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Body Height and its Estimation Utilizing Arm Span Measurements in Female Adolescents from Southern Region in Montenegro

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A B S T R A C T

The purpose of this study was to examine the body height in Montenegrin female adolescents from southern 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. Our investigation analyses 139 female adolescents from the southern region in Montenegro. The anthropometric measurements were taken according to the protocol of the 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. The results displayed that female Southern-Montenegrins are 168.73±6.79 cm tall and have an arm span of 167.23±7.79 cm. Compared to other studies, the results of this study have shown that this gender made Southern- Montenegrins the tall population, taller than female population across the Europe and the rest of World. On the other hand, expectably, the arm span reliably predicts body height in this gender. However, the estimation equations which have been obtained in Southern-Montenegrins are, different alike in general population, since arm span was shorter than the body heights (1.50±1.00 centimetres), much more than in general population. This study also confirms the necessity for developing separate height models for each region in Montenegro.

Key words: *stature, armspan, region, girls, Montenegro*

Introduction

The unusual tallness of Montenegrin highlanders was a fact recognized by European anthropologists more than 100 years ago (Bjelica, Popović, Kezunović, Petković, Jurak, & Grasgruber, 2012). Pineau et al. (2005) have contributed to an update of average body heights among European populations. Although this study doesn't contain the exact data of Montenegrin female population, it represents the most recent study related to the average body height of modern female Montenegrins. Pineau et al.'s investigation showed that, contrary to the general belief, the female population in the Dinaric Alps, with an average height of 171 centimeters come a close second to girls in the Netherlands (Pineau et al., 2005). Thus, this study has challenged many scientists to believe that female Montenegrins might be the tallest population in Europe and Bjelica and his collaborators (2012) confirm they are very tall but not the tallest with 168.37 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 female adolescents were 169.48 centimeters tall. From this reason the modern Montenegrins fall partly into the Dinaric racial classification (Bjelica et al., 2012), the authors did believe the female population that live in the southern region might be taller than average Dinaric Alps subjects, mostly due to the much better lifestyle in the coastal area. Hence, the purpose of this study was twofold. The first purpose was to examine the body height in Montenegrin female adolescents from southern 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.

Methods

The nature and scope of this study qualifies 139 female adolescents from the southern region in Montenegro to be subjects. The average age of the male subject was 18.40±0.62 years old (range 17-20 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-Southern Montenegrin.

According to Marfell-Jones, Olds, Stew, and Carter (2006),

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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 female subjects was 167.23±7.79 centimeters, which was 1.50±1.00 centimeters less than the body height and statistically insignificant ($t=1.720$, $p<0.087$).

Table 1. Anthropometric Measurements of the Population

Body Height Range (Mean±SD)	Arm span Range (Mean±SD)
153.8-189.5 (168.73±6.79)	148.7-188.6 (167.23±7.79)

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 applied sample.

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

Correlation Coefficient	95% confidence interval	Significance p-value
0.686	0.640–0.805	<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.

The relationships between arm span measurements and body height among the above subjects is plotted as a scatter diagram.

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
0.828	3.819	68.6	17.301	0.000

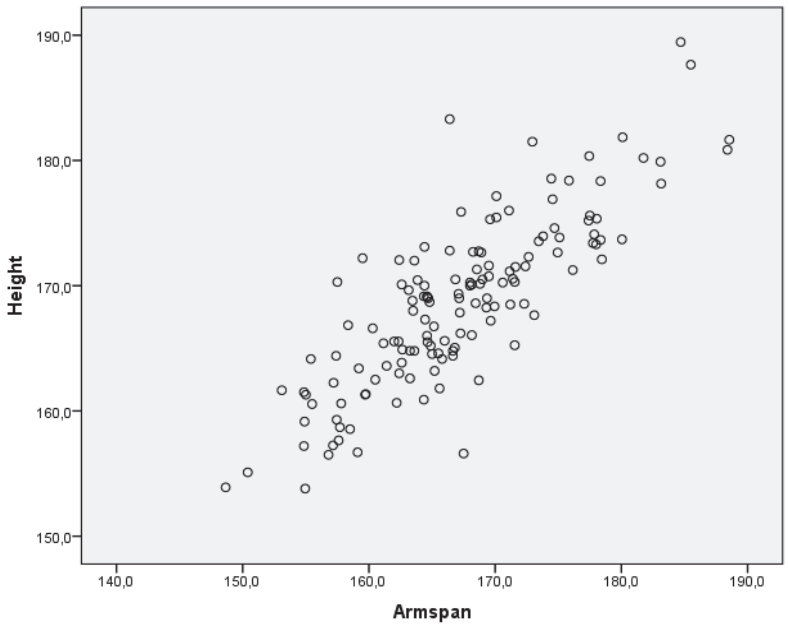

Figure 1. Scatter Diagram and Relationship Between Arm Span Measurements and Body Height Among the Appled Sample

Discussion

The results of this study proved that Southern-Montenegrin females are very tall with an average of 168.73 centimeters, taller than general female population in Montenegro with 168.37 centimeters (Popović, Bjelica, Molnar, Jakšić, & Akpinar, 2013; Quanjer et al., 2014) but not taller than Central-Montenegrins with 169.24 centimeters (Bubanja, Vujović, Tanase, Hadžić, & Milašinović, 2015). The results proved that Montenegrin females are tall on average but not as tall as 171.1 centimeters of the female population in the Dinaric Alps (Pineau et al., 2005) and 170.7 centimeters of the Netherlands (Popović, Bjelica, Tanase, & Milasinovic, 2015). However, there is a hypothesis that Montenegrin females 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, & Hadžić, 2014; Popović, Bjelica, Petković, Muratović, & Georgiev, 2014). 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 Southern-Montenegrins are, different alike in general population, since arm span was shorter than the body heights (1.50±1.00 centimetres), much more than in general population (Bjelica et al., 2012) and a litle bit more than in Central-Montenegrins (Bubanja et al., 2015). This also confirms the necessity for developing separate height models for each region in Montenegro.

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