Original research article

Correlation between Humerus Length and Height in Medical Students at Jambi University

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ABSTRACT

Background: Anthropometry is essential in identifying biological profiles, including height. One of the most commonly used anthropometric data to estimate height is the length of the humerus bone. This study analyzes the correlation between humeral length and height among medical students at UNJA. **Methods:** This study is an analytical correlational study conducted cross-sectionally. The sample consisted of male and female students who met the inclusion criteria: active medical students at UNJA who were willing to participate by signing an informed consent form. The exclusion criteria included deformities, a history of injuries, or bone disabilities. The humeral length was measured using a measuring tape, and height was measured using a microtoise. **Results:** The study found a correlation coefficient between humeral length and height ranging from 0.660 to 0.788 ($p < 0.001$). The simple linear regression equation obtained showed a Standard Error of the Estimation (SEE) ranging from 3.802 to 4.912 ($p < 0.001$). **Conclusion:** A strong positive correlation exists between humerus length and height, indicating that height can be estimated by measuring humerus length and applying it to the simple linear regression equation.

Keywords: Anthropometry; Humeral length; Height; Regression equation

INTRODUCTION

Anthropometry plays a crucial role in identifying an individual's biological profile. Forensic doctors can use anthropometric data to estimate height, gender, weight, time of death, and cause of death and identify potential pathological abnormalities in the individual.[1] The most commonly used anthropometric data for estimating human height is the length of long bones such as the humerus, radius, ulna, femur, tibia, and fibula, as numerous studies have shown that the length of

these long bones has a strong correlation with height.[2]

Research on the correlation between humerus length and height has been widely conducted, such as a study on the Gorkha population in India. This study involved a sample of 160 individuals aged 25-40 years. The long bone used as the research object was the humerus. The study found a significant correlation between humerus length and height.[3] Another study was conducted at HKBP Nommensen University in Medan in 2020. The population in this study included students, staff, and faculty members of HKBP Nommensen University, with a sample size of 72 individuals, consisting of 27 men and 25 women. The bone used in this research was also the humerus. The study concluded that there is a strong correlation between humerus length and height among Batak students.[4]

Numerous factors influence height. Therefore, the correlation factors observed in one region may not necessarily apply to another. Thus, regional studies are essential to achieve comprehensive results and conclusions.[5] Previous studies have explored factors influencing height, including nutrition and physical activity. Nutritional status can be assessed using BMI, six, and physical activity can be measured using the IPAQ questionnaire.[7] BMI can be measured by dividing the weight (kg) by the square of the height (m).[8, 9, 10, 11]

Based on the previous explanation, many studies have explored the correlation between humerus length and height, but none have been conducted in the Jambi region, particularly among medical students at UNJA. Therefore, the author is interested in researching the correlation between humerus length and height among medical students at UNJA.

METHODS

This study utilized a correlational analytic design to examine the relationship between humeral length and height. The research was conducted using a cross-sectional approach. The population in this study consisted of all active medical students at UNJA. The sample consisted of 92 medical students selected using purposive sampling. The inclusion criteria were active medical students at UNJA who agreed to participate in the study by signing an informed consent form. The exclusion criteria included the presence of deformities in the humerus, limbs, or spine, a history of bone injuries affecting height, and any disability involving the long bones and spine. The research instruments included an informed consent form to obtain respondents' willingness to participate in the study, personal data, and a measurement sheet for recording respondents' personal information, including height and humerus length.

Additionally, the International Physical Activity Questionnaire (IPAQ) was used to assess the level of physical

activity. To calculate BMI, both weight and height need to be measured.[12, 13, 14] Height was measured using a microtoise[15], while weight was measured using a digital scale[16]. The humeral length was measured using a measuring tape.

Height measurement was conducted by asking the respondent to stand upright, facing forward, with their back, heels, and head against the wall and arms at their sides. The examiner measured the respondent's height using a microtoise three times to ensure accuracy, and the results were recorded on the respondent's measurement sheet. The length of the left and right humerus was measured by asking the respondent to stand upright with their arms slightly away from their thighs. The examiner measured the humerus length from the acromion to the lateral epicondyle using a measuring tape, repeating the measurement three times to ensure accuracy. The results were recorded on the respondent's measurement sheet.

The data in this study were processed using univariate analysis to obtain the characteristics of the sample. Normality tests were conducted using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Bivariate analysis was performed to determine the correlation between the two variables using Pearson and Spearman tests and simple linear regression analysis to develop an estimation formula for height based on humerus length.

RESULTS

The univariate analysis of the study sample described the sample characteristics based on gender, age, BMI, physical activity, and ethnicity.

Table 1. Sample Characteristics

Variable	Frequency	Percentage
Gender		
Male	32	34,8
Female	60	65.2
Age (years)		
17	4	4.3
18	17	18.5
19	18	19.6
20	10	10.9
21	28	30.4
22	14	15.2
23	1	1.1
BMI		
Underweight	15	16.3
Normal	58	63
Overweight	19	20.7

Variable	Frequency	Percentage
Physical activity		
Light	33	35.9
Moderate	43	46.7
Heavy	16	17.4
Ethnicity		
Sumatra	68	73.9
Jawa	24	26.1

The table above (**Table 1**) shows that most of the sample were female. Most participants were 21 years old, with other age groups ranging from 17 to 23. The majority of the sample had a normal BMI. Moderate physical activity was the most dominant among the participants. Regarding ethnicity, the majority were from the Sumatra ethnic group (73.9%), with the remainder from the Javanese ethnic group (26.1%).

Table 2 presents the average lengths of the humerus and the height based on gender. The average humerus length in male samples is longer than in female samples for both the right and left humerus. The average height of male samples is also more significant than that of female samples.

Table 2 Measurement Results of Average Humerus Length and Height

Gender	The average length of the right humerus (SD)	The average length of the left humerus (SD)	Average Height (SD)
Male	30.812 (1.727)	30.161 (1.720)	168.643 (6.023)
Female	28.736 (1.674)	28.729 (1.668)	156.615 (5.109)
Overall	29.458 (1.954)	29.040 (1.944)	160.798 (7.903)

Table 2 also presents the average measurements of the samples' right and left humerus length and height based on gender. In the male samples, the average right humerus length, left humerus length, and height were more significant than those in the female samples. Overall, the average right humerus length was slightly larger than the average left humerus length. **Table 3** shows that BMI and physical activity have a weak positive correlation with both right and left humerus length but no correlation with height.

Table 3 Correlation Results of BMI and Physical Activity with Humerus Length and Height

Category	Correlation					
	Right Humerus		Left Humerus		Height	
	C. Coefficient	p-value	C. Coefficient	p-value	C. Coefficient	p-value
BMI	0.256	0.014	0.255	0.014	0.198	0.058
Physical activity	0.208	0.046	0.211	0.043	0.183	0.080

Table 4 shows that in males, the right humerus length has a robust correlation with height (correlation coefficient r = 0.781, p < 0.001), as does the left humerus length (r = 0.784, p < 0.001). In females, a strong correlation was also found, with the right humerus length having a correlation coefficient of r = 0.660 (p < 0.001) and the left humerus length r = 0.660 (p < 0.001). Overall, both right and left humerus lengths show a robust correlation with height, with correlation coefficients of r = 0.787 (p < 0.001) and r = 0.788 (p < 0.001), respectively.

Table 4 Correlation Test Results Between Humerus Length and Height

Gender	Variable	Correlation With Height	
		C. Coefficient	p-value
Male	Right Humerus	0.781	<0.001
	Left Humerus	0.784	<0.001
Female	Right Humerus	0.660	<0.001
	Left Humerus	0.660	<0.001
Overall	Right Humerus	0.787	<0.001
	Left Humerus	0.788	<0.001

The estimation of height from humerus length is obtained through linear regression analysis. This analysis produces an equation connecting the independent and dependent variables.

Linear regression is used when the dependent variable is numeric. The results of the linear regression analysis can be seen in **Table 5**.

Table 5 Linear Regression Test Results

Gender	Variable	Coefficient	The standard error of the estimation	p-value
Male Height	Right Humerus	2.722	3.827	<0.001
	Constant	84.772		
	Left Humerus	2.745	3.802	<0.001
	Constant	84.146		
Female Height	Right Humerus	2.013	3.872	<0.001
	Constant	98.760		
	Left Humerus	2.021	3.870	<0.001
	Constant	98.545		
Overall Height	Right Humerus	3.180	4.908	<0.001
	Constant	67.132		
	Left Humerus	3.196	4.912	<0.001
	Constant	66.711		

Based on the linear regression analysis results in **Table 5**, a linear regression equation can be formulated as y = a + bx. The relationship between humerus length and height was determined using linear regression equations. For the male sample, the height can be predicted using the following equations: Height (cm) = 84.772 + 2.722 x right humerus length (cm) and height (cm) = 84.146 + 2.745 x left humerus length (cm). For the female sample, the equations are: Height (cm) = 98.760 + 2.013 x right humerus length (cm) and height (cm) = 98.545 + 2.021 x left humerus length (cm). For the overall sample, the predicted height is given by the equations: Height (cm) = 67.132 + 3.180 x right humerus length (cm) and height (cm) = 66.711 + 3.196 x left humerus length (cm).

DISCUSSION

The sample in this study consisted of 92 individuals, with 32 males and 60 females. There were more female participants than male participants. The majority of students in this study had a normal BMI category. Another study by Makmun and Andry also found similar results, where most students in their sample had a normal BMI.[17] The majority of the sample engaged in moderate physical activity. A similar finding was reported in another study by Liando et al., where most students engaged in moderate physical activity, followed by light and heavy physical activities.[18] Most of the samples in this study are from ethnic groups on the island of Sumatra, accounting for 73.9%, while the remaining 26.1% are from ethnic groups on the island of Java. This indicates that students

with a background from Sumatra dominate the population in this study.

The results of this study show that the average right humerus length is longer than the average left humerus length. This is consistent with the research conducted by Petisa et al.[19] Various anthropometric studies comparing the two sides of the human body have shown size differences between the right and left body parts. This difference, referred to as asymmetry, is consistently found in individuals with spinal deviations. In specific populations, more than one type of asymmetry can coincide. The growth of the right and left extremities is influenced by the similar morphogenetic processes of both sides of the body, which develop based on mirror symmetry with the embryonic midline as a reference. Asymmetry in the extremities is associated with specific musculoskeletal disorders and can occur spontaneously without pathological causes. Additionally, asymmetry in the upper extremities tends to be more pronounced than in the lower extremities.[20] The average height obtained in this study varies across each category, indicating that human height is influenced by many factors such as genetics, gender, age, nutrition, environment, and ethnicity.

In this study, the correlation between BMI and physical activity with humerus length is positive, but the strength of the correlation is weak. No correlation was found between BMI and physical activity with height. BMI is a simple tool or method to monitor the nutritional status of adults, particularly related to underweight and overweight conditions.[17] In adulthood, bone growth in length has ceased, so its contribution to BMI differences becomes less significant compared to muscle mass and fat. A study by Sperrin et al. showed that the correlation between height and BMI is a very weak negative correlation. This further supports the notion that BMI does not significantly affect height in adulthood.[21] The results may differ, possibly influenced by sample size and other variables. Another study that aligns with this research is the one conducted by Savitri et al., which found no significant relationship between physical activity and height in late adolescence.[22]

The study found a statistically significant correlation (p-value < 0.05) between humerus length and height, with a strong correlation coefficient indicating a close relationship. The positive correlation suggests that an increase in humerus length is associated with an increase in height. This result aligns with Purba et al.'s study, which also found a strong positive correlation between humerus length and height.[4] Another study that aligns with these findings is the research by Vivekanand et al., which found a strong positive correlation between humerus length and height ($r = 0.82$, $p < 0.001$).[23]

During fetal development, most bones in the body initially form from cartilage, which then transforms into bone through endochondral ossification. However, exceptions like the clavicle,

mandible, and skull bones develop directly from mesenchymal cells without going through a cartilage phase using intramembranous ossification. During growth, the epiphyseal plate, a layer of cartilage that actively divides, is located between the ends of long bones (epiphysis) and the bone shaft. This activity allows for the elongation of bones, which is crucial in the overall growth process of the body.[24] Bone growth through endochondral ossification occurs in the long bones of the extremities, such as the humerus, radius, ulna, femur, tibia, and fibula. A previous study by Maulina found a significant positive correlation between femur length and height. This is understandable because the femur, as the primary long bone in the lower extremities, directly contributes to a person's height. In the same context, the humerus is also a long bone that undergoes growth through endochondral ossification, similar to the femur. Therefore, it is logical to consider that the humerus may have a similar relationship with height.[25]

Height estimation can be done using a specific regression formula. In this study, a linear regression equation was found to predict height from humerus length. The equation has a Standard Error of the Estimate (SEE) ranging from 3.802 to 4.912. SEE is a good indicator of the relationship between actual and predicted values. The smaller the SEE value, the more accurate the regression equation is.[26]

The linear regression equation from this study can only be applied to the population in this research. This is because previous studies have shown that measurements of the hand tend to vary across different populations. Therefore, the regression equation developed to estimate height based on different ethnic groups within one population cannot be applied to other ethnic groups.

It is important to note that height growth is greatly influenced by environmental factors, particularly those related to an individual's development and growth. Additionally, height increase has been documented to be affected by nutrition, living environment, and healthcare across different countries. Therefore, it is recommended that the latest regression formula be used to avoid significant errors.[27]

CONCLUSION

The majority of the medical students at UNJA are female. Most students are 21 years old, have a normal BMI, engage in moderate physical activity, and come from the Sumatra ethnic group. The average humerus length and height of male medical students at UNJA are greater than those of female students. A strong positive correlation was found between humerus length and height in the medical students, with a strong correlation strength. Special formulas for estimating height based on humerus length were derived for the medical students at UNJA.

For male students, the formulas are: height (cm) = 84.772 + 2.722 x right humerus length (cm) and height (cm) = 84.146 + 2.745 x left humerus length (cm). For female students, the formulas are: height (cm) = 98.760 + 2.013 x right humerus length (cm) and height (cm) = 98.545 + 2.021 x left humerus length (cm). For the entire sample, the formulas are: height (cm) = 67.132 + 3.180 x right humerus length (cm) and height (cm) = 66.711 + 3.196 x left humerus length (cm).

RECOMMENDATIONS

Based on the research process conducted in this study, the researcher recommends that future studies use a larger sample size to enhance the reliability of the results. It is also suggested that a more balanced distribution of samples across each category be ensured. Future research could also focus on each category for more in-depth analysis. Moreover, studies exploring other bones in the human body could provide valuable insights for similar investigations.

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