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IJAE
Vol. 121, n. 1: 43-50, 2016
ITALIAN JOURNAL OF ANATOMY AND EMBRYOLOGY

Research article – Basic and applied anatomy

Stature estimation and formulation of based on ulna length in Kurdish racial subgroup

Kimia Ghanbari[1], Ali Reza Nazari[1], Ali Ghanbari[2,*], Shima Chehrei[3,*]

[1]Student Research Committee, [2]Fertility and Infertility Research Center, Kermanshah University of Medical Sciences, Kermanshah and [3]Department of Biology, Arak Branch, Islamic Azad University, Arak, Iran

Abstract

Measuring stature is useful for forensic and anthropometrical sciences. The present study was conducted to calculate the stature from ulna length among Kurdish racial subgroup living in Iran. In this study, 50 females aged 19-24 were recruited. The ulna length of subjects was taken independently on left and right sides using a digital sliding caliper. The height was measured between vertex and floor. The height (Y) was also estimated by linear regression formulas from the length of right (X1) or left side ulna (X2). For right side, Y1 = 59.48 + 4.005 X1 ± 4.09295 (R=0.753); for left side, Y2 = 63.44 +3.887 X2 ± 4.24106 (R=0.731). The derived formulae are population specific and are designed for use in forensic and anthropometric skeletal analysis of Kurdish racial subgroup. These data provide a scientific basis for further investigations on racial subgroups living in Iran.

Key words

Forensic, Physical anthropology, Ulna, Stature, Kurd, Iran

Introduction

Knowledge about physical characteristics of a racial subgroup may be a resource for forensic medicine and physical anthropology (anthropometry). Anthropometrical studies evaluate the effect of environment, sex and ethnic group on physical characteristics of populations. Although identification of race is difficult because of intermingling of populations amongst generations, belonging to one population subgroup through three ancestors is considered a valid method to establish the ethnicity of subjects (Farkas et al., 2005; Durtschi et al., 2009; Ghanbari and Bayat, 2009).

Many direct and indirect methods have been proposed to categorize racial subgroups from molecular and cellular levels up to gross appearance. DNA profiling, blood typing, blood and tissue sampling in the remnants of corpses or in living bodies offer accurate information to estimate the ethnic origin of subjects, and at gross levels fingerprints, footprints and physical architecture are used for this purpose (Krane et al., 2008; Verma and Goswami, 2014).

The estimation of stature is one of the most important parameters in physical anthropometry and forensic medicine. However, the estimation of stature is difficult in old people, myopathy and spinal disorder patients and also in incomplete and decomposing corps. In such difficult cases, indirect methods have been developed to estimate the stature (Mohanty,1998; Ilayperuma et al., 2010).

* Corresponding authors. E-mail: aghanbari@kums.ac.ir, sh-chehreii@iau-arak.ac.ir

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http://www.fupress.com/ijae
DOI: 10.13128/IJAE-18343

Measuring long bones is an indirect method for estimating the stature of both for living and dead individuals. The importance of long bones is that they remain for many years after death and are subcutaneous in some cases, like tibia and ulna (Trotter and Gleser, 1952; Gauld et al., 2004; Dayal et al., 2008; Agnihotr et al., 2009; Ghanbari and bayat, 2009; Gupta et al., 2014).

In the case of Iran, there are not enough studies to establish the physical characteristics of living or dead people. This study was conducted to estimate the stature of an ethnic group living in the west of Iran named Kurds. The ulna length and height were measured to compute a formula useful to estimate the stature for Kurdish ethnic subgroup through an indirect anthropological method.

Materials and methods

This cross sectional study was carried out on 50 Kurdish female subjects, medical students in basic science or physiopathology courses at Kermanshah University of Medical Sciences. The individuals with asthma; preterm birth; spinal deformity; previous treatments with growth affecting drugs; neuromuscular diseases; and any growth retardation signs were excluded from the study. The individuals were selected from those whose last three generations belong to Kurd ethnic subgroup (Ghanbari and Bayat, 2009).

Stature, body weight, left and right ulna length, arm span, wrist circumference were measured. All measurements were performed in light clothing with shoes and socks removed. Weight measurements were in kilograms to the nearest 100 g (Gauld et al., 2004).

The ulna length was defined as the direct distance between the tip of the olecranon and the styloid process in full flexion of the elbow joint. Ulna length was taken independently on the left and right side of each individual using a digital sliding caliper to the nearest 0.01 mm. To measure height the persons were standing in anatomical position and the head in the Frankfurt plane. Then the distance between vertex and the floor was measured to the nearest 0.1 cm.

All the measurements were taken at a fixed time between noon and 1:00 p.m.to eliminate discrepancies due to diurnal variation. Furthermore, the measurements were recorded by the same person to minimize the errors in methodology (Ilayperuma et al., 2010).

The data were expressed as mean and standard error of the mean (S.E.) and analyzed using the SPSS software for Windows (version 19.0; SPSS Inc, Chicago, IL). Student's *t*-test for paired values was used to evaluate the difference between right and left ulna length. Pearson's product-moment correlation coefficient between variables was computed. The relation between the ulna length and stature was investigated by linear regression analysis. Significance limit was set at $p<0.05$.

Results

The age of subjects was in the range 19 years and 5 months to 23 years and 11months. The mean age was 21.99 ± 0.145 (Tab. 1). The height ranged between 149.5

Table 1 – Anthropometrical parameters and age of Kurdish females under study.

	Height	Weight	BMI	Wrist	Arm	Right	Left Ulna	Age
Mean	162.01	57.06	21.64	14.65	163.94	25.604	25.361	21.99
S.E.M	0.870	1.198	0.392	0.127	0.931	0.161	0.163	0.145

Table 2 – Correlation coefficients between estimated parameters in Kurdish females (*p<0.05, **p<0.001).

	Height	Weight	BMI	Wrist	Arm	Right ulna	Left ulna	Age
Height	1	0.508**	0.000	0.218	0.861**	0.753**	0.731**	-0.062
Weight	0.508**	1	0.853**	0.773**	0.413**	0.371**	0.381**	-0.016
BMI	0.000	0.853**	1	0.774**	-0.040	-0.027	-0.008	0.033
Wrist	0.218	0.773**	0.774**	1	0.158	0.093	0.117	0.059
Arm	0.861**	0.413**	-0.040	0.158	1	0.837**	0.831**	-0.146
Right ulna	0.753**	0.371**	-0.027	0.093	0.837**	1	0.987**	-0.184
Left ulna	0.731**	0.381**	-0.008	0.117	0.831**	0.987**	1	-0.180
Age	-0.204	-0.080	0.047	0.008	0.295**	-0.333*	-0.310*	1

cm and 174.5 cm and the maximum number of subjects (more than 50%) were in the range 160-169 cm. The mean height was 162.01 ± 0.870 (Tab. 1).

The mean length of right ulna was 25.604 ± 0.161, range 23.18 to 28.12 cm, and that of left ulna was 25.361 ± 0.163, range 23.12 to 27.73 cm (Tab 1). Right ulna was significantly longer than left one ($p < 0.05$; Fig. 1; Tab. 1).

Pearson's correlation coefficient showed that height was significantly correlated with weight ($p < 0.05$) and arm span ($p <= 0.05$) but not significantly with body mass index, wrist circumference and age (Tab. 2). Height was also positively correlated with right and left ulna length ($p < 0.5$; Tab. 2).

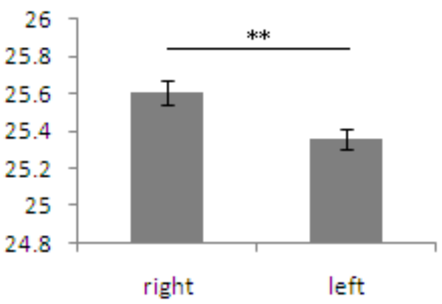

Figure 1 – Length of right and left ulna in Kurdish females (**p<0.001).

Regression analysis was applied to estimate individual's height from ulna length. Simple correlation coefficient (R) between height and ulna length was 0.753 for right ulna and 0.731 for left ulna respectively, suggesting a positive correlation between the length of ulna and height. Then, estimation of total skeletal height (y) from ulna length (x) was computed as $y = a + bx$ ± S.E. assuming linear regression. The formulas for right ($y1$, $x1$) and left ($y2$,

Table 3 – Regression equations for stature and length of ulna in Kurdish females (S.E.E= Standard Error of Estimate).

Observations	Right	Left
Independent variable (x)	Length of ulna (x1)	Length of ulna (x2)
Intercept (a)	59.48	63.44
Regression coefficient (b)	4.005	3.887
R Square(R2)	0.566	0.534
S.E.E	4.09295	4.24106
Regression formula: y = a + bx ±SE	y1 = 59.48 + 4.005 x1 ±SE	y2 = 63.44 +3.887 x2 ±SE

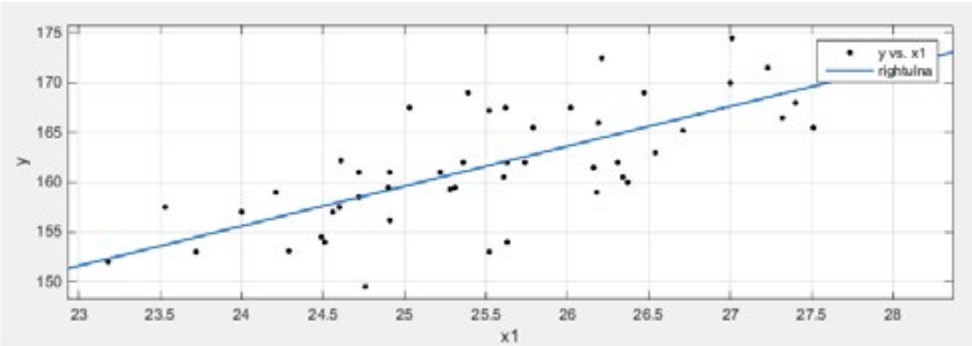

Figure 2 – Correlation between length of right ulna and stature in Kurdish females.

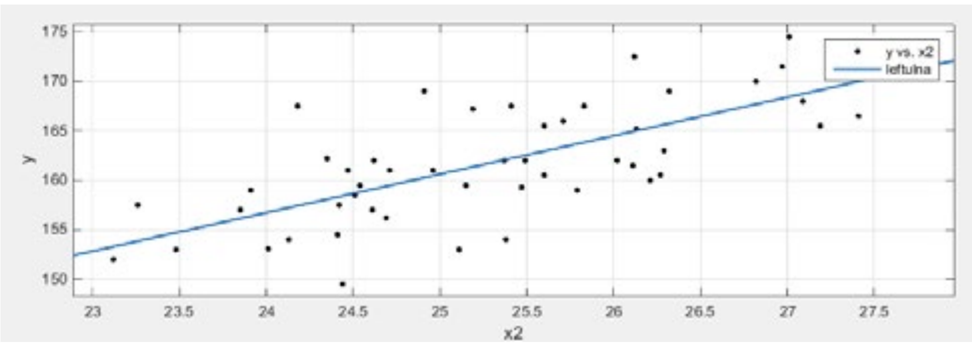

Figure 3 – Correlation between length of left ulna and stature in Kurdish females.

x2) side were: *y1*= 59.48 + 4.005 *x1* ± 4.09295 and y2= 63.44 +3.887 *x2* ± 4.24106 (Tab. 3).

Scatter diagrams were drawn to show the distribution of individuals' height against right (Fig. 2) and left ulna length (Fig. 3).

Discussion

Estimation of stature by ulna length was one aim of present study; the results and derived equations are unique for Kurdish racial subgroup.

The length of a long bone has different relationship with the stature of each individual subject. Thus, addressing only the mean length of long bones the individuality of each body would be missed. To resolve this problem we took into account the standard error of estimate derived from regression equation (Mohanty, 1998).

In this study, the standard error of estimate was 4.09 for computations from the right ulna and 4.24 for computations from the left one. The standard errors of estimate for computations from other bones are somehow higher than long bones that indicates that long bones are best suitable for this estimate. In details, standard error of estimate ranged from 2.40 to 3.79 cm when using long bones according to Dayal et al. (2008) and was comparable or slightly higher according to other studies; for whites, Trotter and Gleser (1952) displayed values of 2.99 to 4.45 cm, Dupertuis and Hadden (1951) of 2.25 to 3.09 cm and Lundy and Fledesman (1987) of 2.77 to 3.83 cm. Barbaosa et al. (2012) from Portugal found a standard error of 4.6 cm using ulna length. The results from other studies using other bones showed standard error of estimates of 5.89 to 7.28 cm when starting from the skull (Chiba and Terazawa, 1998), 5.30 to 5.49 cm from the vertebral column (Tibbetts, 1981), 5.10 to 8.14 cm from metacarpals (Musgrave and Harnejac, 1978; Meadows and Jantz, 1992) , 4.65 to 7.60 cm from metatarsals (Byers et al., 1989) and 4.13 to 6.07 cm for the talus and calcaneus (Holland, 1995; Bidmos and Asala, 2005) . This indicates that the long limb bones produce the lowest error of estimates and should be used as first choice to estimate stature whenever possible. In predicting height, the ulna length proved to be superior to arm span and hand length (Ilayperuma et al., 2009). Furthermore, linear regression equation of height on ulna length has definitive advantage over that of tibial length, as it can be useful in cases where the lower extremities are deformed along with the deformities of the trunk (Joshi et al., 1964).

A study that attempted to reconstruct stature from ulna length in Hindu population in Gujarat State found a regression coefficient between height and ulna length of +3.506 for males (Joshi et al., 1964). A study on North Indian males found a regression coefficient for tibia of 2.37 for the right side and 2.39 for the left side (Dayal et al., 2008). In the present study a regression coefficient of 4.057 was found for the right ulna and of 3.887 for the left ulna.

Although a variety of methods have been proposed to predict stature from long limb bones, regression analysis proved to be the easiest and most reliable method (Meadows and Jantz, 1999; Krane et al., 2008).

Our findings are in keeping with those of previous researchers that found an accurate relationship between height and long bone (radius and ulna) length using regression analysis (Celbis and Agritmis, 2006; Agnihotr et al., 2009, for Mauritius and those of Barbosa et al., 2012, for Portugal).

Ethnic variations in the relationship between height and ulna length has been clearly demonstrated by comparative studies between Black, White and Asian subjects (Madden et al., 2008). Trotter et al. (1952) computed different regression equations for different populations and emphasized that for every particular age group and sex of each population a proper table is required to estimate height using various parameters (Trotter et al., 1952).

Farsinejad et al. (2014) estimated the stature of females (20-40 years old) in a sample population of Iran (n=52). They found a significant positive correlation between the length of ulna and of tibia with body height for both sexes and estimated that average height was 160 ± 3.9 centimeters for females (Farsinejad et al., 2014). It has also been seen that the stature of people differs not only among States but also among different regions of the same State (Gupta et al., 2014); hence it is necessary to achieve a new formula to estimate stature in each area.

Age is another factor affecting stature. All epiphyses and diaphyses would be joined by the age of 20. Therefore Indians stop growing in height by that age, as confirmed by several authors (Hepworth, 1929; Pillai, 1936; Galstaun, 1937; Basu et al., 1938; Lall et al., 1939). In the present study the age of studied subjects was restricted to the narrow range from 19 years 5 months to 23 years 11 months, therefore the effect of age on the length of ulna could not be investigated.

In conclusion, this study presents unique data about the range of ulna length in girls of Kurdish ethnic subgroup and for the estimation of stature in Kurdish ethnic subgroup on the basis of ulna length. The data may be useful for further investigations on ethnic subgroups living in Iran.

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