

ARAŞTIRMA / RESEARCH ARTICLE

Estimation of Stature from Second- and Fourth-Digit Lengths in Young Adults

Genç Yetişkinlerde İkinci ve Dördüncü Parmak Uzunlukları Ölçümlerinden Boy Uzunluğu Tahmini

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Abstract

Objective: Estimating stature from long extremity bones, such as femur, humerus, is commonly used during forensic examinations. The aim of this study is to estimate stature by anthropometric measurements of right and left-hands second (2D) and fourth digit (4D) lengths.

Materials and Methods: The sample group consisted of 140 young adults, 70 male and 70 females (aged 21-19 years), whose (2D) and (4D) lengths were measured (using digital vernier caliper) of their left and right hands. One measurement was taken directly from landmarks from the proximal metacarpophalangeal crease to the finger tips.

The program SPSS (Version 17.0) was used to make a descriptive analysis, Student's t-test was used to analyze the difference in height (2D) and (4D) between males and females. One-way ANOVA was used to determine the potential interactions between anthropometric measurements within each other and stature. Pearson Correlation coefficient and related P values were also used. Statistical significance was assigned to p values <0.05. Linear and multiple regressions were also developed.

Results: The differences between the right-and the left fingers length values were statistically significant for both sexes (p<0.001). In all, the measurements of (2D) and (4D) in males were significantly higher than females. The correlation coefficients between stature and the measurements of second and fourth digit were found to be positive and statistically significant. The highest correlation coefficient between stature and digit length for males regarded the right second digit (r=0.505), and for females, the left second digit (r=0.596). Regression equations were checked for accuracy by comparing the estimated stature and actual stature.

Conclusion: Both regression models can be used to estimate the stature from 2D and 4D finger lengths in both sexes.

Keywords: Digit Length; Anthropometry; Stature Estimation.

Öz

Amaç: Femur, humerus gibi uzun ekstremitte kemiklerinden boy tahmini, adli incelemelerde yaygın olarak kullanılmaktadır. Bu çalışmanın amacı, sağ ve sol el ikinci (2D) ve dördüncü parmak (4D) uzunluklarından boy tahmini yapmaktır.

Gereç ve Yöntem: Örneklem grubu 19-21 yaş aralığında olan 70 erkek ve 70 kadın olmak üzere toplam 140 genç erişkinden oluşmuştur. Sol ve sağ ellerinin (2D) ve (4D) uzunlukları dijital elektronik kumpas kullanılarak ölçülmüştür. Parmakların uzunluklularını ölçmek için proksimal metakarpofalangeal kıvrımdan başlanarak, parmakların uçlarına kadar olan uzunluk esas alınmıştır. Antropometrik ölçümler ile boy arasındaki potansiyel etkileşimleri belirlemek amacıyla tek yönlü ANOVA ve Pearson Korelasyon katsayısı, SPSS programı kullanılarak hesaplanmıştır. Doğrusal ve çoklu regresyon denklemleri de geliştirilmiştir.

Bulgular: Sağ ve sol parmak boyu değerleri arasındaki farklar her iki cinsiyet için istatistiksel olarak anlamlıydı (p<0.001). Toplamda, erkeklerin antropometrik ölçümleri kadınlardan anlamlı derecede yüksekti. Boy ile (2D) ve (4D) parmak uzunlukları ölçümleri arasındaki korelasyon katsayıları, istatistiksel olarak anlamlı pozitif bulundu. Erkeklerde boy ve parmak uzunluğu arasındaki en yüksek korelasyon katsayısı, sağ ikinci parmak için (r=0.505) ve kadınlarda sol ikinci parmak için (r = 0.596) olarak hesaplandı. Regresyon denklemleri, tahmini boy ile gerçek boy karşılaştırılarak doğruluk açısından kontrol edildi.

Sonuç: Doğrusal ve çoklu regresyon modelleri, her iki cinsiyette de (2D) ve (4D) parmak uzunlukları ölçümlerinden boy uzunluğunun tahmin edilmesinde kullanılabilir.

Anahtar Kelimeler: Parmak uzunluğu; Antropometri; Boy tahmini.

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1. Introduction

Anthropometric indices are traditionally used to study body shape variations between human populations (1). Evaluations of age, gender, height, race and unknown bodies can be identified using these indices. Moreover, the relationship between different parts of the body, such as the head, upper and lower extremities, and height has attracted the attention of anthropologists, forensic and medical scientists for many years (2-5). In forensic science, the determination of gender and the length of the missing skeleton fragments and the disintegrating human remains are of particular importance because of the increase in the number of catastrophic natural or man-made events which have caused massive numbers of death. These disasters, which include floods, tsunamis, earthquakes, plane crashes, train accidents, and terrorist attacks, often require victims to be identified from fragmented human remains (2-5). Many studies have used body remains, especially long bones to estimate stature. For example, some studies have successfully estimated the stature from hand, finger and phalange length (5-11), some from isolated long bone or other bones (12, 13), and some from percutaneous body measurements (3, 14). Some studies have also presented estimation of stature using radiographic material (15, 16). Estimation of stature will be helpful to develop the anthropometrical databases. Moreover, as these databases become population specific, it becomes imperative to collect data from more populations to create a comprehensive database. There are many inherent population differences across different populations. This creates a need to for different formulae to be derived from different populations. There is currently very little data that can be used for the estimation of stature from various parts of the body available in our country (1, 4). The aim of this study is to determine whether or not anthropometric measurements of second- and fourth-hand fingers can be used to estimate height. The present study was undertaken to create a regression equation for the determination of relationships between stature and (2D) and (4D) lengths in Turkey. From this direction, with the low error margin for size estimation, it is necessary to formulate regression formulas suitable for our population.

2. Materials and Methods

The study sample consisted of 140 young adults (males: 70; females: 70) aged between 19 and 21 years old that were students at Çukurova University, Faculty of Health Science between March and July of 2018. Students whose measurements were taken are all agreed to

participate in the study and were randomly selected. Approval was obtained from the study sites, Çukurova University, Faculty of Health Science and Ethics Committee of Çukurova University, Faculty of Medical School. 2D and 4D lengths were measured on the ventral surface of the hand from the basal crease of the digit to the tip of the second and fourth digits in both right and left hands using a digital vernier caliper that measured to 0.01 mm (TTI Vernier caliper, 0-200 mm), as described by Manning et al. (1998) and Kosif and Diramalı, (2012). (17, 18). (2D) and (4D) length data were categorized based on subject sex and subjected to statistical analysis.

2.1. Statistical Analyses

The data were statistically analyzed for correlation, regression, paired *t*-test and one-way analysis of variance (ANOVA). The descriptive analysis was done to obtain mean, standard deviation and measurement range. ANOVA was used to analyze the differences in stature, (2D) and (4D) between the male and the female subjects. Paired *t*-test was used to assess the differences in the length of the (2D) and the (4D). Pearson's correlation analyses were performed to determine the relationship between stature, (2D) and (4D). Linear regression models were derived to individually estimate stature from (2D) and (4D), multiple regression models were derived to estimate stature from a combination of (2D) and (4D) as co-variables. Difference were deemed statistically significant with *p*-values < 0.05. The statistical analysis was done using SPSS (Statistical Package for Social Sciences, version 21.0) computer software (SPSS, Inc., Chicago, IL, USA).

3. Results

Descriptive characteristics of parameters studied in males and females are shown in (Table 1). Mean (\pm SD) age of the study sample were 19.80 (\pm 2.13) for males and 19.42 (\pm 1.94) for females respectively. The results from this investigation reveal that stature is significantly higher in males than in females and ranged from 164 cm to 183 cm in males and 151 cm to 178 cm in females (*p*<0.001).

The mean (2D) length on the right and left hands were 71.60 \pm 4.44 mm and 72.41 \pm 5.07 mm, respectively, in males. The mean (2D) length on right and left hands were 67.95 \pm 3.78 mm and 68.06 \pm 3.94 mm, respectively, in females. The mean (4D) length on the right and left hands were 72.15 \pm 4.86 mm and 71.65 \pm 4.65 mm, respectively, in males. The mean (4D) length on the right and left hands were 68.67 \pm 4.03 mm and 68.35 \pm 3.91 mm, respectively, in females. Finger length measurements (2D,

4D) were higher in males than females and these sex differences are statistically significant ($p < 0,001$).

Linear and multiple regression equations for estimation of stature (cm) from measurements of right and left second and fourth digit lengths in males and females are presented in Table 2 and in Table 3. The highest correlation coefficients between stature and digit length were on

the right second digit (R2D) ($r = 0.505$) in males and on the left second digit (L2D) ($r = 0.596$) in females (Table 2).

Table 4 presents the estimated stature using linear and multiple regression equations.

The linear and multiple regression equations showed significant ($P < 0.001$) ability to predict stature from the right and left 2D and 4D.

Table 1. Descriptive characteristics of parameters studied in males and females. Values in parenthesis are minimum to maximum.

	Male (n=70) Mean \pm SD	Female (n=70) Mean \pm SD	t	p
Age	19,80 \pm 2,13	19,42 \pm 1,94	1,077	0,283
Height (cm)	176,06 \pm 5,88	163,31 \pm 6,19	12,51	<0,001
Weight (kg)	73,44 \pm 11,70	58,44 \pm 9,60	8,28	<0,001
Right 2D (mm)	71,60 \pm 4,44	67,95 \pm 3,78	5,24	<0,001
Right 4D (mm)	72,15 \pm 4,86	68,67 \pm 4,03	4,61	<0,001
Left 2D (mm)	72,41 \pm 5,07	68,06 \pm 3,94	5,66	<0,001
Left 4D (mm)	71,65 \pm 4,65	68,35 \pm 3,91	4,54	<0,001

Table 2. Linear regression equations for estimation of stature (cm) from measurements of right and left second and fourth digit lengths in males and females.

Equations	SEE	t	r	r ²	p
Males (n=70)					
St = 127,961 + 0,668 * (R2D)	5,11	4,827	0,505	0,255	<0,001
St = 135,841 + 0,554 * (R4D)	5,26	4,257	0,458	0,198	<0,001
St = 137,095 + 0,535* (L2D)	5,25	4,286	0,461	0,201	<0,001
St = 141,059 + 0,485* (L4D)	5,47	3,453	0,383	0,134	<0,001
Female (n=70)					
St = 113,947+ 0,727* (R2D)	5,59	4,080	0,443	0,197	<0,001
St = 112,900 + 0,734 * (R4D)	5,48	4,484	0,478	0,228	<0,001
St = 99,657 + 0,935 * (L2D)	5,01	6,117	0,596	0,355	<0,001
St = 105,356 + 0,848 * (L4D)	5,26	5,243	0,537	0,288	<0,001

*St= Stature, R2D= Right second digit, R4D= Right fourth digit, L2D= Left second digit, L4D= Left Fourth digit.

Table 3. Multiple regression equations for estimation of stature (cm) from measurements on 2D and 4D in males and females.

Sex	n	Equations	SEE	t	r	r ²	p
Males	70	St=127,608+0,581*(R2D)+0,091*(R4D)	5,14	12,69	0,506	0,257	<0,001
		St=138,344+0,606*(L2D)+-0,089*(L4D)	5,29	2,388	0,462	0,214	<0,001
Females	70	St=95,699+0,459*(R2D)+0,530*(R4D)	5,29	7,33	0,538	0,289	<0,001
		St = 91,673+0,677*(L2D)+0,374*(L4D)	4,93	8,180	0,620	0,384	<0,001

*St= Stature, R2D= Right second digit, R4D= Right fourth digit, L2D= Left second digit, L4D= Left Fourth digit.

Table 4. Estimated stature using linear and multiple regression equations

n=70	L2D	L4D	R2D	R4D	L2D+L4D	R2D+R4D	Actual stature
Male	176,97	177,21	174,66	174,55	179,34	178,91	176,06 \pm 5,88
Female	163,53	163,29	165,88	162,65	160,04	161,42	163,31 \pm 6,19

4. Discussion

This study was conducted to determine if there is a relationship between (2D) and (4D) lengths with human height and determine if these parameters can be used to predict height, as different body parts have been used for the prediction of height and the possible identification of individuals in forensic investigations. In a study it was found that estimation of stature from index and ring finger measurements can be a useful approach when part of the hand with intact fingers is brought for examination in cases where other body parts are not available for medico-legal examination (10).

Earlier studies conducted on finger length dimensions in different populations report larger finger dimensions in males rather than females. According to Danborn et al. (2008), in Nigeria, Jee et al. (2015) in Korea and Kanchan et al. (2008), in India and found that finger lengths are longer in males rather than females (5, 11, 20). Our findings are similar with other studies and support their observations. Most anthropometric studies show that almost all of the measurements taken from men are higher than the measurements taken from women. This is explained by the fact that the closure of bone epiphysis is earlier in women than in men, and it is thought that men have more than two additional years of bone development due to this later closure (21).

Extensive work has been carried out from hand measurements to estimate stature (4, 5, 8-11, 17, 19-21). Many researchers have used the ratio of the length of the second digit to the fourth digit (2D:4D) (18). Digit ratio has also been associated with higher levels of putatively androgen related outcomes such as left-handedness (22), enhanced and athletic ability (23). In a study carried out by Manning and Taylor (2001), it was indicated that the males who have low 2D:4D ratios are more successful in many sports and have better balance and coordination skills, which is a positive feature in sports (23). According to Kosif and Diramalı (2012), they did not detect any significant difference between males and females for the 2D:4D ratio (18). In contrast with other studies, they have calculated all of the digit ratios. The 2D:5D, 3D:5D, and 4D: 5D ratios were found to be significantly smaller in the left-handed females when compared to the right-handed females. Kosif and Diramalı also observed differences only for the fifth digit length. According to their results, they claim that there is an asymmetry between left- and right-handed adults for digit length. They report that left-handed women may have better sporting abilities, due to the left hand in left-handed women, and they might be more successful, particularly in sports that require grasping a ball (18).

In present study, all the measurements exhibit statistically significant correlation coefficients with stature ($p < 0.05$). The highest correlation coefficients between stature and digit length were on the right second digit R2D ($r = 0.505$) in males and on the left second digit L2D ($r = 0.596$) in females (Table 2).

In our study, it was revealed that the correlation coefficients between the length of the fingers and the stature taken from women were higher than in men. Similar results were obtained by Christal et al. (2018), Bardale et al. (2013), Sen et al. (2014) for (2D) and (4D) length (8,9,10). However, Danborn et al. (2008), Raju et al. (2014) and Krishan et al. (2012) and in their studies found that the correlation coefficient was higher in males than in females (5, 19, 21). This may be related to the anatomical and the inter-communal physical structure of these societies.

Comparisons of actual stature and stature estimated from regression equations were performed and are presented in Table 4. The mean estimated stature was close to the actual stature. It was calculated that the stature estimation could be determined with an estimated standard error of around 5 cm. We also note that the left second digit in females exhibit a low Standard Estimated Error (SEE) (± 5.01 cm) and relatively higher correlation coefficients between stature, which gives the best predictive model using linear regression equations (Table 3). In males with the lowest SEE (± 5.11) the predictive model was measured for the (R2D) (Table 3). It was determined that the relationship between stature and measurements taken from the females were higher than males.

The estimated stature (using linear regression equations) was closer to the actual stature than the estimated stature using multiple regression equations. In addition, a more accurate stature could be estimated using regression equations from the (2D) and (4D) lengths in females than males.

As a result, both regression models can be used to estimate the height from the second and fourth finger lengths in both genders. It should be noted, however, that anthropometric measurements vary according to societies. These variations originate from genetic and environmental factors. Therefore, these regression equations are only useful for our own population. Although anthropometric evaluations do not yield definitive results in identification, when used in conjunction with other methods, these evaluations reduce the number of individuals that are matched and saves human resources, time and money. Estimation of stature from (2D) and (4D) finger measurements can be a useful approach for forensic and medico-legal examination. For example, when part of a hand with intact fingers is brought for examination in cases when other more reliable samples like long bones or other body

parts are not available these measurements could be helpful for identifying unknown bodies.

In conclusion, we believe that this study will be useful for forensic scientist, anthropologists as well as the anatomists in ascertaining medico-legal cases.

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References

1. Ocakoglu G, Ercan I. Traditional and modern morphometrics. *Turkiye Klinikleri Journal of Biostatistics*. 2013;5(1):37–41.
2. Beddoe J. On the stature of the older races of England as estimated from the long bones. *J R Anthropol Inst*. 1887-1888;17:202- 207. DOI: <https://doi.org/10.2307/2841929>.
3. Ozaslan A, Iscan MY, Ozaslan I, Tugcu H, Koc S. Estimation of stature from body parts. *Forensic Sci Int*. 2003;132:40–5. DOI: [https://doi.org/10.1016/S0379-0738\(02\)00425-5](https://doi.org/10.1016/S0379-0738(02)00425-5).
4. Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a North Indian population. *J Forensic Legal Med* 2007;14:327–332. DOI: <https://doi.org/10.1016/j.jcfm.2006.10.008>.
5. Danborn B, Adebisi S, Adelaiye A, Ojo S. Estimation of Height and weight from the Lengths of Second and Fourth Digits in Nigerians. *The Internet Journal of Forensic Science*. 2008;3(2).
6. Wright LE, Vasquez MA. Estimation of the length of incomplete long bones: Forensic standards from Guatemala. *Am J Phys Anthropol*. 2003;120:233-251. DOI: <https://doi.org/10.1002/ajpa.10119>.
7. Menezes RG, Kanchan T, Kumar, GP, Rao PJ, Lobo SW, Uysal S, et al. Stature estimation from the length of the sternum in South Indian males: a preliminary study. *Journal of forensic and legal medicine*. 2009;16 (8):441-443. DOI: <https://doi.org/10.1016/j.jflm.2009.05.001>.
8. Christal GP, Manve P, Ahuja MS. Dahiya, Estimation of Stature from Finger Length. *J Forensic Sci & Criminal Invest*. 2018;7(2):555-709. DOI: <https://doi.org/10.19080/JFSCI.2018.07.555709>.
9. Bardale RV, Dahodwala TM, Sonar, VD. Estimation of Stature from Index and Ring Finger Length. *J Indian Acad Forensic Med*. 2013;35(4):353-357.
10. Sen J, Kanchan T, Ghosh A, et al., Estimation of stature from index and ring fingers in northeastern Indian population. *J Forensic Leg Med*. 2014;22:10–15. DOI: <https://doi.org/10.1016/j.jflm.2013.11.010>.
11. Jee SC, Yun MH. Estimation of stature from diversified hand anthropometric dimensions from Korean population. *Journal of forensic and legal medicine*. 2015;35:9-14. DOI: <https://doi.org/10.1016/j.jflm.2015.06.014>.
12. Holland TD. Estimation of adult stature from fragmentary tibias. *J Forensic Sci*. 1992;37:1223–1229. DOI: <https://doi.org/10.1520/JFS13309J>.
13. Radoinova D, Tenekedjiev K, Yordanov Y. Stature estimation from long bone length in Bulgarians. *Homo*. 2002;52:221–232. DOI: <https://doi.org/10.1078/0018-442X-00030>.
14. Duyar I, Pelin C, Zagypayan R. A new method of stature estimation for forensic anthropological application. *Anthropol Sci*. 2006;114:23–27. DOI: <https://doi.org/10.1537/ase.041217>.
15. Himes JH, Yarbrough C, Martorell R. Estimation of stature in children from radiographically determined metacarpal length. *J Forensic Sci*. 1977;22:452–455. DOI: <https://doi.org/10.1520/JFS10609J>.
16. Karaman G, Teke HY, Günay I, Dogan B, Bilge Y. Height estimation using anthropometric measurements on X-rays of wrist and metacarpal bones. *Internet J Biol Anthropol*. 2008;2(1):1-22.
17. Manning JT, Scutt D, Wilson J, Lewis-Jones DI. The ratio of 2nd to 4th digit length: a predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. *Hum.Rep*. 1998;13:3000–3004. DOI: <https://doi.org/10.1093/humrep/13.11.3000>.
18. Kosif R, Diramalı M. Comparison of All Hand Digit-Length Ratios In Left- And Right-Handed Individuals. *Turk J Med Sci*. 2012;42(3):545-552. DOI: <https://doi.org/10.3906/sag-1006-858>
19. Raju GM, Shahina S, Dubey S, Vijayanath V. Estimation of stature from index and ring finger length in Davangere district. *Int J Clin Trials*. 2014;1:18-21.
20. Kanchan T, Kumar GP, Menezes RG. Index and ring finger ratio--a new sex determinant in south Indian population. *Forensic science international*. 2008;181:(1-3):53.e1-4. DOI: <https://doi.org/10.1016/j.forsciint.2008.08.002>.
21. Krishan K, Kanchan T, Asha N. Estimation of stature from index and ring finger length in a North Indian adolescent population. *Journal of Forensic and Legal Medicine*. 2012;19:285-290. DOI: <https://doi.org/10.1016/J.Jflm.2011.12.036>.
22. Manning JT, Trivers RL, Thornhill R, Singh D. 2nd to 4th digit ratio and left lateralized preference in Jamaican children. *Laterality* 2000;5:121–32.
23. Manning JT, Taylor RP. 2nd to 4th Digit ratio and male ability in sport: implications for sexual selection in humans. *Evol Hum Behav*. 2001;22:61–9. DOI: [https://doi.org/10.1016/S1090-5138\(00\)00063-5](https://doi.org/10.1016/S1090-5138(00)00063-5)