Adıyaman Üni. Sağlık Bilimleri Derg, 2018; 4(2):957-967

ADIYAMAN ÜNİVERSİTESİ SAĞLIK BİLİMLERİ DERGİSİ
E-ISSN 2458-9179
dergipark.gov.tr/adiyamansaglik

Araştırma/Research

Regression analysis in stature estimation from upper extremity dimensions in Turkish females

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Abstract

Objectives: This study's aim was to determine the relationship between stature and measurements of the upper extremity segments in healthy adult females and obtain regression equations for prediction of stature from upper extremity dimensions in Turkish females.
Materials and Methods: The study group consisted of 130 females mean aged 31.91±7.00 years. Dominant and non dominant upper extremity measurements were obtained from all subjects. Additionally, SPSS version 21 software package program was used for all analysis. A parametric test or non-parametric test was applied according to the Kolmogorov-Smirnov test results. Moreover, the Chi square test and Spearman Pearson Correlation analysis were used. Significance was set at $p<0.05$.
Results: The data of this study were analyzed, the mean values of metacarpal width, metacarpal circumference, wrist width, wrist circumference, arm length and hand length were 7.12 cm, 17.97 cm, 4.76 cm, 14.76 cm, 65.88 cm and 17.43 cm in dominant side, respectively; whereas, the same values were found as 7.10 cm, 17.88 cm, 4.75 cm, 14.67 cm, 65.70 cm and 17.39 cm in non-dominant side, respectively. Moreover, the mean value of arm span and height were measured as 158.66 cm and 163.35 cm, respectively. Furthermore, there were no significant difference as statistically in the mean value of upper extremity measurements in dominant and non-dominant side. In stature estimation which was performed by using arm span, this parameter was more valid than the other measurements.
Conclusion: Due to our findings, stature can be estimated higher by using arm span measurement than the other measurements. The observations presented in this report have defined anatomic parameters and regression formula about upper extremity dimensions that need to be taken into consideration for reference data to determine population discrepancies and to help for anatomists, forensic scientists and anthropologists.

Key Words: Upper extremity segment; stature estimation,and arm span

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DOI: 10.30569/adiyamansaglik. 449726

Geliş Tarihi:	**31.07.2018**
Kabul Tarihi:	**08.08.2018**

Türk kadınlarında üst ekstremite boyutlarından elde edilen boy uzunluğu tahmininde regresyon analizi

Öz

Amaç: Bu çalışmanın amacı sağlıklı yetişkin Türk kadınlarında üst ekstremite segmentlerinin ölçümleri ve boy uzunluğu arasındaki ilişkiyi belirlemek ve Türk kadınlarına ait üst ekstremite bölümlerinden boy uzunluğu tahmini için regresyon denklemi oluşturmaktı.

Yöntem: Çalışma grubu ortalama yaşı 31.91±7.00 yıl olan 130 kadından oluşmuştur. Çalışma grubunu oluşturan kadınlardan dominant ve dominant olmayan taraftan üst ekstremite ölçümleri alındı. Ayrıca, analizler için SSPS 21.0 paket programı kullanıldı. Kolmogorov-Smirnov test sonucuna göre parametrik veya non-parametrik test uygulandı. Ayrıca, Ki-kare testi ve Spearman Pearson Korelasyon analizi yapıldı. Anlamlılık için $p<0.05$ kabul edildi.

Bulgular: Çalışma bulguları analiz edildiğinde, dominant tarafta sırasıyla metakarpal genişlik, metakarpal çevre, el bileği genişliği, el bileği çevre, kol uzunluğu ve el uzunluğu sırasıyla 7.12 cm, 17.97 cm, 4.76 cm, 14.76 cm, 65.88 cm ve 17.43 cm iken, dominant olmayan tarafta aynı ölçümler sırasıyla 7.10 cm, 17.88 cm, 4.75 cm, 14.67 cm, 65.70 cm ve 17.39 cm olarak bulundu. Ayrıca, kulaç uzunluğu ve boy uzunluğu sırasıyla 158.66 cm ve 163.35 cm olarak bulundu. Dahası, dominant ve dominant olmayan tarafta üst ekstremite ölçümlerinin ortalama değerleri arasında istatistiksel olarak anlamlı farklılık bulunmamıştır. Kulaç uzunluğu kullanılarak yapılan boy uzunluğu tahmininde kulaç uzunluğu ölçümü diğer uzunluk ölçümlerinden daha geçerli bulundu.

Sonuç: Çalışma bulgularına göre boy uzunluğu, diğer ölçümlerden ziyade kulaç uzunluğu ölçümü ile daha yüksek tahmin edilebilir. Bu çalışmada sunulan bulgular populasyon farklılıklarını belirlemek, anatomistlere, adli tıp uzmanlarına ve antropologlara yardımcı olmak için referans data oluşturmada dikkate alınması gereken üst ekstremite boyutları ile ilgili regresyon formülünü ve anatomik parametreleri tanımlamaktadır.

Anahtar kelimeler: Üst ekstremite segmenti, boy uzunluğu tahmini, kulaç uzunluğu,

Introduction

Identification of the unrecognised subject is the one of the main cases of forensic researches (1). In the identification of dismembered remains, the stature detection is a primary step (2). The stature is the major section for evaluate growth and nutrition, calculating body surface area and foresee pulmonary function during childhood (2,3). In some conditions, the stature measurement is difficult because of trunk, leg deformities or amputation, decomposing human remains, kyphosis, scoliosis or in patients unable to walk or stand (3-7). Especially, in mass disaster, murders, accidents it can be found some parts of body at crime scenes (1,3). When a whole body is found, the stature estimation is an easy occupation; however, if there is no complete body, the stature detection can be trouble (8). Thus, this remains are essential for using to estimate stature (1,4). To date, the relationship between body parts and whole body or stature has been important for scientist, anatomist and anthropologists (3,4). Moreover, the various body segments like hand and foot dimensions, the limb long bones and arm span have been used to estimate stature (4,6,7). Some of these parameters are also used in age and sex estimation (5). Height is most crucial and practical anthropometric data and especially this parameter is used by medico-legal experts (5). In spite of the relationship between various body segments have been stated, these measurements are public specific. Therefore, these data vary by population (4). Furthermore, the stature is affected from genetic and enviromental factors (7). It is declared that equations formulated for a population can not comply with each other due to ethnic and geographic variations. Additionally, In a study, it was stated that arm span length can be used for estimating of age related loss in stature (9).

It was determined that disorders of the upper extremity were more common in females and hand tools or devices which have been designed especially were not produced for only females. Moreover, the data performed in females is inadequate (10). So, we aimed to

determine the relationship between the stature and upper extremity segments and obtain regression equations for prediction of stature from these measurements in Turkish adult females.

Materials and Methods

The study was approved by our institutional review board and ethics committee approval also was obtained. Bilateral upper extremity dimensions were obtained from 130 healthy adult females mean aged 31.91±7.00 years with no history of trauma or congenital anomalies or previous surgery about columna vertebralis, lower-upper extremity and fracture of columna vertebralis and upper - lower extremity. Moreover, the measurements were recorded in centimeters to the nearest 0.1 cm. A measurement was performed three times in each individuals. The following parameters were measured using a vernier caliper and tape measure (1,5,11-14).

- The stature was defined as the distance between vertex and floor (1,5).
- Hand length measurements were taken, when the subjects placed their hand supine on a flat surface with the fingers extended and adducted position. Distance between the most distal point on the radius styloid process and the tip of the middle finger were measured (1,13).
- Arm length was measured from acromial process to the tip of the middle finger (14).
- Hand width was measured when the subjects placed their hands prone on a flat surface and fingers (thumb abducted) extended and adducted position. Distance between the most lateral point on the caput ossis metacarpi II and the most medial point of the caput ossis metacarpi V were measured (1).
- Arm-span length was measured from the most distal point of the middle finger of one hand to the most distal point of the middle finger on the other hand, while subject was

standing with his/her back to the wall with both arms abducted to 90º, the both elbow and wrist extended position (11,13).

- Wrist width was measured as the distance between ulnar and radial styloid processes (14). After these measurements, multiplication factor and regression equation were calculated as follows:

Multiplication factor = $\frac{\text{Stature}}{\text{Physical variables (hand length, arm length or arm-span) (11).}}$

Additionally, regression equation for stature estimation was derived as follows;

Height=91.68+1.08 (arm length right)

Height=100.123+0.96 (arm length left)

Height=108.37+3.15 (hand length right)

Height=117.07+2.66 (hand length left)

Height=72.06+0.57 (arm span)

Statistical analysis were performed using SPSS for Windows version 21.0. The descriptive statistics for measurements were calculated and from these measurements means, standard deviations (SD), maximum and minimum values were obtained. After these measurements, the correlation between measurements was evaluated by Pearson's correlation coefficient (r) analysis. The accuracy of the stature estimation of each regression equation were assessed by the coefficient of determination (R^2). The significance (p) level of the present study was set at 0.05.

Results

The records of 130 females were assessed. The mean age of participants was 31.91±7.00 years. Descriptive statistics for stature and upper extremity measurements for females in this study were shown in Table 1. When we analyzed the data in this study, the

mean values of metacarpal width, metacarpal circumference, wrist width, wrist circumference, arm length and hand length were found as 7.12 cm, 17.97 cm, 4.76 cm, 14.76 cm, 65.88 cm and 17.43 cm in dominant side, respectively; whereas, the same values were 7.10 cm, 17.88 cm, 4.75 cm, 14.67 cm, 65.70 cm and 17.39 cm in non-dominant side, respectively. The means of arm span and height were found as 158.66 cm and 163.35 cm, respectively (**Table 1**). Moreover, in comparing the mean values of the dominant hand with that of the non-dominant hand, there was no significant difference between them for all subjects (P>0.05). Furthermore, after these measurements correlation coefficient and regression analysis were calculated. While Pearson's correlation coefficients between stature and upper extremity segment measurements for females were shown in **Table 2.** Simple linear regression equations for estimation of stature from upper extremity segment measuremens for females were shown in **Table 3**; whereas, multiplication factor which was formed from upper extremity segment measuremens for females were in **Table 4.**

Table 1. Descriptive statistics for stature and upper extremity segment measurements in females

Measurements (cm) Females=130		Mean* Median**	SD	P
Metacarpal width**	Dominant Side	7.12	0.37	0.454
	Non-dominant side	7.10	0.38	
Wrist width*	Dominant side	4.76	0.26	0.778
	Non-dominant side	4.75	0.36	
Wrist circumference*	Dominant Side	14.76	0.76	0.341
	Non-dominant side	14.67	0.76	
Arm length*	Dominant side	65.88	3.49	0.665
	Non-dominant side	65.70	3.38	
Hand length**	Dominant side	17.43	1.12	0.751
	Non-dominant side	17.39	1.11	
Metacarpal circumference*	Dominant side	17.97	1.03	0.487
	Non-dominant side	17.88	0.54	
Arm span		158.66	7.39	
Height		163.35	5.993	

***Independent Samples T Test, **Mann Whitney U Test**

Table 2. Pearson's correlation coefficients between stature and upper extremity segment measurements in females

Measurements (cm)	Females =130	
	r	p
Metacarpal width (right)	0.453	<0.001
Metacarpal width (left)	0.432	<0.001
Wrist width (right)	0.257	0.001
Wrist width (left)	0.165	0.027
Wrist circumference (right)	0.116	0.089
Wrist circumference (left)	0.040	0.322
Arm length (right)	0.634	<0.001
Arm length (left)	0.543	<0.001
Hand length (right)	0.592	<0.001
Hand length (left)	0.492	<0.001
Metacarpal circumference (right)	0.434	<0.001
Metacarpal circumference (left)	0.269	0.001
Arm span	0.709	<0.001

Table 3. Simple linear regression equations for estimation of stature from upper extremity segment measurements for females

Measurements (cm)	Regression equation	β
Hand length (right)	108.374+3.154*(X)	% 59.2
Hand length (left)	117.066+2.662*(X)	% 49.2
Arm span	72.063+0575*(X)	% 70.9
Arm length (right)	91.682+1.088*(X)	% 63.4
Arm length (left)	100.123+0.962*(X)	% 54.3

X: Measurement value, *:Multiplication process

Table 4. Multiplication factor from upper extremity segment measurements for females

Measurements (cm)	Females (n=130)	
	Multiplication factor (Stature/Measurement variable)	
	Mean	SD
Hand length (right)	9.16	1.40
Hand length (left)	9.03	1.81
Arm span	1.03	0.34

Discussion

Estimation of a subject's stature is a critical parameter in forensic medicine and anthropological studies. It was declared that body parameters varied from race to race due to factors like nutrition, genetics or physical activity level (2,4). Therefore, this study was performed to determine the relationship between upper extremity segments and stature in Turkish adult females. However, the determination of stature has been a problem in the medical sciences especially if there is an isolated extremity (5). Additionally, it was reported that upper extremity segment like hand or arm length could be used to estimate the stature (1,13). In our study, the stature can be estimated from some upper extremity dimensions with accuracy using the regression equations in Turkish adult females.

Stature is considerable to determine the energy requirements, physical capacity and to perform the drug dosage. Sometimes, stature could not be measured directly. In this situation, some parameters like arm-span and length measurements can be used to determine the stature (4,6,7,11). From these parameters, arm-span was found as a reliable measurement to estimate the stature (11). Multiplication factor can be defined as the ratio of the stature to the physical variables including hand length and arm-span and it is used for estimating the stature (11). The mean values of the arm-span and multiplication factor (stature/arm-span) were assessed as 154.74±5.69 cm and 0.99 in Bangladeshi females (11). In our study, these parameters were evaluated as 158.66 cm and 1.03.

Moreover, regression equation which is one of the better method indicates the relationship between the body part and the stature (12). The regression equation formula between arm-span and stature were calculated as 72.06+0.57 X arm-span in this paper. Additionally, it was determined that stature could be estimated accurately from hand length and width by using regression equation formula (3). In this paper, the mean values of stature, hand length (right-left) and multiplication factor derived from hand length (right-left) were 163.35 cm, 17.43 cm (right), 17.39 (left) and 9.16 (right), 9.03 (left) respectively. Due to these reports, a comparison between our results including stature those of previous study which is reported from Bengali (6), Sri Lankan (4), Indians (3,7), Maharasthra (5) and Thai population (1), these values were lower than our results. Conversely, our multiplication factor findings for hand length were lower than literature including Bengali (6) and Indians (3,7).

The regression equation derived from hand length for stature estimation was reported as 76.73+4.84 and 81.00+4.53 in right and left side for Maharashtra females, respectively (5). However, in Indian females, this value was 84.54+4.24 (12); whereas, the same dimension was found as 93.69+3.62 for Sri Lankan females (4). Whereas, these findings were reported as 110.64+2.95 and 110.69+2.95 for right and left side in Gujarat region for females, respectively (7). In Thais, the same values were 84.59+4.50 and 91.32+4.12 in right and left side (1). Our study indicated that the regression equation for the hand length and arm length were 91.68 + 1.09 (right) and 100.12 + 0.96 üz(left); 108.37 + 3.15 (right) and 117.07 + 2.66 (left) in females, respectively. A comparison between our result and those of previous study which are reported from literature shows that their values were lower than our results (1,4,5,12). Additionally, according to a study performed in Gujarat region our finding was closer to this study (7). We think that these diversities could depend on some factors like race, genetic characteristics, age and individual variations.

The evaluations are made for estimation of the age, height, gender and race by using anthropometric methods. In populations, it is accepted that in the estimation of height, regression analysis which is formed with different antropometric measurements is the most significant method (15). In literature, there are many studies about the higher relation between height and arm span, upper extremity, length of arm, forearm and hand. The stature estimation is an important and principal determinant to reveal for the identity of a subject (13,15-18). It is reported that the arm span is a valid measure of height and this parameter use in stature estimation in subject with physical disabilities (17). Especially, the society specific anthropometric characteristics including height, arm-span, hand length are changing continuously. So, this kind studies are becoming even more important for forensic scientists, anatomists or anthropologists.

In summary, due to regression analysis, our study showed 79.1 % for the change of the stature. So, our values could determine the relationship between the stature and the upper extremity segment measurements. We believe that studies performed by using arm span and arm length measurements are more accurate than hand measurement used commonly. This information could be helpful for anthropological studies and the untoward situations like mass disaster or flood or wars. When it was

thought that the upper extremity disorder were more common in females and hand tools or devices which was designed, especially were not produced for only females and the data performed in females was inadequate (10). The data about upper extremity segments of females obtained in this study can provide useful information for forensic science expert, anatomist or anthropologist. Moreover, the observations presented in this study have defined anatomic parameters that need to be taken into consideration for investigate the relationship between stature and upper extremity dimensions, derive the regression equation for estimation of stature and guidelines for determine the reference values in females group. As a result, the data can be used as reference values for evaluating the changes in the upper extremities and the measurement results obtained could be useful in phylogenetic studies performed from past to present to reconstitute the skeleton.

The authors declare that there is no financial support and there is no conflict of interest.

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