Estimation of Stature from Hand Dimensions

Ahmet Kürşad Açikgöz[1], Raciha Sinem Balci[2], Pınar Göker[3], Memduha Gülhal Bozkir[4]

ABSTRACT

Introduction: Stature is a crucial parameter in the definition of the physical identity of an individual, along with age, gender, and race. The purpose of this study was to create a regression equation for estimating stature from hand-finger measurements in a young adult population, and use it actively in forensic sciences.
Material and Methods: In this study, stature, hand lengths (HLs), hand widths (HWs), and second and fourth finger lengths (SFLs, FFLs) of the individuals were measured among 420 students aged 18-25 years.
Results: The mean values in males and females, respectively, were stature: 178.24 ± 6.55 and 165.57 ± 5.31; right HL: 18.97 ± 0.94 and 17.68 ± 0.67; left HL: 19.01 ± 0.98 and 17.84 ± 0.76; right HW: 8.59 ± 0.42 and 7.73 ± 0.41; left HW: 8.57 ± 0.42 and 7.67 ± 0.39; right SFL: 7.28 ± 0.44 and 6.75 ± 0.42; left SFL: 7.32 ± 0.43 and 6.74 ± 0.41; right FFL: 7.33 ± 0.44 and 6.71 ± 0.40; and left FFL: 7.34 ± 0.44 and 6.71 ± 0.40 cm. Measurements between genders were statistically significantly different ($P < 0.001$). There were statistically significant differences between right and left HWs and SFLs in males, and HWs in females ($P < 0.05$). The strongest correlation with stature was in right HLs in males and right SFLs in females.
Conclusion: The regression equations obtained exhibited potential for use in many areas, especially quite successfully in Forensics and Forensic Anthropology in estimating stature from hand dimensions in Turkish society.

Keywords: Second and Fourth Finger Lengths, Body Height, Regression Equation, Forensics, Forensic Anthropology

INTRODUCTION

Identification of an individual plays very important roles in forensics, crime scene investigation, and forensic anthropology. Specifically, stature is of great importance in defining the physical identity of an individual, and constitutes one of the four major parameters that are important in identification, along with age, gender, and race.[1,2,3]
Regression equations, which were created by Pearson in 1899, a mathematician, have been used quite widely in estimating stature, and have pioneered studies conducted in this field.[4] However, in studies conducted to date, it was concluded that the most accurate estimation of stature was obtained using regression formulas obtained from the society in which the individual originated.[5]
When the literature was reviewed regarding the estimation of stature, it was seen that there was a large pool of materials in which there were living individuals, skeletons obtained from excavations, cadavers, and measurements obtained from radiological images.[6,7,8,9] In addition, in the literature, these different study materials were used together with regression equations for stature estimation from various body parts, including the long bones of the lower and upper extremities, hand, finger and foot measurements, pelvic measurements, sacral and lumbar measurements, arm span measurements, and head and facial measurements in different societies.[6,9,10,11,12,13,14,15,16]
Forensics and crime scene investigation are very important in determining stature from fragmented body parts or limbs, especially in extraordinary situations like mass disasters or wars, and when the use of DNA analysis is limited. In the current study, the purpose was to create a regression equation for estimating stature from hand and finger measurements in young adult individuals in the Turkish population, and use these equations actively and successfully in forensic sciences.

MATERIAL AND METHODS

Of a total of 420 students who volunteered to participate in the study, 380 individuals (191 females, 189 males), who were between 18 and 25 years of age, constituted the study group, and 40 individuals (20 females, 20 males) constituted the control group. The students were from different regions of Turkey and were studying at Cukurova University. The research protocol of this study was approved by the ethics committee of the School of Medicine, Cukurova University. Before measurements were taken, all of the participants were informed about the study, and informed consent forms were obtained. In addition, demographic data (i.e. age, gender, and city of origin) were obtained by asking each individual. Individuals who had any disease or injury that could affect the morphology of the stature or hands, and those who had metabolic or developmental disorders were not included in the study. Height was measured to the nearest millimeter with the individual standing barefoot using a stadiometer, and hand dimensions were measured with a millimetric-sliding caliper. The following measurements were performed:
Stature: The vertical distance between the vertex, the highest point on the top of the head, and the floor, with the subject standing barefoot in anatomical position and their head in the

[1]PHD, Department of Anatomy, [2]PHD Student, Department of Anatomy, [3]Professor, Department of Anatomy, [4]Prof. Dr., Department of Anatomy, Cukurova University, Turkey

Corresponding author: Dr. Ahmet Kürşad Açikgöz, Ph.D., Çukurova University, Faculty of Medicine, Department of Anatomy, 01330 Adana Turkey

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Frankfurt horizontal plane.

Hand length (HL): The vertical distance from the transverse axis of the outermost point of the radius and ulnae styloid process, and the most distal point of the third finger (Figure-1).

Hand width (HW): The transverse distance at the level of the outermost point of second and fifth metacarpophalangeal joint (Figure-1).

Second finger length (SFL): The distance from the midpoint of the second metacarpophalangeal joint and the most distal point of the second finger (Figure-1).

Fourth finger length (FFL): The distance from the midpoint of the fourth metacarpophalangeal joint and the most distal point of the fourth finger (Figure-1).

STATISTICAL ANALYSIS

The statistical analysis was performed using IBM SPSS Statistics 21.0 software (Armonk, NY, USA). A descriptive analysis was performed to obtain the mean, standard deviation, and range of the measurements. The student t test was utilized to analyze the differences in stature and hand dimensions between the male and female individuals. The differences between the right and left hand measurements in both genders were analyzed with the independent t test. The Pearson correlation test was used for the relationship between the stature and hand dimensions. Linear and multiple regression analyses were used to obtain the equation of stature estimation using the hand dimensions. $P < 0.05$ was considered to be statistically significant.

RESULTS

A total of 420 young adults who originated from different regions of Turkey were included in the present study. In addition to demographic data, stature and hand dimensions were taken from the individuals. Age distribution among the 189 examined male individuals was 20.56 ± 2.28 years, while among 191 female participants, it was 20.19 ± 2.49 years, with a range of 18 to 25 years in all of the participants. The mean and standard deviation values of both genders for stature, bilateral HL, HW, SFL, and FFL obtained from the individuals participating in the study are shown in Table-1. Based on the data obtained in the study, it was found that all of the measurement values of the males were statistically and significantly higher when compared to those of the females

Measure-ments	Males			Females			T-value (gender differences)	
	Mean	SD	Min-max	Mean	SD	Min-max	T	P
Stature (mm)	178.24	6.55	161–197	165.57	5.31	151–181	20.68	0.000
RHL (mm)	18.97	0.94	16–21.12	17.68	0.77	15–20	14.52	0.000
LHL (mm)	19.01	0.98	16.4–23.4	17.74	0.76	15.3–20.1	13.99	0.000
RHW (mm)	8.59	0.42	7.03–10.15	7.73	0.41	6.23–8.95	20.08	0.000
LHW (mm)	8.57	0.42	6.98–10.19	7.67	0.39	6.35–8.96	21.75	0.000
RSFL (mm)	7.28	0.44	6.28–8.48	6.75	0.42	5.58–7.67	12.19	0.000
LSFL (mm)	7.32	0.43	6.24–8.64	6.74	0.41	5.76–7.84	13.52	0.000
RFFL (mm)	7.33	0.44	6.27–8.68	6.71	0.40	5.71–7.89	14.06	0.000
LFFL (mm)	7.34	0.44	6.49–8.72	6.71	0.40	5.44–7.78	14.69	0.000

RHL: right hand length, LHL: left hand length, RHW: right hand width, LHW: left hand width, RSFL: right second finger length, LSFL: left second finger length, RFFL: right fourth finger length, LFFL: left fourth finger length.

Table-1. Descriptive statistics for the stature and lengths of the right and left hand dimensions in both genders

Variable	Males				Females			
	Mean difference (right–left)	SD	T-value	P-value	Mean difference (right–left)	SD	T-value	P-value
HL	–0.033	0.373	–1.235	0.218	–0.056	0.297	–2.621	0.009
HW	0.024	0.137	2.445	0.015	0.067	0.148	6.219	0.000
SFL	–0.042	0.168	–3.436	0.001	0.005	0.153	0.403	0.687
FFL	–0.014	0.127	–1.538	0.126	0.006	0.142	0.564	0.573

Table-2: Bilateral differences in the hand dimensions of the males and females

Variable	r-value			
	Males		Females	
	Right	Left	Right	Left
HL	0.442**	0.363**	0.456**	0.488**
HW	0.196**	0.202**	0.311**	0.359**
SFL	0.318**	0.324**	0.519**	0.501**
FFL	0.304**	0.263**	0.493**	0.495**

Correlation was significant at 0.01 (2-tailed).

Table-3: Correlation between stature and hand dimensions in both genders

Males			Females			Both		
Regression equations	±SEE	R^2	Regression equations	±SEE	R^2	Regression equations	±SEE	R^2
S= 120.29 + 3.054 × RHL	5.89	0.196	S= 110.04 + 3.14 × RHL	4.74	0.208	S = 71.05 + 5.502 × RHL	6.37	0.465
S= 132.32 + 2.416 × LHL	6.12	0.132	S= 105.46 + 3.389 × LHL	4.65	0.238	S = 75.39 + 5.252 × LHL	6.59	0.429
S= 152.06 + 3.047 × RHW	6.44	0.039	S = 134.38 + 4.032 × RHW	5.07	0.097	S = 95.68 + 9.336 × RHW	6.69	0.411
S = 150.99 + 3.181 × LHW	6.44	0.036	S = 128.08 + 4.89 × LHW	4.98	0.124	S = 93.97 + 9.598 × LHW	6.50	0.444
S= 143.45 + 4.777 × RSFL	6.23	0.101	S = 121.16 + 6.581 × RSFL	4.56	0.270	S = 96.58 + 10.735 × RSFL	6.82	0.387
S= 142.12 + 4.931 × LSFL	6.22	0.105	S = 121.58 + 6.524 × LSFL	4.62	0.251	S = 94.97 + 10.935 × LSFL	6.69	0.411
S= 145.39 + 4.484 × RFFL	6.26	0.093	S = 122.08 + 6.479 × RFFL	4.64	0.243	S = 97.25 + 10.635 × RFFL	6.69	0.410
S= 149.57 + 3.906 × LFFL	6.34	0.069	S = 121.29 + 6.604 × LFFL	4.63	0.245	S = 97.94 + 10.531 × LFFL	6.72	0.405

Table-4: Linear regression equations for stature (mm) prediction from the hand dimensions

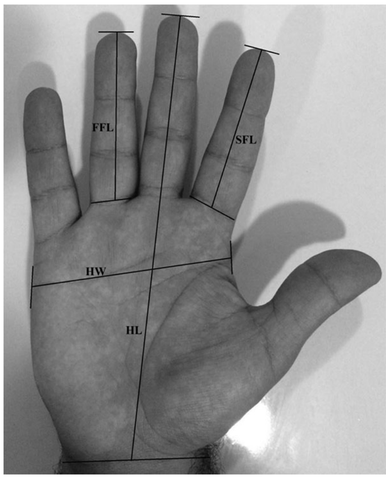

Figure-1: Measurements of the HL, HW, SFL, and FFL.

(P < 0.001).

The bilateral differences in hand sizes in both genders are shown in Table-2. In the males, the right side was significantly higher for HW measurement; however, the left side was higher at a significant level for the SFL (P < 0.05). In females, the left side was significantly higher for HL measurement; however, the right side was significantly higher in the HW measurement (P < 0.05).

The correlation coefficients between stature and right and left hand dimensions in both genders are shown in Table-3. All of the measurements showed statistically significant correlation coefficients with height (P < 0.01). In the males, the RHL (r = 0.469) provided higher correlation with stature; however, in the females, the RSFL provided the highest correlation (r = 0.523).

The linear regression equations that were created to estimate stature from the bilateral hand dimensions in the group where males and females were together are shown in Table-4. In these equations, it is seen that the lowest standard error of estimate (SEE) in males was in the RHL (±5.89), and the lowest SEE in females was in the RSFL (±4.56). The lowest SEE was in the RHL (±6.37) in the group where both genders were together.

The equations created to estimate stature and compare the actual and estimated statures were applied to the 40 individuals in the control group. No statistically significant differences were detected between the estimated stature and the actual stature in any of the equations created (P >

Measurements	Males			Females			Both		
	Estimated stature	Actual stature	P-value	Estimated stature	Actual stature	P-value	Estimated stature	Actual stature	P-value
RHL	177.74	176.5	0.381	164.30	162.5	0.182	170.33	169.5	0.466
LHL	177.77	176.5	0.399	164.23	162.5	0.167	170.32	169.5	0.486
RHW	177.91	176.5	0.371	165.61	162.5	0.069	171.43	169.5	0.180
LHW	177.68	176.5	0.473	165.42	162.5	0.083	170.88	169.5	0.346
RSFL	177.57	176.5	0.464	164.84	162.5	0.105	170.55	169.5	0.451
LSFL	177.51	176.5	0.509	164.96	162.5	0.071	170.56	169.5	0.439
RFFL	177.78	176.5	0.360	165.34	162.5	0.051	170.63	169.5	0.346
LFFL	178.15	176.5	0.274	164.70	162.5	0.100	171.23	169.5	0.157

Table-5: Comparison of the means of the actual stature and estimated stature from the hand dimensions

0.05). The mean actual and estimated stature values of these individuals are shown in Table-5.

DISCUSSION

It is a top priority to determine the biological profile of a victim or suspect in forensics and crime scene investigation. In this respect, stature is one of the parameters with great importance in creating the biological profile. Today, stature estimation is practically and theoretically involved in many scientific studies like forensics, forensic anthropology, and anatomy. The regression equations for stature estimation were first seen in a study by Pearson conducted in 1899. These studies, which started with Pearson, have continued to present day via development and diversification.[4] When these studies were analyzed, it was observed that various body parts and bones, such as the upper extremities, lower extremities, and heads of living individuals, cadavers, or skeletons, were measured by radiological and anthropometric methods and regression equations are created.

A good number of studies have been conducted in this field in Turkey. However, there are not many studies on estimating stature based on the dimensions of the hand. Sanli et al. conducted a study with young adults in Turkey, and created regression equations for estimating stature based on hand and foot length. The SEE was found in the range of 3.49–4.59 cm in the equations obtained from HL in a group consisting of males and females. Ozaslan et al.[18] created equations based on HL and HW measurements for estimating stature, and obtained a SEE in the range of 5.62–6.58 cm. In another study of Ozaslan et al.[19], they obtained the SEE in the range of 5.46–6.77 cm in linear regression equations that consisted of HL and HW measurements. In the present study, the linear regression equations obtained with hand measurements were found to be between 4.56 and 6.82 cm. In addition, no statistically significant differences were detected between the estimated stature and actual stature values in any the equations created ($P < 0.05$).

In studies conducted on Indian society, anthropometric measurements of the hands and fingers were used, as well as handprint measurements. They obtained a SEE between 3.78–5.92 cm in linear regression equations obtained from these measurements; however, in multiple regression equations, they obtained a SEE between 4.29 and 5.73 cm.[3,20,21] Linear and multiple regression equations were created for measuring stature based on handprint measurements with the hand and finger anthropometric measurements of individuals in another Asian country, Malaysia. The SEE was obtained as 4.36–6.46 cm with hand and finger measurements in linear regression equations, and as 4.67–7.02 cm with handprint measurements; however, the SEE was obtained as between 3.78 and 4.72 cm in the multiple regression equations. In the regression equations that were created, the best (i.e. low) estimated error was obtained with HL.[22,23,24] Kim et al.[10] created equations to estimate stature from HL and HW measurements, and Jee & Yun[25] created equations to estimate stature from hand and finger measurements. They obtained a SEE of 4.95–6.24 cm in the linear regression equations, and 4.50–5.72 cm in the multiple regression equations. Although they obtained a lower SEE in the multiple regression equations, it was observed that the best estimation value was obtained with the HL measurements. In a Chinese population, Tang et al. created linear and multiple regression equations based on HL and HW measurements, and the lowest SEE measurements were obtained with the HW in these equations.[26] Asadujjaman et al. conducted a study in a Bangladeshi population, and created linear and multiple regression equations based on hand measurements, where, similar to other studies, they found that a low SEE was obtained with the HL. In addition, the SEE values in females were found to be lower than in males.[27]

Habib & Kamal and Paulis created regression equations based on HL and handprint measurements for individuals in Egyptian society. The SEE was in the range of 4.54–6.61 cm in the equations they created.[6,28] Howley et al., who conducted a study on an Australian population, created linear and multi-regression equations for estimating stature based on HL and HW, and obtained a SEE in the range of 4.20–5.83 cm.[29] Uhrova et al. conducted a study on a Slovakian population, and used HL and HW measurements for stature estimation. They created linear and multiple regression equations based on these measurements, wherein the SEE was found to be in the range of 5.01–6.11 cm.[30]

CONCLUSION

Knowledge of the stature, which is an important parameter in creating biological profile, is vital in forensics, forensic anthropology, and crime scene investigation. The data obtained in the present study showed that hand dimensions can be used very successfully in estimating stature in the Turkish population. It is our belief that the data of the present study will be useful in creating biological profiles based on broken hands and finger pieces of missing victims, especially for skeletons obtained in excavations, in mass events like earthquakes, and wars, or broken hands and finger pieces of a missing victim, especially in the Turkish population.

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