

# **Body height in Kosovo population and its estimation from tibia length: National survey**

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## **Abstract**

The purpose of this research study was to examine the body height in both sexes of Kosovan adults. Furthermore, the relationship between tibia length and body height was used as an alternative to estimating the body height for some groups of the population. The studied sample included 1,623 individuals (830 men, aged  $18.26 \pm 0.45$  and 793 women, aged  $18.24 \pm 0.43$ ). The anthropometric measurements were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). The results have shown that the male Kosovans are  $179.52 \pm 5.96$  cm tall and have a tibia length of  $40.19 \pm 2.90$  cm, while the female Kosovans are  $165.72 \pm 4.93$  cm tall and have a tibia length of  $36.48 \pm 2.41$  cm. The results have also shown that the body height of males and females from Kosovo is lower than in the tallest European nations. The analysis also showed that tibia length fairly reliably predicts body height in males and females from Kosovo.

KEYWORDS: prediction, body height, tibia length, Kosovo

## **Introduction**

Kosovo covers an area of 10,908 km<sup>2</sup> on the central region of the Balkan Peninsula in southeastern Europe. It is a landlocked country, and it borders with four countries: Albania (112 km), Macedonia (160 km), Montenegro (76 km), and Serbia (366 km). From the demographic point of view, the total population of Kosovo is 1,883,018 (Central Intelligence Agency, 2016). The country's particular historical events make the ethnic population of Kosovo a very specific and very complex. According to the same source, the largest ethnicity in the country is the Kosovar ethnic group, which represents 92.9% of the total population, followed by the Bosniaks, who make up 1.6% of the total population, Serbs with 1.5%, Turks with 1.1%, Ashkali with 0.9%, Egyptian with 0.7%, Gorani with 0.6%, Roma with 0.5%, and other/unspecified ethnicities with 0.2%.

The research carried out by European anthropologists a century ago proved the assumption that the tallest people inhabit the Dinarides (Pineau, Delamarche & Božinović 2005). As modern Kosovans, like other former Yugoslavian nations, fall into this racial

classification, it is believed by the researchers that Kosovan adults might be equally tall or slightly shorter than the tallest populations in the Europe (Popovic 2016), harmonious with the Bosnians (boys: 183.9 cm; girls: 171.8 cm), Dutch (boys: 183.8 cm; girls: 170.7 cm), Montenegrins (boys: 183.21 cm; girls: 168.37 cm) and Serbians (boys: 182.0 cm; girls: 166.8 cm). When compared with the Western European countries, Kosovo falls behind, and the expected data about the average body height among Kosovan populations is highly beneficial as well as its relationship with tibia length measurements, mostly by virtue of estimation of body height when the usual measurement with stadiometer is not possible (Popovic, Bjelica, Tanase & Milasinovic 2015).

Scientific literature provides the findings that body height measurement is a vitally important variable when assessing nutritional status (Datta Banik 2011), as well as, according to Golshan et al. (2003, 2007), Mohanty, Babu and Nair (2001), and Ter Goon, Toriola, Musa and Akusu (2011), when assessing the growth of children, evaluating their basic energy requirements, adjusting the measures of physical capacity, determining drug dosage and setting standards of physiological variables (e.g., muscle strength, metabolic rate, lung volume, and glomerular filtration). Nonetheless, the exact body height, according to Quanjer et al. (2014), cannot always be identified and resolved the usual way (e.g., due to paralysis, fractures, amputation, scoliosis, and pain). Because of these factors, an estimate of body height has to be acquired from other reliable anthropometric indicators, such as tibia length (Duyar & Pelin 2003; Agnihotri, Kachhwaha, Jowaheer, & Singh 2009), hand and foot lengths (Sanli et al. 2005; Agnihotri, Purwar, Googoolye, Agnihotri, & Jeebun 2007; Kanchan et al. 2008), knee height (Hickson & Frost 2003; Fatmah 2010), length of the forearm (Ilayperuma et al. 2010), sternum length (Menezes et al. 2009; Menezes et al. 2011), length of the vertebral column length (Nagesh & Kumar 2006), sitting height (Fatmah 2010), length of scapula (Campobasso, Di Vella, & Introna 1998), arm span (Jarzem & Gledhill 1993; Mohanty et al. 2001; Hickson & Frost 2003; Fatmah 2010; Datta Banik 2011; Ter Goon et al. 2011; Bjelica et al. 2012; Popovic et al. 2015) as well as cranial sutures (Rao et al. 2009), skull (Bidmos & Asala 2005; Bidmos 2006), facial measurements (Sahni et al. 2010), and others. All these anthropometric indicators, which can be used as alternatives to estimating body height, are very important in predicting decreases in body height as a result of ageing. Likewise, these are of high value for diagnosing individuals with disproportionate growth abnormalities and skeletal dysplasia or body height loss during surgical procedures on the spine (Mohanty et al. 2001), as well as for anticipating body height in older people, as it is very difficult to measure this precisely, sometimes even impossible, due to the mobility problems and kyphosis (Hickson & Frost 2003).

As it has been stated above, the researchers of this study believed it would be reasonable to find the benefit of using tibia length in estimating body height in the Kosovan population. In addition to that, the relationship of long bones and body height was found to vary in different ethnic and racial groups (Bjelica et al. 2012; Brown, Feng & Knapp 2002; Steele & Chenier 1990). Thus, the researchers have derived different equations for calculating body height from long bones for each ethnic/race group. The mentioned variations might be the case with tibia length predictions too, mostly because

the population of Dinaric Alps has specific body composition from the national as well as regional perspectives (Popovic 2016). Even though many studies on this subject regarding neighbouring countries as well as on worldwide population are available, the only data available on Kosovan subjects is the one conducted by Popovic, Arifi and Bjelica (2017) and it covered the whole population of the Republic of Kosovo. This is the only regional analysis that has confirmed that Western-Kosovans have specific body height/foot length ratio in comparison to the general population of Kosovo (Popovic et al. 2017). Considering the rather sparse recent scientific literature on the subject, the purpose of this research was to examine the body height in both Kosovan genders and its association with tibia length. Even though many studies are available on Western populations, limited data is available for this specific population.

## **Methods**

The sample included 1,623 last year high-school students (830 boys and 793 girls) from Kosovo. Two criteria qualified the selected individuals: the first is related to the fact that the growth of an individual usually terminates by this age, while the second is related to the fact that there is no age-related loss in body height at this age yet. The average age of the male subjects was  $18.26 \pm 0.45$  years old (range 18-20 years), while the average age of the female subjects was  $18.24 \pm 0.43$  years old (range 18-20 years). Individuals with physical deformities were excluded from the data analysis.

The anthropometric measurements, including body height and tibia length, were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (Marfell-Jones, Olds, Stew & Carter 2006). The same trained measurers have measured each selected anthropometric indicator while the quality of their performance was evaluated against the prescribed ISAK Manual. The age of each subject was obtained directly from the birth date.

Body height was measured by using a stadiometer to the nearest 0.1 cm with the participants standing barefoot upright against it. The subjects had to bring their feet together and move back until their heels touched the bottom of the stadiometer upright. Their buttocks and upper part of their back were also in contact with the stadiometer upright, but the back of their heads needed not touch the stadiometer. The subjects' heads had to be in the Frankfort horizontal plane, which was achieved when the lower edge of the eye socket (the orbitale) was horizontal with the tragion. The vertex had to be the highest point on their head; otherwise, the subjects had to raise or lower their chin until their heads were properly aligned.

The tibia length is the span between the tibiale mediale (the most superior point on the medial border of the head of the tibia) and the sphyrion tibiale (the most distal tip of the medial malleolus). It has been measured by using anthropometer to the nearest 0.1 cm with the participants seated with the right ankle resting over the left knee so that the medial aspect of the leg is able to be measured. This represents the tibia length. One branch of the anthropometer is placed on the marked tibiale mediale site, and the other branch is positioned on the marked sphyrion site.

The analysis was performed using the Statistical Package for Social Sciences (SPSS) version 23.0. Means and standard deviations (SD) were obtained for both anthropometric variables. A comparison of means of body height and tibia length within each sex group and between sexes was performed using a t-test. The body height and tibia length ratio were determined by using simple correlation coefficients at 95% confidence interval. Then, a linear regression analysis was performed to examine the extent to which the tibia length can reliably predict body height. Statistical significance was set at  $p < 0.05$ .

## Results

A summary of the anthropometric measurements for both sexes is presented in Table 1. The mean of the body height for male was  $179.52 \pm 5.96$  cm and tibia length was  $40.19 \pm 2.90$  cm, while for female the body height was  $165.72 \pm 4.93$  cm and tibia length was  $36.48 \pm 2.41$  cm. The sex difference between body height and tibia length measurements was highly statistically significant (body height:  $t = 50.685$ ;  $p < 0.000$ . and tibia length:  $t = 27.842$ ;  $p < 0.000$ ).

*Table 1: Anthropometric measurements of the population*

<b>Subjects</b>	<b>Body Height Range (Mean±SD)</b>	<b>Tibia Length Range (Mean±SD)</b>
Male	161.4-198.8 (179.52±5.96)	31.0-56.2 (40.19±2.90)
Female	153.3-185.0 (165.72±4.93)	30.1-45.8 (36.48±2.41)

The simple correlation coefficients and their 95% confidence interval analysis between the anthropometric measurements are shown. The body height and tibia length ratio were significant ( $p < .001$ ) in this sample, in males ( $r = .584$ ) and females ( $r = .578$ ).

The first linear regression model was extracted by including age as a covariate. However, it was found that the contribution of this covariate was insignificant and, therefore, the age covariate was dropped, and estimations were derived as a univariate analysis. The values of the regression coefficient for males ( $R = 0.584$ ) and females ( $R = 0.578$ ) signify that tibia length can fairly reliably predict body height in Kosovan males ( $t = 20.707$ ,  $p < .001$ ) and females ( $t = 19.930$ ,  $p < .001$ ), which confirms that 34.1% of the variation of height in males and 33.4% of the variation in females can be explained by tibia length.

## Discussion and conclusion

This study enhances a very important update of average body height among both Kosovan sexes. The results of this study proved that Kosovan boys, with an average height of 179.52 cm, are not as tall as the tallest Europeans (Table 4), given 183.9 cm of the Bosnians (Popovic et al. 2015), 183.2 cm of the Montenegrins measured in 2011 (Bjelica et al. 2012), 182.4 cm of the Dutch measured in the lifestyle, preventive screening in 2010-2013 (Statistics Netherlands 2016), and 182.0 cm of the Serbians measured in 2012 (Popovic, Bjelica, Molnar, Jaksic & Akpinar 2013).

The mean stature of Kosovan boys is still shorter than Lithuanians with 181.3 cm (Tutkuviene 2005), 180.9 cm of the Estonians (Kaarma et al. 2008), Icelanders with 180.6 cm (Dagbjartsson, Thorsson, Palsson & Arnorsson 2000), Croats with 180.5 cm (Jureša, Musil & Tiljak 2012), Swedes with 180.4 cm (Werner & Bodin 2006), Slovenians with 180.3 cm (Starc & Strel 2011), Danes (Statistics Denmark 2011), Czechs (Vignerová, Brabec & Bláha 2006) and several other nations, which indicated that Kosovans are a fairly tall nation, but are not close to the top 10 nations in height worldwide (Table 2).

*Table 2: World's Top 10 Nations with the tallest men (Arifi et al. 2017)*

	<b>Country</b>	<b>Mean Body Height</b>	<b>Source</b>
1	Bosnia and Herzegovina	183.9	Popovic et al. 2015
2	Montenegro	183.2	Bjelica et al. 2012
3	Netherland	182.4	Statistics Netherlands 2016
4	Serbia	182.0	Popovic et al. 2013
5	Lithuania	181.3	Tutkuviene 2005
6	Estonia	180.9	Kaarma et al. 2008
7	Iceland	180.6	Dagbjartsson et al. 2000
8	Croatia	180.5	Jureša et al. 2012
9	Sweden	180.4	Werner & Bodin 2006
10	Slovenia	180.3	Starc & Strel 2011

The mean body height of Kosovan girls was 165.72 cm on average, which is shorter than in Bosnians with 171.8 cm (Popovic et al. 2015), Dutch with 168.8 (Statistics Netherlands 2016), Montenegrins with 168.3 cm (Bjelica et al. 2012), 167.5 cm of the Lithuanians with 167.5 cm (Tutkuviene 2005), Slovenians with 167.4 cm (Starc & Strel 2011), and several other nations ranked in the top 10 tallest female nations, according to the available sources (Table 3).

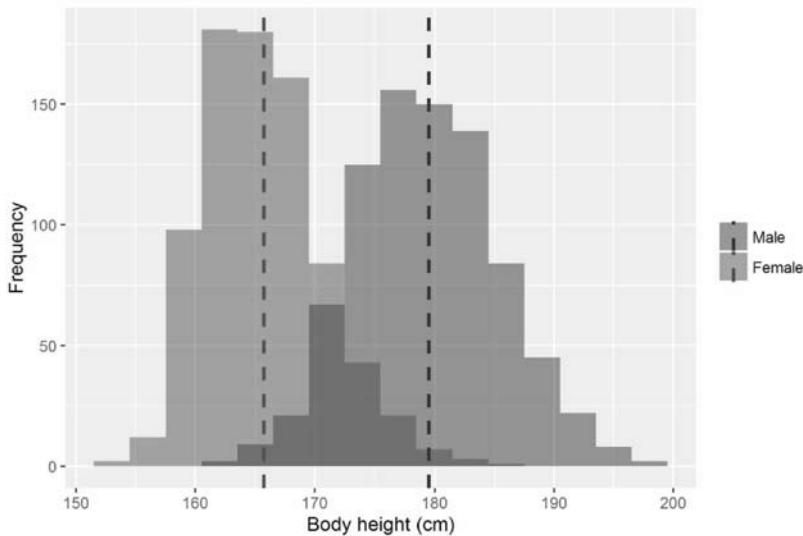
*Table 3: World's Top 10 Nations with the tallest women (Arifi et al. 2017)*

	<b>Country</b>	<b>Mean Body Height</b>	<b>Source</b>
1	Bosnia and Herzegovina	171.8	Popovic et al. 2015
2	Netherland	168.8	Statistics Netherland 2016
3	Montenegro	168.3	Bjelica et al. 2012
4	Germany	167.7	Hesse et al. 1997
5	Lithuania	167.5	Tutkuviene 2005
6	Slovenia	167.4	Starc & Strel 2011
7	Iceland	167.2	Dagbjartsson et al. 2000
8	Check Republic	167.2	Vignerová et al. 2006
9	Latvia	167.1	Gerhards 2005
10	Sweden	167.0	Werner & Bodin 2006

However, we could hypothesise that residents of Kosovo have not reached their full genetic potential yet due to various environmental factors that might have influenced their development (wars in the former Yugoslavia, continued poor economic situation) in

recent decades. We can assume that these circumstances had a negative bearing on the secular trends in Kosovo and surrounding countries alike. It is, thus, expected that the secular changes influencing stature will ascend in the next two or three decades in comparison to some developed countries where this trend has already completed such as for Dutch (Schönbeck et al. 2013).

It is also intriguing to mention that the frequency of very tall individuals appears to be distinctive for the Kosovan boys, since 5.1 percent measured 190 cm or more in body height. If a specified percent in Kosovo was to be compared with the 20.2 percent in Bosnia and Herzegovina (Popovic et al. 2015), 20 percent in the Netherlands (Pineau et al. 2005), 14 percent in Serbia (Popovic et al. 2013) and 13 percent in Montenegro (Bjelica et al. 2012), it would imply that the frequency of very tall males in Kosovo does not appear likely in the Dinaric Alps in general, because this number is much closer to the non-Dinaric Alps nations such as 2.7 in Macedonia (Popovic, Bjelica, Georgiev, Krivokapic & Milasinovic 2016) or 1.5 percent in France (Pineau et al. 2005). With the frequency of very tall female individuals in regards, it does not appear to be characteristic of the Kosovan girls, since less than one percent (0.8%) reached 180 cm or more in body height (Figure 1).



*Figure 1: Density of body height among both sexes*

The assessment of body height using various anthropometric measures is very typical from the past centuries and it has been attempted to be studied by many researchers. However, it is important to accentuate that the arm span has been recognized as the most reliable body indicator for predicting the body height of an individual (Mohanty et al. 2001; Ter Goon et al. 2011), while tibia length was very close too (Khatun, Sharma, Jain & Gupta 2016; Kaore et al. 2012; Agnihotri et al. 2009). In parallel, it is important

to emphasize that the individual and ethnic variations referring to body height and its association with tibia length might differ from one ethnic group to another as well as from one race to the other, because the racial and ethnic differences can affect these measures and reduce the possibility of generalizing (Bjelica et al. 2012). High linear correlation between body height and tibia length in both genders was confirmed in existing studies (Agnihotri et al. 2009; Khatun et al. 2016).

The analysis has confirmed the necessity for developing separate body height models for each population from the aspect of ethnic differences. A recent study conducted by Popovic and his collaborators (2017) analysed the entire Kosovan population and have found specific correlation coefficient between body height and foot length in Kosovan male ( $r=0.669$ ) and female ( $r=0.625$ ) population. Another recent study has, however, confirmed the regional differences between the same ethnic groups as well (Arifi 2017), which requires additional caution. Therefore, the main goal of this research was to test the hypothesis if the above-mentioned facts are true for Kosovan adults. As the correlation between tibia length and body height was significant in both Kosovan genders, the tibia length measurement seems to be a fairly reliable indirect anthropometric indicator for estimating body height in both genders of Kosovan population.

The results of the studies (Popovic et al. 2017; Arifi et al. 2017) confirm the need for developing separate body height models for both genders in Kosovo; however, the authors of the same studies have recommended that further studies should consider dividing the population of this country to regional subsamples and analysing them separately in order ensure that there are no environmental differences that can influence the average body height in both Kosovan genders and its relationship with tibia length. This concern is based on the fact that Kosovo does not entirely fall into Dinaric Alps typical population. In parallel, this study also confirms that it is necessary to develop separate body height models for each population on account of regional variations in Kosovo.

The obvious limitation of this research might also be the composition of the measured sample that consisted of high school students. This limitation is based on the fact that there are some studies evidencing that the growth of an individual does not end by this age (Grasgruber personal communication 2016; Jurak personal communication 2017). This assumption might be supported by the fact that university students have been found to be taller than the high school population in Bosnia and Herzegovina (Grasgruber et al. 2017), Poland (Wronka & Pawlinska-Chmara 2009) and Hungary (Szollosi 1998). In contrast, this was not found to be so for Montenegro (Popovic, Bjelica, & Hadzic 2014). Another obvious limitation of this study is also the aforementioned fact that both genders of Kosovo have not yet reached their full genetic potential, since various environmental factors might have had an impact on their development, which we were unable to control for in the analysis. It would be advisable to follow the height trends in the future to observe whether the secular changes influencing body height will ascend in the coming two or three decades due to improved living conditions and economic development.

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## Izveček

Namen raziskave je bil preučiti telesno višino obeh spolov na Kosovu. Kot alternative za oceno telesne višine za nekatere skupine prebivalstva smo preverili tudi razmerje med dolžino golenice in telesno višino. Zajetih je bilo 1623 posameznikov (830 moških, starih  $18,26 \pm 0,45$  in 793 žensk, starih  $18,24 \pm 0,43$ ). Antropometrijske meritve so bile izvedene po protokolu Mednarodnega društva za napredek kinantropometrije (ISAK). Rezultati so pokazali, da so moški s Kosova visoki  $179,52 \pm 5,96$  cm in imajo dolžino golenice  $40,19 \pm 2,90$  cm, medtem ko so ženske s Kosova visoke  $165,72 \pm 4,93$  cm in imajo dolžino golenice  $36,48 \pm 2,41$  cm. Rezultati so pokazali, da moški in ženske s Kosova ne dosežajo telesne višine odraslih prebivalcev najvišjih evropskih držav. Analiza je tudi pokazala, da je iz dolžine golenice pri moških in ženskah s Kosova mogoče precej zanesljivo napovedovati višino telesa.

**KLUČNE BESEDE:** napoved, telesna višina, dolžina golenice, Kosovo

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