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Standing Height and its Estimation Utilizing Sitting Height Measurements in Adolescents from the Western Region in Kosovo

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Abstract

The purpose of this research is to examine standing height in both Kosovan genders in the western region of as well as its association with sitting height, as an alternative to estimating standing height. A total of 664 individuals (338 male and 326 female) participated in this research. The anthropometric measurements were taken according to the ISAK protocol. The relationships between standing height and sitting height were determined using simple correlation coefficients. A comparison of means of standing height and sitting height between genders was performed using a t-test, while linear regression analyses were carried out to examine the extent to which sitting height can reliably predict standing height. The results reveal that Western Kosovan males are 179.71±6.00 cm tall and have a sitting height of 94.79±3.60 cm, while Western Kosovan females are 166.26±5.23 cm tall and have a sitting height of 90.28±3.25 cm. The results have shown that both genders made Western-Kosovans tall and somewhat taller than the general Kosovan population. Moreover, the sitting height reliably predicts standing height in both genders but not arm span sufficiently reliably. This study also confirms the necessity of developing separate height models for each region in Kosovo as the results from Western-Kosovans do not correspond to the national values.

Key words: *prediction, measurement, stature, sitting height, Kosovan*

Introduction

According to Arifi et al. (2017), Kosovo is a democratic, secular and multi-ethnic republic, which is administratively divided into seven districts (Ferizaj, Gjakova, Gjilan, Mitrovica, Peja, Pristina, and Prizren) and five regions (Eastern, Western, Northern, Southern and Central). This study analyses the relationship between standing height and sitting height measurements in adolescents in the western region of Kosovo. Within this region are two districts (Peja and Djakova) and seven municipalities (Deçan, Gjakova, Junik, Rahovec, Pejë, Istok and Klina). The territory of western Kosovo (Figure 1) covers 2,494 square kilometres, and its population consists of 368,907 inhabitants (Gardasevic, Masanovic, & Arifi, 2018). Kosovo does not have a large territory, but its terrain is highly varied. Most of Kosovo's border areas are dominated by mountains and high grounds (Masanovic, Gardasevic, & Arifi, 2018). One of the most noticeable topographical features is the Bjeshkët e Nemuna, also known as the Albanian Alps. They are a geological continuation of the Dinaric Alps that run laterally through the west along the border with Albania and Montenegro (Arifi, Gardasevic, & Masanovic, 2018). It is widely known that body height and body proportions are specific for populations living on the Dinarides (Grasgruber et al., 2019). People from this area were recognized as tall people by European anthropologists more than 100 years ago (Masanovic, 2018; 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 socio social, economic and geographical characteristics as a potential influencing factor (Gardasevic, 2019).

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Figure 1. Geographical Location of Western Region in Kosovo

The measurement of standing height is a vitally important variable when evaluating nutritional status (Masanovic, Bavcevic, & Prskalo, 2019). Furthermore, there are many scientifically based findings that confirm that the measurement of standing height is an important variable when assessing the growth and development of children, the demands of energy, muscle strength, metabolic rate, lung volumes, and glomerular filtration, as well as adjusting the measures of physical abilities and predicting the appropriate dosage of medicine (M. Golshan, Crapo, Amra, Jensen, & R. Golshan, 2007; Saari et al., 2011; Bjelica et al., 2012; Popovic, 2018). Exact standing height sometimes cannot be measured in the usual way (Frederiks et al., 2005); because of some acute and chronic conditions, such as paralysis, fractures, amputation, scoliosis and pain, an estimate of standing height has to be differently estimated, from other reliable anthropometric indicators. For the most reliable anthropometric indicators, we consider sitting height, hand and foot lengths, knee height, length of the forearm, of the sternum, length of scapula, arm span, and others (Masanovic, Gardasevic, & Arifi, 2019; A. Ozaslan Iscan, I. Ozaslan, Tugcu, & Koc, 2003; Fatmah, 2010; Masanovic, Gardasevic, & Arifi, 2018a). In the older subjects, these anthropometric indicators can give us a better estimate of real growth due to the loss of standing height associated with ageing. In accordance with this, they are even more important when we want to diagnose individuals with abnormalities in growth or standing height loss during surgical procedures on the spine (Mohanty, Babu, & Nair, 2001), as well as to anticipate standing height in people who are too old to stand properly, thus making it very difficult to measure precisely, and sometimes impossible because of problems with movement and kyphosis (Bjure, Grimby, & Nachemson, 1968; Chumlea, Roche, & Steinbearagh, 1985; Popovic, Gardasevic, Masanovic, Arifi, & Bjelica, 2017). Finally, this information is of vital importance in sport, since the standing height represents a significant factor that influences the success in almost all sports disciplines (Popovic, 2014; Gusic, Popovic, Molnar, Masanovic, & Radakovic, 2017; Masanovic, 2019; Arifi, Bjelica, Masanovic, 2019).

The benefit of using various body parameters in predicting standing height has been verified several times (Yun et al., 1995; Hickson & Frost, 2003), and arm span, foot length and sitting height reported to be among of the most reliable ones (Mohanty, Babu, & Nair, 2001; Ozden, Balci, Demirüstü, Turgut, & Ertugrul, 2005; Dangour, Schilg, Hulse, & Cole, 2002). The complicating circumstance is that the relationship of long bones and standing height has revealed to vary in different ethnic and racial groups (Steele, & Chenier, 1990; Quanjer et al., 2014) as well as various regions (Norgan, 1994; Bjelica et al., 2012). For example, the average sitting height/standing height ratio of populations from Europe is 0.52, while the population from Africa in general, have slightly longer legs and ratios around 0.51. Populations from Asia have slightly shorter legs with a ratio of 0.53–0.54, and finally, at the bottom of the range for sitting height/standing height ratio are Australian Aborigines with ratios of 0.45–0.49 (Abou-Hussein, Abela, & Savona-Ventura, 2011; Ukwuma, 2009). Consequently, a specific formula for calculating standing height from the long bones for each ethnic group is required. The mentioned variations might also be relevant for sitting height predictions, mostly because the population from the Dinaric Alps has specific body proportions from the perspectives of both the nation and the region (Popovic, 2017). Even though several studies about this issue are available on the global population, only narrow data is available on European subjects (Frederiks et al., 2005; Ariba-Munoz et al., 2013), while there were no regional analyses thus far in the Dinaric Alps population. Regarding the rather scant scientific material, the purpose of this research was to examine standing height in both Western-Kosovan genders and determine its association with sitting height.

Method

This study included a sample of 664 fourth-year secondary school students (338 male and 326 female) from the Western Region of Kosovo. This group of respondents was selected for two reasons: the first is connected to the fact that the growth process of an individual ceases by this age, while the second is related to the fact that there does is not age-related loss in standing height at this age. The average age of the male subjects was 18.24±0.43 years, while the average age of the female subjects was 18.25±0.45 years. It should be noted that excluded from the data analysis were the individuals with physical deformities, as well as those without informed consent. Another exclusion criterion was being non-Western Kosovan.

The anthropometric measurements that were needed for this research (standing height and sitting height) were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Olds, Stew, & Carter, 2006).

Selected anthropometric indicators were measured by trained measurers, while the quality of their performance was estimated by the prescribed "ISAK Manual". The age of each subject was rated directly from their birthdays.

The analysis was conducted by using the Statistical Package for Social Sciences (SPSS) version 20.0. For both anthropometric variables, means and standard deviations (SD) were obtained. 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 (95% confidence interval). To examine the extent to which the sitting height can reliably predict standing height, a linear regression analysis was carried out. Statistical significance was set at $p<0.05$.

Results

In Table 1, a summary of the anthropometric measurements of both genders is shown. The mean of the standing height for males was 179.71±6.00 centimetres, and sitting height was 94.79±3.60 centimetres, while for females the standing height was 166.26±5.23 centimetres, and sitting height was 90.28±3.25 centimetres. The gender difference between standing height and sitting height measurements was statistically significant (standing height: t=30.759; p<0.000, and sitting height: t=16.936; p<0.000).

Table 1. Anthropometric Measurements of the Study Subjects

Subjects	Standing Height Range (Mean±SD)	Sitting Height Range (Mean±SD)
Male	163.5-196.4 (179.71±6.00)	83.3-105.0 (94.79±3.60)
Female	153.3-181.8 (166.26±5.23)	80.0-98.7 (90.28±3.25)

The simple correlation coefficients and their 95% confidence interval analysis between the anthropometric measurements are displayed in Table 2. The associations between standing height and sitting height were significant (p<0.000) and high in this sample, for both genders (male: 0.661; female: 0.614).

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

Subjects	Correlation Coefficient	95% confidence interval	Significance p-value
Male	0.661	0.581-0.742	<0.000
Female	0.614	0.527-0.700	<0.000

In Table 3, the results of the linear regression analysis are shown. First, all models were extracted by including age as a covariate. However, it was found that the contribution of age was insignificant and, therefore, the age was dropped, and estimations were derived as univariate analysis. The high values of the regression coefficient (male: 0.661; female: 0.614) signify that sitting height notably predicts standing height in both Western Kosovan genders (male: t=16.157, p<0.000; female: t=13.998, p<0.000), which confirms the R-square (%) for the male (43.7) as well as for the female (37.7).

Table 3. Results of Linear Regression Analysis in which Sitting Height Predicts Standing Height

Subjects	Regression Coefficient	Standard Error (SE)	R-square (%)	t-value	p-value
Male	0.661	4.507	43.7	16.157	0.000
Female	0.614	4.137	37.7	13.988	0.000

The associations between sitting height measurements and standing height among the above models are presented as a scatter diagram (Figure 2).

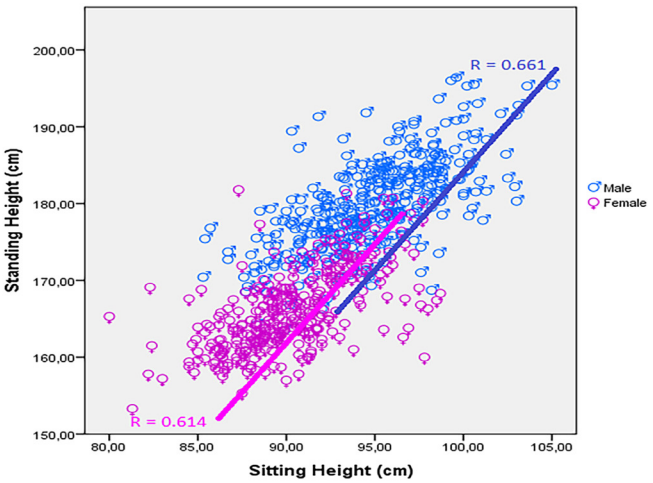

Figure 2. Scatter Diagram and Relationship between Sitting Height Measurements and Standing Height among Both Genders

Discussion

In previous centuries, many researchers attempted to assess standing height using various anthropometric measures. They concluded that the arm span is the most reliable body indicator for predicting the standing height of an individual (Datta Banik et al., 2011; Gardasevic, Rasidagic, Krivokapic, Corluka, & Bjelica, 2017), while sitting height was very close (Arriba Munoz et al., 2013). The study conducted by authors Frederiks et al. (2005) and Arriba Munoz et al. (2013) confirmed a very high linear correlation between standing height and sitting height in both genders of the Spanish population, while the research study conducted by Fatmah et al. (2010) shows a significant correlation between standing height and sitting height in both genders of the Indonesian population. The highest correlation coefficient in this population was found for sitting height in males (r=0.661) as well as in females (r=0.614).

However, researchers also found that the individual and ethnic variations exist with regard to standing height and its association with sitting height, i.e., that the relationship between standing height and some other anthropometric measures are different from ethnic group to ethnic group as well as race to race. Therefore, we conclude that racial and ethnic differences reduce the possibility of generalizing (Bjelica et al., 2012; Quanjer et al., 2014), i.e., that there are a need and necessity for developing separate standing height models for each population on account of ethnic differences.

Previous studies that have analysed the entire population confirm that there is a specific correlation coefficient in males (r=0.691) and females (r=0.629) from Kosovo (Popovic 2019). However, some recent studies have also confirmed that the regional differences between the same ethnic groups also exist (Popovic, 2017; Masanovic, 2019), which caused the need for additional caution. Therefore, the main goal of this research was to investigate the above-mentioned facts, and test their validity for Western-Kosovans, that is, for one of the five Kosovan regions. Specifically, in the present research, it was remarked that the sitting height/standing height ratio in Western-Kosovan male is quite smaller (male: 43.7%; female: 37.7%) in comparison to the entire Kosovan population (male: 47.7%; female: 39.6%) and other available populations that estimate over 70% each and more in the male population, while the female population is much more in parallel to previously measured populations. The sitting height measure seems to be a reliable indirect anthropometric indicator for estimating standing height in both genders of the Western-Kosovan population; consequently, the correlation between sitting height and standing height was significant in both Western-Kosovan genders. Despite similar relations, the estimation equations that are obtained in the Western-Kosovans differ considerably from the entire population of Kosovo and other available populations.

The results of the previous studies confirm the necessity for developing separate standing height models for both Kosovan genders, but it also recommended that subsequent studies should consider the division criteria of the population of this country to regional subsamples. Analyses should be done separately, to ensure that there are no geographical differences (such as type of soil) influencing the average standing height in both genders from Kosovo, as well as its association with sitting height. The reason for concern was based on the fact that the whole territory of Kosovo does not fall into Dinaric Alps racial classification. This study confirms the assumption that it is necessary to develop separate standing height models for each part of Kosovo on account of regional variations.

Another limitation of this research might also be the composition of the measured sample that consisted of high school students. There are some studies that assumed that the growth of an individual was not completed at this age (S. Popovic, personal communication, 2019). This assumption might be supported by the fact that in several previous studies we can find that university-educated individuals are taller than the high school individuals in Hungary, Poland, and Bosnia and Herzegovina (Szollosi, 1998; Wronka & Pawlinska-Chmara, 2009; Gardasevic et al., 2017). However, the results show that this was not so in Montenegro, where the situation is reversed (Popovic, 2017). Comparing the average standing height measures of this study with the results of the average standing height measures of a study that examines university students might provide much more precise conclusions.

A further limitation of this study is also the fact that both Kosovan genders had not yet reached their full genetic potential, since various environmental factors controlled their development. Further continuous monitoring is necessary, mostly because it is expected that the secular changes influencing standing height will ascend in the following two or three decades.

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

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