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Relationship between Sitting Height Measurements and Standing Height: A Prospective Regional Study among Adolescents in the Northern Region of Kosovo

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Abstract

The purpose of this research is to determine a regression equation for the estimation of stature from sitting height measurements in the northern region of Kosovo. This research was carried out on 177 individuals (87 male and 90 female). The anthropometric measurements were taken according to the ISAK protocol. The relationships between standing height and sitting height measurements were determined using simple correlation coefficients at a ninety-five per cent confidence interval. A comparison of the means of standing height and sitting height between genders was performed using a t-test, following which a linear regression analysis was carried out to examine the extent to which sitting height can reliably predict standing height. The results reveal that northern Kosovan males are 180.29±5.72 cm tall and have a sitting height of 95.64±3.93 cm, while northern Kosovan females are 165.36±4.56 cm tall and have a sitting height of 90.19±3.03 cm. The results indicate that both genders made northern Kosovans a tall group, slightly taller than the general male and a slightly shorter than the general female Kosovan population. Moreover, the sitting height reliably predicts standing height in both genders, but not as reliably as arm span. This study also confirms the necessity for developing separate height models for each region in Kosovo as the results from northern Kosovans do not correspond to the values of the general Kosovan population.

Keywords: *prediction, measures, stature, sitting height, northern Kosovan*

Introduction

This study was conducted with to analyse the standing height and the possibility of its prediction utilizing sitting height measurements in adolescents in the northern region of Kosovo. Northern Kosovo is one of five Kosovan regions (eastern, western, northern, southern, and central), and in includes seven municipalities: Leposavić, Mitrovica, North Mitrovica, Skenderaj, Vushtrri, Zubin Potok, and Zvečan (Gardasevic, Masanovic, & Arifi, 2019; Masanovic et al., 2018a). It extends over an area of 2,077 square kilometres and has a population of 272,247 inhabitants, while average density per square kilometre is 110 inhabitants (Arifi, Sermaxhaj, Zejnullahu-Raçi, Alaj, & Metaj, 2017). The territory of Kosovo is small but has a highly varied relief. Most of Kosovo's borders are dominated by mountains and high grounds (Popovic, Gardasevic, Masanovic, Arifi, & Bjelica, 2017). The most noticeable topographical features are the Albanian Alps, which are a geological continuation of the Dinaric Alps that run laterally through

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the west along the border with Albania and Montenegro (Gardasevic, Masanovic, & Arifi, 2018). It is widely known that body height and body proportions are specific with regard to populations living on the Dinarides (Grasgruber et al., 2019; Starc et al., 2019; Masanovic et al., 2020). People from this area were recognized as tall by European anthropologists more than 100 years ago (Popovic, 2019). Based on that, one possible conclusion is that this fact might influence the main objective of this study, because of the soil type, as well as other social, economic and geographical characteristics as potential influencing factors (Gardasevic, Rasidagic, Krivokapic, Corluka, & Bjelica, 2017).

Every diagnostic procedure begins with measuring standing height and other morphological parameters, regardless of whether it is a health assessment of children or a physical fitness assessment of adults (De Onis et al., 2019; Nugent et al., 2019). Particularly important is the parameter of standing height, because of its diverse application in different procedures. The systematic monitoring of standing height, its changes, and changes of body proportion enables the determination of preschool and school children development stadium (Eiben et al., 2005), as well as the prediction of final growth, which is essential for the talent identification process in sport (Gusic, Popovic, Molnar, Masanovic, & Radakovic, 2017; Arifi, Bjelica, & Masanovic, 2019; Masanovic, 2019). Lastly, according to this parameter, it is possible to rate basic energy needs and to determine dosages of medication for each individual when necessary (Tanner, Hayashi, Preece, & Cameron, 1982).

However, when it is impossible to measure standing height in the standard way, because deformity, amputations, bone fractures and ageing-caused height loss cause problems, there is a necessity to predict objective standing height indirectly, in accordance with specific anthropometric measures (Quanjer et al., 2014; Masanovic, 2018). According to data from all previous studies, the relationship between arm span and standing height is marked as the most reliable parameter for indirectly determining standing height (Bjelica et al., 2012; Popovic et al., 2016; Popovic, Bjelica, Georgiev, Krivokapic, & Milasinovic, 2015). In these studies, the most reliable parameters are the foot length and standing height ratio, and the sitting height and standing height ratio (Kanchan et al., 2008; Abou-Hussein, Abela, & Savona-Ventura, 2011; Masanovic et al., 2018b; Masanovic, Arifi, & Gardasevic, 2019). The foot length and standing height ratio is the recommended parameter to predict adolescents' standing height, because short bones ossify more quickly, so that the dimension in this period is the most approximate to the final size (Jakhar et al., 2010). In contrast, the sitting height and standing height ratio is the recommended parameter to predict adult's standing height because that relationship changes during growth process (extremities grow faster in the first stage of adolescence, and torso tracks growth slightly later), and adequate data during adolescence would not be obtained (Leung et al., 1996).

Nonetheless, the fact that the relationship between individual anthropometric parameters and standing height is different in different ethnic and racial groups makes determining indirect standing height difficult (Quanjer et al., 2014; Steele, & Chenier, 1990). For example, the Cormic index (which provides an estimate of relative trunk length and is expressed as sitting height/standing height × 100) of the European population is 52%, while the African population have slightly longer legs on average; for them, this index is about 51%. Asian populations have slightly different body proportions, so this index is 53–54%, and lastly, the Cormic index of Australian Aborigines is between 45% and 49% (Ukwuma, 2009). Therefore, researchers agree that it is necessary to create specific formulas for indirect standing height calculation for each ethnic and racial group (Reeves, 1996; Chumlea et al., 1998). Furthermore, for standing height, regional variations for residents of Montenegro and Kosovo have proven (Popovic, 2017; Masanovic, Bavcevic, & Prskalo, 2019a), and it is also necessary to test the regional differences for standing height and sitting height ratios. The number of studies addressing this problem in Europe is quite limited (Fredriks et al., 2005; Ariba-Munoz et al., 2013), and regional analyses for standing height/sitting height ratio in the Dinaric Alps has been insufficient.

Consequently, the purpose of this study is to examine the standing height and sitting height ratio of men and women in the northern region of Kosovo.

Methods

The study included 177 final grade high-school students (87 male and 90 female) from the northern Region of Kosovo as subjects. There are two reasons that this group was selected: the fact that the growth of an individual ceases by this age, yet there is not yet any related loss in standing height. The average age of the male subject was 18.25±0.46 years old (range 18-20 years), while the average age of the female subject was 18.29±0.46 years old (range 18–19 years. It should be noted that the researchers have excluded from the data analysis the individuals with physical deformities as well as those without informed consent. Another exclusion criterion was also being non-northern Kosovan.

Standing height and sitting height were measured according to the protocol of the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Olds, Stew, & Carter, 2006). Measurement conducted trained measurer, while the quality of their performance was evaluated against the prescribed "ISAK Manual". Lastly, the age of each subject was obtained directly from their birthdays.

The analysis was performed by using the Statistical Package for Social Sciences SPSS version 20.0 (Chicago, IL, USA). Means and standard deviations (SD) were obtained for both anthropometric variables. A comparison of means of standing height and sitting height between genders was performed using a t-test. The relationships between standing height and sitting height were determined using simple correlation coefficients at a ninety-five per cent confidence interval. A linear regression analysis was then carried out to examine the extent to which the sitting height can reliably predict standing height. Statistical significance was set at $p<0.05$.

Results

The overview of anthropometric measurements in both genders is presented in Table 1. The mean of the standing height for male was 180.29±5.72 centimetres, and sitting height was 95.64±3.93 centimetres, while for female the standing height was 165.36±4.56 centimetres, and sitting height was 90.19±3.03 centimetres. The gender difference between standing height and sitting height measurements was statistically significant (standing height: $t=19.234$; $p<.000$, and sitting height: $t=10.334$; $p<.000$).

Table 1. Anthropometric Measurements of the Study Subjects

Subjects	Standing Height Range (Mean±SD)	Sitting Height Range (Mean±SD)
Male	167.9-197.3 (180.29±5.72)	86.2-103.3 (95.64±3.93)
Female	158.7-182.0 (165.36±4.56)	83.2-101.9 (90.19±3.03)

The simple correlation coefficients and their ninety-five per cent confidence interval analysis between the anthropometric measurements are presented in Table 2. The relationship between standing height and sitting height were significant (p<0.000) and high in this sample, regardless of gender (male: 0.735; female: 0.586).

Table 2. Correlation between Standing Height and Sitting Height of the Study Subjects

Subjects	Correlation Coefficient	95% confidence interval	Significance p-value
Male	0.735	0.588-0.881	<0.000
Female	0.586	0.414-0.757	<0.000

The results of the linear regression analysis are presented in Table 3. The first model was extracted by including age as a covariate. However, the contribution of age was insignificant, and therefore, age was excluded, and estimates were obtained as univariate analysis. The high values of the regression coefficient (male: 0.735; female: 0.586) signify that sitting height notably predicts standing height in both northern-Kosovan genders (male: t=9.984, p<0.000; female: t=6.780, p<0.000), which confirms the R-square (%) for the male (54.0) as well as for the female (48.5).

Table 3. Results of Linear Regression Analysis Where the Sitting Height Predicts the Standing Height

Subjects	Regression Coefficient	Standard Error (SE)	R-square (%)	t-value	p-value
Male	0.735	3.901	54.0	9.984	0.000
Female	0.586	3.719	58.5	6.780	0.000

The relationship between sitting height measurements and standing height among the above models is sketched as a scatter diagram (Figure 1).

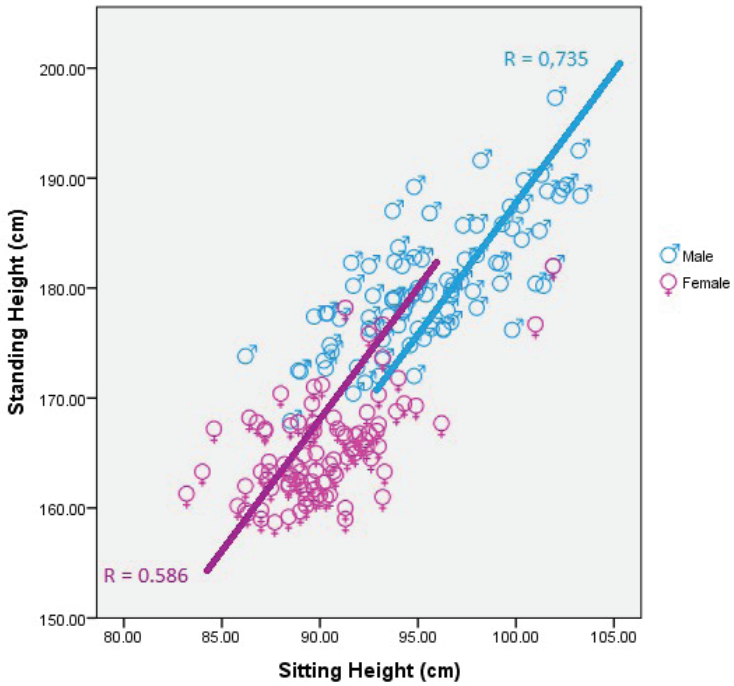

FIGURE 1. Scatter Diagram and Relationship between Sitting Height Measurements and Standing Height among Both Genders

Discussion

It's been over a century since researchers attempted to discover which anthropometrical method is the best for the indirect assessment of authentic standing height. All of them agree that the most reliable predictor is the relationship between standing height and arm span (Datta Banik, 2011; Arifi et al., 2017; Masanovic, Arifi, & Gardasevic, 2020). This study confirms a very high linear correlation between standing height

and sitting height in both northern Kosovan genders (r=0.735 in males; r=0.586 in females), which is in line with studies conducted on the population of the Netherlands, Indonesia, and Spain (Fredriks et al., 2005; Fatmah, 2010; Arriba Munoz et al., 2013).

However, it is essential to emphasize that standing height and body proportions might vary from ethnic group to ethnic group as well as race to race, because the racial and ethnic differences are affective on these measures and reduce the possibility of generalizing (Bjelica et al., 2012; Grasgruber et al., 2019). Nevertheless, some recent studies have confirmed that there are regional differences in standing heights between the same ethnic group members (Popovic, 2017; Masanovic et al., 2019a), and it has also been proven for foot length and standing height ratio (Popovic et al., 2017), also for tibia length and standing height ratio (Gardasevic, 2019). Whether the same applies to the relationship between sitting height and standing height is debatable. This study determined that regional differences also exist in sitting height and standing height ratios. For the population of northern Kosovo, a different correlation coefficient for sitting height and standing height ratio (r=0.735 in males and r=0.586 in females) was calculated compared to other regions. The population of eastern Kosovo has a correlation coefficient for sitting height and standing height ratio r=0.743 in males and r=0.705 in females (Gardasevic, 2018), while the population of western Kosovo has a correlation coefficient r=0.661 in males and r=0.614 in females (Masanovic et al., 2019). Even though these relations are similar, the estimation equations that are obtained in the northern Kosovans differ considerably from the populations of other regions in Kosovo, which confirms that it is necessary to develop separate standing height models for each population on account of regional variations in Kosovo. The reason for developing separate regional models for both genders in Kosovo was also based on the fact that all of Kosovo does not fall into Dinaric Alps racial classification (Mustafa et al., 2012; Arifi, Gardasevic, & Masanovic, 2018).

Limitations of this study may be the structure of the selected sample as final grade high-school students, because there are studies that indicate that the growth and body development of persons of this age remain active (Grasgruber et al., 2017; Wronka & Pawlinska-Chmara, 2009). However, if review studies implemented in Montenegro (Bjelica et al., 2012; Popovic, 2018), we can see that body height difference between university students and final grade high-school students is not found, "and can easily happen that the same case is established with the Kosovo population, given the certain similarities between Montenegrins and Kosovars, or some common specific features in relation to other populations in the region" (Popovic, 2019). Another limitation is the fact that residents of all regions in Kosovo have not reached their full genetic potential, and that positive secular trend may lead to change in body proportions. Quanjer et al., 2015 claims that in low-income countries, improving health conditions drive increases in standing height, and changes in relative leg length. This increase in height has been due almost entirely to longer legs (Tanner et al., 1982), which results in changes in body proportions, which implies that height-based prediction equations for such populations will need to be periodically updated. It also implies that predicting equations must be revised after a certain period. In the literature, an update period of every ten years is commonly cited. (Kubota et al., 2014).

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Conflict of Interest
The authors declare that there are no conflicts of interest

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