Standing Height Estimation from Sitting Height Measurements in Adolescents in the Central Region of Kosovo

Bojan Masanovic[1], Fitim Arifi[2] and Jovan Gardasevic[1]

[1]University of Montenegro, Faculty for Sport and Physical Education, Niksic, Montenegro, [2]University of Tetovo, Faculty of Physical Education, Tetovo, North Macedonia

Abstract

The purpose of this research is to determine a regression equation for the estimation of stature from sitting height measurements in the Central Region of Kosovo. This research was carried out on 193 subjects (100 male and 93 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. After that, a linear regression analysis was carried out to examine the extent to which sitting height can reliably predict standing height. The results revealed that Central Kosovan males are 180.32±5.88 cm tall and have a sitting height of 95.36±3.26 cm, while Central Kosovan females are 166.77±4.72 cm tall and have a sitting height of 89.84±2.92 cm. The results have shown that both genders make Central-Kosovans a tall group, taller that general Kosovan population. The results of this research study confirmed that sitting height reliably predicts stature in both genders of adolescents in the Central Region of Kosovo and revealed a very useful finding for physical anthropologists and experts from related fields.

Keywords: assessment, measures, stature, sitting height, Kosovan

Introduction

This study analyses the relationship between standing height and sitting height measurements in adolescents in the region of Central Kosovo, which is one of five Kosovan regions (Eastern, Western, Northern, Southern and Central). This region contains eight municipalities (Glogovac/Drenas, Gračanica, Kosovo Polje/FushëKosovë, Lipljan, Novo Brdo, Obilic, Podujevo. and Pristina), covers the area of 2,470 square kilometres and has a population of 477,312; the average density per square kilometre is 233 inhabitants (Arifi, Gardasevic, & Masanovic, 2018). The territory of Kosovo is small but has a highly varied terrain. Most of Kosovo's borders are dominated by mountains and high plains (Popovic, Gardasevic,

Masanovic, Arifi, & Bjelica, 2017). The most noticeable topographical feature is the Albanian Alps, which are a continuation of the Dinaric Alps that run laterally through the west along the border with Albania and Montenegro (Gardasevic, Masanovic, & Arifi, 2018). It is widely known that body height and body proportions are distinct in populations living in the Dinarides (Grasgruber et al., 2019). People from this area were recognized as tall people by European anthropologists more than 100 years ago (Popovic, 2019; Masanovic, Gardasevic, & Arifi, 2018; Vukasevic, Mitrovic, & Masanovic, 2020). 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 socio social, economic, and geographical

Correspondence:

B. Masanovic
University of Montenegro, Faculty for Sport and Physical Education, Narodne omladine bb, 81400, Niksic, Montenegro
E-Mail: bojanma@ucg.ac.me

characteristics as potential influencing factors (Gardasevic, Rasidagic, Krivokapic, Corluka, & Bjelica, 2017).

Systematic monitoring of the standing height, body weight, body mass index (BMI) and body proportions of children provides useful information on their development (Gusic, Popovic, Molnar, Masanovic, & Radakovic, 2017; NCD Risk Factor Collaboration, 2019). Additionally, every functional and diagnostic procedure for assessing the physical fitness of athletes and the health of adults usually begins by measuring standing height, body weight, and other body dimensions (Aslan et al., 2019). The data obtained form the basis for determining functional abilities and diagnosing a health condition. The importance of measuring standing height and predicting final growth in the selection process for certain sports disciplines is widely known and proven through numerous studies (Monson et al., 2018; Masanovic, 2018; Masanovic, Corluka, & Milosevic, 2018; Arifi, Bjelica, & Masanovic, 2019; Masanovic, 2019; Masanovic, Bavcevic, & Bavcevic, 2019; Gardasevic, Akpinar, Popovic, & Bjelica, 2019; Gardasevic & Bjelica, 2020). Furthermore, measuring standing height is essential when assessing the growth of children and their nutritional status, evaluating the basic energy requirements, adjusting measures of physical capacity and determining medication doses and setting standards of physiological variables (Masanovic, 2018; Masanovic, Gardasevic, & Arifi, 2018a; Popovic, 2019). However, in cases in which deformities (scoliosis, kyphosis, lordosis), bone fractures, amputations, height loss associated with ageing, and similar conditions do not allow the real standing height to be measured in a standard manner, the relative standing height must be calculated using various anthropometric measures that reliably predict objective standing height (Gardasevic, Masanovic, & Arifi, 2019; Masanovic, Popovic, Jarani, Spahi, & Bjelica, 2020). Previous studies have promoted the arm span and standing height relationship as the parameter that is most reliable in the indirect determination of standing height (Arifi et al., 2017a). Next, the relationship between foot length and standing height, and the relationship between sitting height and standing height as very reliable parameters are mentioned (Kanchan et al., 2008; Abou-Hussein et al., 2011; Nataraja Moorthy et al., 2014). The foot length measurement is used to indirectly determine standing height in subjects whose growth has not yet been fully completed because short bones of the foot complete the ossification process earlier, and this dimension is at that time closest to the final length (Jakhar et al., 2010). In contrast, it is known that the growth process is that the ratio of sitting height and standing height changes, meaning that the extremities initially grow faster and the trunk grows later, which is why the measure of sitting height is recommended for use only after the growth process is completed (Leung et al., 1996).

An aggravating circumstance in this way of determining standing height is that the relationship between long bones and standing height differs in various ethnic and racial groups (Masanovic, Gardasevic, & Arifi, 2019b), as well in residents of different regions (Norgan, 1994; Arifi et al., 2017b). For example, the Cormic index (provides an estimate of relative trunk length, and it is expressed as (Sitting height/standing height × 100) of the European population is 52%, while the African population has slightly longer legs on average, and this index is about 51% for them. Asian populations have shorter legs, so this index is slightly different (53–54%); at the low end of the scale, the Cormic index of Australian Aborigines is between 45% and 49% (Ukwuma, 2009). Therefore, it is neces-

sary to establish specific formulas for each ethnic group when it is necessary to determine standing heights based on sitting height indirectly; the same applies to other parameters. Given that studies on local geographic differences in standing height conducted on the populations of Montenegro (Popovic, 2017) and Kosovo (Masanovic et al., 2019a) confirm the difference in standing height, it is necessary to conduct a similar study on the relationship of standing height and sitting height. The number of studies addressing this problem in Europe is quite limited (Fredriks et al., 2005; Ariba-Munoz et al., 2013), and no previous regional analyses exist. Considering the lack of suitable research, the purpose of this study was to examine the relationship between standing height and sitting height of men and women in the Central region of Kosovo.

Method
Subjects
The study included 193 final grade high-school students (100 male and 93 female) from the Central Region of Kosovo to be subjects. There are two reasons why this group was selected: the fact that the growth of an individual ceases by this age, and that no age-related loss in standing height exists at this age. The average age of the male subject was 18.26±0.44 years old (range 18-19 years), while the average age of the female subject was 18.15±0.36 years old (range 18-19 years). It should be noted that the researchers excluded individuals with physical deformities and those without informed consent from the data analysis. Another exclusion criterion was being non-Central Kosovan.

Variables
Standing height and sitting height were measured according to the protocol of the International Society for the Advancement of Kinanthropometry (Marfell-Jones et al., 2006). The measurement conducted trained measurer, while the quality of their performance was evaluated against the prescribed ISAK Manual". The age of each subject was reached directly from the birthdays.

Statistical Analysis
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, following which a linear regression analysis was 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 the anthropometric measurements of both genders is presented in Table 1. The mean of the standing height for male was 180.32±5.88 centimetres, and sitting height was 95.36±3.26 centimetres, while for female the standing height was 166.77±4.72 centimetres, and sitting height was 89.84±2.92 centimetres. The gender difference between standing height and sitting height measurements was statistically significant (standing height: t=17.955; p<.000, and sitting height: t=12.355; p<.000).

Table 1. Anthropometric Measurements of the Study Subjects

Subjects	Standing Height Range (Mean±SD)	Sitting Height Range (Mean±SD)
Male	170.3-198.8 (180.32±5.88)	86.7-104.3 (95.36±3.26)
Female	157.3-185.0 (166.77±4.72)	83.8-99.8 (89.84±2.92)

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<.000) and high in this sample, regardless of gender (male: 0.756; female: 0.782).

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

Subjects	Correlation Coefficient	95% confidence interval	Significance p-value
Male	0.756	0.625-0.887	<0.000
Female	0.782	0.652-0.912	<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; therefore, age was excluded, and estimates were obtained as univariate analysis. The high values of the regression coefficient (male: 0.756; female: 0.782) signify that sitting height notably predicts standing height in both Central-Kosovan genders (male: t=11.434, p<.000; female: t=11.964, p<.000), which confirms the R-square (%) for the male (57.2) as well as for the female (61.1).

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	0.756	3.871	57.2	11.434	0.000
Female	0.782	2.956	61.1	11.964	0.000

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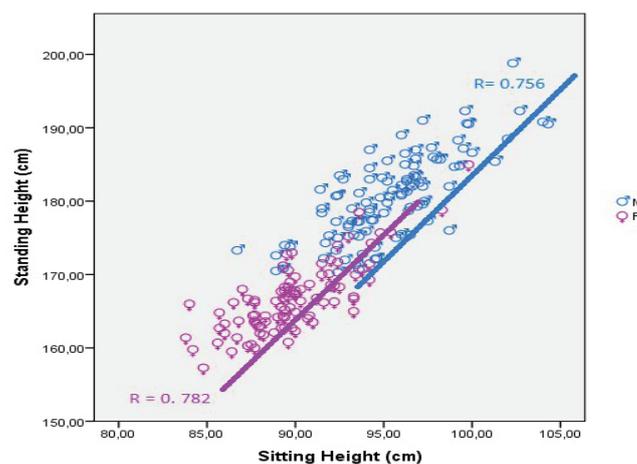

FIGURE 1. Scatter Diagram and Relationship between Sitting Height Measurements and Standing Height among Both Genders.

Discussion

The assessment of standing height of an individual using arm span has been studied by many researchers, each of whom emphasizes it as the most reliable parameter for predicting the standing height (Mohanty et al., 2001; Ter Goon et al., 2011). The studies conducted by Fredriks et al. (2005), Fatmah et al. (2010), and Arriba Munoz et al. (2014) also confirmed a very high linear correlation between standing height and sitting height in both genders of Dutch, Indonesian and Spanish populations. The high correlation coefficient in this population was calculated for sitting height in males (r=0.756) as well as in females (r=0.782), which fully confirms the studies

mentioned above. However, it is important 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 affect these measures and reduce the possibility of generalizing (Bjelica et al., 2012; Grasgruber et al., 2019). Taking all of that into consideration, some recent studies have confirmed the regional differences between the same ethnic groups too, for stature (Popovic, 2017; Masanovic et al., 2019a), for the ratio of foot length and standing height (Popovic et al., 2017), and for the ratio of tibia length and standing height (Gardasevic, 2019); which is proved by the fact that for the population of Eastern Kosovo the calculated correla-

tion coefficient for sitting height and standing height ratio was r=0.743 in males and r=0.705 in females (Gardasevic, 2018). For the population of Western Kosovo, the correlation coefficient was r=0.661 in males and r=0.614 in females (Masanovic et al., 2019b), which is different when compared to the population in Central region of Kosovo (r=0.756 in males; r=0.782 in females).

All the above-mentioned results require additional caution and have confirmed the necessity for developing separate standing height models for each population on account of regional differences. Therefore, the main goal of this research was to examine the hypothesis that above-mentioned facts are true for the Central-Kosovan regions. As the correlation between sitting height and standing height was significant in both Central-Kosovan genders, the sitting height measure, therefore, seems to be a reliable indirect anthropometric indicator for estimating standing height in both genders of the Central-Kosovan population. Even though these relations are similar, the estimation equations, which are obtained for the Central-Kosovans, differ considerably from populations from other regions in Kosovo, which confirms that it is necessary to develop separate standing height models for each population

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on account of regional variations in Kosovo. The reason for regional differences for both genders in Kosovo can be based at the fact that the whole of Kosovo does not fall into the Dinaric Alps racial classification (Mustafa et al., 2012).

One limitation of this research might also be the composition of the measured sample that consisted of high school students. Some studies assume the growth of an individual does not cease at this age, which might be supported by the fact that university-educated individuals have been found to be taller than the high school population in Bosnia and Herzegovina (Grasgruber et al., 2017), in Poland (Wronka & Pawlinska-Chmara, 2009) and in Hungary (Szollosi, 1998). In contrast, this was not so in Montenegro (Popovic, 2017); comparing the average standing height measures of this study to the results of a study sample of university students might yield much more precise conclusions. Another obvious limitation of this study is the that the respondents were born in a time of war and poor economic situation, and it is thus assumed that both genders of Kosovo did not yet reach their full genetic potential. In the future, continuous monitoring is necessary, because it is expected the secular changes influencing standing height will rise in the following two or three decades.

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