# Determination of Stature from Upper Arm Length in Medical Students

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## ABSTRACT

**Introduction:** In order to make a dimensional proportion between human and equipment or environment, anthropometric data bank is essential. Anthropometry has an important role in industrial management and ergonomic design. This information is needed to be collected regularly in every society. The purpose of this study was to determine arm length to height ratio according to gender in adults, between ages 19-21 in students of Medical Sciences, Tehran.

**Methods:** This cross-sectional investigation was performed on 100 students (50 males and 50 females) from Tehran University of Medical Sciences (aged 19-21 years). Participants were selected randomly and they didn't have any physical deformities or any previous history of trauma. Standing height (stature) and upper arm length (UAL) were measured for each subject. Measurements were performed in standard position.

**Results:** The mean age of cases was 21±1.32 years. Mean age of male cases was 20±1.2 years and female cases was 21±1.81 years and there wasn't significant difference in the age of sex groups (P=0.219). A significant differences were observed in the height between the two sexes (P=0.0001, and Table 1). Also, there was a significant difference in the upper arm length of sex groups (P=0.0001). In addition, there was a correlation between height and upper arm length of cases (r =0.716, P=0.0001).

**Conclusion:** According to the results, UAL can be a reliable factor for predicting the stature in Iranian medical students.

## 1. Introduction

Assessing height of an individual from measurement of different parts of the body has always been one of the most interests of anthropologists. Stature has been one the most important factor in the description of the individual characteristics for a long time [1-6]. The estimation of height from various parameters has been performed in various studies [7-12].

Anthropometric data from different races, age and sex groups can be useful in designing a product and in addition it can reduce human errors [13-15]. The results

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of these studies are helpful in different branches such as forensic medicine, surgery, ergonomics and biomedical engineering [16]. Furthermore, identification of dismembered human remains that are frequently found in cases of mass disasters and criminal is a challenging task for the medicolegal experts [17].

Also, the living stature can be predicted by anatomical and mathematical techniques [18]. Bones as the body segments were mostly used for stature estimation in different studies [7, 19-21], however percutaneous length of bones was evaluated in several studies [22-26].

Some researches could evaluate the relation between stature and upper arm length (UAL) or percutaneous humerus length and define formulas for this relationship in different age groups. According to the results of these studies, the reliability and prediction power of the derived formulae were different [27-29].

Arm morphology is an important element to determining upper limb movement behavior [30]. The design of devices for orthopedic goals depends on the anatomical and physical characteristics of the bones. Also, measurements of arm dimensions in the different populations can be assigned in design of industry products such as orthopedic prostheses [31].

These researches can be helpful for prediction of stature in individuals with disproportionate growth abnormalities and skeletal dysplasia or height loss during surgical procedures on the spine [32]. The purpose of this study was to estimate the stature from length of arm in Iranian population.

## 2. Materials & Methods

One hundred subjects (50 male and 50 females) from 19-25 year-old medical students, of Tehran University of Medical Sciences, Tehran, Iran were enrolled into the study. Metallic and plastic tape was used for anthropometric measurements. All the measurements were taken by a unique person.

### Length of arm measurement

The length of arm was measured in 90 degrees bended elbow in persons with standing position. The length of arm was defined as the distance between acromion end of clavicle and olecranon process [33].

### Stature measurement

During the stature evaluation, subjects were in standing barefoot position and were on the platform of the stadiometer with the upper back buttock and heels pressed against the upright position of the instrument. In addition, the subject's head was positioned in the Frankfort horizontal plane, the shoulders were relaxed, the back was straight, upper surface of the thighs was horizontal, the feet supported and the back of the knee joint was clear of the stool and then the head vertex was contacted to firm and the number was recorded (3).

Data analysis: Data were collected for each sex and analyzed by SPSS version 22.0. Mean±Standard Deviation (SD) was used for descriptive analysis. T-test was used for evaluation of differences between groups. The correlation between height and arm length was evaluated, and the simple linear regression model was used for describing the formula of the population. Then standard error of estimate (SEE) and coefficient of determination ($R^2$) were calculated for the relation.

## 3. Results

The mean age of cases was 21±1.32 years. Mean age of male cases was 20±1.2 years and female cases was 21±1.81 years and there wasn't significant difference in the age of sex groups (P=0.219).

Mean height of all subjects was 171.23±3.02 m. Mean height of males and females was 176.21±2.77 cm and 162.36±4.39 cm, respectively. Significant differences were observed in the height between the two sexes (P=0.0001, and Table 1). According to Table 1, there was a significant difference in the UAL of sex groups

**Table 1.** Comparison of height and upper arm length in males and females.

| | Sex | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Male | | | | Female | | | |
| | Mean | SD* | Maximum | Minimum | Mean | SD | Maximum | Minimum |
| Height | 180.52 | 5.77 | 195.00 | 167.00 | 162.92 | 4.40 | 171.00 | 154.00 |
| UAL** | 33.72 | 2.30 | 38.00 | 28.00 | 30.12 | 2.29 | 34.00 | 23.00 |

* Standard Deviation/ ** Upper Arm Length

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**Table 2.** Linear regression for estimation of stature from upper arm length of medical students.

| Regression equation | ±SEE | $R^2$ | P-Value |
|---|---|---|---|
| S=91.641+2.509×UAL (cm) | 7.16 | 0.513 | 0.0001 |
| SM=127.197+1.581×UAL (cm) | 4.52 | 0.398 | 0.0001 |
| SF=not defined | 4.32 | 0.035 | 0.102 |

S: stature, M: male, F: female, UAL: upper arm length, SEE: Standard Error of Estimate, $R^2$: Coefficient of Determination.

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(P=0.0001). There was a correlation between stature and UAL of cases (r=0.716, P=0.0001, Figure 1). There was a correlation between height and FAL of male cases (r=0.631, P=0.0001). However, this correlation wasn't significant for female cases (r=0.231, P=0.102).

According to the linear regression, there was a relation between height and UAL of all cases (SEE=7.16, $R^2$=0.513, Table 2) and male cases (SEE=4.52, $R^2$=0.398, Table 2).

## 4. Discussion

Identification is the most important issue in forensic. The long bones and their relation with stature can be useful in forensic identifications. In living populations percutaneous length of bones can be used for prediction of stature in different populations and different age groups [22-26, 18]. In the present study, UAL or percutaneous humerus length was evaluated in 19-25 year old medical Students as a sample from Iranian population.

In the present study, the length of arm was 33.72±2.30 cm for males and 30.12±2.29 cm for females. The results of other studies were similar to the present study in the evaluation of length of arm.

In Croatia, cadavers of 21 males and 19 females have been studied extensively by Petrovečki et al. (2007). They have determined the relationship between the length of the long bones and the height with the help of radiographic images. The results showed that there was a significant difference in the stature and maximum length of long bones between female and male cadavers. The correlation between the stature and long bone length was best for the humerus in females and the tibia in male [34]. In another

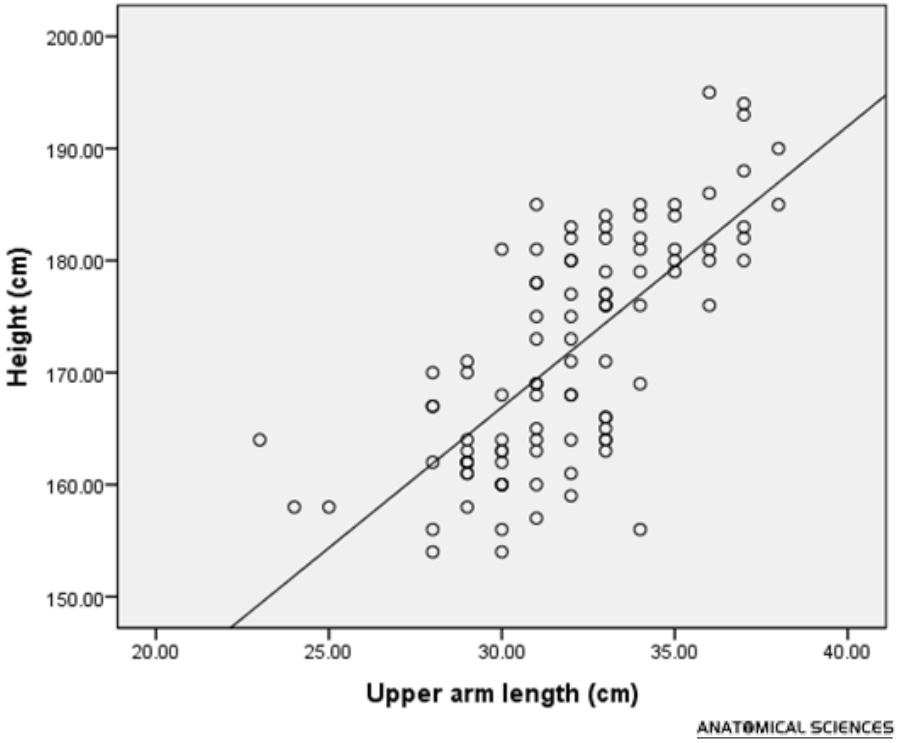


**Figure 1.** Correlation between height and upper arm length of cases (r=0.716, P=0.0001).

study in China, Zheng et al. (2011) evaluated the relation of upper limb bones including tibia and fibula with stature. The measurements were taken from computed radiography and mathematical models were used to establish the formulae in teenagers population (from 14 to 18 years old) [35]. De Mendonça et al. (2000), conducted on 200 individuals (100 male and 100 female) from the northern districts of Portugal. In this study, height and bones length were measured directly. Estimation of stature is obtained by applying a mathematical method based on a multivariable linear regression between the height of lengths of humerus and femur. Due to high values of standard deviation, their results weren't applied [36].

In this study, there was correlation between height and UAL and this factor was a predictor for height estimation (SEE=7.16, $R^2$=0.513) in Iranian population. In addition, correlation between stature and UAL in males was significant. However, it was a poor predictor for stature estimation (SEE=4.52, $R^2$=0.398, Table 2).

Nath and Krishan (1990) could formulate multiplication factors for predicting the stature from UAL in 276 Hindu (Baniya) females of Delhi (ages 15-22 years). The SEE was 4.95 whereas in comparison to our study the SEE was 7.16 for Iranian population [37]. In another study conducted by Nath, Garg and Krishan, 160 male Rajputs of Tehsil Chakrata; district Dehradun, Uttar Pradesh (aged 16-35 years) were evaluated for the relation between UAL and stature. SEE for this study was 5.12 [38].

Kaur et al. (2011) conducted a study on 400 cases for evaluation of UAL and stature in North Indians. SEE was 5.621 for males and 5.326 for females. They could formulate this relation by linear regression equations (S=14.75±1.95 UAL) [39].

Shah et al. (2015) introduced a model for height estimation from shoulder width, arm length and foot length in Muslim and Hindu of Gujarat, Indian populations. In this study, 160 subjects (128 male and 32 female, aged 20-50 years) were studied. Multiple regression analysis was performed for finding the relation between height and the evaluated factors. SEE was 6.65 for both sexes. $R^2$ was 0.564 in this study and was a moderate predictor for height estimation in this study.

Their result was similar to the results of present study [40]. In this study, the linear regression equations were used for calculating the stature from UAL in Iranian medical students: S=91.641+2.509×UAL (cm).

According to the results of present study, there was relationship between the UAL of and height and UAL can be a moderate predictor for stature estimation.

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