ORIGINAL RESEARCH REPORT

Humerus Length Correlates with Stature among Nias Ethnic Students at HKBP Nommensen University Medan

Athalia Famelinda Gracia[1], Saharnauli Janna Verawaty Simorangkir[2*], Joice Sonya Gani Panjaitan[3]

[1]Bachelor of Medicine Education Program, Faculty of Medicine, HKBP Nommensen University, Medan, Indonesia.
[2]Department of Anatomy, Faculty of Medicine, HKBP Nommensen University, Medan, Indonesia.
[3]Department of Dermatology and Venereology, Faculty of Medicine, HKBP Nommensen University, Medan, Indonesia.

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***Corresponding author**:
Saharnauli Janna Verawaty Simorangkir
saharnauli@uhn.ac.id

ABSTRACT

Background: The identification of stature is an essential component of forensic anthropology. The measurement of stature with a single long bone of the upper limbs provided an alternative technique for estimating stature when the commonly used lower limb bone is missing. **Objective**: To determine the correlation between humerus length and stature among Nias ethnic students at HKBP Nommensen University, Medan, Indonesia. **Materials and Methods**: The study employed correlational analytics with a cross-sectional design. The study population comprises 100 active Nias ethnic students at HKBP Nommensen University, according to the inclusion and exclusion criteria, consisting of 50 males and 50 females. Sampling was done by purposive sampling. Conducting a bivariate analysis to ascertain the correlation between humerus length and stature. The linear regression analysis was conducted to derive a formula for predicting stature from humerus length. **Results**: The length of the male humerus bone was significantly related to stature, with a correlation coefficient of r = 0.949 ($p<0.001$). The length of the female humerus bone showed a significant correlation with stature, with correlation coefficients ranging from 0.783 to 0.785 ($p<0.001$). The precise regression equation is established according to the minimal Standard Error of the Estimate (SEE) value within each sex group. The linear regression equations obtained were the stature of males (cm) = 78.844 + 3.001 x length of left humerus (cm) and the stature of females (cm) = 19.694 + 5.189 x length of right humerus (cm). **Conclusion**: Among the Nias ethnic students at HKBP Nommensen University, the study discovered a strong correlation between the lengths of the right and left humerus bones and stature. As a result, stature might be calculated using a linear regression equation to measure the humerus length of the bone.

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Highlights

1. Robust statistical analyses and substantial sample size contribute to understanding anthropometric patterns and forensic medicine implications.
2. Humerus length can be used to predict stature for the Nias tribe in North Sumatra, Indonesia.

BACKGROUND

Positive identification is an important component of forensic anthropology. Identification methods assist forensic investigators in determining the true identities of individuals (Hamburda, 2019). Most human remains received by hospital forensic pathology departments exhibit signs of trauma, decomposition, or disarticulation, and are seldom recovered in a completely intact condition. This is because bodies obtained by the forensic department are victims of accidents, natural disasters, mutilation murders, and other crimes (Purwanti, 2014; Gehl & Darryl, 2017).

In the pursuit of identifying each victim in such incidents, it is necessary to employ additional forensic identification to examine crucial parameters. Stature estimate is one parameter that can be utilized. The biological profile comprises assessments of sex, age, ancestry, and height. The inclusion of age and stature estimates further refines the search. If these estimates are erroneous, the unidentified human remains may stay unrecognized. Consequently, stature information is essential for forensic anthropology identification. This is also in line with Forensic and Medicolegal Medicine textbooks, which state that stature is part of the external examination of corpses (Parinduri, 2020; Spradley, 2016).

Stature measurement can be simply performed using an anatomical method, from the vertex (top of the head) to the bottom of the plantar pleats (the sole of the foot) (Saputra, 2021). However, other techniques are required to estimate stature in situations where the corpse is not entire and complete bone remains are not accessible. Measuring a single long bone yields an alternate approach to assessing stature (Albanese, et al., 2016). Based on long bones, a person's stature can be calculated using two formulas: the Trotter and Glesser formula (femur, tibia), and the Stevenson formula (femur, humerus, tibia, radius) (Nandarini, et al., 2021). However, there are differences in stature among individuals influenced by genetic factors and environmental factors (Jelenkovic, et al., 2020; Ananda, et al., 2021; Yan & Yuling, 2022). Indonesia is a country with a diverse array of ethnic groups. This diversity of ethnic groups in Indonesia is another element that influences stature (Widyanti, et al., 2015). Research on the correlation between bone length and height has been conducted in Indonesia. A study by Simorangkir, et al., (2020) to determine the correlation between humerus length and height in Batak students at HKBP Nommensen University demonstrated a strong and significant correlation overall with an r value of 0.784 ($p<0.05$). Furthermore, another research demonstrated a significant correlation between the lengths of the right and left humeri bones and height in Balinese men at the University of Lampung, with a significance value of <0.001. The correlation coefficient for the left and right humerus bones was interpreted as r = 0.8 - 1.00, indicating a very strong correlation (Petisa, et al., 2019). A subsequent study conducted by Duangto & Mahakkanukrauh, (2019) utilized a sample of 300 randomly selected tibiae from native Thais (150 males and 150 females) to determine stature. The findings indicated a robust link between height estimation and humerus length in both genders, with the highest correlation coefficient (r = 0.833).

Therefore, in this context, the authors are intrigued by investigating the correlation between stature and humerus length in the Nias tribe, one of the ethnic groups with a population of 911,820 individuals, which is primarily concentrated in the North Sumatra Province (Adnan, et al., 2024). Nonetheless, the Nias tribe lacks detailed anthropometric data for forensic and identification purposes. This matter is urgent due to Indonesia's frequent natural disasters and criminal prosecutions. Consequently, we sought to examine the relationship between height and humeral length within the Nias tribe.

OBJECTIVE

This study aimed to determine the correlation between humerus length and stature among Nias ethnic students at HKBP Nommensen University. In addition, a linear regression equation was developed to estimate stature based on humerus bone length.

MATERIAL AND METHOD

This study was conducted in November 2023 and employed a cross-sectional design and analytical correlation analysis. The length of the humerus bone and stature, both measured on a numerical scale, were the study variables. The study population consisted of all enrolled Nias tribal students at HKBP Nommensen University located in Medan. Of the 100 people who fulfilled the inclusion and exclusion criteria, 50 were male and the remaining 50 were female. The study used purposive sampling to select participants. The inclusion and exclusion criteria included subjects who were willing to sign an informed consent form, were at least 21 years old at the time of the study, and were primarily right-handed. Furthermore, they must be from Nias descent, had not married into another ethnic group for at least two generations, had no history of trauma or medical procedures that would have affected the length or stature of their humerus, and have no history of congenital anomalies or growth hormone imbalance (Dwarfism and Acromegaly), as well as no history of spinal abnormalities (lordosis, kyphosis, scoliosis).

Stature was measured using a stadiometer, with the vertex and the heel (the lowest point of the calcaneus) as reference points. A sliding caliper was used for measuring the left and right humeri. The first step in measuring the length of the humerus bone was identifying the measurement sites. The acromion and epicondyles on the left and right humerus bones were palpated to define the measuring points. All research subjects had their measurements collected between 8:00 and 10:00 a.m. to account for diurnal variation. The same examiner conducted measurements three times to minimize measurement errors. The data used were the mean of the three measurements. Furthermore, the data were processed using univariate analysis to produce descriptions of the variables and subject characteristics.

The Kolmogorov-Smirnov test was applied to perform normality testing. In this test, the data will undergo linearity testing to ascertain its suitability for correlation analysis. If the relationship between two datasets is linear, a correlation test may be employed. In contrast, if the relationship is non-linear, then the correlation test is not applicable. The Pearson correlation test will be employed to assess correlation in linear data when both datasets have a normal distribution. However, the Spearman correlation test will be utilized if either dataset deviates from normality. In this study, following the outcomes of the normality and linearity tests, the data exhibited a normal distribution and a positive linear relationship. Therefore, the Pearson correlation test was used in bivariate analysis to find the connection between the two variables. Moreover, the regression equation was derived from the data analysis utilizing linear regression analysis. The statistical analysis was conducted using SPSS for Windows version 25.0 and Microsoft Excel 2016. The Health Research Ethics Community, Faculty of Medicine HKBP, Nommensen University, provided its approval for the study on 4 September 2023, with approval number 525/KEPK/FK/IX/2023.

RESULT

The univariate test on the research sample resulted in a description of sample characteristics based on age and sex. The examined sample consisted of 100 individuals, with 50 males (50.0%) and 50 females (50.0%). Among the sample, there were 57 individuals aged 21 years (57.0%), 31 individuals aged 22 years (31.0%), and 12 individuals aged 23 years (12.0%).

Table 1. The results (in cm) of measuring humerus length and stature based on sex.

Variable	Males	Females
	Mean (SD)	Mean (SD)
Right humerus length	29.71 (1.342)	26.167 (0.784)
Left humerus length	29.720 (1.362)	26.445 (0.781)
Stature	168.031 (4.263)	155.481 (5.186)

The variable description revealed that the average length of the right humerus bone for males was 29.371 cm, and for females was 26.167 cm. The average length of the left humerus bone for males was 29.720 cm, and for females was 26.445 cm. Furthermore, the average stature for males was 168.031

cm, and for females was 155.481 cm. The correlation between humeri lengths and stature was assessed using the Pearson correlation test:

Table 2. The results of the Pearson correlation test between humerus length and stature.

Variable	r value	
	Males (*p-value*)	**Females (*p-value*)**
Right humerus length and stature	0.959 (<0.001)	0.785 (<0.001)
Left humerus length and stature	0.959 (<0.001)	0.783 (<0.001)

Table 2 illustrates a significant correlation between the length of the left and right humeri and stature in male subjects, with Pearson correlation coefficient values of 0.959 ($p<0.001$) and 0.959 ($p<0.001$), respectively. The table also indicates a significant correlation between the length of the right and left humeri and stature in females, with Pearson correlation coefficient values of 0.785 ($p<0.001$) and 0.783 ($p<0.001$), respectively.

The estimation of stature from the length of the humerus was obtained through linear regression analysis. This linear regression analysis will create equations that can connect independent variables and dependent variables. Table 2 shows the results of the linear regression analysis:

Table 3. The results of the linear regression test.

Variable		Constant	Coefficient	Standard error of the estimation	P
Stature of males	Right humerus	78.598	3.045	1.223	<0.001
	Left humerus	78.844	3.001	1.220	<0.001
Stature of females	Right humerus	19.694	5.189	3.245	<0.001
	Left humerus	18.013	5.198	3.259	<0.001

Table 3 demonstrates that the values of the Standard Error of the Estimate (SEE) for the right humerus in males are 1.223, and for the left humerus are 1.220. The table also illustrates that the values of the Standard Error of the Estimate (SEE) for the right humerus in females are 3.245, and for the left humerus are 3.259. The stature estimates can be calculated by finding specific regressions. This study successfully found a linear regression equation using the length of the humerus bone to estimate a person's stature. This equation has a Standard Error of the Estimate (SEE) ranging from 1.220 to 3.259. In the male sample, the lowest SEE value was on the left humerus bone, which is 1.220. This finding suggests that stature estimation in males is more accurate using a linear regression equation on the left humerus bone. In the female sample, the lowest SEE value was on the right humerus bone, which is 3.245. This finding suggests that stature estimation in females is more accurate using a linear regression equation on the right humerus bone. Based on the results of linear regression analysis in Table 3, the correlation between humerus length and stature is obtained through the following linear regression equations:

1. In the male sample:
   a. Male stature (cm) = 78.598 + 3.045 x right humerus length (cm)
   b. Male stature (cm) = 78.844 + 3.001 x left humerus length (cm)
2. In the female sample:
   a. Female stature (cm) = 19.694 + 5.189 x right humerus length (cm)
   b. Female stature (cm) = 18.013 + 5.198 x left humerus length (cm)

DISCUSSION

Based on the univariate data processing results, the average stature of male Nias students in this study was 168.031 cm, which was higher than the average stature of female students, at 155.481 cm. This finding aligned with studies on other ethnic groups. For instance, an investigation by Simorangkir, et al., (2020) in the Batak tribe found that the average male stature is 170.20 cm and the average female stature is 153.4 cm. The results also indicate that males are typically taller than females. The difference in average stature between males and females may be due to differences in growth rate starting from the age of 12, resulting in adult males being taller than adult females (Wineski, 2019; Schäppi, et al., 2022). Similar findings were observed in five tribal groups in Southern Nigeria, where notable stature disparities between men and women were presented among the tribes (Eboh & Ohaju-Obodo, 2019). The observed differences in stature between the studied ethnic groups imply that ethnicity has an impact on the development of human bones. This growth process is influenced by several additional variables, including nutrition, genetics, and environmental circumstances (Simorangkir, et al., 2020).

Based on the results of this study, it was found that the average length of the right and left humeri bones in males is longer than in females. In both sexes, the pre-pubertal development rate is greater in the appendicular skeleton compared to the axial skeleton. During the onset of puberty, there is a significant acceleration in truncal growth, while appendicular growth increases only marginally before decelerating at puberty's conclusion. The extended period of pre-pubertal growth, primarily in the appendicular skeleton, in males results in the average male having longer legs and hands than the average female (Almeida, et al., 2017). This result is consistent with research conducted by Duangto & Mahakkanukrauh, (2019) on indigenous populations in Thailand and research conducted by Simorangkir, et al., (2020) on the Batak tribe at HKBP Nommensen University, Medan. Univariate analysis results on the length of the humerus bone showed no significant difference between the average length of the right and left humerus bones. This finding aligns with previous research on humerus bone length conducted by Petisa, et al., (2019) in the Bali tribe in Lampung, which demonstrates an average length of the right humerus bone of 29.41 cm and the left 29.30 cm. Measurements obtained from the right and left sides of the body differ, according to anthropometric research. Individuals with asymmetry between their right and left sides of the body are said to have asymmetrical bodies. Asymmetry in bodily parts can exist independently of pathological issues with the structure of the bones and muscles (Dare, et al., 2019).

The correlation analysis results between the length of the right humerus bone and stature in males demonstrated a significant correlation strength, $r = 0.959$ ($p < 0.001$). This result was consistent with research by Petisa, et al., (2019), which found a significant correlation strength, $r = 0.82$ ($p < 0.05$), between the length of the right humerus bone and the stature of Balinese men. However, this result differed from the results of research conducted by Wube, et al., (2019) on undergraduate students at Debre Markos University, North West Ethiopia, where there was a moderate correlation between the length of the right humerus bone and the stature of male students $r = 0.539$ ($p < 0.05$).

The correlation analysis results between the length of the right humerus bone and stature in females demonstrated a significant correlation strength, $r = 0.785$ ($p < 0.001$). Different outcomes were found in a study conducted by Wube, et al., (2019) on undergraduate students at Debre Markos University, North West Ethiopia, where there was a very weak correlation between the length of the right humerus bone and the stature of female students, $r = 0.163$ ($p < 0.05$) (Wube, et al., 2019).

The linear regression equations identified in this study are only relevant to the Nias tribe. This is because previous studies showed that hand sizes among different ethnic groups have variations. Therefore, the linear regression equations formulated to predict stature based on hand size in one ethnic group cannot be directly applied to other ethnic groups (Mubela & Sutysna, 2020).

Various factors, including internal ones such as heredity, ethnicity, race, and sex, as well as external ones like environment, dietary habits, socioeconomic status, and degree of physical activity, affect variations in body proportions among different groups (Casadei & Kiel, 2022). Due to these differences, linear regression equations used to predict the relationship between variables such as stature and bone length in one population may not accurately apply to another population. Therefore, it is crucial to find different linear regression equations for each population to provide more precise and accurate estimation results (Simatupang & Sutysna, 2017).

Strengths and limitations

The research provides valuable anthropometric insights by thoroughly examining the correlation between humerus length and stature among Nias ethnic students. Furthermore, the methods are applied thoroughly and even include diurnal, age, and examination of spinal disorders. The use of robust sample sizes and meticulous statistical analysis enhances the credibility of this research. Several external factors can influence a person's body proportions, and not all of these factors have been excluded or homogenized in this study. A single ethnic group's sole focus reduces generalizability, and the exclusion of certain external factors may limit the ability to establish causal relationships. In addition, cross-sectional data may also restrict the causal inference. Notwithstanding these limitations, the research makes a substantial contribution to forensic medicine and anthropometry, inspiring more diverse population studies.

CONCLUSION

The humerus bone length and stature of Nias ethnic students at HKBP Nommensen University in Medan have a significant correlation in this study, with correlation coefficients ranging from strong to very strong. Therefore, in the Nias population, stature can be estimated using linear regression equations based on the length of the humerus bone.

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Conflict of Interest

All authors have no conflict of interest.

Ethic Consideration

Health Research Ethics Commission Faculty of Medicine HKBP Nommensen University (No. 525/KEPK/FK/IX/2023, on 04-09-2023).

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None.

Author Contribution

All authors have contributed to all process in this research, including preparation, data gathering and analysis, drafting and approval for publication of this manuscript. AFG contributed to the conception and design, analysis and interpretation of the data, obtaining funding, and administrative, technical, or logistical support. SVS contributed to the drafting of the article, critical revision of the article for important intellectual content, final approval of the article, provision of study materials or patients, statistical expertise, and obtaining funding. JSP contributed to obtaining funding, administrative, technical, or logistical support, and provision of study materials or patients.

Data Availability

None.

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