The estimation of body stature based on the tibial length among Acehnese population

Mulkan

Abstract. The stature reconstruction is commonly predicted statistically among different populations. Among long bones, tibia has been opted to predict the body stature as it has given better correlation of coefficient (r) and coefficient of determination (r^2). There were 117 Acehneses involved in the study. Both body stature and tibial length were measured. The results of study showed better r and r^2 i.e. 0.81 and 0.66 respectively. The formula of stature estimation was Y = 88.63 + 2.14* tibia ± 3.01. The stature estimation showed insignificant difference ($p > 0.05$) as compared to the actual body stature. The variation of body stature might be seen different among populations and nations throughout the world.

Keywords: *stature reconstruction, Acehnese, tibial length, stature estimation, insignificant difference.*

Introduction

Aceh is a province in Indonesia situated in the most Northwestern part of Sumatra Island. This province is mostly inhabited by people known as Acehnese along with other small populations from other parts of Indonesia. After the earthquake and tsunami hit coastal areas of Aceh on 26th December 2006, many victims were unidentified as many of bodies were evacuated in incomplete remains. Most of them were buried in mass cemetery without undergoing any process of identification. This tragedy might lead the study to conduct the stature reconstruction among Acehnese people. The body stature has been estimated among human by using the body remains. Regarding the relationship towards body stature, lower limbs had better accuracy as compared to lower limbs. Among long bones, tibia has shown better correlation in order to predict body stature[1-3]. Previous studies have estimated the body stature by measuring tibial length radiologically[3, 4], some measured percutaneously[5-4] and the others did the study by using dried bone of tibia[1]. Some studies employed living individuals, whereas others took cadavers as subjects.

Mulkan adalah dosen pada bagian Anatomi Fakultas Kedokteran Universitas Syiah Kuala

Many researches were done to invent formulae of stature estimation for their own certain population since the average of stature varies among different populations. They have found old formulae derived by Trotter and Gleser (1958) for certain groups of people were inappropriate to apply for present populations due to improved stature among populations[1, 3, 5]. In Indonesia, such studies have been developed for Javanese and Indonesian in general[15]. But, none was constructed specifically for Acehnese people.

Material and method

This study protocols was approved officially by the Ethics Committee of Faculty of medicine, Syiah Kuala University, Banda Aceh-Indonesia. According to the statistical calculation, there were 117 males of medical students who participated in the study. Their age was from 18-25 year old. The recruited subjects were only 3rd generation of Acehnese whose both parents and grandparents are Acehnese. After completing the consent form and questionnaire, they had to undergo the measurement of body stature and tibial length. The actual height of a subject was measured by projecting horizontal sliding bar to the vertex in cm. Subjects were asked to stand bare footed with both feet were in close contact with each other. The head was adjusted according to the Frankfort

horizontal plane with eyes looking forward and the trunk braced along the vertical board [6]. Then, the subject was asked to sit on a chair by putting the everted right calf on the left knee. The tibial length was measured from the proximal part of medial condyle to the distal part of medial malleolus[18]. The unit of measurement was in 0.1 centimeter (cm), and those measurements were taken by a same observer in order to prevent biased data. The formula of stature estimation derived from the tibial length was $Y = a + b * (x) \pm SEE$. Y is the stature estimation, a is intercept, b is slope, x is tibial length, and SEE is the standard error of estimate [3]. The statistical tests used for this study were: the Pearson correlation, the simple linear regression, and the paired t test. Those test were used to find out the correlation of tibia towards the body stature, to invent the formula of stature estimation, and to examine the difference between actual and estimated body stature.

Results

The data of body stature and tibial length were taken from subjects as shown in table 1. The data showed mean, standard of deviation, minimum and maximum.

Since the tibial length fulfilled the assumptions as shown in figure 1 and figure 2, the statistical tests such as the correlation and the simple linear regression were employed to reveal the correlation of tibia and to formulate the equation of stature estimation. Figure 1 shows the normal distribution of tibial length. And figure 2 describes the linearity of the tibial length towards the body stature. Additionally, the tibial lengths were displayed in elliptical shape.

Table 1 : The characteristics of body stature and tibial length among Acehnese population

	Acehnese		
	Mean (SD)	Min	Max
Body stature (cm)	169.80 (5.13)	157.70	180.10
Right tibia (cm)	38.01 (1.95)	33.0	43.0

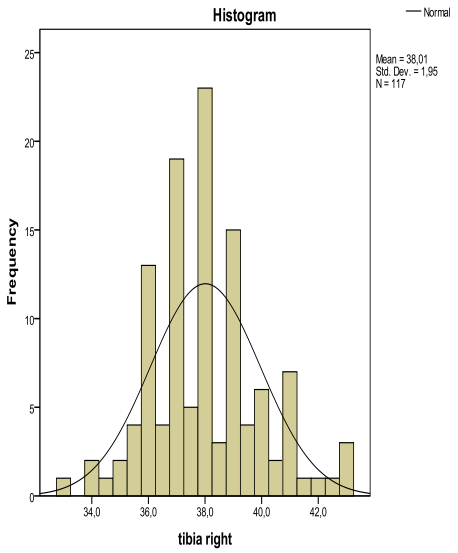
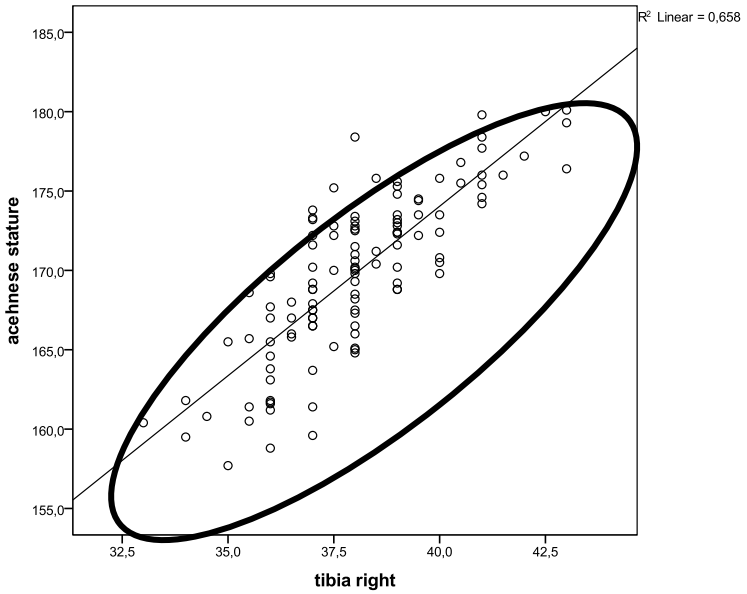


Figure 1 : The histogram of tibial length



Tibia

Figure 2 : The simple scatter plot diagram of the tibial length

Table 2 illustrates the correlation (r) of tibial length towards the body stature. The results shows better correlation (0.81) and significant P value ($p < 0.05$).

Table 2 : The correlation of coefficient of tibial length

	Body stature	
	r	P value
The right tibia	0.81	< 0.001

The table 3 depicts the coefficient of determination (r^2) of tibial length. Those results also shows better coefficient of determination (0.66) and significant P value ($p < 0.05$).

Table 3 : The coefficient of determination of tibial length

	b (95% CI)	*t* statistics	P value	r^2
Right tibia	2.14 (1.85, 2.41)	14.89	< 0.001	0.66

The table 4 displays the intercept (a), slope (b), and the standard error of estimate (SEE). It helps to construct formula of stature estimation accordingly as Y = a + b * (x) ± SEE. The formulated equation was Y = 88.63 + 2.14* tibia ± 3.01.

Table 4 : The intercept, slope, and SEE for equation formulation

	Intercept	Slope	SEE
Right tibia	88.63	2.14	3.01

The mean of stature estimation derived by the formula was insignificant difference ($p > 0.05$) as compared to the actual body stature. This result was shown in table 5.

Table 5 : Characteristics of body statures between actual and stature estimations

	Mean (SD) cm		t statistics (df)	P value
	Actual stature	Stature estimation		
Body stature (cm)	169.80 (5.13)	169.98 (4.17)	- 0.649 (116)	0.518

Discussion

Since prior studies suggested that tibia has shown better accuracy to estimate the body stature, this present study also selected tibia as the predictor of body stature. There have been some approaches which have been used to measure tibia either measuring dried bone, percutaneously, or radiologically. This study measured tibial length percutaneously among living individuals. This approach has been carried out by prior workers such as Mohanty (1998), El Meligy (2006), Duyar et al. (2006), Agnihotri *et al.* (2007), and Didia *et al.* (2009). They also proved the accuracy of tibial length for estimating the body stature. Furthermore, they summarized that their formulae were more applicable for their respective population.

In this study, the tibial length showed better correlation i.e. 0.801, meaning that 80% of tibial length could correlate well towards the body stature. And it also noticed the significant P value ($p < 0.05$). The closer to +1 means the better correlation resulted by the dependent variable[16]. This percentage of correlation was higher as compared to study done by Shia Muslim ($r = 0.765$)[12], Egyptian ($r = 0.7486$)[6], and less than study done by Japanese ($R = 0.897$)[13], Croatian ($r = 0.891$)[3], and Oriya population ($r = 0.9518$)[7].

The statistical test could be employed to reveal the equation for stature estimation. The simple linear regression was chosen to manage the data of tibial length for predicting the body stature. The formula derived from the tibial length showed better coefficient of determination i.e. 0.65, meaning that 65% of body stature could be estimated well by this formula. This study showed r^2 which was stronger than Korean ($r^2 = 0.61$)[1], Egyptian ($r^2 = 0.56$)[6]. But it was lower than previous studies done by Nigerian ($r^2 = 0.827$)[5], and Turkish people ($r^2 = 0.816$) [14]. The intercept (a), slope (b), and SEE helped to construct the formula of stature estimation.

Subsequently, the stature estimations were calculated by entering the data of tibial length into the formula. After that, Results of stature estimation were statistically analyzed and evaluated to the actual body statures. The results showed the insignificant difference of stature estimation as compared to the actual body stature. The results might emphasize that tibial length has shown suitability for estimating the body stature [1, 7, 11, 12]

The study invented a specific formula of stature estimation based on the tibial length. However, the formula was limitedly applied

for Acehnese population inhabiting Indonesia. Since Indonesia consists of hundreds local populations extending from Sumatra island to Papua island, they are supposed to have their own characteristics in physical appearances particularly body stature. This study also suggested that different population shows different mean of body stature as well as formula of stature estimation, so that the application of other's formulae might not appropriate to estimate certain population around the world. The study might subsequently lead such research among Indonesian and surrounding ASEAN countries to find out the formulae of stature estimation based on any parts of human body.

References

1. Choi, B., et al., *Correlation between the postmortem stature and the dried limb-bone lengths of Korean adult males.* Yonsei Med J, 1997. 38(2): p. 79-85.
2. Porter, A., *The prediction of physique from the skeleton.* International Journal of Osteoarchaeology, 1999. 9(2): p. 102-115.
3. Petrovecki, V., et al., *Prediction of Stature Based on Radiographic Measurements of Cadaver Long Bones: A Study of the Croatian Population*.* Journal of forensic sciences, 2007. 52(3): p. 547-552.
4. Kieffer, C., *Tibia and Fibula Stature Formulae for Modern Female Populations Based on Digital Radiographic Measurements.* Journal of forensic sciences, 2010. 55(3): p. 695-700.
5. Didia, B., E. Nduka, and O. Adele, *Stature estimation formulae for Nigerians.* Journal of forensic sciences, 2009. 54(1): p. 20-21.
6. El-Meligy, M., et al., *Estimation of human body built in Egyptians.* Forensic science international, 2006. 159(1): p. 27-31.
7. Mohanty, N., *Prediction of height from percutaneous tibial length amongst Oriya population.* Forensic science international, 1998. 98(3): p. 137.
8. Stevenson, R., *Use of segmental measures to estimate stature in children with cerebral palsy.* Archives of Pediatrics and Adolescent Medicine, 1995. 149(6): p. 658.
9. Özaslan, A., Iscan, M.Y., Özaslan, I., Tugcu, H., Koc, S., *Estimation of stature from body parts.* Forensic science international, 2003. 3501: p. 1-6.
10. Duyar, I., C. Pelin, and R. Zagyapan, *A new method of stature estimation for forensic anthropological application.* Anthropological Science, 2006(0): p. 511290018.
11. Agnihotri, A., et al., *Estimating stature from percutaneous length of tibia and ulna in Indo-Mauritian population.* Forensic science international, 2009. 187.
12. Nath, S. and Bhavna, *Use of Lower Limb Measurements in Reconstructing Stature among Shia Muslims.* Anthropology Today: Trends, Scope and Aplications, 2007. 3: p. 219-222.
13. Hasegawa, I., et al., *Stature estimation formulae from radiographically determined limb bone length in a modern Japanese population.* Legal Medicine, 2009. 11(6): p. 260-266.
14. Duyar, I. and C. Pelin, *Body height estimation based on tibia length in different stature groups.* American journal of physical anthropology, 2003. 122(1): p. 23-27.
15. Devison, R.J., *Penentuan Tinggi Badan Berdasarkan Panjang Lengan Bawah*, in *Departemen Kedokteran Forensik*. 2009, Universitas Sumatera Utara: Medan-Indonesia. p. 77.
16. Chan, Y., *Biostatistics 201: Linear regression analysis.* Singapore Medical Journal, 2004. 45(2): p. 55-61.