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ANTHROPOMETRIC STUDY IN DEUTERO-MALAY ETHNIC IN SEARCH OF ACCURATE HEIGHT FORMULAS FOR NUTRITIONAL STATUS ASSESSMENT

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Abstract: Nutritional status can be assessed using a person's height. Sometimes it is difficult to quantify for example in bedrest patient or abnormal stature, so it needs an alternative anthropometric measurement, such as height estimation based on long-bones measurement. Little information is available about the accuracy of these measurements, especially in deutero-malay ethnic. The present study aimed to compare accuracy for estimating height from several long-bones lengths to search an accurate anthropometric formula for nutritional status assessment. This study used an observational analytic method with cross sectional approach. The samples are students of Medical Faculty of University of Jember that meet the inclusion and exclusion criteria. Data were analyzed with Kolmogorov-Smirnov test, Pearson Correlation test and linear regression. The method is by measuring height with microtoise and bones length with medline. The result showed strong and positive ($r > 0.5$) correlation between height and length of long-bones, so linear regression can be done. Among ulna, femur, humerus and radius bones, femur formula showed the highest accuracy both in men (r right = 0.904; left =0.906) and women (r right = 0.911; left = 0.900). We conclude that anthropometric formula from estimation of height by length of femur is the most accurate from all formula, thus the most preferable to be used for height estimation in deutero-malay ethnic when assessing nutritional status.

Keywords: anthropometric formulas, height estimation, nutritional status, deutero-malay

Introduction

Measurement of height is very important both for children, adults, and elderly (elderly). This is important because by knowing a person's height, his or her nutritional status can be assessed. Assessment of nutritional status is often done by calculating the body mass index (BMI). BMI is measured by weight ratio (in kilograms) divided by squared height (in meters) (Goon, et al, 2011). Therefore we need accurate height measurement. The usual measurement of height is by measuring from the top of the head (vertex) to the tip of the heel in an upright position or called the stature (Barbosa, et al, 2012). In some cases where height cannot be directly determined, as in the case of individuals with disabilities, we needs an alternative height measurement to asses nutritional status. Disability is the abnormality of limb shape from birth and due to abnormal growth including spinal deformities. In addition also in individuals who have difficulty to stand because of using a wheelchair, neuromuscular weakness and in individuals with amputation conditions. (Goon et al, 2011).

Based on a survey conducted by WHO, the number of people with disabilities worldwide by age 15 years and over in 2013 is 975 million people, or about 19.4% of the total world population, while for under 15 years reaches 190 million people or about 3.8% of the world's total population. Based on WHO (2013) data, 65% of people with disabilities worldwide come from poor and developing countries. Indonesia is one of developing country with a large number of people with disabilities. Indonesia ranks second in Southeast Asia after

Vietnam as a country with a disability number reaching 3.5 million from the total population of Indonesia (WHO, 2013). The number of people with disabilities in Indonesia reaches 1,652,741 people and 67,5% of them are in productive age (18 - 60 years old). Leg disabilities accounts up to 33.75%, while the other 12% have body deformities (BPS, 2013).

Height has an important role in determining nutritional status and hence we required the need for a good height estimators for individuals with disabilities and other conditions that might cause height cannot be determined directly. Therefore, if the estimation of the height is done by using an unsuitable tool it will have an impact on the calculation of energy needs that are not in accordance with nutritional status. It then encourages the development of research on accurate height measurement alternatives. One of the alternative height measurements can be performed on people living on a percutaneous basis (Madden, et al, 2012). The results show that long bones can be used to formulate a high-estimate formula because long bones have a linear relationship with height (Reinhard, et al, 2013). Linear regression formulations derived from one or more body parts may be used for estimation of height (Krishan and Sharma, 2007, Chikhalkar, et al, 2010, Ahmed, 2013). The use of a linear regression formulation to determine an estimation of height based on a particular body part is an accurate method compared to other methods (Tsokos, 2008).

In Indonesia, the Ministry of Health has not established an official alternative method of measuring height in specific conditions (where height cannot be measured directly). One alternative height measurement using long bones is to use the length of the humerus, radius, ulna and femur. Several studies of the effectiveness of bone length of humerus, radius, ulna and femur as high estimators were performed in various age, ethnic, and gender groups (Ilayperuma, et al, 2010, Thumar, et al, 2011, Prasad et al, 2012, Barbosa et al, 2012, Honandar, 2014) with good correlation results. According to Ozaslan (2006), ulna has a better accuracy than the other long bones of the upper extremities. The British Association for Parenteral and Enteral Nutrition recommends the length of the ulna as an alternative to individual height measurements for the assessment of nutritional status. In addition, as an alternative measurement, we may also use the length of the lower extremity bone such as femur. The estimate formula of height by using the length of the bone of the femur percutaneus has the best accuracy when compared with the long bones of other lower extremities (Itsna, 2015).

The use of long bone length as an estimator of height is limited to specific populations, races and environments. Therefore, further testing is required when it is done with different areas, populations, and races. In addition, differences in a person's height is affected by several factors, one of which is gender. The average male height is greater than the female. Therefore, we need to separate the formula of height estimation between men and women (Schell, et al, 1985, Papaloucas, et al, 2008). Research on height measurement alternatives using humerus, radius, ulna and femur length is still rare in Indonesia especially in deutero-malay ethnic and it is still very rare to distinguish by sex. Therefore, the researcher is interested to develop the estimation formula of height by using humerus, radius, ulna and femoral length of bone in each gender.

Methods

This research used observational analytical method with a cross sectional approach and consecutive sampling technique. This study was conducted at the Faculty of Medicine, University of Jember in November 2016. The study population is 3rd and 4th year students of Faculty of Medicine, University of Jember with the age of more than 21 years old. Slovin formula used to calculate the sample size in this study to obtain representative sample and more definite or close to the existing population (Sugiyono, 2010). Based on a population of 102 persons with an error rate set to 5% or 0.05, then the minimum sample size in this study is 81.2 (rounded to 82). This research involving 88 subjects who fulfilled the inclusion criteria of being able to stand upright, including in the deutero-malay ethnic (Javanese, Sundanese, Madurese, Balinese, Acehnese, Minangkabau, Lampung, Makasar, Bugis, Manado and Minahasa tribes) and willing to sign informed consent, as well as the exclusion criteria of having a history of fractures on the upper and lower extremities.

The method used is measuring height from vertex to heel by using microtoise capacity of 200 cm. Then measure the length of the humerus bone from the major tuberosity to the lateral epicondyle, the radius length of the radius from the radii cap until the Styloideus radii processus, the ulna length from the tip of the elbow (olecranon process) to the middle of the protruding bone at the wrist (styloid process) and the border of the femur is determined by palpation and then measured from the femoral major trochanter to the lateral condyle of the femur using a 150 cm tape measure capacity.

The data obtained were analyzed using IBM SPSS Statistics software version 20.0. The test was Kolmogorov Smirnov normality test. Because the result of normality test p> 0,05 (normal distributed data) then Pearson Correlation test was done. After that, the Linear Regression test was done to determine the approximate formulation of height. This research has got permission of ethical clearance from ethics commission of Medical Faculty of Jember University.

Results and Discussions

Total number of female respondents (65.9%) is more than the number of male respondents (34.1%). It is because of the limitation of the total population that the number between men and women have a large difference. In the results of the study, the average height in men is 167.58 cm, higher than the female height of 156.99 cm (Table 1). This result is relevant with theory that the comparison of male height to woman is 100 : 90. The difference can also be influenced by male activity factor which tend to be more severe than female (Schell, et al, 1985, Papaloucas, et al, 2008). Therefore, looking for height requires a separate formula between men and women. Respondent age range is between 21 and 23 years with mean of 21.23. From the data obtained the average length of humerus and radius is longer on the right side of both the male and female, while ulna and femur slightly longer on the left side (Table 1).

*Table 1 Descriptive data of deutero-malay ethnic samples in this study.**

Skeletal Element	n	Minimum	Maximum	Mean	Std. Deviation
Male Right:					
Humerus	30	26	33.85	29.9	1.5
Radius	30	19.75	27.65	23.09	1.5
Ulna	30	21	30	26.46	1.94
Femur	30	38.01	46.31	42.08	2.11
Male Left:					
Humerus	30	26	33.85	29.85	1.52
Radius	30	19.75	27.65	22.93	1.49
Ulna	30	21	30	26.53	1.94
Femur	30	37.98	46.11	42.09	2.1
Female Right:					
Humerus	58	24	31.25	27.46	1.69
Radius	58	17.9	24.85	21.03	1.43
Ulna	58	21	28.5	25.43	1.75
Femur	58	33.67	44.34	38.96	2.36
Female Left:					
Humerus	58	24	31.25	27.44	1.69
Radius	58	17.9	24.85	20.98	1.43

Ulna	58	20.8	28.5	25.53	1.81
Femur	58	33.54	44.52	38.97	2.36

*All measurements are reported in centimeters

The regression equation is calculated separately for each side and for each limb dimension as body height = a + bx, where "a" is the regression coefficient of the dependent variable ie height and b is the regression coefficient of the independent variable ie the length of the limb (length Humerus bone and radius bone length) and "x" denotes measurements of limb length or bone calculated (Krishan and Sharma, 2007). r square (r^2) or coefficient of determination is to measure the quality or accuracy of the regression equation that gives the proportion or percentage of total variation in the dependent variable (height) described by the independent variable (long bone length) (Anupriya and Kalpana, 2016). Accuracy of the resulting formula is said to be better if r square is approaching 1 (one). The resulting formula from linear regression can be seen in Table 2.

*Table 2 Regression formula for height estimation of deutero-malay ethnic samples in this study and statistic parameters.**

Skeletal Element	n	Regression Formula	r	r^2
Male Right:				
Humerus	30	71.440 + (3.215 x Right Humerus)	0.862	0.743044
Radius	30	96.173 + (3.092 x Right Radius)	0.828	0.685584
Ulna	30	105.156 + 2.321 (Right Ulna)	0.818	0.669124
Femur	30	68.096 + 2.339 (Right Femur)	0.904	0.817216
Male Left:				
Humerus	30	73.272 + (3.159 x Right Humerus)	0.851	0.724201
Radius	30	95.80 + (3.131 x Radius Left)	0.827	0.683929
Ulna	30	105.190 + 2.313 (Left Ulna)	0.822	0.675684
Femur	30	66.974 + 2.365 (Left Femur)	0.906	0.820836
Female Right:				
Humerus	58	93.782 + (2.300 x Right Humerus)	0.868	0.753424
Radius	58	100.737 + (2.673x Right Radius)	0.852	0.725904
Ulna	58	93.239 + 2.643 (Right Ulna)	0.803	0.644809
Femur	58	94.101 + 1.610 (Right Femur)	0.911	0.829921
Female Left:				
Humerus	58	93.847 + (2.300 x Left Humerus)	0.863	0.744769
Radius	58	101.145 + (2.659 x Left Radius)	0.848	0.719104
Ulna	58	95.386 + 2.549 (Left Ulna)	0.803	0.644809
Femur	58	94.046 + 1.611 (Left Femur)	0.9	0.81

*All regression formulas are in centimeters

The correlation test result showed there is a significant relationship so the linear regression analysis to determine the estimation formula of height based on the length of the humerus, radius, ulna and femur can be done. This is consistent with the theory that long bones with height have a linear relationship (Glesser and Trotter, 1958). That makes a certain bone length can be used to formulate a formula for estimating height by linear regression analysis. Accuracy of anthropometric formula of height based on left femur for male and right femur for female bone length have the best accuracy among all formulas of height estimation obtained because the value of r and r square are 0.91 and 0.91 or 0.82 and 0.83. It means that the formulas represent 82 and 83 percent of the samples height variance. This is probably because femur contributes directly to height (Nor, et al, 2013) . In addition, based on Anderson's (1993) study on long bone contribution to growth, femur contributes 36% to growth and height in both sexes, while other bones contribute less than 30%.

The estimated height formula generated in this study was compared with the estimation formula of some previous studies. From the results of these analyzes, it turns out the estimative formula of researchers and estimative formula of UGM's Body Anthropology (Kusuma and Yudianto, 2010) shows the results of measurements close to the actual height of respondents. This happens because the age range of research subjects is almost the same. The study subjects from the Anthropology of the Orthodontology were 25 to 30 years old while in this study were 21 to 23 years old. In addition, subjects in anthropological studies have the same racial race with the subject of this study, which is the mastoloid malayan race. This is also in accordance with the research conducted by Akhlaghi, et al (2012) that height is affected by various factors of age, gender, environment, and race of the subjects.

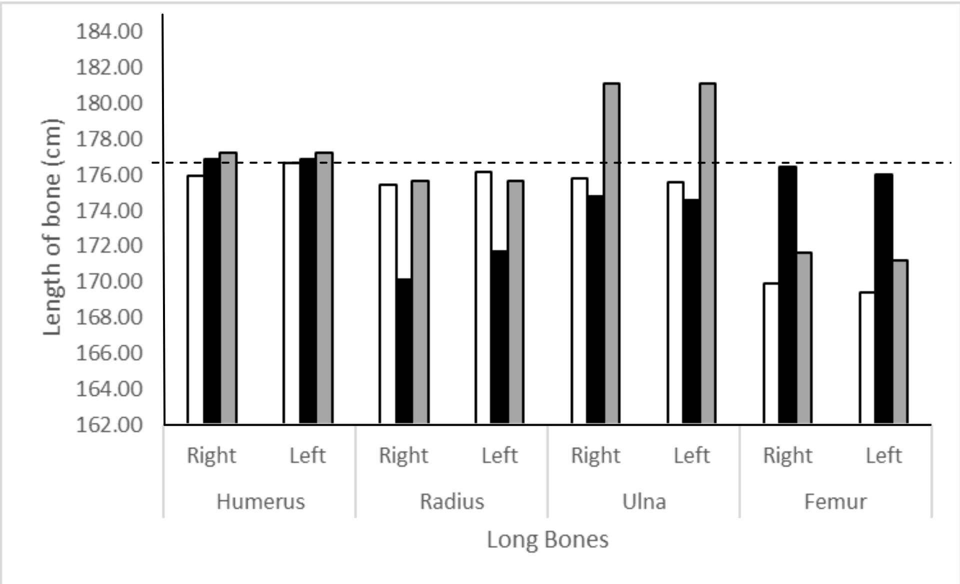

Figure 1 Comparison Between Researchers' Formulas with Some Other Formulas. Measurement based on sample of male height 176.5 cm showed by dash line. White, black and gray bar each represent height estimation using UGM's body anthropology formula, this study formula and Trotter Gleser formula.

From the regression formula obtained then the researcher also tried to test with other existing formulas such as Trotter Gleser's formula (1958). The bone length used in this study is percutaneous, which is still covered in joints, muscles and skin, while the formula to be compared is based on the bone in a dry state, so to insert into the existing formula must first reduce the measurement value of 2.5 cm (Devinson, 2009). Figure 1 showed that the researcher's formula, Trotter Gleser formula, and UGM's Body Anthropology formula have a similarity or close to the actual height of the respondent for humerus length based. This is because the sample of Trotter Gleser's research uses the subject of the mongoloid race and the subject of this study uses a deutero-malay ethnic which is a sub of the mongoloid race so it has a resemblance. As for the formula of UGM's Body Anthropology using research subjects of the Javanese tribe that is part of the deutero-malay ethnic. However, both the formula of Trotter Gleser and UGM's Body Anthropology only conducted research on men, so the formula cannot be set on women.

Formula on other bone length based were slightly different to the actual height, these might be because the differences on calculating dry bone and percutaneous bone and on setting the bone border boundaries measurement on dead and living object (Agnohotri, et al,). In elderly or persons with disabilities, height measurements cannot be measured precisely. In order to know the height of a subject, we need to use formulas based on several parameters such as knee height, arm length and two arm lengths (Cilik, et al, 2010). The formula in this study can be an alternative of a more precise height measurement because it is designed to be used in living object. Therefore, according to the purpose of this research, our formula is more suitable to be used in height estimation than those other formulas compared above.

The formulas obtained in this study must be used carefully since it can only be used in populations of the same character and age. This estimation formula is tested on Javanese, Madurese, Sundanese and Balinese tribes, so it can be used to represent height estimations formulas in Malayan mongoloid races, especially deutero-malay ethnic of the same age range. This is because the height is influenced by several factors i.e. age, sex, race and residential environment (Barbosa, et al, 2012). To know the accuracy of this formula in other population groups, we need to test the validity first in a more varied population.

Although the researcher has tried maximally to control every step in conducting this research, there were still few limitations in this research. The subjects in this research were still limited to medical faculty students who have homogenous physical activity and narrow age range. In addition, the limitation of this study was the determination of bone-measurement borders that were still done manually, therefore for further research needs to be done with more accurate methods such as X-rays to determine and confirm bone measurement borders. It is also suggested to be done with a bigger population with diverse activities and equal number of gender.

Conclusions

Anthropometric approach such as an indirect height measurement help to assess nutritional status in disabled persons, or where direct method is not possible to be done. Based on the result of data analysis, height estimation formulas based on femur length are the best height estimation formulas and feasible to be applied in deutero-malay ethnic. When comparing with other formulas (UGM’s Body Anthropology and Trotter Glesser), according to the purpose of this research, our formula especially the femur length based is the most suitable to be used in height estimation than those other formulas. However, to overcome the limitation of this study, it is suggested to conduct future research with larger number of samples, wider age range and proportioned number of samples between men and women. It is also suggested to add an X-rays examination as a measurement validity confirmation.

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Appendix

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Ulna	58	95.386 + 2.549 (Left Ulna)	0.803	0.644809
Femur	58	94.046 + 1.611 (Left Femur)	0.9	0.81

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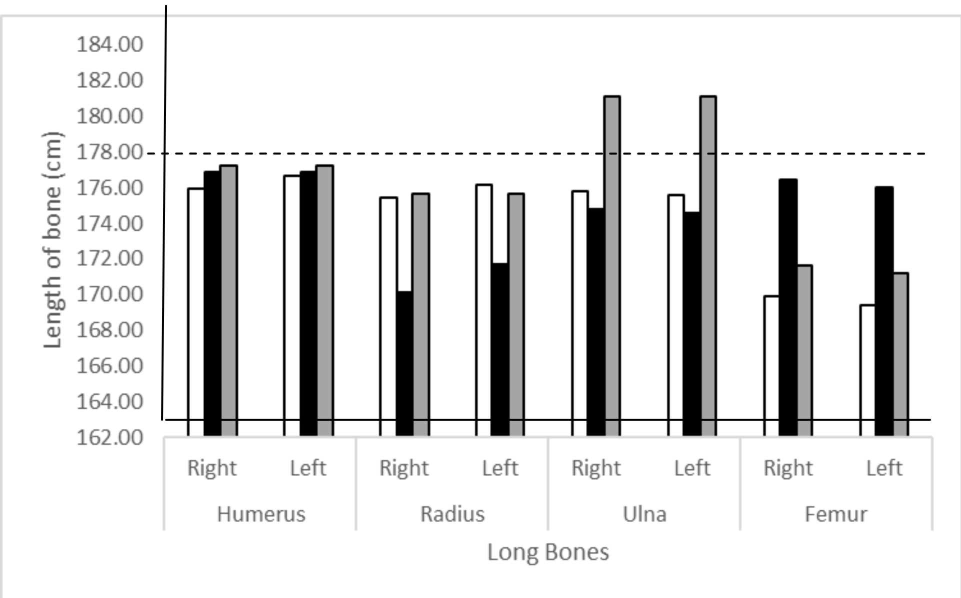

Figure 1 : Comparison between researchers' formulas and some other formulas. Measurement based on sample of male height 176.5 cm showed by dash line. White, black and gray bar each represent height estimation using UGM's body anthropology formula, this study formula and Trotter-Gleser formula