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BODY HEIGHT AND ITS ESTIMATION UTILIZING ARM SPAN MEASUREMENTS IN MALE ADOLESCENTS FROM CENTRAL REGION IN MONTENEGRO

INTRODUCTION

The unusual tallness of Montenegrin highlanders was a fact recognized by European anthropologists more than 100 years ago (cited in Bjelica, Popović, Kezunović, Petković, Jurak & Grasgruber, 2012). A sample of 800 Montenegrin men measured by Robert W. Ehrich (Coon, 1975) at the beginning of the 20th century gave the highest average in all of Europe (177 cm), with some districts approaching 178 centimeters. Furthermore, a contemporary research study conducted by Pineau, Delamarche, & Božinović (2005), showed that the male population of the Dinaric Alps is on average, the tallest in whole Europe. Thus, this study has challenged many scientists to believe that Montenegrins are still the tallest population in Europe and Bjelica and his collaborators (2012) confirm they are very tall but not the tallest with 183.2 centimeters. From the reason the sample in this study was created by university students, a more recent study was conducted as a national survey (Popović, Bjelica & Hadžić, 2014) and it confirmed the results of the previous study and found the average body height of Montenegrin male adolescents were 183.74 centimeters tall. From this reason the modern Montenegrins fall partly into the Dinaric racial classification (Bjelica et al., 2012), the authors did believe the male population that live in the central region might be much taller than average Dinaric Alps subjects. Hence, the purpose of this study was twofold. The first purpose was to examine the body height in Montenegrin male adolescents from central region as the authors did believe this is the place where the population can reach the full potential of the Dinaric Alps, while the second purpose was to examine the relationship between body height and arm span as an alternative to estimating the body height, which would vary from region to region in Montenegro.

METHOD

The nature and scope of this study qualifies 546 male adolescents from the central region in Montenegro to be subjects. The average age of the male subject was 18.67±0.49 years old (range 18-20 yrs). It is also important to emphasize that the authors could not accept adolescents with physical deformities that could affect body height or arm span, and without informed consent were excluded from the study. The exclusion criterion was also being non-Montenegrin.

According to Marfell-Jones, Olds, Stew & Carter (2006), the anthropometric measurements, including body height and arm span were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). The trained anthropometrist (the same one for each measure) whose quality of performance was evaluated against prescribed "ISAK Manual" prior to the study performed these measurements. The age of the individuals was determined directly from their reported date of birth.

The body height presents the perpendicular distance between the top of the head (the vertex) and the bottom of the feet. It was measured using stadiometer to the nearest 0.1 centimeters in bare feet with the participants standing upright against a stadiometer. The respondents had to put their feet together and move back until their heels touched the bottom of the stadiometer upright. Their buttocks and upper part of their back have also been touching the stadiometer upright while their head didn't have to touch the stadiometer. The respondent's head had to be in the Frankfort horizontal plane. This was achieved when the lower edge of the eye socket (the orbitale) is horizontal with the tragion. The vertex was the highest point on their head, otherwise the respondents had to raise or lower their chin until it was in the Frankfort horizontal plane to align their head properly.

The arm span is the anthropometric measurement of the length from the tip of the middle fingers of the left and right hands when raised parallel to the ground at shoulder height at a one-hundred eighty degree angle. It was measured using a calibrated steel tape to the nearest 0.1 centimeters in bare feet on a level concrete floor with their upper backs, buttocks and heels against the wall which provide support. The participant's head was also in the Frankfort horizontal plane and the arms were outstretched at right angles to the body with palms facing forwards. The measurement were taken from one middle fingertip to the other middle fingertip, with the tape passing in front of the clavicles while two field workers supported the elbows. The measurements were taken twice, and an average of the two readings was calculated. When the two measurements agreed within 0.4 centimeters, their average was taken as the best estimate for the true value. When the two initial measures didn't satisfy the 0.4 centimeters criterion, two additional determinations were made and the mean of the closest records was used as the best score.

The analysis was carried out using Statistical Package for Social Sciences (SPSS) version 20.0. Means and standard deviations (SD) were obtained for both anthropometric variables. A comparison of means of body heights and arm spans within this gender group was carried out using a t-test. The relationships between body height and arm span were determined using simple correlation coefficients and their 95% confidence interval. Then linear regression analyses was performed to examine the extent to which arm span can reliably predict body height. Finally these relationships were plotted as scatter diagrams and regression lines. Statistical significance was set at $p<0.05$.

RESULTS

A summary of the anthropometric measurements is shown in Table 1. The mean of the arm span for male subjects was 184.99±8.30 centimeters, which was 1.33±1.37 centimeters more than the body height and statistically significant (t=-2.876, p<0.004).

Table 1. *Anthropometric Measurements of the Population*

Body Height Range (Mean±SD)	Arm span Range (Mean±SD)
160.9-204.2 (183.66±6.93)	156,7-208,3 (184.99±8.30)

The simple correlation coefficient and their 95% confidence interval analysis between the anthropometric measurements are presented in Table 2. The relationships between body height and arm span was high and significant in the sample.

Table 2. *Correlation Between Body Height and Arm Span of the Study Subjects*

Correlation Coefficient	95% confidence interval	Significance p-value
0.837	0.804–0.865	<0.000

The results of the linear regression analysis are shown in Table 3. The first of all models were derived by including age as a covariate. However, it was found that the contribution of age was insignificant and therefore the age was dropped and estimates were derived as univariate analysis. The high values of the regression coefficient signify that arm span significantly predicts body height in the applied sample.

Table 3. *Results of Linear Regression Analysis Where the Arm Span Predicts the Body Height*

Regression Coefficient	Standard Error (SE)	R-square (%)	t-value	p-value
0.837	3.793	70.1	35.741	0.000

The relationships between arm span measurements and body height among the above subjects is plotted as a scatter diagram.
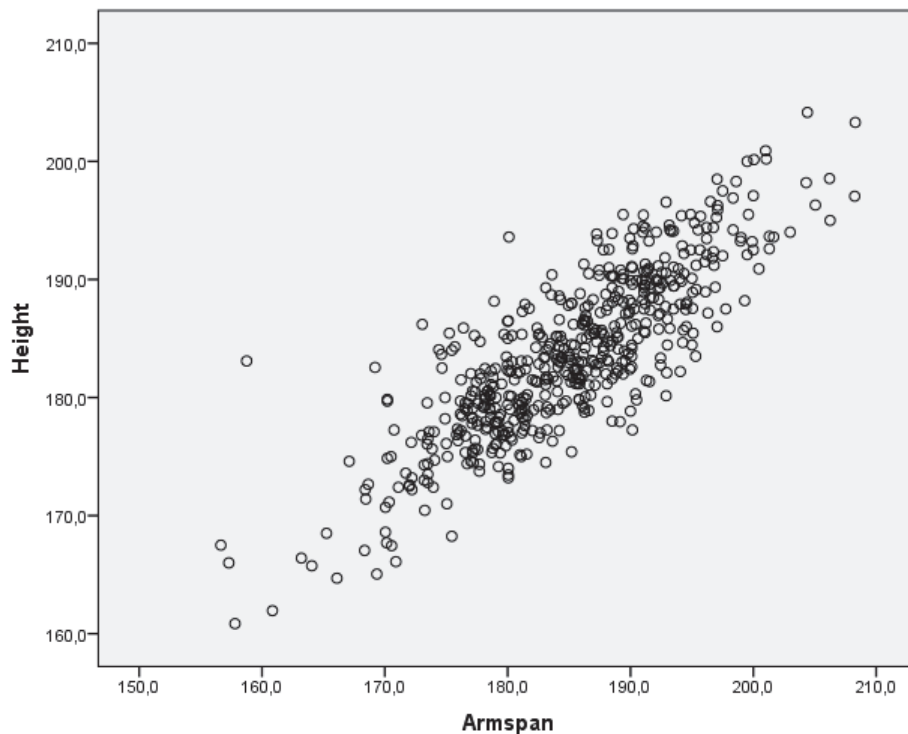
Figure 1. *Scatter Diagram and Relationship Between Arm Span Measurements and Body Height Among the Appled Sample*

DISCUSSION

The results of this study proved that Central-Macedonian males are very tall with an average of 183.66 centimeters, taller than general male population in Montenegro with 183.21 centimeters (cited in Quanjer et al., 2014). On the other hand, they are not the tallest in Europe. It does not come close to 184.6 centimeters documented by Pineau et al. (cited in Popović, Bjelica, Petković, Muratović, & Georgiev, 2014) and 183.8 centimeters of the Dutch male population measured in the last nationwide survey in 2010 (TNO, 2010). On the other hand, the 183.66 centimeters average height of Central-Montenegrin men is taller than 181.3 centimeters of the Lithuanians (cited in Popović, Bjelica & Hadžić, 2014), 180.9 centimeters of the Serbs (J. Grozdanov, personal communication, 1 December 2011), 180.6 centimeters of the Icelanders (cited in Bjelica et al., 2012) et cetera. However, there is a hypothesis that Montenegrin males did not reach their full genetic potential yet, since they have been influenced by various environmental factors (wars, poor economic situation, etc.) in the last few decades (Popović, Bjelica, Molnar, Jakšić, & Akpinar, 2013). Therefore, the authors believe that these circumstances had a negative bearing on the secular trend in Montenegro,

while it is expected that the secular changes affecting height will go up in the following 20 years, comparing it to developed countries where this trend has already stopped.

On the other hand, expectably, the arm span reliably predicts body height in this gender. However, the estimation equations which have been obtained in Central-Montenegrins are, different alike in general population, since arm span was closer to body heights (1.33±1.37 centimetres), more than in general population (cited in Bjelica et al., 2012). This confirms the necessity for developing separate height models for each region in Montenegro.

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Anthropologists recognized the tallness of nations in the Dinaric Alps long time ago (Popovic et al, 2013). As the modern Montenegrins fall partly into the Dinaric racial classification (Bjelica et al., 2012), the purpose of this study was to examine the body height in Montenegrin male adolescents from central region as well as the relationship between arm span as an alternative to estimating the body height, which would vary from region to region in Montenegro. Method: Our investigation analyses 548 male adolescents from the central region in Montenegro. The anthropometric measurements were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). Means and standard deviations regarding the anthropometric measurements were obtained. A comparison of means of body heights and arm spans within this gender group were carried out using a t-test. The relationships between body height and arm span were determined using simple correlation coefficients and their 95% confidence interval. Then a linear regression analysis was performed to examine the extent to which the arm span can reliably predict body height. Results: The results displayed that male Central-Montenegrins are 183.66±6.93 cm tall and have an arm span of 184.99±8.30cm. Discussion: Compared to other studies, the results of this study have shown that this gender made Central-Macedonians the tall population, taller than general male population in Montenegro (Bjelica et al., 2012). On the other hand, expectably, the arm span reliably predicts body height in this gender. However, the estimation equations which have been obtained in Central-Montenegrins are, different alike in general population, since arm span was closer to body heights (1.33±1.37 centimetres), more than in general population (Bjelica et al., 2012). This confirms the necessity for developing separate height models for each region in Montenegro.