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Is it Possible to Determine the Length of the Human Body by the Parameters of the Mandible?

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Abstract: *This study was conducted to investigate the possibility of determining the length of the human body by the size of the mandible. The material of the study was craniological series of Azerbaijanis in number of 50 male mandibles from the museum collection. On each mandible 13 metric features were studied, and the body length of the individual (whose skull was studied) was known. The database of mandible metrics and body length was subjected to statistical analysis. The results of the correlation analysis showed that 6 mandible parameters had an acceptable relationship with body length in the context of regression analysis (r value>0.4). Using these dimensions and applying mathematical modeling it was possible to construct 1 equation of multiple linear regressions for reconstruction of human body length by mandible parameters. This equation can be used only as an additional research method.*

Keywords: *body length reconstruction, metric parameters of the mandible, multiple linear regression equation.*

1. INTRODUCTION

Identification of a person by the bones of the skeleton continues to be one of the urgent tasks of forensic anthropology [1, 2]. Despite the development of DNA technologies, the determination of the signs of the human phenotype (age, height, physique, appearance, etc.) is still very relevant, especially when solving various problems in historical archeology and ethnography [3]. In forensic medicine, if an expert receives a mandible for examination, this allows the expert to determine most of the group personality traits [4, 5]. However, the establishment of the length of the human body by the size of the mandible is not considered in the professional literature and is considered unpromising. Below we present a report on the work, during which we tested the possibility of predicting the length of a person's body from the size of his mandible.

2. MATERIALS AND METHODS

The material of the study was 50 preparations of the mandibles of Azerbaijani men (aged 25 to 55 years) from the museum collection, which is stored in the archives of the Persons of Public Law Association of the FME and PA of the Ministry of Health of the Republic of Azerbaijan. We reported in detail about this collection in some of our previous publications [6, 7]. According to the museum registry, we had information about the sex, age and body length of the individuals whose bones were studied. 13 different mandible sizes were studied on each preparation. When taking measurements, we adhered to the long-known and generally accepted standards recommended by Rudolf Martin [8].The following tools and instruments were used: digital caliper Mitutoyo (accuracy 0.01 mm), caliper (accuracy 0.1 mm), measuring tape, goniometer (accuracy 1^{o}), coordinate caliper (accuracy 0.1 mm). The measurement results were analyzed using standard statistical procedures, as well as correlation and regression analysis [9]. Mathematical modeling and calculations were carried out using the statistical software package Microsoft Excel (version 2016) and MATLAB (version 8.6).

3. RESEARCH RESULTS

Before presenting the results of the study, we note that we studied many more signs on the lower jaw than the 13 that are presented in this publication. In previous years, we worked on the problem of determining the length of the body from the skull as a whole and considered more than 200 craniometric measurements (reference to the relevant sources is available in [7]). In this article, we decided to present only those mandible sizes that had a correlation coefficient with body length r>0.1. Below are the basic statistical characteristics of the studied parameters of the mandible (Table 1).

Table1. *Statistical parameters of the studied mandible dimensions and body length*

Conditional abbreviation	Craniometric signs (number and names according to Martin)	N	x	σ	S_x
Z1	65. Condylar width	50	119,7	3,95	0,4721
Z2	66. Corner Width	50	100,6	5,64	0,6741
Z3	68. Mandible length from corners	50	79	6,4	0,8552
Z4	68(1). Length of mandible from condyles	50	107,2	5,24	0,6263
Z5	70. Branch height	50	63,9	5,5	0,6574
Z6	71a. Smallest branch width	50	31,5	2,83	0,3963
Z7	67. Front width	50	44,9	2,45	0,2928
Z8	69. Height of mandible symphysis	50	31,6	3,15	0,3765
Z9	69(1). Mandible body height	50	31	4,95	0,7071
Z10	69(3). Mandible body thickness	50	10,5	1,35	0,1929
Z11	79. Angle of mandible branch	50	120	5,93	0,8471
Z12	IMC. Mandible notch length	50	27,1	3,07	0,4854
Z13	IMS. Mandible cutting depth	50	6,77	1,42	0,2245
Z14	L. Mandible body length (in cm)	50	169,7	5,28	0,8318

Using the results of our measurements, we then carried out a correlation analysis. For 8 traits, a value of r>0.3 was obtained, showing the average correlation between the parametric parameters of the mandible and body length. An r value above 0.5, indicating a closer relationship between the studied characteristics, was observed in 3 cases. Data on the correlation coefficients of mandible size with body length are given in Table 2.

Table2. *Correlation coefficients between mandible parameters and body length*

Parameter	r	Parameter	r	Parameter	r
Z1. Condylar width	0,567	Z6.Smallestbranchwidth	0,387	Z11. Angle of mandible branch	-0,05
Z2. Corner Width	0,506	Z7. Front width	0,401	Z12.Mandible notch length	0,011
Z3. Mandible length from corners	0,356	Z8. Height of mandible symphysis	0,526	Z13.Mandible cutting depth	0,382
Z4. Length of mandible from condyles	0,431	Z9. Mandible body height	0,302	–	–
Z5. Branch height	0,438	Z10. Mandible body thickness	0,347	–	–

A strong connection (r>0.7) in the studied correlation matrix was not revealed for any of the mandible parameters. However, there were 6 traits in which the correlation coefficient with body length was r>0.4. To a certain extent, these signs could be used to construct regression equations for predicting body length. With the help of 6 features that showed the relationship of an average and above average degree with the body length, it was possible to build several models of multiple linear regression, which allows reconstructing the body length according to the mandible parameters. However, for the implementation of the plan, one condition had to be observed - the minimum correlation of the parameters used for the forecast with each other. According to this message, the correlation coefficients of the traits we studied were calculated for all possible combinations in pairs of the indicated traits. In total, in order to determine the compatibility of mandible sizes, r values for 15 pairs of features were obtained as part of a specific regression equation (they are presented in Table 3).

Table3. *Coefficients of correlation between mandible parameters*

Conditional parameter designations	Z1	Z2	Z4	Z5	Z7	Z8	
Z1	1	0,365	**0,486**	0,251	0,187	0,347	Correlation coefficients
Z2		1	**0,461**	0,262	0,143	0,218	
Z4			1	0,273	0,343	**0,470**	
Z5				1	0,171	0,356	
Z7					1	0,307	
Z8						1	

The analysis of this correlation matrix showed the possibility of association in the format of a specific equation of almost all established regressor features, with the exception of the Z69 parameter (the coefficients that determine multicollinearity are in bold). Subsequently, by step-by-step introduction into the mathematical model of regressors, an equation of multiple linear regression was constructed to calculate the lifetime length of the body of a male individual according to the parameters of the mandible. We do not present here the procedure for calculating the statistical parameters of the equation and estimating the prediction realized with its help. In the final application, the designed model has the form of the following formula:

$$У = 28{,}666 + 0{,}4097xZ1 + 0{,}4242xZ2 + 0{,}1289xZ5 + 0{,}5819xZ7 + 0{,}4513xZ8 \pm 6{,}45;$$

Here: Y is the parameter to be determined (body length in cm); Z1, Z2, Z5, Z7, Z8 are the values of the studied features (mandible dimensions in mm); + 6.45 is the standard error of the equation (S_d). When using the equation, conversion of metric units is not required. The dimensions of the mandible are measured in mm (as is customary in craniometry) and entered into the model, and the values are automatically obtained in cm.

4. Discussion of the Study Results

As we have already noted, there is extremely little information in the relevant literature regarding the possibility of predicting the length of the human body by the size of the mandible. We found only one work, the author of which shares information on the possibility of predicting human growth by the size of teeth [10]. Our results, in fact, did not change the idea of the weak predictive potential of mandible size in this context. The presented equation has a forecast error of more than 6.4 cm and cannot be unconditionally recommended for use in expert practice. In addition, this formula can only be used when examining a mandible that belonged to a male person. It should be noted that in our collection we were not able to collect a sufficient number of female mandibles (corresponding to the age range of 25-55 years) that would not have signs of involution.

Thus, we see that the formula shown above can only be used as an additional diagnostic method when there is a sufficient number of skeletal bones that allow one to determine the growth of an individual using proven traditional methods. When planning the present study, we in principle expected such a result. True, we hoped that within a narrow population with a predominance of a certain body type, more stable relationships of the metric dimensions of the human body are possible [11]. However, in this particular context, these expectations did not materialize. Nevertheless, the developed formula is not completely devoid of prospects for application. If the study does not aim for maximum accuracy (for example, during historical restorations, which are often carried out by archaeologists) and the expert does not have another bone besides the mandible, then using the presented model, it will be possible to approximately speak about the length of the individual's body (to whom this mandible belonged).

5. Conclusions

Some dimensions of the mandible in modern male Azerbaijanis are interconnected by correlation-regression relationships with body length. This relationship can be described using a multiple linear regression equation. But this equation cannot be applied in expert practice for a number of reasons. Nevertheless, under certain circumstances (archaeological research, historical restoration research, etc.), the proposed equation may be of value as a method for diagnosing body length.

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