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OSTEOMETRIC METHOD FOR RECONSTRUCTING THE BIACROMIAL BREADTH OF THE SHOULDERS FROM THE CLAVICLES IN FORENSIC EXAMINATION OF BONE REMAINS

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ABSTRACT

Positive identification of unknown corpses and bone remains often pose significant challenges for practitioners and requires the use of forensic anthropological methods. The purpose of this study was to develop new methods for reconstructing the antemortem biacromial breadth of the shoulders (BAB) using osteometric measurements of the human clavicle. For this purpose, bone samples from two anatomical collections were used: collection of the Department of Anthropology of Lomonosov Moscow State University and collection of the Russian Center for Forensic Medical Examination (Moscow, Russia). The study showed the possibility of correct reconstruction of BAB using regression equations with expanded (13) or reduced (3-5) sets of osteometric parameters. The methods described in the article can be applied both in forensic context and in anthropological studies.

Keywords: – clavicle, biacromial breadth of the shoulders, shoulder breadth, linear multiple regression, forensic anthropology, human identification.

INTRODUCTION

Positive identification of unknown corpses and bone remains often pose significant challenges for practitioners and truly considered as one of the cornerstones of forensic medicine. A medical examiner can be involved in the identification of human remains due to the peculiarities of the current geopolitical situation, in cases of man-made or natural disasters, as well as when investigating the cases of homicide. Working with bone remains means using the methods of physical anthropology widely as they make it possible to estimate the four most important primary identifiers (sex, age, race, body length) and carry out the identification with minimal time and without the use of complex and expensive equipment [1]. Positive identification of an unknown person largely depends on the degree of preservation of the objects submitted for examination. The clavicles, along with other bones of the shoulder girdle, are an important object for forensic osteological research [2], as they have some important features: 1. as a rule, the clavicles are quite well preserved; 2. they reflect individual characteristics peculiar to a particular person (for example, the presence of a rhomboid fossa, signs of osteoporosis or the consequences of a fracture) and common features such as sex, age, body type, skeleton massiveness and somatometric signs including body length and shoulder breadth.

Shoulder breadth (biacromial, BAB) is the horizontal distance between the right and left acromial landmarks (ac-ac). The average values of BAB in Caucasian populations are 386.06±23.09 mm for men and 349.26±20.88 mm for women [3]. There are several methods for BAB reconstruction from the clavicles developed over the past 50 years and using different approaches [4-7]. Despite this fact, the need for the development of new osteometric methods for the purposes of forensic medicine that meet the criteria of validity, reliability and objectivity is still great.

The aim of the study was to develop new methods for reconstructing the antemortem biacromial breadth of the shoulders from clavicle osteometrics using linear multiple regression models.

MATERIAL AND METHODS

Bone samples from two documented anatomical collections were used: series 1 – a collection of skeletons from the Department of Anthropology of Lomonosov Moscow State University (Russians, mid-20th century, N=83); series 2 – «RCFME» (Russians, 20^{th} century, N=152), bone samples from the osteological collection of the Russian Center for Forensic Medical Examination (Moscow, Russia). The total number of bone samples examined was 235. The definitions of clavicle measurements follow the standard methodology [8-9]:

CLM-1. The total length of the clavicle: the distance between the most medial point of the sternal end of the clavicle and the most lateral point of its acromial end.

CLM-4. The length of the clavicle shaft: the distance from the sternal end of the clavicle to the most forward-protruding point of its diaphysis. The value is measured in parallel with the total length of the clavicle (CLM-1).

CLM-5. The clavicle circumference: the perimeter of the clavicle in the middle of the shaft. The measurement site is defined as half the total length of the clavicle.

CLM-6. The largest diameter of the clavicle: the empirically determined maximum size at the mid-shaft of the bone.

CLM-6A. The sagittal diameter of the clavicle: the straight distance between the anterior and the posterior edges of the mid-shaft of the clavicle.

CLM-7. The smallest diameter of the clavicle: the empirically determined minimum size at the mid-shaft.

CLM-7A. The vertical diameter of the clavicle (clavicle thickness): the distance between the cranial and the caudal surfaces of the mid-body of the clavicle.

CLM-8. The height of the clavicle shaft arc: the height of the most forward-protruding point of the anterior side of the clavicle shaft edge above the straight line connecting the most retracted points of the sternal and the acromial ends of the clavicle at its posterior side.

CLM-8A. The depth of the sternal end arc: the projection distance from the deepest point of the sternal end arc to the tangent passing through the apex of the acromial end arc and the posterior edge of the sternal end.

CLM-9. The height of the arc of the clavicle acromial end: the height of the most forward-protruding point of the anterior side of the clavicle acromial end above the straight line connecting the most retracted points of the sternal and the acromial ends of the clavicle at its posterior side.

CLM-9A. The depth of the acromial end arc: the projection distance from the deepest point of the acromial end arc to the tangent passing through the apex of the sternal end arc and the anterior edge of the acromial end.

CLM-10. The length of the deltoid tuberosity: the straight distance between the most anterior point of the clavicle acromial end to the most medial point of its deltoid tuberosity.

Osteometric measurements were collected using a standard sliding caliper, osteometric board, and millimeter measuring tapes. Pearson parametric correlation analysis was performed to study the relationship between osteometric clavicle measurements and antemortem shoulder width ($p<0.05$). The linear multiple regression equations were calculated using the StatSoft STATISTICA 10.

RESULTS AND DISCUSSION

After data processing, two groups of linear multiple regression equations were obtained: 1. With a reduced set of osteometric measurements including the total length of the clavicle (CLM-1), the length of the clavicle shaft (SLM-4), the clavicle circumference (SLM-5), the length of the deltoid tuberosity (SLM-10); 2. With an extended set of 13 measurements. In order to select the measurements for the resulting equations correctly, the correlation analyses was performed between antemortem BAB and osteometric measurements of the human clavicle. Moderate correlations were found between BAB and CLM-5 (r=0,28); BAB and CLM-6 (r=0,27); BAB and CLM-8 (r=0,26). Strong correlation was observed only between BAB and CLM-$1_{dex+sin}$ (r=0,96).

Table 1 shows the coefficients of the regression functions (models). To work with these models, the researcher needs to substitute the values of the clavicle osteometric measurements in the following equation: $y=a+b_1x_1+b_2x_2+...+b_nx_n$, where *a* – the constant, *b* – osteometric parameter, *x* – regression coefficients. The sex is not taken into account.

Table 1. *Shoulder breadth (biacromial) estimation from the clavicle using the linear multiple regression*

Measurements	Coefficients		
	Model 1	Model 2	Model 3
CLM-1_{dex}	0,921	0,470	1,188
CLM-1_{sin}	0,763	0,794	-0,009
CLM-4		1,181	0,571
CLM-5		1,782	2,761
CLM-6			4,125
CLM-6A			-2,020
CLM-7			-2,856
CLM-7A			-3,560
CLM-8			1,945
CLM-8A			-0,376
CLM-9			-0,351
CLM-9A			3,071
CLM-10		0,347	-1,168
Constant	104,213	49,950	49,530
R	0,533	0,670	0,823

The adequacy of the obtained models was evaluated using the multiple correlation coefficient R, which varies within $0 \leq R \leq 1$ and, as it approaches 1, indicates an increase in the closeness of the relationship between two or more variables. In all cases, the models for which the R statistics exceeds 0,5 were selected. The best result, as can be seen in Table 1, was demonstrated by Model 3, which includes the maximum number of measurements (R=0.823).

A noteworthy feature was the presence of correlations between the shoulder width and the longitudinal size of the clavicles (the total length of the clavicle, CLM-1), and also between the shoulder width and transverse dimensions, which also contribute to the resulting regression models (the clavicle circumference, CLM-5; the largest diameter of the clavicle, CLM-6). These results are consistent with previous studies [6] and indicates that for the correct calculation of BAB, it is not enough to measure only the total length of the clavicle, as recommended in [5] and [7].

CONCLUSION

The study showed the possibility of reconstruction of the biacromial breadth of the shoulders from clavicle osteometrics. Using the linear multiple regression, 3 diagnostic models were calculated for reconstruction of BAB regardless of the sex using an expanded or a reduced set of measurements, which is important when working with a limited set of isolated skeletal elements or their fragments. The method described above can be applied for comparison between osteometric and anthropometric datasets both in forensic context and in anthropological studies.

AUTHOR CONTRIBUTION

Dmitriy Sundukov designed the study; Askold Smirnov collected, analysed, interpreted data and provided the table. Askold Smirnov and Dmitry Sundukov prepared the manuscript for submission.

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