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ORIGINAL ARTICLE

Medicine Science International Medical Journal

Medicine Science 2022;11(3):1336-9

Height estimation by evaluating morphometric measurements of hands and fingers

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Received 12 August 2022; Accepted 25 August 2022
Available online 28.08.2022 with doi: 10.5455/medscience.2022.08.188

Abstract

Biological bodily integrity is often lost in deaths due to undesirable situations such as femicides, natural disasters and plane crashes. For forensic scientists, accurate estimation of the person's stature is important for identification. In our study, it was aimed to obtain simple and multiple linear regression formulas required for stature calculation from hand and finger morphometric measurement values of young women. This study was carried out with the voluntary participation of 65 healthy young adult women between the ages of 18-24. Measurements were made on the palmar side of the hand using a digital caliper. In the study participants, the mean values of the measured variables; stature 164.45 cm, hand length 17.40 cm, hand width 7.70 cm, palm length 9.92 cm. Simple and multiple regression equations were obtained for stature estimation. The most reliable one of the regression equations obtained for stature estimation was the equation based on hand length. There was no correlation between thumb length and stature. The correlation value between index finger and stature was greater than the values obtained from other fingers ($r=0.344$, $p<0.01$). The correlation value between palm length and stature was higher than the correlation value between fingers and stature ($r=385$, $p<0.01$). Moderate and high positive correlation values were found between finger lengths and each other. The highest correlation value was between middle finger length and 4th finger length ($r=872$, $p<0.01$). The correlation value between thumb and little finger lengths was the smallest ($r=415$ $p<0.01$). The correlation value between hand length and stature is higher than the values obtained from finger lengths. In cases where total hand length cannot be measured, linear regression formula based on palm length should be preferred. Regression analysis results showed that palm length gave a better estimation of stature compared to finger length measurements.

Keywords: Stature estimation, Regression equation, Hand morphometry, Finger length, Hand length

Introduction

Four important unknowns need to be resolved in order to clarify forensic events. These unknowns are the race, gender, stature and age of the victims. Anthropometric methods can be used to estimate the person's stature. In the period from childhood to adulthood, human stature increases at varying rates depending on many genetic and environmental factors. With aging, the human stature decreases somewhat due to the degeneration and compression of the cartilage structures in the body, and also the decrease in elasticity in the intervertebral discs. Many studies on estimating stature from bone formation have been reported in the literature. The lengths of long bones better reflect human stature [1-3]. Chibba et al. revealed the calculation of the tibia's stature and the person's stature from the measurement values of different parts of the tibia [1]. Feldesman, determined that the ratio between femur length and human stature was 26.47%. They also found it interesting that this ratio was independent of ethnicity and gender [2]. Duyar et al. carried a study for estimation of stature in 121 male subjects. They emphasized that this issue should be considered in the formulas obtained for the estimation of stature from bone lengths, since the long bone/stature ratio is not the same in people with different phenotypic characteristics [3]. Mahakkanukrauh et al. used the lengths of six long bones (humerus, femur, tibia, fibula ulna, and radius) for stature estimation in a study they carried in Thailand. They reported that the best estimation of stature among these bones was made with the fibula bone in men (Standart Error of Estimate / SEE:4.89) [4]. Ari et al. made an estimation of bone length from the talus and calcaneus bones, and also compared the anthropometric values of Byzantine and contemporary human societies [5]. The estimation of stature from bones is also very important in terms of archaeological studies. The determination of many features such as gender, stature values, lifestyle and

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diet of people who lived in the ancient period contributes to the filling of the information treasure about archaeological societies. Acar, obtained data on the individual characteristics of the ancient society (Yoncatepe population) by determining the stature and gender from the talus and calcaneus found in the archaeological excavations [6]. When formulas obtained for a society are used for different ethnicities, races and societies, it cannot be expected to give accurate results. For this reason, it is seen that similar studies have been done for different races and societies in the literature. Regression formulas for stature estimation can also be obtained from foot length. The studies of estimating stature from foot lengths of North Bengal, North Indian, Malasian, Slavak societies can be given as an example for this method [7-10]. Özaslan et al., in a study, obtained results for estimating stature from the length and width measurements of different parts of the lower extremity [11].

In this study, we aimed to obtain simple linear regression formulas and multiple linear regression formulas required for stature calculation from hand and finger morphometric measurement values of young adult women and to evaluate the relationship between them.

Material and Methods

This study was was carried out in 65 healthy young adult women aged 18-24 years. The individuals participating in the study were right hand dominant and did not play any professional sports. Measurements were done on the palmar side of the hand with a digital caliper (Baker Digital Caliper). Finger lengths were measured from the fingertip to the midpoint of the finger root line. Hand length, palm length and hand width measurements were made using standard techniques.

Exclusion criteria from the study

Those who have surgery on the arm, shoulder and spine region

Those with spinal pathology

Those with leg, thigh and hip pathology

Statistical analysis

Data were evaluated with IBM Statistical Package for the Social Sciences (SPSS) 26 software. Descriptive statistical analysis (median, minimum, maximum, standard deviation) was performed. The distribution of the obtained data was determined by the Shapiro-Wilk test. In this study, the relationship between the measured values of the variables was examined by Pearson correlation analysis. Simple linear and multiple linear regression equations were obtained using SPSS software.

Results

In the study participants, the mean values of the measured variables; stature 164.45cm, hand length 17.40cm, hand width 7.70cm, palm length 9.92cm. Descriptive statistical data obtained from finger lengths and other morphometric measurements are given in Table 1.

Simple linear regression and multiple linear regression equations were obtained for stature estimation (Table 2-3).

The smallest "Std. Error of the Estimate" value belonged to the equation obtained for hand length (SEE: 5.11252). The SEE value of the stature estimation regression equation created using the palm length was found to be 5.14161. There was no correlation between thumb length and stature. The correlation between index finger and stature was greater than the values obtained from other fingers (r=0.344, p<0.01). The correlation value between palm length and stature was higher than the correlation value between fingers and stature (r=385, p<0.01). Moderate and high positive correlation values were found between finger lengths and each other. The highest correlation value was between middle finger length and ring finger length (r=872, p<0.01). The correlation value between thumb and little finger lengths was the smallest (r=415 p<0.01) (Table 4).

Table 1. Descriptive statistics

Variables	N	Mean (cm)	Minimum (cm)	Maximum (cm)	Std. Deviation
Hand Length	65	17.40	16.00	19.20	0.71
Hand Wrist	65	7.70	6.79	9.00	0.52
Palm Length	65	9.92	9.07	11.30	0.48
Digit 1	65	5.85	5.09	6.88	0.35
Digit 2	65	6.78	5.87	7.80	0.42
Digit 3	65	7.46	6.68	8.50	0.40
Digit 4	65	6.89	6.07	7.90	0.37
Digit 5	65	5.62	4.90	6.60	0.38
Stature	65	164.45	151.00	176.00	5.53

Table 2. Linear regression formulas

Stature= 3.073xHand Lenght+110.696	SEE 5.11252
Stature= 3.363xHand Wrist+138.536	SEE 5.28005
Stature= 4.423xPalm_Lenght+120.584	SEE 5.14161
Stature= 3.318xDigit-1 +145.024	SEE 5.44432
Stature= 4.560xDigit-2+133.531	SEE: 5.23117
Stature= 3.367xDigit-3+139.334	SEE: 5.40212
Stature= 4.616xDigit-4+132.636	SEE: 5.29281
Stature= 3.716xDigit-5+143.575	SEE: 5.39043

Table 3. Multiple regression formulas

Stature= (2.564X Hand-Length)+ (1.047xHand-Wrist) + 111.764	SEE: 5.13660
Stature= (-0.473xDigit-1)+(5.503xDigit-2)+(-5.407xDigit-3)+(4.552xDigit-4)+(0.810xDigit-5)+134.313	SEE: 5.30644

Table 4. Pearson correlations of the variables

	N=65	Stature	Hand Length	Hand Wrist	Palm Length	Digit 1	Digit 2	Digit 3	Digit 4	Digit 5
Stature	r	1	0.397**	0.319**	0.385**	0.212	0.344**	0.245*	0.312*	0.253*
	p		0.001	0.010	0.002	0.089	0.005	0.050	0.011	0.042
Hand Length	r	0.397**	1	0.663**	0.874**	0.521**	0.722**	0.741**	0.738**	0.594**
	p	0.001		0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hand Wrist	r	0.319**	0.663**	1	0.668**	0.284*	0.600**	0.688**	0.601**	0.440**
	p	0.010	0.000		0.000	0.022	0.000	0.000	0.000	0.000
Palm Length	r	0.385**	0.874**	0.668**	1	0.431**	0.536**	0.600**	0.565**	0.528**
	p	0.002	0.000	0.000		0.000	0.000	0.000	0.000	0.000
Digit 1	r	0.212	0.521**	0.284*	0.431**	1	0.555**	0.394**	0.468**	0.415**
	p	0.089	0.000	0.022	0.000		0.000	0.001	0.000	0.001
Digit 2	r	0.344**	0.722**	0.600**	0.536**	0.555**	1	0.834**	0.780**	0.601**
	p	0.005	0.000	0.000	0.000	0.000		0.000	0.000	0.000
Digit 3	r	0.245*	0.741**	0.688**	0.600**	0.394**	0.834**	1	0.872**	0.626**
	p	0.050	0.000	0.000	0.000	0.001	0.000		0.000	0.000
Digit 4	r	0.312*	0.738**	0.601**	0.565**	0.468**	0.780**	0.872**	1	0.671**
	p	0.011	0.000	0.000	0.000	0.000	0.000	0.000		0.000
Digit 5	r	0.253*	0.594**	0.440**	0.528**	0.415**	0.601**	0.626**	0.671**	1
	p	0.042	0.000	0.000	0.000	0.001	0.000	0.000	0.000	

**. Correlation is significant at the 0.01 level (2-tailed)
*. Correlation is significant at the 0.05 level (2-tailed)

Discussion

Studies have shown that height estimation can be made with the length of the bones. The lengths of some long bones better reflect human height. Since the ratio of long bones to height is not the same in people with different phenotypic characteristics, this issue should be considered in formulas obtained from bone lengths for height estimation. The relationship between bones and height is important for the anatomy literature, as well as for forensic studies and archaeological/anthropological studies [1-4]. In our study, obtaining simple linear regression formulas and multiple linear regression formulas required for calculating height of young adult women from hand and finger morphometric measurement values and the relationship between them were investigated.

Asadujjaman et al. in a study carried in Bangladeshi population (150 women, 18-60 years old), they reported that the most reliable equation in the equations obtained from the measurements of the right hand fingers belonged to the middle finger, and the least reliable equation belonged to the index finger (SEE values; 3.99, 4.39, respectively) [12]. Interestingly, in our study, when the five fingers of the hand are compared, the most reliable regression equation is the one for the index finger, and the SEE value is smaller than the other fingers (Table 2). In addition, the second reliable regression equation belongs to the ring finger when the fingers are compared with each other for stature estimation in our study. According to these differences in results, it can be said that there are probably significant differences in 2D-4D finger ratios between the populations participating in these two studies. One of the common results of the two studies is that the regression equations obtained from hand length are more reliable than the regression equations obtained from finger lengths. One of the different points in our study is that the reliability of the equation created for the estimation of stature from hand width is higher than the other 4 fingers except the equation created for the index finger. In the Bangladeshi population, the equation for estimating stature from hand width is less reliable than the equations obtained from finger lengths. In our study, the multiple regression formula obtained from all five fingers did not give a better result than the linear regression formulas. In a study carried in Bangladeshi society, the reliability of the multiple regression formula obtained from hand length, hand width and length of five fingers is not more than the reliability of the equation created for estimation of stature from hand length alone [12].

The reliability of the regression equation that Uhrova et al. created for estimating stature from hand length in their study in Slovakia in adults (130 women, average stature 166 cm) is very close to our results (SEE: 5.06). However, the reliability of the regression equations obtained for the estimation of stature from hand width in their study is less than the reliability of the regression equations obtained from hand width [10].

In a study carried on 97 young adult women in Iran, the correlation between finger lengths and stature was examined. It was found that the highest correlation value among the five fingers was between middle finger length and stature. Correlation values between stature and finger lengths, from largest to smallest, respectively; reported as middle finger, ring finger, thumb, little finger, and index finger (first to fifth finger, r=0.430 r=0.398 r=0.582 r=0.534 r=0.455, respectively) [13]. In our study group, however, very different results were obtained. Correlation values between stature and finger lengths, from largest to smallest, respectively; reported as index finger, ring finger, little finger and middle finger (first to fifth finger, r=0.212 r=0.344 r=0.245 r=0.312 r=0.253, p<0.005 except thumb, respectively). The correlation between thumb and stature was not statistically significant.

Sanli et al., in their study on 75 women (mean stature of approximately 160 cm, average right hand length of 18.9 cm), found a very high correlation between stature and hand length (r=0.709, p<0.001). In our study, the mean stature of the participants was 164.4, the mean hand length was 17.4 cm, and a moderate positive correlation was found between stature and hand length (r=0.397, p<0.001). The SEE value was found to be 3.496 in the simple linear regression formulas obtained by Sanli et al. for the estimation of stature from hand length, and the SEE value was found to be 5.112 in the regression equation we obtained in our study. These results show that the regression formula obtained by Sanli et al in their study gives better reliable results for the population in that settlement [14].

Habib and Kamal, found the correlation value between hand length and stature as r=0.495 in their study on 77 young adult women in Egypt. In the regression equation they created for stature estimation, the SEE value was reported as 4.77 [15]. In our study on 65 healthy young adult women, the correlation value between hand length and stature was found to be r=0.397, and the SEE value of the regression equation for stature estimation was found to be 5.11. It can be said that the results of the regression equations obtained for the two societies are close to each other.

Conclusion

The reliability of the regression formulas created for the estimation of stature based on finger lengths differs between fingers. The correlation value between hand length and stature is higher than the values obtained from finger lengths. In cases where total hand length cannot be measured, linear regression formula based on palm length should be preferred for stature estimation. Regression analysis results show that palm length gives a better estimation of stature compared to finger length measurements.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
Ethics committee approval of the study was approved by Uşak University Faculty of Medicine Clinical Research Committee's decision numbered 92-92-07.

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