Orijinal Araştırma / Original Investigation
Aegean J Med Sci 2022;2:40-43

Obtaining Linear Regression Formulas Depending On Upper Arm Length For Estimating Stature

Boy Tahmini İçin Üst Kol Uzunluğuna Bağlı Lineer Regresyon Formüllerinin Elde Edilmesi

Sinan Bakırcı[1], Mahmut Çay[2]

1. Department of Anatomy, School of Medicine, İzmir Katip Çelebi University, İzmir/Turkey
2. Department of Anatomy, School of Medicine, Uşak University, Uşak/Turkey

ÖZET

AMAÇ: Çalışmamızda genç erişkin kadın ve erkek bireylerin üst kol uzunluğu değerlerinden boy tahmini için lineer regresyon formülleri elde edilmesi ve sağ ve sol taraf asimetrisinin regresyon formüllerine etkisinin incelenmesi amaçlanmıştır.

GEREÇ VE YÖNTEM: Çalışma, sağlıklı 18-36 yaş aralığında, 70 genç erişkin gönüllü üzerinde (35 erkek, 35 kadın) gerçekleştirildi. Üst kol uzunluğu, akromiyondan olekranona olan mesafe ölçülerek elde edildi. Asimetri ve cinsiyetler arası farklılıklar analiz edildi. Boy tahmini için cinsiyetlere göre lineer regresyon analizi ile regresyon formülleri oluşturuldu.

BULGULAR: Boy tahmini için gerekli olan lineer regresyon formülleri elde edildi. Üst kol uzunluğuna dayalı lineer regresyon formüllerinden standart tahmin hatasının (SEE) en küçük değeri kadın sağ koluna aitti. SEE değerleri kadınlarda sağ kol için 5.22882 ve sol kol için 5.4979; erkeklerde sağ kol için 6.62943 ve sol kol için 6.60019 olarak bulundu. Her iki cinsiyette de kol uzunluğu ile boy arasında orta düzeyde pozitif bir ilişki bulundu. Pearson korelasyon katsayısı kadınlarda sağ taraf için r=500, sol taraf için r=413, erkekler için sağ taraf için r= 487, sol taraf için r=494, p<0.05 idi.

SONUÇ: Erkeklerde kol uzunluğunda boy tahmini için elde edilen formüllerde SEE değerleri kadınlardakinden daha yüksek bulunmuştur. Regresyon analizine göre, kadınlardaki üst kol uzunluğu değerleri, erkeklerle kıyaslandığında daha iyi bir boy tahmini sonucu vermektedir. Kadınlarda sağ ve sol taraf üst kol uzunlukları arasında asimetri bulunmaktaydı. Sağ tarafın regresyon denkleminin daha güvenilir olduğu tespit edildi.

Anahtar Kelimeler: asimetri, boy tahmini, regresyon denklemi, regresyon formülü, üst kol uzunluğu

ABSTRACT

OBJECTIVE: In our study, it was aimed to obtain linear regression formulas for estimating stature from upper arm length values of young adult female and male individuals and to examine the effect of right-left side asymmetry on regression formulas.

MATERIALS AND METHODS: The study was carried out on 70 healthy young adult volunteers (35 males, 35 females) aged 18-36 years. Upper arm length was obtained by measuring the distance from the acromion to the olecranon. Asymmetry and gender differences analyzed. For the estimation of stature, regression formulas were created by simple linear regression analysis separately according to the genders.

RESULTS: The linear regression formulas required for the stature calculation were obtained. Among the linear regression formulas based on upper arm length, the Standard Error of the Estimate (SEE) value was the lowest in the female upper right arm. SEE values for women were 5.22882 for the right upper arm and 5.4979 for the left upper arm; in men it was 6.62943 for the right upper arm and 6.60019 for the left upper arm. A moderately positive correlation was found between arm length and stature in both genders.

CONCLUSION: In the formulas obtained for the estimation of arm length in men, the SEE value was found to be higher than in women. According to the regression analysis, arm length values in women give a better estimation of stature compared to men. In women, asymmetry was detected between the right and left upper arm lengths. The regression equation of the right side was found to be more reliable.

Keywords: asymmetry, stature estimation, regression equation, regression formula, upper arm length

INTRODUCTION

In cases where bodily integrity is lost due to natural disasters, terrorist attacks, murder, etc., one of the most important points for forensic doctors and law enforcement officers in identifying the victim is to calculate the stature of the person (1). Formulas used for estimating stature from body parts differ according to populations (2). Many body parts such as hand length, foot length, radius and ulna lengths, and metatarsals have been used in different societies for stature estimation (1-5).

Yazışma Adresi/Address for Correspondence: Mahmut Çay, PhD, Uşak University, School of Medicine, Department of Anatomy, Uşak/Turkey
E-Posta/E-Mail: mcanatomi@gmail.com || **Tel:** +90 276 21 21/6241
Received/Geliş Tarihi: 17 05 2022 || **Accepted/Kabul Tarihi:** 14 06 2022

Generally, stature estimation can be made from bone collections. However, it is not always possible to obtain bone collections. For this reason, regression formulas are created for estimating stature with anthropometric measurements. Above all, the average stature and body proportions of the population change over time. It has been reported that there has been an increase in the average stature of the world population in the last hundred years (5). For this reason, it seems important to update the formulas used for stature estimation over time. There are right and left side differences and asymmetry between some parts of the human body (6). Therefore, it is important to consider the existence of asymmetry in the creation of these formulas. In our study, it was aimed to examine the asymmetry between the upper arm lengths of young adult men and women and to derive simple linear regression formulas for stature estimation.

MATERIAL & METHODS

Upper arm length was measured as the distance between the acromion and the olecranon. Measurements were made on both right and left arms. Stature was measured from the vertex point of the skull in a standing person leaning against a vertical wall. Measurements were made with a tape measure. Study approval was obtained from Uşak University Faculty of Medicine Non-Interventional Clinical Research Ethics Committee with the decision numbered 07.04.2021/13.

Statistical analysis

IBM SPSS 26 program was used for statistical analysis. Descriptive statistical analysis (median, minimum, maximum, standard deviation) was performed. The distribution of the obtained data was evaluated using the Shapiro–Wilk test. The relationship between stature and arm length was evaluated with Pearson correlation. Right and left side differences were analyzed with the paired-t test, and the analysis of gender differences was performed with the independent samples-t test. For the estimation of stature, regression formulas were created by simple linear regression analysis separately according to the genders.

RESULTS

The average stature of the volunteers participating in the study; It was 179.11 cm in men and 164.45 cm in women. The mean right upper arm length was 36.43 cm in men and 33.37 cm in women. The mean left upper arm length was 36.48 cm in men and 33.66 cm in women. The measurement values obtained from men were found to be greater than women's, the difference was statistically significant ($p<0.01$).

When the right and left upper arm lengths were compared, there was no significant difference in men $p=0.745$. In females, a significant difference was found between the lengths of the right and left sides, $p=0.01$. Other descriptive statistical values are given in Table 1.

Table 1: *Descriptive statistics and comparison of variables for genders.*

		n	Mean	Min	Max	SD
F	RUAL *	35	33.37**	30.00	38.90	1.91
	LUAL *	35	33.66**	30.00	38.00	2.03
	Stature*	35	164.11	150.00	180.00	5.95
M	RUAL *	35	36.43	32.50	41.10	2.40
	LUAL *	35	36.48	32.60	44.20	2.64
	Stature*	35	179.11	164.00	195.00	7.48

F: *female,* ***M:*** *male* ***SD:*** *Standard Deviation* ***RUAL:*** *Right upper arm lenght,* ***LUAL:*** *Left upper arm lenght* *******$p<0.01$ *difference for genders,* ********$p=0.01$ *difference for sides* ***n:*** *number* ***Min:*** *Minimum* ***Max:*** *Maximum*

In the study, the linear regression formulas necessary to calculate the stature estimation were obtained by using the upper arm length values (Table 2).

Table 2: *Pearson's correlation analyses*

Genders	Variables		RUAL	LUAL	Stature
M, n=35	RUAL	r	1	.944**	.487**
		p		0.000	0.003
	LUAL	r	.944**	1	.494**
		p	0.000		0.003
	Stature	r	.487**	.494**	1
		p	0.003	0.003	
F, n=35	RUAL	r	1	.952**	.500**
		p		0.000	0.002
	LUAL	r	.952**	1	.413*
		p	0.000		0.014
	Stature	r	.500**	.413*	1
		p	0.002	0.014	

F: *female,* ***M:*** *male* ***SD:*** *Standard Deviation* ***RUAL:*** *Right upper arm lenght,* ***LUAL:*** *Left upper arm lenght* *******$p<0.01$ *difference for genders, * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).*

Among the linear regression formulas based on upper arm length (female, male, right and left sides), the Standard Error of Estimate (SEE) value of the female right upper arm formula was the smallest. SEE values were SEE:5.22882 for female right upper arm and SEE:5.4979 for female left upper arm; SEE:6.62943 for male right upper arm, and

SEE:6.60019 for male left upper arm. A moderate positive correlation was found between upper arm length and stature in both genders. Pearson correlation coefficient for women was r=500 for the right side, r=413 for the left side (p<0.01 and p<0.05, respectively), r=487 for the right side for men, r=494 for the left side, p<0.01 (Table 3).

Table 3: Linear regression formulas

	Linear regression formulas	SEE	R Square
F	Stature = 1.559 x RUAL + 112.072	5.2288	0.25
	Stature = 1.210 x LUAL + 123.381	5.4979	0.171
M	Stature = 1.518 x RUAL + 123.811	6.62943	0.237
	Stature = 1.399 x LUAL + 128.093	6.60018	0.244

***F:** female, **M:** male **SD:** Standard Deviation **RUAL:** Right upper arm lenght, **LUAL:** Left upper arm length **SEE:** Standard Error of Estimate*

DISCUSSION

Stature estimation is one of the four important determinants in determining the identity information of the corpse from human remains. Anatomical sections where anthropometric measurements are made can be affected by many factors such as racial characteristics, gender, geographical and regional characteristics, sportive life, lifestyle, nutrition styles. Therefore, every society has to obtain regression equations suitable for their genetic and environmental characteristics.

In a study conducted in a young population in Iran (mean upper arm length is 33.72cm in men, 30.12cm in women), they found the SEE value of 4.52 in the regression equation obtained from the arm length values of men. They did not report a regression equation since there was no statistical significance between arm length and stature in women (7). In our study, regression equations were obtained for both sexes. The SEE value of the equation obtained from men was 6.62 for the right arm and 6.60 for the left arm. In addition, a moderate positive correlation was found between arm length and stature in women in our study (r=500, p<0.01), and SEE values were found to be 5.22 for the right arm and 5.46 for the left arm in the regression equations obtained.

Shah T et al. They created regression equations for estimating stature from foot length and upper extremity lengths in two groups, Hindu group (n=80) and Muslim group (n=80) in India. In the equations obtained from the upper extremity length in the Muslim group, they reported the SEE value as 6.9193 in men and 3.5586 in women. In the same study, they found the SEE value as 4.1724 in men and 4.2382 in women in the regression equation obtained from the Hindu group. The SEE value obtained in men in the Muslim group is greater than the SEE value in our study (8).

Özaslan et al. in a study they conducted, they found the R square value for the estimation of stature based on upper arm length as 0.20 in men and 0.43 in women. In our results, however, the regression equations obtained from the upper arm length do not have a superiority in terms of women and men. In our study, the R square values of the equations for estimating stature from upper arm length were close to each other in men and women (0.24 in men and 0.25 in women) (9). In addition, in our study, it was concluded that there was asymmetry in terms of right and left upper arm lengths in women, and this affected the success of the regression formulas.

In a study conducted in Sudan (mean upper arm length is 31.65 cm in males and 28.90 cm in females), the regression equations obtained from the upper arm length seem to be more successful than our equations in both genders. The SEE value of the equation obtained by Altayeb A.A in estimating stature from the upper arm in their study in Sudan was 4.48 in men and 4.40 in women; The R square value was reported as 0.490 for men and 0.414 for women. In addition, the correlation values between upper arm length and stature were found to be higher than our correlation values (r=0.698 for men and r=0.643 for women). This difference is probably due to the racial characteristics of the two different societies (10).

In a study conducted in men in northern India, it was reported that the difference between right and left upper arm lengths was statistically significant and this asymmetry may be significant (p<0.01). For this reason, they emphasized the importance of firstly distinguishing the right and left sides of a body part and then using the regression formula of the appropriate side (6). In our study, there was no asymmetry for the right and left side in terms of upper arm length in men. However, it was determined that there was an asymmetry between the right and left sides in women. It was determined that the regression equation obtained from the right side was more successful than the equation obtained from the left side in women. In women, the SEE and R squared values of the right-side regression equation were 5.2288 and 0.250, respectively.

While on the left side, SSE value was 5.4949 and R square value was 0.171.

CONCLUSION

The estimation of the stature of individuals is very important for units such as archeology, forensic medicine and law enforcement. While using the regression equations obtained from the lengths of the body parts, the characteristics of that society gain importance. In addition, regression formulas obtained from the other side should not be used for body parts with right and left side asymmetry in the human body.

Etik: Bu çalışmanın etik kurulu alınmıştır. 07-04-2021/13

Ethics committee approval had been taken. 07-04-2021/13

Yazar katkı durumu; Çalışmanın konsepti; SB, MÇ, dizaynı; SB, MÇ, Literatür taraması; SB, MÇ, verilerin toplanması ve işlenmesi; SB, MÇ, istatistik; SB, MÇ, yazım aşaması; SB, MÇ,

Author contribution status; The concept of the study; SB, MÇ, design; SB, MÇ, literature review; SB, MÇ, collecting and processing data; SB, MÇ, statistics; SB, MÇ, writing phase; SB, MÇ,

Yazarlar arasında çıkar çatışması yoktur.

The author declares no conflict of interest.

Finansal Destek: yoktur / Funding: none

doi: https://doi.org/10.33713/egetbd.1117836

REFERENCES

1. Duyar I, Pelin C. Estimating body height from ulna length: need of a population specific formula. Eurasian J Anthropol. 2010;1(1):11–17.

2. Hisham S, Mamat CR, Ibrahim MA. Regression analysis for stature estimation from foot anthropometry in Malaysian Chinese. Aust J Forensic Sci. 2012;44(4):333–341. doi:10.1080/00450618.2012.673637

3. Bidmos MA. Metatarsals in the estimation of stature in South Africans. J Forensic Leg Med. 2008;15:505–509. doi:10.1016/j.jflm.2008.05.007

4. Sanli G, Kizilkanat ED, Boyan N, Ozsahin ET, Bozkir MG, Soames R, Erol H, Oguz O. Stature estimation based on hand length and foot length. Clin Anat. 2005;18:589–596. doi:10.1002/ca.20146.

5. Silventoinen K. Determinants of variation in adult body height. Journal of Biosocial Science. 2003;35 (2):263-285. doi:10.1017/S0021932003002633

6. Krishan K, Kanchan T, DiMaggio JA. A study of limb asymmetry and its effect on estimation of stature in forensic case work. Forensic science international. 2010;200(1-3): 181.e1-e5. doi:10.1016/j.forsciint.2010.04.015

7. Navid S, Mokhtari T, Alizamir T, Arabkheradmand A, Hassanzadeh G. Determination of stature from upper arm length in medical students. Anatomical Sciences Journal. 2014;11(3):135-140.

8. Shah T, Patel M, Nath S, Menon SK. A model for construction of height and sex from shoulder width, arm length and foot length by regression method. Journal of Forensic Science & Criminology. 2015;3(1):102.

9. Özaslan A, Koç S, Özaslan İ, Tuğcu H. Estimation of stature from upper extremity. Military medicine. 2006;171(4):288-291. doi:10.7205/MILMED.171.4.288

10. Ahmed AA. Estimation of stature from the upper limb measurements of Sudanese adults. Forensic science international. 2013;228(1-3), 178.e1-e7. doi:10.1016/j.forsciint.2013.03.008