have an average height and greater radius length. The average height of males reaches 168,440 cm, while females are 155,267 cm. The average right radius of males is 27,029 cm and females of 24,373 cm. The average left radius of males is 26,842 cm and females is 24,139 cm. In both sexes, the right radius is slightly longer than the left radius.

Table 2. Height and radius length by gender.

Variabel	Male Rerata(SD)	Women Rerata(SD)
Right Radius Length	27,029(1,298)	24,373(1,223)
Length of Left Radius	26,842(1,195)	24,139(1,399)
Height	168,440(5,039)	155,267(3,119)

Correlation of Radius Length with Height

The data met the distribution assumptions for parametric analysis. The significance value of normality in males was 0.065 and females 0.200. Both were greater than 0.05. Pearson

correlations showed a positive and meaningful relationship between height and bilateral radius length. In males, the r -value was 0.507 for the right radius and 0.564 for the left radius. In females, the r -value was 0.548 for the right radius and 0.546 for the left radius. The entire relationship had a $p < 0.001$.

Table 3. Pearson correlation between height and radius length.

Variabel	Value r	
	Male (<i>p-value</i>)	Women (<i>p-value</i>)
Height with bone length right radius	0,507 ($<0,001$)	0,548 ($<0,001$)
Height with the length of the left radius	0,564 ($0,001$)	0,546 ($0,001$)

The direction of all coefficients was positive. Respondents with longer radius tended to have greater height. Correlation values showed a moderate to strong relationship, but radius length did not explain all height variations. Height is the result of the combined length of the lower limbs, vertebral column, skull, and other skeletal components. Genetics, nutrition, hormones, and health during growth contribute to adult body proportions [7], [15], [16].

Regression Equations by Sex and Side

Linear regression yields four equations. In males, the right-radius equation is $\text{height} = 115.232 + 1.969(\text{right radius length})$, while the left-radius equation is $\text{height} = 104.584 + 2.379(\text{left radius length})$. In females, the right-radius equation is $\text{height} = 121.211 + 1.397(\text{right radius length})$, while the left-radius equation is $\text{height} = 125.897 + 1.217(\text{left radius length})$. All measurements are expressed in centimeters.

Table 4. Simple Linear Regression Equation For Height Estimation.

Variabel		Konstanta	Coeficin	Standard error of the estimate	p
Male height	Right radius	115,232	1,969	4,387	<0.001
	Radius kiri	104,584	2,379	4,203	<0.001
Female height	Radius kiri	125,897	1,217	2,641	<0.001
	Right radius	121,211	1,397	2,636	<0.001

In males, the left-radius model produced a lower SEE than the right radius, which was 4.203 compared to 4.387 cm. In females, the right-radius model was slightly lower than the left-radius model, which was 2.636 compared to 2.641 cm. Both female models had almost the same precision. The left radius was the best choice for males, while the right radius gave the lowest SEE value to females in this sample.

Comparison with Previous Research

These findings are in line with a general pattern in anthropometric research in Indonesia. Marthing and colleagues found a strong relationship between height and bilateral radius length in the Minahasa population with a higher coefficient than this study [2]. Wulan and Indharaswari reported a moderate correlation in Lampung and Javanese males [1]. Research on the Batak tribe at HKBP Nommensen University also showed a strong association [4]. Coefficient differences can arise due to sample composition, age, sex, landmarking techniques, and body proportions of the population.

Descriptive results support the existence of sexual dimorphism in adult body size. Males have a larger height and radius length on average. Studies of bone length, arm span, tibia, and femur in other Indonesian groups also showed a comparable pattern [5], [10]-[12]. These findings support the use of separate equations. The combination of males and females in a

single equation can cause bias because the constants and coefficients come from different distributions.

Forensic Implications

The examiner should ensure that the bones or surface landmarks allow for reliable radius measurement. Sex needs to be estimated through a separate method because the equations are specific. The length of the radius is then entered into the equation that corresponds to the sides and sex. The estimated results should not be reported as an exact value. The SEE should be considered as a measure of uncertainty. The interpretation of the case needs to be combined with age, dental examination, DNA, fingerprints, and other contextual evidence.

This study demonstrates an approach that can be applied with simple equipment. Microtoise and sliding calipers are relatively readily available. However, the ease of the tool does not diminish the importance of standardization. The examiner must use the same landmark definitions, maintain the position of the subject, check the calibration of the tool, and document the side being measured. Remeasurements by the same examiner and other examiners are required to assess reliability.

Strengths and Limitations

The balanced composition of males and females allowed for the formation of separate models. Measurements of both sides of the radius also provided a basis for comparing the precision of the right and left models. A focus on under-researched communities added to the local data of forensic anthropology. The exclusion criteria reduced the influence of spinal deformities, injuries, and skeletal disorders that could alter the measurement results.

Purposive sampling limits generalization. The age range is only 21-30 years so the equation cannot be directly used in adolescents or the elderly. Studies have not reported external validation, cross-validation, confidence intervals, determination coefficients, and intra- and inter-examiner reliability. Measurements in living subjects also involve soft tissue and are not entirely the same as osteometry in the shin. Follow-up research needs to use larger samples, multicenters, and separate validation groups.

Further Research Directions

Subsequent validation needs to assess the difference in actual height and predicted results in independent Tamil samples. Mean absolute error, root mean squared error, bias, and proportion of predictions within a given error limit can provide a clearer picture of performance than correlation alone. Prediction intervals also need to be included as their use relates to individual estimates in the forensic process.

The reliability of the measurement can be tested by measuring a portion of the respondents twice by the same examiner and a different examiner. Technical error of measurement and intraclass correlation coefficient can be used. Multicenter research on Tamil communities in several areas of North Sumatra will increase representation. Other variables of arm span, sitting height, weight, and bone length can be analyzed to build a multivariable model, but the model must still be tested on external data to avoid overfitting.

5. Conclusion

The length of the right and left radii had a positive and meaningful relationship with height in Tamil adults aged 21-30 years in Medan City. The average height of males was 168.440 cm and females 155.267 cm. The highest correlation in males was found in the left radius with $r=0.564$. In females, the correlation between right and left radii was almost the same, namely $r=0.548$ and $r=0.546$. The left-radius equation had the lowest SEE in males at 4.203 cm, while the right-radius equation had the lowest SEE in females at 2.636 cm. This equation can support forensic estimation in individuals that match the characteristics of the sample. Its application must be accompanied by other identification methods and external validation before it is used more widely.

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Data Availability: Supporting data may be obtained from the authors of correspondence upon reasonable request with due regard to ethical and privacy provisions.

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Bibliography

- Ambarita, E. O., Setyawati, I., & Yulihastuti, D. A. (2022). The anthropometric relationship of long bones to the height of Batak Toba students in Bekasi City. *J. Udayana University*, (1).
- Anwar, S., et al. (2023). Determination of height estimation based on femur bone length in Toraja people. *Jurnal Kesehatan Tambusai*, 4(4), 5308–5314.
- Ekkarandy, R. D., & Arafat, M. R. (2021). Forensic identification of victims of mass plane accidents reviewed from forensic medicine. *Jurnal Hukum Positum*, 6(2), 273–283.
- Izzani, T. A., Octaria, S., & Linda, L. (2024). Adolescent development. *Jispendiora*, 3(2), 259–273.
- Kristina Sihalo, A. S. (2023). Determining the relationship between height based on lower limb length in members of the Medan single sector police. [Journal title not provided], 13, 590–599.
- Kusuma, T. U., & Rosidi, A. (2018). Reliability of knee height calipers in height determination. *JHeS*, 2(1), 96–102.
- Lubis, M. I., & Siregar, N. P. (2022). The relationship between tibia bone length and height in students of FK UISU. *Jurnal Kedokteran dan Kesehatan FK UISU*, 21(2).
- Marthing, S., Wongkar, D., & Kaseke, M. (2020). The relationship between height and radius length in the Minahasa ethnic group in Kakaskasen 3 Village, North Tomohon District. *Jurnal Biomedik*, 12(1).
- Nicky, Gunadi, K., & Purbowo, N. A. (2022). Application of human height and weight measurement using morphological image processing. *Jurnal Infra*, 10(1), 1–7.
- Parinduri, A. G. (2022). Identification of bones. *Majalah Ilmiah Methoda*, 12(1).
- Saputra, S. (2021). Correlation of extremity bone length with height in forensic identification. *Indonesian Journal of Legal Forensic Science*, 11(1), 28.
- Simatupang, R. M., Ticoalu, S. H. R., & Wongkar, D. (2013). Correlation of radius length with height in students of the Faculty of Medicine Unsrat. *Jurnal Biomedik*, 4(3), 101–108.
- Sihalo, A. S. K. (2023). Determining the relationship between height based on lower limb length in members of the Medan single sector police. [Journal title not provided], 13, 590–599.
- Soetjningsih, & Ranuh, I. N. G. (2020). *Child growth and development* (2nd ed., pp. 61–72).
- Surdan, Z., et al. (2023). Height estimation using arm span in Bugis students of the Faculty of Medicine, Muslim University of Indonesia. *Indonesian Nursing Journal of Education and Clinic*, 3(2), 46–50.
- Tobing, G. S. A. Br., Simorangkir, V., & Sihombing, J. R. (2021). Correlation between radius bone length and height in the Batak tribe at HKBP Nommensen University Medan. *Nommensen Journal of Medicine*, 6(2).
- Wijaya, H., Agustini, F., & Sabrina, N. (2021). A glimpse of the life of the Indian ethnic community in Medan City. *Jurnal Pendidikan Ilmu Sosial*, 13(2).
- Wulan, A. J., & Indharaswari, D. (2018). Correlation between radius bone length and height in adult men of the Lampung tribe and the Javanese tribe in Gisting District, Tanggamus Regency. *J. Unila*, 2.