

## Body Height Estimate Based on Length of Arm Span in Mongoloid Javanese Young Adult Females

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### Abstract

Length of arm span has been proven to be one of the most reliable predictors for the estimate approach in determining body height. The objective of this research was to find the correlation between arm span length and body height, and to determine the formula for body height estimation. This is a cross-sectional observational analytic study design. It was conducted on 220 samples of Mongoloid Javanese females aged 18 to 23 years in Surabaya. We chose Javanese it is the biggest ethnic group in Indonesia, and we chose Surabaya because it is the second largest city in Indonesia. We measured length of arm span and body height and calculated the distribution. The data were normally distributed ( $p > 0.05$ ). We used Pearson's correlation for determining the linear regression to obtain the formula for body height estimation ( $p < 0.05$ ). There is a strong correlation between length of arm span and body height ( $r = 0.759$ ). The results of this study suggest that, among the Mongoloid Javanese, the average body height is 1535.68 mm, while the average length of arm span is 1545.86 mm. The formula for estimating body height based on the length of arm span is  $597.717 + 0.607^* \text{ length of arm span (in mm)}$ . We conclude that the length of arm span is reliable to estimate body height and can be applied in medico-legal cases.

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### Introduction

Body height is an important consideration in various circumstances. It can be used as indicators of growth, body size, physical capacity and of nutritional status.<sup>1,2</sup> The length of certain bone and body parts represents the relationship between body shape and height. After the skeleton formation process is completed, its proportion does not change in line with the ageing process.<sup>2,3</sup> However, there are some circumstances in which it is not possible to conduct body height measurement, such as in leg form anomaly or with patients of physical and mental weaknesses, such as patients tied to wheelchairs or confined to bed and those suffering from osteoporosis, post-amputation or

backbone fracture.<sup>4</sup> It may also happen in mutilated bodies (e.g., natural disasters, accidents, wars, terrorism) in which only certain separated body parts are found.

In certain cases, victim identification has to be conducted based on their separated body pieces, where the body height must be estimated using other body parameters, such as length of arm, length of foot, or length of arm span.<sup>3,5</sup> This formula is also important to predict the body height in individuals with disproportionate growth in skeletal dysplasia or the reduction of body height due to surgery.<sup>4,6,7</sup> In this matter, the anthropometry is important for the identification process or of medicolegal interest.<sup>2,4,7</sup> The body height of adults among the population frequently differs significantly<sup>1,7-10</sup>, depending on the body proportion that differs from one population to another.

Some researchers have reported the effectiveness of using various body parameters in estimating body height.<sup>11-13</sup> Thus, someone can be identified based on their body height, and the correlation between their various body parts, such as length of arm span, length of arm, length of foot, demi-span and others, can also be used

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as an alternative to estimate body height in standing position. The correlation between the length of arm span and body height shows variety between different ethnic groups.<sup>4,7,9,10</sup> This body height estimate requires anatomy techniques, and the use of mathematics and statistics in writing its formula.<sup>14</sup>

Although some studies have been conducted on Western populations, the available data are very limited in Indonesia, including the limited data from the Mongoloid Javanese ethnicity. Therefore, the purpose of this study is to find the correlation between arm span and body height and to seek the regression equation of body height estimate based on arm span in Mongoloid Javanese female young adults in Indonesia. This observation will result in a formula of body height estimate based on arm span in Mongoloid Javanese females.

## Materials and methods

This study used an observational analytic method for 220 samples, which consisted of Mongoloid Javanese females aged 18-23 years old. We explained all the procedures, the possibility of a little discomfort during the measurements, and the benefits that they may have after the measurements. The individuals' willingness to be our subjects of measurements were confirmed by signing informed consent forms.

The data consist of body height and length of arm span. The anthropometric measurements were carried out in accordance with ISAK—International Society for the Advancement of Kinanthropometry protocol. Body height was measured from vertex to the bottom of foot pad, while the head was positioned according to the Frankfurt horizontal line.<sup>15</sup> Body height was measured using GPM Anthropometer that can measure accurately to the nearest millimeter.<sup>15</sup> The length of arm span was measured using a flexible steel tape that can measure accurately to the nearest millimeter. The measurement was from the tip of the middle finger on one hand to the tip of middle finger on the other while the individual was standing, his/her back facing the wall, the corner of both arms raised up to 90 degrees, elbow and wrist widespread, and his/her palms directly facing forward.<sup>2,4</sup> The body height and arm span measuring were carried out in the morning. We

wanted to avoid gravity affecting the measurement of standing height. We exclude individuals that did not match our criteria such as when she was not a Mongoloid Javanese, or having physical anomaly that would influence body height and arm span.

We used Kolmogorov-Smirnoff for testing the distribution of data, and Pearson for testing the correlation. The calculation was performed by using SPSS version 16. The formula of body height estimate was obtained through a single/multiple linear regression statistic calculation. The general equation for single (univariate) linear regression is  $Y = a + b x \pm SEE$ .<sup>16</sup> Y = dependent variable (body height estimate), a = constant, b = regression coefficient of independent variable, x = individual variable / length of arm span measuring, SEE = Standard of Error in Estimate.

## Results

The average body height of Mongoloid Javanese females is 1536. mm ( $s = 47.220$ ). We found that the average of arm span is 1545.86 mm (Table 1).

Parameter	Total Sample	Minimum (mm)	Maximum (mm)	Mean (mm)	Standard Deviation
Body height	220	1420	1670	1535.68	47.220
Length of Arm Span	220	1363	1710	1545.86	59.076

**Table 1.** Descriptive Statistics of Sample of Mongoloid Javanese Females Aged 18-23 years old.

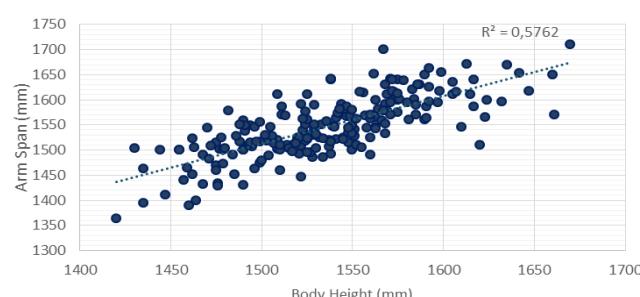
All data were normally distributed ( $p > 0.05$ ). The Pearson correlation result for arm span and body height indicates a strong correlation in the 220 samples ( $r = 0.759$ ). Table 2 is the result of the Pearson correlation between length of arm span and body height.

Figure 1 is the data distribution to illustrate the correlation between body height and arm span. The value of R squared is 0.5762 (Fig. 1). The formula of body height estimate based on length of arm span (in mm) can be written as follows:

$$\text{Body Height} = 597.17 + 0.607 * \text{length of arm span} \\ \pm 30.809$$

Subject	Correlation Coefficient	Standard Error (SE)	R-square	T	p-value
Mongoloid					
Javanese Females	0.759	54.516	0.576	10.964	<0.001
Intercept	597.17				
Slope	0.607				
SEE=					
30.809					

**Table 2.** Analysis Results of Linear Regression to Estimate Body Height Based on Arm Span in Mongoloid Javanese Females.



**Figure 1.** Correlation of body height and arm span.

## Discussion

The average body height of Mongoloid Javanese females is 1535.68 mm ( $s=47.220$ ). If accurate measurement of body height cannot be obtained, it can then be calculated by using other substitutes. Length of arm span is mostly used in such cases<sup>17</sup> and is considered the best alternative to determine body height<sup>18</sup>, mainly for seniors, because arm span does not change incredibly as an individual ages.<sup>19</sup>

Arm span is proven to be consistently reliable in estimating body height, although the strength of correlation varies from one population to another. A study of the correlation of arm span and body height conducted among black and white women aged 35-89 years old determined coefficient correlations of 0.852 and 0.903, respectively.<sup>9</sup> In a similar research, black people from both sexes in the age group of 22-49 showed a coefficient correlation of 0.87.<sup>20</sup> Our study found a strong correlation between length of arm span and body height, too (= 0.759), which is nearly the same as found in other research of several other populations. It is similar to the correlation coefficient of Nigerian adult males (=0.77), and for Nigerian adult females

(0.72).<sup>4</sup> In a study of females in Ahmedabad,<sup>2</sup> the results suggest a correlation coefficient of 0.869. The correlation obtained in female students in Uttar Pradesh was 0.783.<sup>6</sup> Although the correlation coefficient obtained varies, and is nearly similar, the body height value is different from that of other populations.<sup>7</sup> The regression equation which results in the estimate formula obtained is obviously different from that in other populations.

We suggest that there will be further investigation from various populations, in both sexes, and in wider age span, using larger samples for predicting body height using the length of arm span measurement. In Indonesia alone there are so many islands and various populations that have various body build and body proportions.

## Conclusions

The results of this study imply that one's body height can be estimated by using the length of arm span. Length of arm span is strongly correlated with the body height in young adults. This research may be beneficial for certain circumstances, such as in measuring the height of unidentified mutilated individuals. The regression equation is useful for amputated corpses, and for victims of mass disasters and terrorism; that sometimes happen in Indonesia.

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## Declaration of Interest

We declare that we have no competing interests.

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