*Rom J Leg Med [19] 171-176 [2011]*
*DOI: 10.4323/rjlm.2011.171*


# Stature estimation from bi-acromial and bi-iliocristal measurements

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**Abstract:** Identification studies about stature estimation provide useful information in individual cases. Many studies put forward the relationship between height and some parts of the skeleton and the body parts in consideration. The classical measurements (foot, hand and long bones) for stature estimation have been already studied in different populations, whereas very few is available concerning Bi-acromial Breadth (BAB) and Bi-iliocristal Breadth (BICB). Anthropometrical measurements were performed by middle-income 337 volunteers; 216 males and 121 females. These measurements were studied by SPSS routines and linear regression formulas were defined for variables included in significant correlation related to stature. There was a statistically significancy ($p<0.01$) between stature and variables (BAB, BICB). Sex differences were found to be highly significant for all the measurements. In this research, best correlation was examined in males for BAB ($r=0.42$), but for BICB there was a very weak correlation in both males ($r=0.21$) and females ($r=0.19$). When both variables were studied, relation with stature in males reached to $r=0.43$. Even though variables' relations with stature were found weak, in cases of impaired integrity of corpses, regression formulas about stature estimation specific to Turkish population may provide useful information.
**Key Words:** identification; stature estimation; bi-acromial breadth; bi-iliocristal breadth; turkish population; forensic anthropology population data

Branch of science that uses the data obtained from body parts and skeletons from the living or dead people for forensic purposes are called "Forensic Anthropology" [1]. It is an important discipline that includes required methods and many significant variables to identify people that cannot be identified or whose identity is suspected. Obtained data are used to determine age, sex, height and race of unidentified people. Estimation of stature is an important criteria in terms of detecting the identity [2, 3].

Many studies in order to reveal variations peculiar to the identification of human skeleton have been carried out. These studies reveal estimation of stature from body parts is the topic of most interest [4-6]. If impaired integrity of the body size exists, the most reliable parameters for prediction are the measurements of the upper and lower extremities [7]. However, other parts of the body can also be used. Besides anthropometric data obtained from the regression formulas are specific to that community. The implementation of these formulas to other communities may lead inaccurate results and these have been shown in some studies [8, 9].

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In the present study, the relationship between different body measurements and actual stature of Turkish population were analyzed. It is aimed at revealing specific data among Turkish population by obtaining Bi-acromial Breadth (BAB) and Bi-iliocristal Breadth (BICB) measurements from people living in Turkey in order to estimate the stature.

**Materials and Methods**

This research was composed of anatomically healthy adults living in Turkey, who had at least 5 years from elementary school education and middle-class social economy. 216 male and 121 female volunteers were studied. These 337 volunteers were enlightened through an informed consent.

For standard measurements, the dimensions were taken in millimeters using standard anthropometric instruments such as sliding and spreading calipers, anthropometer, steel tape and scale. All measurements were taken by first author (A.Ozaslan). Obtaining the data and analyzing statistics were in millimeters.

The subjects were asked to remove their shoes and clothings except underwears. Following the International Biological Program Protocol [10, 11], two anthropometrical variables as BAB and BICB were measured. They were oriented in the standard anatomic position with the head on the Frankfort Horizontal Plane.

Stature: It was taken from the vertex to the floor obeying the anatomic position and Frankfort Plane.

BAB: To give a maximum shoulder width, the subject stands with his shoulders relaxed to the point of slumping forward. Standing behind the subject, the measurer feels for the outside edge of the acromial process of the shoulder blade which can be felt as a ridge just above the shoulder joint. He then places the edge of one arm of the anthropometer along the external border of one acromial process and brings the other arm of the anthropometer inwards until its edge rests on the opposite acromial external border (Figure 1) [12].

BICB: The subject stands with his heels together and the anthropometer arms are brought into contact with the iliac crest at the place which gives the maximum diameter. Strong pressure is applied to the anthropometer blades to push aside any fat covering the bone. This measurement is more easily taken with the measurer standing front of the subject (Figure 2) [12].

The data were subjected to statistical analysis for determining Means, Standard Error (SE), Standard Error Estimation (SEE), Pearson's 'R'-value, and Linear Regression Equation using SPSS 14 statistics software. The data were analyzed applying various subroutines of SPSS and regression formulas were developed for various combinations to reach the best estimate possible. Such a statistical approach is commonly used in research of these natures [13, 14].

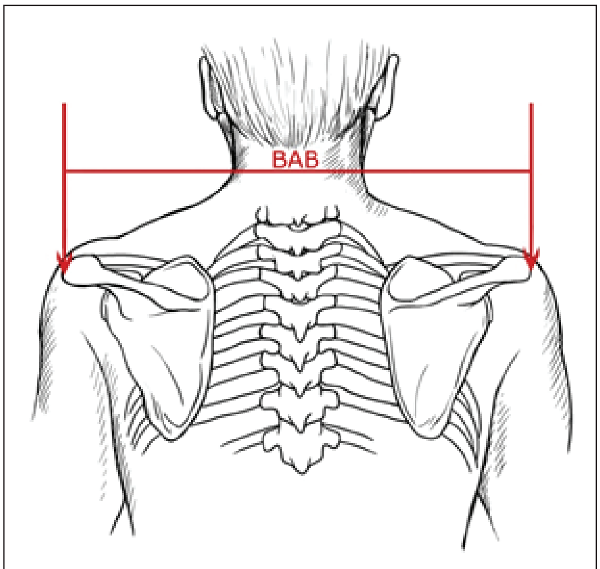


**Figure 1.** Bi-acromial Breadth Landmarks

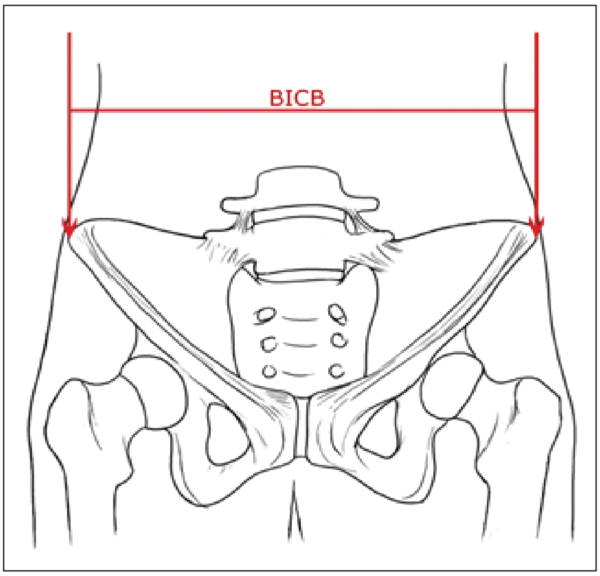


**Figure 2.** Bi-iliocristal Breadth Landmarks

To determine inter-observer error ratios in point of two variables and stature, measurements were repeated in 20 individuals who were chosen randomly and data were evaluated with paired t-test by second author of the study (B. Karadayi).

## Results

When inter-observer's error ratios were evaluated, a significance level of P>0.01 was not determined among measurements. Descriptive statistics was defined for both sexes in Table 1. Males were more varied with higher Standard Deviation (SD) than females in BAB measurements but oppositely in BICB measurements females were more varied with higher SD than males.

**Table 1.** Descriptive statistics of age, stature, BAB and BICB for males (N=216) and females (N=121)

| Variables | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Min. | Max. | Mean | SD | Min. | Max. |
| Age (Years) | 30.43 | 10.20 | 20 | 52 | 34.36 | 9.26 | 20 | 49 |
| Stature (mm) | 1724.36 | 68.04 | 1546 | 1975 | 1618.63 | 61.11 | 1462 | 1848 |
| BAB (mm) | 386.06 | 23.09 | 273 | 458 | 349.26 | 20.88 | 273 | 412 |
| BICB (mm) | 288.92 | 25.94 | 240 | 394 | 273.31 | 27.10 | 220 | 373 |

**Table 2.** Sex differences in stature, BAB, BICB among Turkish individuals using paired t-test

| Measurement | t-value | Degree freedom | Level of significance |
|---|---|---|---|
| Stature | 13.386 | 335 | p < 0.01 |
| BAB | 14.510 | 335 | p < 0.01 |
| BICB | 5.212 | 335 | p < 0.01 |

Maximum difference between sexes was observed in measurements of BAB and also in terms of all variables, there was a significant difference between sexes, too (Table 2). Data were shown in scatter plots diagrams and regression lines for both BAB (Figure 3) and BICB (Figure 4). Each of these variables differed in terms of two sexes.

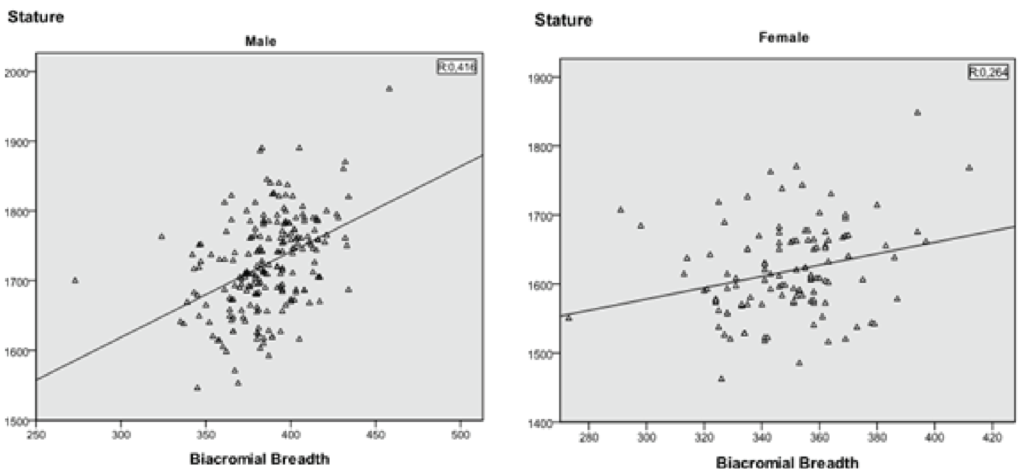


**Figure 3.** Scatterplots and linear regression lines demonstrating the relationship between BAB and stature of Turkish males and females

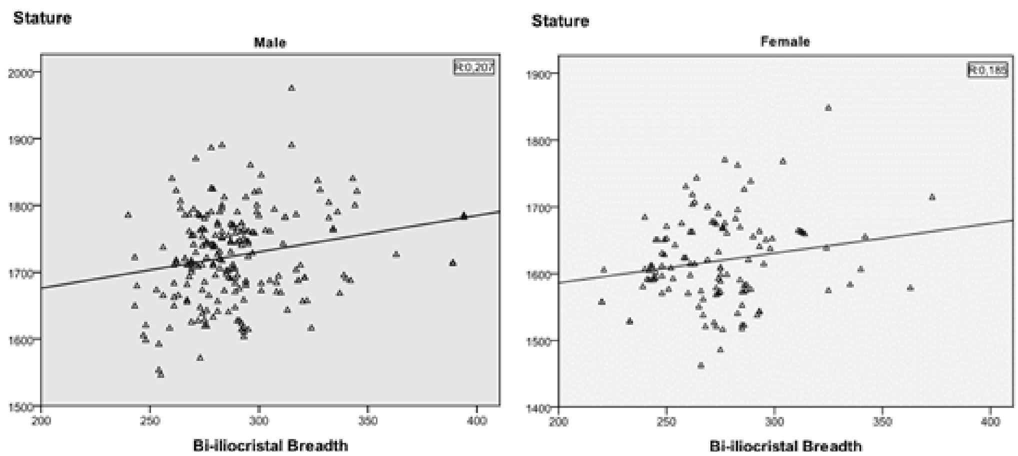


**Figure 4.** Scatterplots and linear regression lines demonstrating the relationship between BICB and stature of Turkish males and females

There was a significant correlation in both sexes for even BAB and BICB. When it was examined the degrees of correlation between BAB and stature, a weak correlation existed (male 0.42, female 0.26), between BICB and stature; a very weak correlation was observed (male 0.21, female 0.19). When both variables were used, the best correlation was obtained (male 0.43, female 0.27) (Table 3).

**Table 3.** Correlation of variables for stature estimation including R, $R^2$ and SEE

| Variables | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | R | $R^2$ | SEE (mm) | R | $R^2$ | SEE (mm) |
| BAB | 0.42* | 0.17 | 62.01 | 0.26* | 0.07 | 63.07 |
| BICB | 0.21* | 0.04 | 66.72 | 0.19* | 0.03 | 64.25 |
| BAB and BICB | 0.43* | 0.18 | 61.74 | 0.27* | 0.08 | 63.16 |

* P< 0.01

Generated regression formulas from a multi and two direct analyses to estimate stature for both sexes and regression coefficients were given in Table 4.

**Table 4.** Regression coefficients used to calculate stature in males and females

| Variables | Regression Equations | | |
|---|---|---|---|
| | Direct regression | | Multi regression |
| | BAB (mm) | BICB (mm) | BAB, BICB (mm) |
| Male | | | |
| BAB (mm) | 1.226 | | 1.145 |
| BICB (mm) | | 0.544 | 0.285 |
| Constant | 1251.10 | 1567.30 | 1200.09 |
| SE | 70.81 | 50.88 | 76.63 |
| Female | | | |
| BAB (mm) | 0.822 | | 0.705 |
| BICB (mm) | | 0.445 | 0.195 |
| Constant | 1331.62 | 1497.09 | 1318.87 |
| SE | 96.47 | 59.42 | 97.85 |

Applications of defined regression equations for stature estimation are as follows:

Stature (Male) (mm) = 1200.09 + 1.145 * BAB + 0.285 * BICB

Stature (Female) (mm) = 1318.87 + 0,705 * BAB + 0,195 * BICB

When we defined linear regression models in case of reconstruction for one variable as BAB or BICB; the least standard error was found for stature estimation (18.632) in females (Table 5).

**Table 5.** Linear regression models for reconstruction of BAB and BICB among males and females

| Regression Equations | R | $R^2$ | SEE(mm) | P-value |
|---|---|---|---|---|
| Male | | | | |
| BAB=320.800+0.226*BICB | 0.254 | 0.064 | 22.395 | <0.001 |
| BICB=178.933+0.285*BAB | 0.254 | 0.064 | 25.151 | <0.001 |
| Female | | | | |
| BAB=252.653+0.353*BICB | 0.459 | 0.211 | 18.632 | <0.001 |
| BICB=65.264+0.596*BAB | 0.459 | 0.211 | 24.187 | <0.001 |

## Discussion

Anthropometry has an important role in many human growth and identification studies by measuring human body and its parts for many years. In cases of unimpaired integrity of bodies, there are not so much problems in identification but identification is much more difficult in impaired integrity of corpses by different reasons such as an earthquake, a war or a brutal murder. Taking into consideration all of these, correlation between stature and two measurements (BAB and BICB) were studied because stature as a crucial role in identification.

It is known that stature differs according to sexes [15,16]. In this study, measured stature, BAB and BICB presented a specific differentiation due to sex.

In previous studies about stature estimation, lots of bone and anatomic structures were analyzed. Coefficients of similar studies about stature estimation are as follows; from long bones studies "r" value was between 0.619-0.968 [17-20], from hand and foot studies "r" value was between 0.294–0.881 [15,16,21-24], from facial bones studies "r" value was between 0.185-0.365 [25]. For present study, correlation between stature and BAB, BICB were weaker than long bones, hand bones and foot bones studies; but it showed a similar correlation with the facial bones study.

In the present study, best correlation with stature estimation was observed in males from BAB (r=0.42). For BICB there was a weak correlation both in males (r=0.21) and females (r=0.19). When two variables were used together, it was detected that a small increase observed in stature of males (r =0.43). This showed that BAB valuation presented sufficiently significant results alone.

In India's South region, relation between stature and inter-anterior spinal distance of 100 people indicated a very weak correlation in males (r=0.24) besides a weak correlation in females (r=0.35) [26]. But in a greater Thai volunteers study group, it was reported that the relation of stature and BICB had a strong correlation [27]. The results of this study were much more in accordance with the study which was performed in India.

In literature, it was not encountered with any study about relation between BAB and stature. In a study about relationship between scapular measurements and stature, it has been suggested that a moderate correlation was detected between maximum scapular breadth and stature (r=0.58) [28]. In this study, the correlation between BAB and stature was found weaker than mentioned study. Differences in correlations might have derived from different anatomical localizations.

Some researchers pointed out that BICB and stature could be used in estimation of body mass and so appropriate regression formulas were defined [29, 30]. But in this study, regression formulas about body mass were not defined, because of intending to estimate stature not body mass.

In the situations that there was no integrity of bodies, studies about measuring existing parts of these bodies and estimating from these for the other parts are important [31]. In mass disasters for identification; Kanchan and et al. improved regression formulas and multiplication factors for Indians in reconstruction of hand and foot measurements to each other [32]. In this study; regression formulas were improved with similar error proportions in reconstruction of BAB to BICB or the other way round, too. In females fewer errors were detected in reconstruction of BAB and BICB.

In forensic practice these measurements may be used in the first decomposition stages, but in these cases the articulated body may provide itself useful information for estimation of body stature. This explains why the BAB and BICB measurements are mainly used for clinical evaluation of growth and variation of human size proportions with time [33].

Although we conclude that stature weakly correlated to variables of BAB and BICB, defined regression formulas may provide useful information in cases of impaired integrity of corpses in this study. But these variables would differ for each population, as a result of this phenomena, it must be taken care by researchers and practices.

## Acknowledgements

Authors are grateful to participants of this study. Without their cooperation, this study could not have been carried out. Authors thank Buket Serdar for drawing Figure 1 and Figure 2. This investigation is supported by the Istanbul Research Fund.

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