RECONSTRUCTION OF HUMERUS LENGTH FROM ITS PROXIMAL FRAGMENTS IN A BULGARIAN MODERN POPULATION

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Abstract:

Estimation of stature from bones has anthropological and forensic importance. It is well known that the intact femur and humerus have the highest correlation with stature. However, the intact femur or humerus are not always recovered in forensic cases. The current study introduces a method of estimating the length of humerus from partial proximal elements specific to the Bulgarian population. 139- adult humeri belonging to known age and sex were studied. The method is based on several landmarks and distance between them, such as circumference of the head, transverse diameter of the head and vertical diameter of the head. Simple linear regressions were obtained to define these estimates. For males, regression formula, which included head circumference measurement, provided the best fit of the data, resulting in the highest correlation. For females, the vertical diameter of the head showed the best correlation with maximum length. The regression formula suggested that the proximal end is the best estimator of humeral length. The derived formulae are population and sex specific.

Keywords: *forensic anthropology, fragmentary humerus, regression equation*

1. Introduction

The estimation of stature is a very important step in developing a biological profile for forensic identification. However, populations vary in terms of the relationship between limb bone lengths and stature, and stature equations have been shown by many researchers to perform less well when developed on one population and applied to another (1–3). Therefore, unique stature estimation equations may be required for each population of interest (4). Many stature studies focus on a set of intact long bones for stature estimation, while a few have focused on fragmentary major bones of the arms and legs (5).

There are two alternative approaches for estimation of living stature from skeletons: anatomical and mathematical (6). The anatomical method was developed by Fully, who summed heights and lengths of skeletal elements directly contributing to stature. It has been shown that anatomically derived stature estimates strongly correlate with living stature (r = 0.98–0.99) and have high accuracy with an average error of < 1 cm. In summary, this method isbased on the measurement of the whole skeleton, including the spinal column and adding the dimensions of soft parts (7,8). The mathematical method is based on proportionality between height and length of long bones (9). The mathematical reconstruction of stature with the help of long bones and their fragments has an established practical application in forensic identification, because in most of the forensic cases, it is difficult to employ the anatomical method due to non-availability of the complete skeleton (5).

The long bones are not always recovered intact at the crime scene, thus the implication of regression equations derived from the whole bones becomes impossible for example when the identity of dead body is obscured by injury, burning, mutilation, post-mortem gnawing by wild animals or mass disasters (5, 10).

The humerus was selected in the present study because it is the best single bone for predicting body height in adult humans as the femur compared with the other long bones. However, complete humerus is rarely preserved in most forensic identifications. In the current study, the length of the humerus was assessed in relation to its proximal fragments. This study is an effort to derive regression equations for reconstruction of the length of the humerus from its fragments. In the absence of intact long bones, these equations can offer a reasonable estimation of maximum humeral length from which the stature can be estimated in sex and population sample.

2. Material and methods

A total of 139 adult humeri belonging to the modern Bulgarian population were measured. These bones were collected in 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 age and sex of all the specimens were documented. All of the individuals examined in this collection were born after 1920. We excluded bones with prostheses, cortical bone deterioration, extreme osteophytic activity and diffuse osteoarthritis.

Three measurements were taken. The measurements were taken using a digital osteometric board, Vernier calliper (precision 0,01 mm) and graph paper according to the standard procedure recommended by Martin and Saller (11): circumference of the head, transverse diameter of the head and vertical diameter of the head. All the measurements are in mm. 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 bones. Statistical package for Social Sciences (SPSS 17.0) was used. For each pair, the humeral parameters were measured on both left and right femora in order to assess if a statistically significant difference between the two sides could be recorded. Paired sample t-test was used to compare the right and left sides. 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. Then, Pearson's correlation coefficients (*r*) and standard error of estimate (SEE) were obtained. As a rule of thumb, we shall consider correlation coefficient between 0.00 and 0.30 as weak, those between 0.30 and 0.70 as moderate and coefficients above + 0.70 as high. The correlation of the humeral fragmentary measurements to the maximum length was studied individually. Regression equations were formulated from these coefficients depending on the sex. In the simple linear regression equations ($y = a + b.x$), y is the maximum length, a is the intercept, b is the slope, x is the measure of the predictor variable. Regression equations with the maximum length of humerus as the dependent variable and other measurements as independent variables were obtained using the male and female sample. Considering the possibility of the proximal end of the humerus being presented for forensic analysis, the regression equations were derived using the three measurements.

3. Results

The characteristics of the sex repartition and the age mean value of the population are detailed in Table 1. 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 sexes ($P > 0.05$), 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 – 139 femora). All measurements are exhibiting highly significant sex differences (Table 2).

SEX	N	Age mean	Range	SD
M	90	56.8	19-83	13.44
F	49	64.3	31-82	13.97

Table 1

Variables	Male		Female		P
	Mean	SD	Mean	SD	
Circumference of the head (CH)	148.5	8.61	128.6	7.77	<0,001
Transverse diameter of the head (TDH)	43.9	2.87	38.01	2.58	<0,001
Vertical diameter of the head (VDH)	47.9	3.02	41.2	2.99	<0,001

Table 2

All the measured variables showed significant positive correlation with maximum length (HML). Head circumference displayed the highest correlation (0.652 at 0.001 level) with maximum length in males. Vertical diameter of the head showed the highest correlation (0.653 at 0.001 level) with maximum length (FML) in females.

Only the best regression equations with reasonable application are presented. Head circumference (CH) showed the highest correlation for individual male measurement, while vertical diameter of the head (VDH) displayed the highest correlation for individual female measurement. The regression equations were derived using the two variables depending on the sex (Table 3).

Equations	**Correlations**	**SEE**	**Sex**
121.31 + 1.41. CH	0.652	14.33	Male
156.63 + 3.36.VDH	0.653	11.80	Female

Table 3

4. Disscussion

During identification of skeletal remains, general living features such as age, sex and ethnic affinity of the individual are determined first. To increase the identification further, estimation of stature of an individual is a cornerstone of medico-legal investigations. For many years intact long bones have been used for stature estimation. But in many cases, the stature has to be calculated from bone fragments. Thus, the mathematical reconstruction of stature plays a key role in forensic anthropology. To know the stature of an individual, the length of the long bones is required, including differences within and between populations (5).

In the current study, the length of the humerus was assessed in relation to the proximal fragments of the bone. This study is an effort to derive regression equations for reconstruction of the length of the humerus from its fragments. In the absence of intact long bones, these equations can offer a reasonable estimation of maximum humeral length from which the stature can be estimated in sex and population sample. For males, regression formula, which included head circumference measurement, provided the best fit of the data, resulting in the highest correlation. For females, the vertical diameter of the head showed the best correlation with maximum length. The regression formula suggested that the proximal end is the best estimator of humeral length. The derived formulae are population and sex specific. Estimating stature from a bone fragment is the weak spot, because in this case the generated error is arising from the cumulative effect of two standard errors (relating to estimating the long bone length from the fragment size and then stature from the estimated long bone length).

5. References

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