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Review Article

Forensic Body Height Estimation by Measuring Unsegmented Fingers of Javanese in Indonesia

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ABSTRACT

Estimation of stature is important in forensic examination. It is difficult to identify the deceased when the body has been mutilated and only fragmented remains are found . Body height estimation from fingers has been useful in establishing stature approximation. The present research attempts to construct a formula from measurements of the whole fingers from proximal to distal ends. The material for the present study comprises fifty (50) Mongoloid Javanese men between the ages of 21 and 25 years. Measurement of fingers and stature are taken on each subject based on internationally recommended standard methods and techniques. This study uses Pearson correlation test, and Regression analyses to determine the body height formula. The results indicate average height of the subject is 1675.96 mm. The results of index, middle, and ring finger measurements are positively correlated ($p < 0.001$) with stature. There are moderate correlations—r=0.4 to 0.5, between the length of fingers and body height. It can be concluded measuring each segment of finger can provide an estimation of stature. However, measuring the intact fingers is easier and more practical and is sometimes appreciated by the victims' families.

Keywords: Finger length, forensics, height estimation, identification, phalanx, stature

INTRODUCTION

The largest ethnic group in Indonesia is the Javanese who live in the most densely populated island of Java in Indonesia. Murderers often dismember the body of the victim to avoid identification and escape law enforcement agents. Forensic anthropology deals with identification, for legal purposes, of the skeleton in which the soft tissue have been lost partially or completely (Iscan &

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Steyn, 2013). Identification of unknown skeletons of individual victims is very important, especially in cases of mutilation, natural disasters, accidents, and fires. Estimation of stature has obvious utility in the identification process. Body height estimation becomes important in cases where only body parts are available for examination (Özaslan et al., 2003). In recent years, there have been many cases that involved dismemberment or mutilated bodies. The presence of soft tissue on the human remains would usually necessitate dissection to expose skeletal elements to derive metric data for stature estimation. Many attempts have been made to find the best formula to estimate the body height of mutilated bodies, and this may differ from one population to another.

Body height is a cumulative or composite measurement, consisting of head and neck height, body height, and leg length. Body height is supported by several body elements, such as *head, vertebral column, pelvis, lower limbs* (consisting of the *femur-tibia*), and ankles. Body height varies among individuals, but what is common is the length of human bones, feet and hands are proportional to their height (Cheng et al., 1998).

In determining body height, it is advisable to utilise the long bones, instead of other bones, to get the best result. A regression formula based on the long bones has been formulated to calculate a person's body height. For Mongoloids, the Trotter and Gleser (Trotter & Gleser, 1958) and Stevenson (1929) regression formulas have been frequently employed. Stature estimation using length of fingers and hands have been done in other populations such as in Nigeria (Oladipo et al., 2015), Iran (Mahakizadeh et al., 2016), and Korea (Jee and Yun 2015).

Studies on body height estimation have been conducted in different countries, for example in India (Jasuda & Singh, 2004), and Iran (Habib & Kamal, 2010) by measuring separated phalanges. It would be useful to know which one is best to estimate body height - by using separated phalanges or by measuring the entire length of the phalanges. The present study, therefore, focuses on estimating body height based on the entire length of the left hand phalanges of Javanese men. Regression equations specific to Mongoloid Javanese population are computed separately for each finger and to study their reliability in estimating the living stature of the individual.

MATERIALS AND METHODS

The subjects of the present study were 50 Mongoloid Javanese males who consented to be part of the study. Inclusion criteria are: ages between 18 and 25, absence of visible shortening of any of the limbs; absence of bone pathology, bone surgery, and any other pathological process in the medical history that may have influenced the height of the individuals. A purposive sampling method was adopted by taking into consideration the specific characteristics of the subjects (Levy & Lemeshow, 2013). All procedures used in the study are in accordance with the ethical standards set by the Helsinki Declaration and Universitas Airlangga who made sure the research was bound by standards of human rights.

The subjects' body height and the length their left hand phalanges were measured. Height measurements were conducted using standardised anthropometer. The left hand phalanges were measured, since the left hands normally performed fewer activities compared with the right hand, which may cause variation in the length of the right fingers. Measurements were conducted by sliding callipers. This method for measuring the phalanges is slightly different from that adopted by Jasuda and Singh (2004) on their Indian subjects. They conducted on the segment of the phalanges, while this study measures the entire phalange length from proximal phalanx to the distal phalanx.

Anthropometer was utilised to measure the height and length of the lower legs of the subjects. During the measurement, the subjects stand upright without any footwear.

The length of the fingers was measured using a sliding calliper. The hand was placed slightly open on a flat surface so that the fingers are apart from one another. The sliding calliper was held above the proximal phalanx of index finger while the other end of the needle is shifted to a distal phalanx position to determine the correct length of the finger. The same process applies for measuring other three fingers, except the thumb. The thumb is not included in this measurement because the shape of the thumb is a little bent, unlike the other fingers, and it only has two segments of phalanges.

The normality of numerical data distribution is tested using Kolmogorov-Smirnov test. Data are presented as means with standard deviation. Association of numerical parameters is assessed by Pearson's correlation coefficient r. Whenever r is significant, univariate regression equations are computed according to the equation $Y = ß0 + ß1 * x \pm SEE$, where Y is the dependent variable (estimated height), ß0 is *intercept* (constant) and ß1 is *slope* (regression coefficient), x is the independent variable (length of fingers) and SEE is the *standard error of estimation* (Petrovecki, 2007). From the general equation of this linear regression, the formula of body height estimation based on the length of each finger is generated. Body height formula is generated using body height as the dependent variable (Y) and length of the finger as the independent variable (X).

RESULTS AND DISCUSSION

Human body morphology is influenced by hereditary, nutritional, climatic, and racial factors (Katzmarzyk & Leonard, 1998). The length of metacarpals and phalanges can be used for sex determination (El Morsi & Al Hawary, 2013). It means that it is most likely to influence variation between populations too. Studies have concluded that hands vary in different populations. Davies et al. (1980) found significant difference in the length of hand among west European, Indian, and West Indian women. A Nigerian female hand is wider and shorter than that of her foreign counterparts (Okunribido, 2000). This is influenced by the length of fingers.

Of the 50 male subjects, the average body height is 1676 mm (s ± 57.547). The average length of left index, middle, ring, and little fingers of the subject is 82.66 mm (s ± 4.614), 90.98 mm (s ± 4.373), 85.36 mm (s ± 4.814), and 67.56 mm (s ± 4.219) respectively.

The formula of body height based on body parts varies among the different populations (such as Karakas et al. (2011), Didia et al. (2009), and Hasegawa et al. (2009)). The formula for one sex cannot be applied to estimate stature of the other. This study results are only applicable to Mongoloid Javanese males only.

The data showed a significant correlation between height and the length of index, middle, and ring fingers; therefore, the formulas are calculated based on the length of those fingers. There is a moderate correlation between body height and the index finger ($r = 0.4$). The ß0 is

1268.506 and the ß1 is 4,929, resulting in the body height (BH) estimation formula (in mm) based on the length of index finger as follows:

BH = 1268.506 + 4.929 * Index Finger Length ($r^2 = 0.16$)

The data shows a moderately significant correlation between body height and the length of the middle finger (r = 0.5). The β_0 is 1085,601 while β_1 is 6.489 which results in the body height estimation formula (in mm) based on the length of the middle finger as follows:

BH = 1085.601 + 6.489 * Middle Finger Length ($r^2 = 0.24$)

The data shows a moderately significant correlation relationship between body height and the length of the ring finger (r = 0.4). The β_0 is 1274,860 while β_1 is 4,699, resulting in the body height estimation formula (in mm) based on the length of the ring finger as follows:

BH = 1274,860 + 4,699 * Ring Finger Length (r^2 =0,16)

The data, however, show no significant correlation between body height and the length of the little finger. This is in contrast with Jasuda and Singh (2004), who reported that all four fingers have significant correlations with body height. The different result may be due to the differences in the methods. On the other hand, Habib and Kamal (2010) showed a significant correlation between three fingers - index finger, middle finger, and ring finger - and stature. Their study also used similar sampling methods as the present study, examining subjects within the age group 18 to 25 years of age, though their sample size is bigger. Their findings support those of the present study in that, the little finger shows no correlation with body height.

The strength of correlation between body height and length of finger is less than that between body height and segments of bony fingers (2004). This indicates that bony landmarks are more reliable indicators of stature than when the skin and other soft tissue are attached to the fingers.

The study does not measure the thumb length to be correlated with stature. However, another study (Chandra et al., 2016) find a correlation between thumb and stature, so that it will be useful to do such a study for adding formulae in stature estimation.

Other studies report the predictive accuracy of stature estimation is higher for females (Sen et al., 2014). It will be very useful to do a similar study on female samples in the near future, so that it can be useful for forensic cases.

CONCLUSION

In general, based on the measurement of the subject of this study, the longer the finger is, the taller the person is. The greatest correlation with body height is found in the middle finger, followed by the index finger, and the ring finger. The little finger of the subject shows no correlation with body height.

Body height shows a positive and significant correlation with the length of fingers; however, the correlation is moderate when measured from proximal to distal ends. Therefore, it can be concluded that to estimate body height from mutilated hands, the measurement of the segments of fingers, rather than measuring the whole length of the phalanx, gives a better prediction of stature, although the latter method is easier and more practical.

However, this formulae will be useful, because sometimes in Indonesia when a human part is found, the family is grateful that the body is not subjected to further dissection. The formula of the intact finger is very useful, because it respect the feelings of the families.

Future studies should look at a bigger sample size and those below the height examined in this study.

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