SEX DETERMINATION FROM THE COMPLETE HUMERUS IN THE FORENSIC PRACTICE

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ABSTRACT

Introduction: Determination of sex from the skeleton is vital to medicolegal investigations. There is no longerany question that populations differ in size and proportions and these differences affect the metric assessment of sex. The purpose of this research is to establish metric standards for sex determination from the humerus of Bulgarian contemporary population.

Materials and methods: Maximum humeral length, minimum and maximum midshaft diameters, midshaft circumference, minimum circumference of humerus, circumference at deltoid tuberosity, circumference of the head, transverse diameter of the head, vertical diameter of the head and epicondylar breadth have been measured in 135 adult humeri of known sex (47 females and 88 males) and subjected to discriminant function analysis.

Results and conclusions: Discriminant function equations were derived for combined variables from the intact humeri. Multivariate stepwise discriminant function analysis included two variables of humerus (maximum length and circumference of the head) and achieved an average accuracy of 89,8%.

Keywords: *Humerus, Sex determination, Discriminant function analysis, Forensic anthropology*

INTRODUCTION

The estimation of sex plays a key role for the forensic analysis of human skeletal remains. The identification is the basic parameter in skeletal analysis since the determination of age, race and stature to an extent depends on the sex of the deceased. When visual assessment of the pelvis and cranium, considered to be the most accurate method for sex estimation, is not possible [1, 2] due to the fragmented state of these bones and severe decomposition [3] of the body, metric estimation is a useful approach if only for the high rates of accuracy [4, 5, 6, 7]. A large number of studies had shown variability in anthropometric dimensions between populations. Regional variations in the standard statistical values for determination of sex are an established fact. Many factors such as genetics, environmental, racial, socio-cultural factors etc. are responsible for these variations [8]. This study aims to demonstrate the accuracy of sex determination through use of the maximum humeral length (MHL), minimum and maximum midshaft diameters (MaMD, MiMD), midshaft circumference (MC), minimum circumference of humerus (MCH), circumference at deltoid tuberosity (CDH), circumference of the head (CH), transverse diameter of the head (TDH), vertical diameter of the head (VDH) and epicondylar breadth of humerus (EBH) among the contemporary Bulgarian population. The study has applied value in the field of forensic anthropology.

MATERIALS AND METHODS

A total of 135 complete humeri from 47 females and 88 males were studied. The bones were collected from the Department of General and Clinical Pathology and Forensic Medicine, Medical University-Plovdiv and the Department of General and Clinical Pathology and Forensic Medicine, Medical University-Varna, Bulgaria. The bones included in this study fulfill the following criteria: show no anomalies, deformations or abrasions; have sustained no fractures previously; have reached skeletal maturity. They belong to Bulgarians born after 1910; the average age of the known male bones is 56,8 ± 13,44 years, and of the female ones 64.3 ±

13,97 years (Mean±SD). A total of four humeral dimensions (to the nearest millimeter) were taken using sliding caliper and steel tape. Measurements include maximum humeral length (MHL), minimum and maximum midshaft diameters (MaMD, MiMD), midshaft circumference (MC), minimum circumference of humerus (MCH), circumference at deltoid tuberosity, circumference of the head (CDT), transverse diameter of the head (TDH), vertical diameter of the head (VDH) and epicondylar breadth of humerus (EBH) and were taken according to the standard procedure of Martin – Saller [9, 10].

Statistical package for social sciences (SPSS 17.0) was used. We defined the protocol as follows: for each pair, the humeral parameters were measured on both left and right humeri in order to assess if a statistical significant difference between the two sides could be recorded. The Paired samples t-test was used to compare the right and the left sides. In order to minimize measurement error, we completed five measurements for each variable of each side. Then we excluded the least measurement and the greatest measurement. Finally, we computed the mean of the three other values and used it to characterize a bone. Basic descriptive statistics were computed. For each side, the values of the bones were tested for normality of the distribution by the Kolmogorov-Smirnov test. The Independent Samples test for equality of means of male and female independent samples was performed for all measured variables. All measurements that were obtained for all variables were also subjected to discriminant function analysis using multivariate stepwise method.

RESULTS

The Kolmogorov-Smirnov test could not reject the hypothesis of normality of the distribution of the mean values computed ($P > 0,05$). No statistical difference was found between the right and left side for the mean values computed for both genders ($P > 0,05$), thus, allowing the bones of both sides to be grouped together. However, only one bone, either the left or right, has been included in the analysis (database – 135 humeri). All measurements are exhibiting highly significant sex differences (Table 1). As a result, these landmarks may successfully be used as sex discriminants.

Only two variables of humerus (maximum length and circumference of the head) were selected by the multivariate stepwise procedure. The discriminant statistics and the classification percentage of the function can be seen in Table 2 and Table 3. The combined accuracy was 89,8 %. A discriminant score is obtained by multiplying each variable by its unstandardized (raw) coefficient and adding them together along with the constant. If the score is greater than the sectioning point, the individual will be classified as male, a value below that point will be female.

DISCUSSION

All measurements of the Bulgarian humerus show the presence of sexual dimorphism. Multivariate stepwise discriminant function analysis including two variables of the intact humerus (maximum length and circumference of the head and) achieves an average accuracy of 89,8 %. However, the upper end is more successful in sex identification than the intact humerus (90.4% vs 89.8%). On the other hand the intact humerus is a better sex predictor than the lower fragment (89.8 % vs 85.6 %). It is concluded that proximal measurements are likely to be more accurate because this area is subjected to greater biomechanical function and stress. Another possible explanation for this phenomenon is the fact that the actions of the elbow joint are more restricted than the actions of the shoulder joint [11].

Potential conflicts of interest. None.

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	M (88)		*F(47)*			
	$\bar{x}$	***SD***	$\bar{x}$	***SD***	***t***	***P***
1. MHL	331.70	18.66	295.95	15.83	11.481	0.001
2. MaMD	22.77	2.17	19.76	1.72	8.439	0.001
3. MiMD	18.79	1.68	15.61	1.76	9.694	0.001
4. MC	69.76	5.43	61.04	4.18	10.121	0.001
5. MCH	66.91	5.11	58.42	4.10	10.286	0.001
6. CDT	69.24	5.29	60.18	4.48	10.118	0.001
7. TDH	43.65	2.89	37.93	2.57	11.704	0.001
8. VDH	47.92	2.96	41.20	2.95	12.506	0.001
9. EBH	64.49	4.70	55.11	4.24	11.425	0.001
10. CH	148.48	8.37	128.38	7.50	14.402	0.001

Table 1. Summary statistics of variables

	Raw coefficient	***Standart coefficient***	***Structure coefficient***	***Sectioning point***
CH	0.088	0.734	0.960	- 0.380
MHL	0.020	0.359	0.821	
Constant	-18.891			

Table 2. Multivariate discriminant function coefficients and sectioning points

Percent correctly classified		
Male	***Female***	***Total***
92.6 %	84.8 %	**89.8 %**

Table 3. Percentage of correct sex classification for the discriminant function equation