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Estimation of Stature From Tibial Length

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TİBİA UZUNLUĞUNDAN BOY UZUNLUĞUNUN TAHMİNİ

Summary

Variation in stature is well documented for most of human populations. It has been further illustrated that both environmental factors and genetics play an important role in the attainment of its final size and therefore body size is population specific. It is therefore necessary to develop stature estimation technique for populations whose genetic and social and physical environment differ from others. The purpose of this study is to develop regression a formula to estimation stature from the tibia for the Turkish population.

In 31 female and 49 male individuals on whom a medico-legal autopsy had been performed at the Council of Forensic Medicine between December 1993 and February 1995, stature and tibial length were measured and analyzed using regression statistical technique.

The results showed that correlation coefficiants were found to be 0,71 in males and 0,62 in females between the stature and tibial length : The regression formulae obtained thus are as follows :

males: Stature= 71,2 + 2,7 x tibial length ± 4,8

females: Stature= 92,4 + 1,9 x tibial length ± 4,0

In application of the formula, a correct stature estimation was obtained in 74,2 % of females and 73,5 % of males. Stature values were within ± 1 standard error.

Key Words : *Forensic anthropology, estimation of stature, tibia.*

Özet

İnsan popülasyonlarında boy değişikliklerinin olduğu bilinmektedir. Bir kişinin nihai boyuna ulaşmasında hem çevre hem de genetik faktörlerin önemli bir rol oynadığı da gösterilmiş olup vücut oranları popülasyona özeldir. Bu nedenle genetik, sosyal ve fiziksel çevresi farklı olan popülasyonlar için boy tahmin formüllerinin geliştirilmesi gereklidir. Bu çalışmanın amacı Türk popülasyonunda tibia uzunluğundan boy uzunluğu tahmin formülü oluşturmaktır.

Aralık 1993-Şubat 1995 tarihleri arasında Adli Tıp Kurumu'nda adli otopsi uygulanan 49 erkek ve 31 kadında tibia uzunluğu ve boy uzunluğu ölçüldü, istatistiksel olarak regression analizi yapıldı.

Tibia ve boy uzunluğu arasındaki korelasyon katsayısı erkeklerde 0,71, kadınlarda 0,62 olarak saptandı. Elde edilen regression formülleri aşağıdadır.

Erkek : Boy uzunluğu : 71.2 + 2.7 x Tibia uzunluğu ± 4.8

Kadın : Boy uzunluğu : 92.4 + 1.9 x Tibia uzunluğu ± 4.0

Formüllerin uygulanması sonucu erkeklerin % 73.5'i, kadınların % 74.2'sinde ± 1 standart sapma dahilinde doğru boy tahmini elde edildi.

Anahtar Kelimeler : *Adli antropoloji, boy tahmini, tibia.*

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INTRODUCTION

Identification of skeletal and decomposing human remains poses a major problem in forensic medicine and osteology. In this framework estimation of stature is essential. Stature estimation is performed either by anatomical or mathematical methods. The anatomical method comprises the measurement of the cranial height, the length of the vertebral column and lower extremities to which factors of correction for soft tissues are added (1,2). This method, however, is appliable only to a complete skeleton, for the cranial height as well as the lengths of the vertebral column, femur, tibia and fibula are needed. In the mathematical method, the stature is estimated from the length of individual bones. With this method, primarily bones of the upper and lower extremity are used. Furthermore, this method is applied more commonly in forensic osteology for the identification of unknown human remains. The respective formulae are only valid for the population for which they have been derived (1,2,3).

The ratio of body parts exhibits differences in each population, whereby this discrepancy is influenced to a large extent by the length of the tibia (4).

It is the goal of the present study to derive mathematical formulae for the stature estimation in the Turkish population. In this framework, an attempt was made to constitute equations for both males and females to estimate the stature from tibial length, thus making a contribution to the identification in cases where only the tibia is present.

MATERIAL AND METHOD

The measurements were carried out on a total of 80 individuals (31 females and 49 males) having lived between 1940 and 1995.

With regard to the geographic distribution of the place of birth, 28,6 % of the males originated from the Black Sea Region, whereas 32,3 % of the females were born in Eastern Anatolia. Individuals from the Aegean and Mediterranean Region were extremely underrepresented.

Stature and tibial length were measured in adult (age 18 or older) 31 females and 49 males autopsied in the Mortuary Section of the Council of Forensic Medicine between December 1993 and February 1995.

The tibial length was measured from the right side. With the bone intact with the remains, proximal and distal interarticular spaces of the tibial bone were exposed by incisions below the patella and the malleolar region. The distance between the eminentia intertubercularis and the distal tip of the medial malleol was measured. All measurements were taken in milimeters.

Measurement were taken within one or two days after death. Taking into account that the antemortem length is shorter than the postmortem one due to the muscle tone 2 cms. were substracted from the stature of the corpse according to Manovrier. Age-based correction was carried out using Trotter and Gleser's formulae in individuals over 30 years of age. Thus in individuals beyond 30 years, the value (age-30) x 0,06 cm. was added to the antemortem stature (2,5,6).

For the tibial length was measured during the medico-legal autopsy, 2 mm. were substracted according to Rollet from the fresh bone length in order to obtain the length of the dry bone (2,5).

To provide standardization, all measurements were carried out, by the same investigator (Günay, Y.) using the same instruments.

Correlation and regression analysis were carried out between tibial length and stature, hereby regarding

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the tibial length as the independent variable and the stature as the dependent one. The findings thus obtained were evaluated on a personal computer using SPSS PC.

In correlation and regression analysis, age-corrected stature and length measurements of dry tibial bones were used.

RESULTS

Table 1. Descriptive statistics on age, stature and tibial length (cm).

	Male	Female
Age range	18-54	18-50
Arithmetical mean	33.1	30.1
Median value	32.0	28.0
Modal value	28.0	30.0
Standard deviation	9.3	9.5
Stature range	156.5-188.1	146.5-166.8
Arithmetical mean	171.4	158.1
Median value	171.0	158.5
Modal value	171.0	151.0
Standard deviation	6.8	5.0
Range of tibial length	33.3-41.2	30.7-38.0
Arithmetical mean	37.7	34.5
Median value	38.2	34.4
Modal value	38.2	33.1
Standard deviation	1.8	1.8

Table 2. Results of correlation and regression analysis in males and females.

	Male	Female
Correlation coefficient (r)	0.71	0.62
r2	0.51	0.38
Regression equation	Stature: 71.2+2.7xT	92.4+1.9xT
Standard error	4.8	4.0

Applying the equation thus elaborated, correct values within the range of ± 1 standard error were obtained in 74.2 % of the males and 73.5 % of the females, respectively. Furthermore, comparison of the values was carried out by employing tibial lengths into the following stature estimation formulae elaborated for European, Asian and African populations.

average, concluding that the measurements performed by the latter had not involved the medial malleolus (14,15).

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Table 3. Percentage of correct estimation within the range of ± 1 standard error unit by formulae elaborated by the besaid authors.

	Males
1. Bretinger, 1937, German (white)	77.6 (p=0.046)
2. Allbrook, 1961, British (white)	63.3 (p=0.038)
3. Shitai, 1983, Mongoloid	63.3 (p=0.038)
4. Lundy, 1983, (black)	0.0

1. Europeans: Bretinger, 1937, German white males: 95.59+1.99xT±4.7
2. Allbrook, 1961, British males : 83.78+2.30xT±3.5
3. Asians: Shitai, 1983, South China, Mongolian males: 54.13+3.01xT±4.59
4. Africans: Lundy, 1983, South Africa, black males: 60.86+2.43xT±3.44
black females: 59.96+2.38xT±4.13.

DISCUSSION

Various authors have suggested that estimation using bones of the lower limbs provides more accurate results than do calculations based on the length of the upper extremity (2,3,5,7,8,9).

The measurements were performed on individuals having lived between 1940 and 1995, thus representing body size of this period. Numerous authors have emphasized that body size may change in time even in the same population, so that it would be wise to review estimation formulae periodically and if necessary develop new models (2,10).

As to the geographic distribution of the place of birth, nearly 90 % of the females originated from the regions Eastern Anatolia, Central Anatolia, Marmara and Black Sea in this order of frequency and 85 % of males from Black Sea, Eastern Anatolia, Marmara and Central Anatolia. Individuals from the Aegaean and Mediterranean Region were extremely underrepresented. Various estimation formulae for stature have been elaborated for different geographic regions, taking into account that geographic conditions may be an important contributory factor in addition to the place of birth. In the present study, only information about the place of birth could be obtained, whereas data about habitation and sociocultural environment during the period of growth and maturation are lacking.

An objection might be made to the small number of subjects included in the study. The representative capacity of a study for the respective population depends on the number of subjects included in it. On this field, the most extensive study has been carried out by Trotter and Gleser, the total number of subjects in their studies in 1952 and 1958 being 6731 (11). Different equations using a more limited material have been also elaborated by Genoves, B. Rother, Ullmann and Wusteneck and Mo Shitai (2). The small

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number in our study was partly caused by the fact that we do not have available to us a bone collection.

The mean stature in men in our study (171.4) was found to be approximately 10 cm. above that of Asian Populations like in China (160.91) and India (161.4), whereas it was nearly within the same range of American and European ones (170.4).

The mean age of subjects in our study is lower than that in the collection of Terry and Todd. The lower limit of age is consistent with the studies of Trotter and Gleser (1952, 1958), as well as of Fully and Pinea and Allbroock (2,5,9).

In previous studies, optimal combinations for multiple regression analysis have been proposed, the best being femur and an additional crural bone. In Turkey, stature estimation formulae using the length of the vertebral column (12) and of the fibula (13) have been published.

Investigating the relationship between stature and tibial length, the correlation coefficient was found to be 0.71 in males and 0.62 in females, respectively. Regression formulae to estimate stature and relevant standard errors are as follows:

males stature : $71.2+2.7xT\pm4.8$

females stature : $92.4+1.9xT\pm4.0$

Standard error values in the literature on the subject vary between 1.9 and 4.7, so that, although being near to the upper limit, our results are in the accordance with the results in previous reports. The standard error of stature estimation by fibular bone length, as reported by Şam, is 4.43 for males and 3.89 for females, respectively, thus being lower than the respective values obtained by estimation from tibial length (13). Taking into account the fact that the same subjects were included in both studies, the relationship between stature and tibial length is more variable than that between stature and fibular length.

Using the formulae elaborated, correct estimation values within the range of ±1 unit standard error were obtained in 73.5 % of males and 74.2 % of females. Using Breitingers formulae (1937) for male Germans, the percentage value was found to be 77.6; applying other formulae, lower percentage values were obtained, thus suggesting that body size of Turkish males is in accordance only with that in the study of Breitinger. This leads us to the conclusion that estimation formulae should be constituted separately for each population.

In their work on the subject, Trotter and Gleser stated to have measured the maximal tibial length. On re-measuring the tibial length in Trotters material of 1952, Jantz, Hunt and Meadows, however, obtained values exceeding them of Trotter by 13 mm on average, concluding that the measurements performed by the latter had not involved the medial malleolus (14,15).

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Since in the present study the maximal tibial length was measured, the accuracy of the formulae elaborated thus was not compared with that of the equations developed by Trotter and Gleser.

Numerous authors emphasize that estimation formulae must be elaborated by taking in account the physical properties like differences in body proportions of each population. These may vary considerably due to race, sex, age, as well as to environmental and individual factors. So, in negroes, the ratio: Tibia to femur is in advantage of the tibia (3). In Denmark, different estimation formulae were constituted for different ethnical groups (4). At present there exist no extensive studies concerning alterations in body proportions of population as a whole and of ethnical groups in Turkey.

Deficient aspects of the present study are the small number of subjects, underrepresentation of certain regions and lack of data about the geographic and socio-cultural environment, so that this preliminary work necessitates further and more extensive investigations involving a larger sample and other long bones.

In the majority of studies on forensic anthropology, collections containing whole skeletons were investigated. The lack of such a collection in Turkey is a major disadvantage for further studies on this topic. A collection containing all relevant data would, therefore, be of great help for future investigations. Furthermore, the constitution of a separate department at the Council of Forensic Medicine, made up of anthropologists, pathologists and a criminalistic staff would be beneficial in this context.

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