Body Height and Its Estimation Utilizing Shoulder Blade Length Measurements of Montenegrin Adolescents of Both Sexes

La Altura del Cuerpo y su Estimación Utilizando Medidas de la Longitud de la Escápula de Adolescentes Montenegrinos de Ambos Sexos

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SUMMARY: The purpose of this research is to determine a regression equation for estimation of stature from shoulder blade length measurements. The sample in this research comprised 1001 adolescents, all of whom were in their final year of high school (504 males and 497 females) among the population of Montenegrin adolescents. The stature and shoulder blade length measurements were taken according to the ISAK protocol, and the data were analyzed statistically. Linear regression analysis determined the prediction of and shoulder blade length on the criterion variable a body height at the significance level of $p < 0.05$. These relations are presented by using a scatter diagram (Fig. 2). Thereby, we obtained the coefficient of determination, the multiple correlation coefficients, the partial correlation coefficient, the regression, t-test and standardized beta coefficient. The research study confirmed that shoulder blade length reliably predicts stature in both sexes of Montenegrin adolescents and revealed a very useful finding for physical anthropologists and experts from related fields. It was confirmed that there is a correlation between shoulder blade length and body height (males: 34.3 %, females: 38.8 %). Therefore, shoulder blade length proves to be a reliable predictor for the actual body height estimates.

KEY WORDS: Prediction; Anthropometry; Shoulder Blade Length; Montenegrin.

INTRODUCTION

Morphological measures require a very professional study and a realistic assessment of the measurements of the human body, the variability of which is so great that differences between people can be defined and the appropriate status of each individual (Arifi, 2018) can be defined Because the specifics of one nation are estimated on the basis of longitudinal measurement values, which are used to determine body height (Dayal *et al.*, 2008) and its relationship with other longitudinal measures as potential predictors of a particular (Golshan *et al.*, 2007).

Montenegro is a country located in the southeastern part of Europe. The geographical position of Montenegro is well separated in terms of relief (terrain), complex in terms of landscape with many contrasts, socio-geographically and historically unique. According to its latitude, Montenegro belongs to the southernmost part of Europe, the Mediterranean, which is characterized by a good climate and beautiful landscapes. Distance between the most the southernmost and northernmost point of Montenegro is 192

km of the airline and between the westernmost and easternmost point is 163 km. It borders with Croatia, Bosnia and Herzegovina to the west, Serbia to the north, and Albania and Kosovo to its east, while the coastal part of the sea forms the border with Italy with its international waters. The area of Montenegro is 13, 821 km2, of the inland sea 347 km2, of the territorial sea 2,047 km2, and of the continental sea 4,917 km2. In defining the importance of the geographical position of Montenegro, the priority certainly belongs to its belonging to the Adriatic-Mediterranean macro region.

Montenegro, together with Croatia, partly Slovenia, Bosnia and Herzegovina, Serbia, partly Albania and Kosovo, is located in the Dinarides, one of the largest mountain ranges on the Balkan Peninsula. This conditioned the connection of the inhabitants in this region, regardless of their greater or lesser importance and mutual relationship in certain periods of history. The highest part of the Dinarides, ie the mountainous regions of Montenegro has been the cradle of birth, life and existence for centuries (Radojicic, 2015).

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A map of Monenegrin is shown in Figure 1. A large number of studies has been conducted worldwide on body height to shoulder blade length ratios involving anthropometric parameters, using similar samples. Morphological measures are a series of systemised measuring techniques that express quantitatively the dimensions of human body and skeleton (Grasgruber *et al.*, 2018). Morphological measures are often viewed as a traditional and even a basic tool in biological anthropology (Cheng *et al.*, 1998), but morphological measures have a longstanding tradition of use in forensic sciences as their finding increase in the field of medical sciences, specificly in the field of forensic medicine (Chandra *et al.*, 2009).

There are very few reaserch papers in forensic literature that use scapular dimensions or use estimates of living stature. Duty of forensics is to make estimates on the living stature of skeletal remains (Ibegbu, 2013). A map of Monenegrin is shown in Figure 1. A large number of studies has been conducted worldwide on body height to shoulder blade length ratios involving anthropometric parameters (Zhang *et al.*, 2016), using similar samples. Morphological measures is a series of systemised measuring techniques that express quantitatively the dimensions of human body and skeleton (Vukotic, 2020a).

Fig. 1. Geographical location of the Republic of Montenegro.

Based on the above research, it is critical for people of Montenegro to have accurate informations, as well as body height to shoulder blade length, which are of great importance to medicine, sports, anthropology and other fields (Vukotic, 2020b).

In addition, it is necessary for the evaluation of child growth for the calculation of nutrition indices of children and adults (Popovic, 2019), the prediction and standardization of variables such as lung capacity, muscle strength, the standardization of physical ability measures for the determination of a patient's proper dose, etc. (Popovic *et al.*, 2017). Furthermore, it can be a excellent parameter for diagnosing persons with various anomalies and body height (Vukotic, 2020c) loss following medical intervention on the spine, as well as for predicting its loss in the case of the elderly (Mohanty *et al.*, 2001).

For this reason, it is important to properly establish the relationship between body height and shoulder blade length in Montenegrins at the national level, which has not been carried out, primarily because in some cases it can be very important to use precisely this anthropometric measure to determine body height, based on aforementioned reasons.

MATERIAL AND METHOD

The sample in this research involved 1001 adolescents, they were in their final year of high school (504 males, 497 females) from the territory of Montenegro. There were two reasons for the selection of this population group, as follows: the first is the fact that an individual's growth stops at this age, while the second is the fact that there is no body weight loss at this age. The average age of the male subjects was 18.68±0.35 years (age span 18–20), while the average age of the female subjects was 18.70±0.33 years (age span 18–20). Also, it is important to note that the authors exclude the study of adolescents with body deformities such as scoliosis, kyphosis, lordo-sis, fractures, amputations, and others. The study is in complience with the Declaration of Helsinki.

Subjects who did not originate from the territory of Montenegro were also excluded from this research. According to Marfell-Jones *et al.* (2006), anthropometric measurements, including body height and shoulder blade length, were taken in compliance with the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). The age of the subjects was determined by asking them their date of birth.

Method of data processing. The statistical processing of the data was performed using the statistical programme (SPSS) 25.0. For both anthropometric variables, central and dispersive parameters were processed within the scope of basic statistics, as follows: range (minimum and maximum value), arithmetic mean and standard deviation. Linear regression analysis determined the prediction of shoulder blade length on the criterion variable a body height at the significance level of p <0.05. These relations are presented in the form of scatter diagram. Thereby, we obtained the coefficient of determination, the multiple correlation coefficients, the partial correlation coefficient, the regression, t-test and standardized beta coefficient.

RESULTS

The results of anthropometric measurements for both sexes are shown in Table I. The average body height for males is 184.09±6.28, ranked with minimum and maximum values of 163.2-202.4 centimetres, while the shoulder blade length amounted to 17.79±1.51 centimetres. In the case of females, the average body height amounts to 170.27± 5.41 centimetres ranked with minimum and maximum values of 152.1-188.1 centimetres, while the shoulder blade length amounted to 16.45±1.02 centimetres.

Table I. Anthropometric measurements of the study subjects.

Subjects	Body Height Range (Mean ± SD)	Shoulder Blade Length (Mean ± SD)
Male	163.2 - 202.4 (184.09 ±6.28)	13.2 – 22.5 (17.79±1.51)
Female	152.1 - 188.1 (170.27±5.41)	13.3– 20.5 (16.45 ±1.02)

The results of the linear regression analysis are shown in Table II. In both sexes, the regression coefficients (R) are identical to the correlation coefficients from the previous analysis and are very high. The high values of the regression coefficient (males: 0.425; females: 0.434) imply that the prediction of shoulder blade length on stature is statistically significant, i.e. that shoulder blade length can predict stature in the case of the Montenegrin population of both sexes (males t=10.512; p <0.000, females t= 10.699; p <0.000). Which is confirmed by R-coefficient (R Square) of determination R-coefficient (%) for males is 34.3 and for females 38.8.

Table II. Results of linear regression analysis where the shoulder blade length predicts the stature.

Subjects	R	R Square (%)	Adjusted R Square	Std. Error of the Estimate	t-value	p-value
Male	.425[a]	.343	.179	56.803	10.512	.000*
Female	.434[a]	.388	.186	48.913	10.699	.000*

The first of these models was performed by including age as a covariate. Regression coefficient values imply that shoulder blade length significantly predicts stature in Montenegrin adolescents of both sexes (Fig. 2).
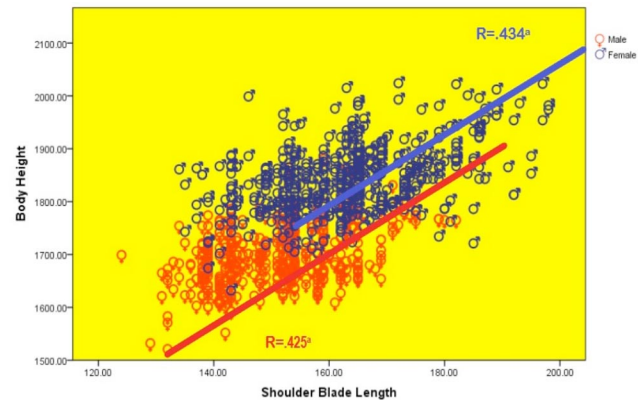
Fig. 2. Scatter diagram and relationship between shoulder blade length measurements and body height among both sexes.

Information on the effect of predictor variable on criterion variable tested through a regression-based procedure, whose values are shown through Beta coefficient of regression (males: 2.165; females: 2.339), and standard errors of the regression coefficient (males: .206; females: .219) show confirmation of statistically significant impact of predictor variable on the criterion variable in both sexes of Montenegrin adolescents (Table III).

Table III. Results of coefficients regression analysis where the shoulder blade length predicts the stature.

Subjects	Coefficients Beta	Std. Error	95 % Confidence Interval	
			Lewer	Upper
Male	2.165	.206	1.683	2.588
Female	2.339	.219	1.916	2.790

The relationship between the measurements of shoulder blade length and stature among the above mentioned models is shown using a scatter diagram (Fig. 3).
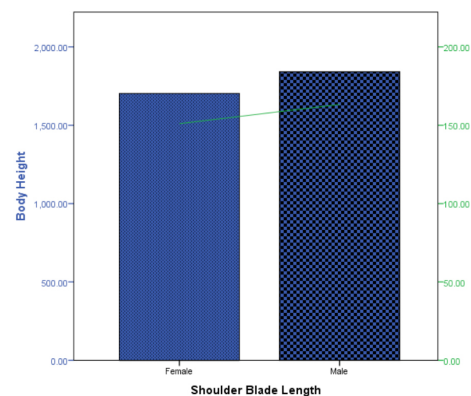
Fig. 3. Diagram and relationship between shoulder blade length Measurements and body height among both sexes.

DISCUSSION

Morphologyof shoulder blade length can be used to estimate the stature. Therefore the study was carried out to investigate the relationship between the stature and shoulder blade length. The results presented in this study will provide relevant data on the correlation between stature and shoulder blade length among the Montenegrin population at the national level. The average body height of the male subjects equals 184.09±6.28 cm and is similar to the average height of the tallest nations in Europe. The average body height of Montenegrin female adolescents equals 170.27±5.41 cm and is similar to the average height among the tallest women in the world. The outlined research further elaborates the specific body proportions mostly with the aim of improving the information on shoulder blade length as a reliable predictor of body height.

The conducted research further elaborates the specific body proportions, primarily with the aim of improving the information on shoulder blade length as a reliable predictor of body height. Numerous studies have confirmed that shoulder blade length can account for 44 % of variations in relation to stature (Giurazza *et al*., 2013), which indicates a significant correlation between body height and other anthropometric parameters.

The above stated points to the necessity of developing separate models for the assessment of body height in relation to other anthropometric parameters. The average shoulder blade length of Montenegrin adolescents equals (males: 17.79± 1.51 cm; females: 16.45± 1.02 cm), which confirms the main notion of this study that the population of Montenegro does have specific body proportions. The research conducted by (Giurazza *et al*.) has demonstrated similar values. It was confirmed that there is a correlation between shoulder blade length and body height (males: 34.3 %, females: 38.8 %).

Therefore, shoulder blade length is proven to be a reliable predictor on the basis of which the actual body height can be empirically estimated. The conducted research of shoulder blade length as a reliable body height predictor is of additional importance, because it is the only research of its kind that was conducted at the national level in accordance with proportional geographic sampling, which is also of crucial importance for future national and regional research of anthropometric predictors.

The results of this study can be used as baseline information for future research based on the Montenegrin adolescent population, and they confirm the need for the development of specific model for the analysis of both sexes of the Montenegrin population. Based on the above, additional questions arise in regard to the potential causes of differences in stature, primarily because some authors presume that the body's growth and development do not stop at this age, (Bjelica *et al*., 2012), because the full genetic potential of both sexes has not been achieved yet, and there are different economic and socioecological factors involved (Vukotic, 2020c), which was confirmed by this research. The obvious limitation of this study can be that neither of the Montenegrin sexes have reached the full genetic potential, as well as a positive secular trend could significantly change the facts confirmed in this study. The majority of studies mixed the secondary sexual characteristics. Many studies used diferent variables of Tanner's original description (Tanner, 1962). Sexual development and maturation is crucial for the appropriate assessment of growth in adolescents, and is of paramount importance to the analysis of adequate growth and of adequate timing of pubertal development of an individual (Marshall & Tanner, 1970).

This method of stature estimation can be used by law enforcement agencies and forensic scientists. The only precaution which should be taken into account is that these formulas are applicable to the population from which the data has been collected since inherent population variations exist in these dimensions, (Mukhra *et al*., 2018) which may be attributed to genetic and other environmental factors such as climate, nutrition etc. Based on this reasoning, a prerequisite is a regular adequate control of facts (Popovic), as there are evident expectation based on the European sample (Fredriks *et al*., 2005), which forsee secular changes in stature in the following decades; therefore, all current assumptions are questionable.

VUKOTIC, M.; MILOSEVIC, Z. & BJELICA, D. La altura del cuerpo y su estimación utilizando medidas de la longitud del escápula de adolescentes montenegrinos de ambos sexos. *Int. J. Morphol., 39(3)*:902-906, 2021.

RESUMEN: El propósito de esta investigación fue determinar una ecuación de regresión para estimar la estatura corporal a partir de las medidas de la longitud del escápula. La muestra estuvo compuesta por 1001 adolescentes, en su último año de estudios secundarios (504 hombres y 497 mujeres) entre la población montenegrina. Las medidas de estatura y longitud del escápula se tomaron de acuerdo con el protocolo ISAK y los datos se analizaron estadísticamente. El análisis de regresión lineal determinó la predicción y la longitud del escápula en la variable de criterio a altura corporal con un nivel de significación de $p < 0,05$. Estas relaciones se presentan mediante un diagrama de dispersión. De ese modo, obtuvimos el coeficiente de determinación, los coeficientes de correlación múltiple, el coeficiente de correlación

parcial, la regresión, la prueba *t* y el coeficiente beta estandarizado. El estudio confirmó que la longitud del escápula predice de manera confiable la estatura en ambos sexos de los adolescentes montenegrinos y reveló información muy útil para los antropólogos físicos y expertos de áreas relacionadas. Se confirmó que existe una correlación entre la longitud del escápula y la altura del cuerpo (hombres: 34,3 %, mujeres: 38,8 %). Por lo tanto, la longitud del escápula demuestra ser un predictor confiable de las estimaciones de la altura corporal real.

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