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Body Height and Its Estimation Utilizing Arm Span Measurements in Bosnian and Herzegovinian Adults

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A B S T R A C T

Anthropologists recognized the tallness of nations in the Dinaric Alps long time ago. As the modern Bosnian and Herzegovinian fall more into the Dinaric racial classification, the purpose of this study was to examine the body height in Bosnian and Herzegovinian adults as well as the relationship between arm span as an alternative to estimating the body height and body height, which vary in different ethnic and racial groups. The nature and scope of this study analyzes 212 students (178 men, aged 22.42±2.79 and 34 women, aged 21.56±2.06) from the University of Banjaluka to be subjects. The anthropometric measurements were taken according to the protocol of the ISAK. Means and standard deviations were obtained. A comparison of means of body heights and arm spans within each gender group and between genders 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 have shown that male Bosnian and Herzegovinians are 183.87±7.11 cm tall and have an arm span of 184.50±8.28 cm, while female Bosnian and Herzegovinians are 171.82±6.56 cm tall and have an arm span of 169.85±8.01 cm. Compared to other studies, the results of this one have shown that both genders make Bosnian and Herzegovinian population one of the tallest nations on the earth, maybe the tallest one. Moreover, the arm span reliably predicts body height in both genders. However, the estimation equations, which were obtained in Bosnian and Herzegovinians, are substantially different alike in other populations, since arm span was close to body heights: in men 0.73±1.17 cm more than the body height and in women 1.97±1.45 centimeters less than the body height. This confirms the necessity for developing separate height models for each population.

Key words: *Prediction; Standing Height; Stature; Armspan; Bosnia and Herzegovina.*

Introduction

The Republic of Bosnia and Herzegovina is an independent, democratic state with a multiparty parliamentary system. The governmental system is based on the division of power into legislative, executive and judiciary and it has a bicameral legislature and a three-member Presidency composed of a member of each major ethnic group (Bosniaks, Serbs and Croats). However, the central government's power is highly limited, as the country is largely decentralized and comprises two autonomous entities: the Federation of Bosnia and Herzegovina and Republic of Srpska, with a third region, the Brčko District, governed under local government. This country is one of the successor states of the former Yugoslavia, from which it declared independence in 1992. Although it is one of the youngest modern countries in the World, this is a region that traces permanent human settlement back to the Neolithic age, during and after which it was populated by several Illyrian and Celtic civilizations. Culturally, politically, and socially, the country has one of the richest histories in the region, having been first settled by the Slavic peoples that populate the area today from the 6th through to the 9th centuries AD. From mid-15th to the late 19th centuries, this area was under the Ottoman Empire that was followed by annexation into the Austro-Hungarian Empire on 1908, which lasted up until the World War I. In the interwar period, Bosnia and Herzegovina was a part of the Kingdom of Serbs, Croats and Slovenes (Kingdom of Yugoslavia from 1929 onward) and after World War II, the country was granted full republic status in a newly formed Socialist Federal Republic of Yugoslavia. Hence, it is not hard to conclude the area of this country was under pressure of all strongest empires and represent the largest crossroads in the World.

Today, the Republic of Bosnia and Herzegovina covers the area of 51,197 sq. kilometers (Central Intelligence Agency, 2014). It is located in Southeastern Europe, on the Balkan Peninsula and it is bordered by Croatia to the north, west and south, Serbia to the east, and Montenegro to the southeast and it is almost landlocked, except for the 20 kilometers of coastline on the Adriatic Sea, around the town of Neum in the Herzegovina-Neretva Canton. Although the city is surrounded by Croatian peninsulas, by the international law, Bosnia and Herzegovina has a right of passage to the outer sea. In the central and southern interior of the country, the geography is mountainous, in the northwest, it is moderately hilly, and the northeast is predominantly flatland. The country's name comes from two regions: Bosnia and Herzegovina, which have an unclear defined border between them. Bosnia occupies the northern areas, which are roughly four-fifths of the entire country, while Herzegovina occupies the rest in the southern part of the country. The country is mostly mountainous, encompassing the central Dinaric Alps. The northeastern parts reach into the Pannonian basin, while in the south it borders the Adriatic Sea. Dinaric

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Alps generally run in east-west direction, and get higher towards the south. Overall, close to 50% of Bosnia and Herzegovina is forested, while less than 1% is covered by water. Most forest areas are in Central, Eastern and Western parts of Bosnia, while Herzegovina has drier Mediterranean climate. Northern Bosnia (Posavina) contains very fertile agricultural land along the river Sava and the corresponding area is heavily farmed. This farmland is a part of the Parapannonian Plain stretching into neighboring Croatia and Serbia.

Bosnia and Herzegovina is home to three ethnic "constituent peoples": Bosniaks, Serbs and Croats. According to the 1991 census, Bosnia and Herzegovina had a population of 4,377,000 inhabitants (Institute for Statistics of Federation of Bosnia and Herzegovina, 2014), while the 1996 UNHCR unofficial census showed a decrease to 3,920,000 inhabitants (Institute of International Cooperation of the German Adult Education Association, 2014). Large population migrations during the Yugoslav wars in the 1990s have caused demographic shifts in the country. No census has been taken during war time, and political disagreements have made it impossible to organize one later on. Nevertheless, a census has been planned for 2012., but that date has been delayed until 2014. The total population of the Republic of Bosnia and Herzegovina, according to the 2014 census, was 3,871,643 inhabitants (Central Intelligence Agency, 2014). Ethnically, according to data from 2014 cited by the Central Intelligence Agency (2014), Bosniaks constitute 52.5 percent of the population, Serbs 33.5 percent, Croats 14 percent, and others around 1 percent. According to the same resource, 40 percent of the population identifies religiously as Muslims, 31 percent as Orthodox Christians, 15 percent as Roman Catholics, and 14 percent other (mostly atheists, Jews, and others). From the reason the ethnicity mostly corresponds to the religious affiliations, the authors of this study assumed the ethnical differences are based mostly on religious backgrounds and it is not realistically based on biological facts.

The tallness of the nations in the Dinaric Alps has been recognized by European anthropologists more than 100 years ago (Pineau, Delamarche, & Božinović, 2005). As the modern Bosnian and Herzegovinians, like the rest of the nations from Former Yugoslavia, fall more into the Dinaric racial classification than any other, it is assumed by the authors of this study that Bosnian and Herzegovinian adults might be equally tall or a bit taller than the tallest nations in the Europe (Bjelica et al., 2012; Popović, Bjelica, Molnar, Jakšić, & Akpinar, 2013): Dutch (male: 183.8 centimeters; female: 170.7 centimeters), Montenegrins (male: 183.21 centimeters; female: 168.37 centimeters) and Serbians (male: 182 centimeters; female: 166.8 centimeters). The authors of this study believed Bosnian and Herzegovinian population might be the tallest in the World, mostly due to the reason most of previous studies investigated all the nations that has been contained in Pineau and collaborators' sample (Bjelica et al., 2012; Popović et al., 2013, Popović, Bjelica, Geogiev, Hadžić and Akpinar, in press), excluding the Bosnians and Herzegovinians. However, any of previously investigated nations didn't reach the tallness that Pineu and his collaborators confirmed. From this reason, the population from Bosnia and Herzegovina might be the key population that increased the average body height of Dinaric Alps population measured by Pineu and his collaborators (2005). However, unlike the most other countries through Western Europe, Bosnia and Herzegovina keeps poor records and an update of average body heights among its populations is beneficial as well as its estimation utilizing arm span measurements, mostly due to the reason that measurement of body height is important in many settings (Bjelica et al., 2012).

It is already well known in scientific literature that the measurement of body height is important in many settings: it is an important measure of body size and gives an assessment of nutritional status (cited in Datta Banik, 2011), as well as an important measure of determination of basic energy requirements, standardization of measures of physical capacity and adjusting drug dosage, and evaluation of children's growth, prediction and standardization of physiological variables such as lung volumes, muscle strength, glomerular filtration and metabolic rate etc. (Golshan, Amra & Hoghoghi, 2003; M. Golshan, Crapo, Amra, Jensen & R. Golshan, 2007; Mohanty, Babu & Nair, 2001; Ter Goon, Toriola, Musa & Akusu, 2011). However, the exact body height cannot always be determined the usual way because of various deformities of the extremities or in patients who have undergone amputations or similar injuries. In such circumstances, an estimate of body height has to be derived from other reliable anthropometric indicators such as hand and foot lengths (A.K Agnihotri, S. Agnihotri, Jeebun & Googoolye, 2008; A.K. Agnihotri, Purwar, Googoolybe, S. Agnihotri & Jeebun, 2007; Kanchan et al., 2008; Rastogi, Nagesh & Yoganarasimha, 2008; Sanli et al., 2005), knee height (Fatmah, 2005; Hickson & Frost, 2003; Karadag, Ozturk, Sener & Altuntas, 2012), length of the forearm (Ilayperuma, Nanayakkara & Palahepitiya, 2010), length of the sternum (Menezes et al., 2009; Menezes et al., 2011), vertebral column length (Nagesh & Pradeep, 2006), sitting height (Fatmah, 2005), length of scapula (Campobasso, Di-Vella & Introna, 1998), arm span (Aggrawal, Gupta, Ezekiel & Jindal, 2000; Bjelica et al., 2012; Datta Banik, 2011; Fatmah, 2005; Hickson & Frost, 2003; Jalzem & Gledhill, 1993; Mohanty, et al., 2001; Ter Goon et al., 2011) as well as cranial sutures (Rao et al., 2009), skull (Bidmos, 2006; Bidmos & Asala, 2005), facial measurements (Sahni et al., 2010) et cetera. Therefore, all these anthropometric indicators which are used as an alternative to estimate body height are very important in predicting age-related loss in body height. Also in identifying 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 predicting body height in many older people as it is very difficult to measure it precisely, and sometimes impossible because of mobility problems and kyphosis (Hickson & Frost, 2003).

According to all mentioned above, the authors believed it would be reasonable to find the effectiveness of using various body indicators in estimating body height in the Bosnian and Herzegovinian population. Furthermore, several studies have reported the effectiveness of using various body parameters in predicting body height and arm span was found to be the most reliable one (Hickson & Frost, 2003; Jalzem & Gledhill, 1993; Mohanty et al., 2001; Ter Goon et al., 2011). However, the associations of arm span and body height was found to vary in different ethnic and racial groups (Bjelica et al., 2012; Brown, Feng & Knapp, 2002; Popović et al., 2013, Popović et al., in press; Reeves, Varakamin & Henry, 1996; Steele & Chenier, 1990). Even though several studies of this nature are available on western populations, very limited data is available on Bosnian and Herzegovinian subjects. In the light of rather scarce recent scientific literature, the purpose of this study was to examine the body height in both genders of Bosnian and Herzegovinian adults and the relationship between arm span and body height.

Methods

The nature and scope of this study qualifies 212 students (178 men and 34 women) from the University of Banjaluka to be subjects. This group was chosen because the growth of an individual ceases by this age and there is no age-related loss in body height at this age. The authors have also believed this

sample might fairly represent the whole population of Bosnia and Herzegovina as students were admitted into the University of Banjaluka regardless of geographical residence and socio-economic status, as well as ethnicity. The average age of the male subject was 22.42±2.79 years old (range 19-32 yrs.), while the average age of the female subject was 21.56±2.06 years old (range 19-26 yrs.). It is also important to emphasize that the authors could not accept students 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-Bosnian and Herzegovinian (twelve participants, five male and seven female were excluded from the data pool). Accordingly, the authors have purposely selected (deliberate sampling) the students from the Faculty of Sport and Physical Education at University of Banjaluka as they believed that most of them could be eligible to participate in the study, as well as this is one of the highly ranked Faculty of Sport and Physical Education in Bosnia and Herzegovina which brings together students from all parts of Bosnia and Herzegovina.

According to Marfell-Jones, Olds, Stew & Carter (2006), 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 did not 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 did not 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 each gender group and between genders 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 a linear regression analysis was performed to examine the extent to which arm span can reliably predict body height. Finally, these relationships were plotted as scatter diagrams. Statistical significance was set at $p<0.05$.

Results

A summary of the anthropometric measurements in both genders is shown in Table 1. The mean of the arm span for male subjects was 184.50±8.27 centimeters, which was 0.73±1.17 centimeters more than the body height and statistically insignificant (t=0.776, p=0.438), and for female subjects it was 169.85±8.01 centimeters, which was 1.97±1.45 centimeters less than the body height and statistically insignificant (t=1.110, p=0.271). The gender difference between body height and arm span measurements was statistically significant (body height: t=9.715; p<.000, and arm span: t=9.68; p<.000).

Table 1. Anthropometric Measurements of the Study Subjects

Subjects	Body Height Range (Mean±SD)	Arm span Range (Mean±SD)
Male	164.2-206.3 (183.87±7.11)	165.4-211.1 (184.50±8.27)
Female	159.3-187.4 (171.82±6.56)	152.1-190.1 (169.85±8.01)

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 sample, regardless of gender.

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

Subjects	Correlation Coefficient	95% confidence interval	Significance p-value
Male	0.876	0.691–0.814	<0.000
Female	0.887	0.590–0.862	<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 both Serbian genders.

Table 3. Results of Linear Regression Analysis Where the Arm Span Predicts the Body Height

Subjects	Regression Coefficient	Standard Error (SE)	R-square (%)	t-value	p-value
Male	0.876	3.445	76.7	24.064	0.000
Female	0.887	3.072	78.7	10.877	0.000

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

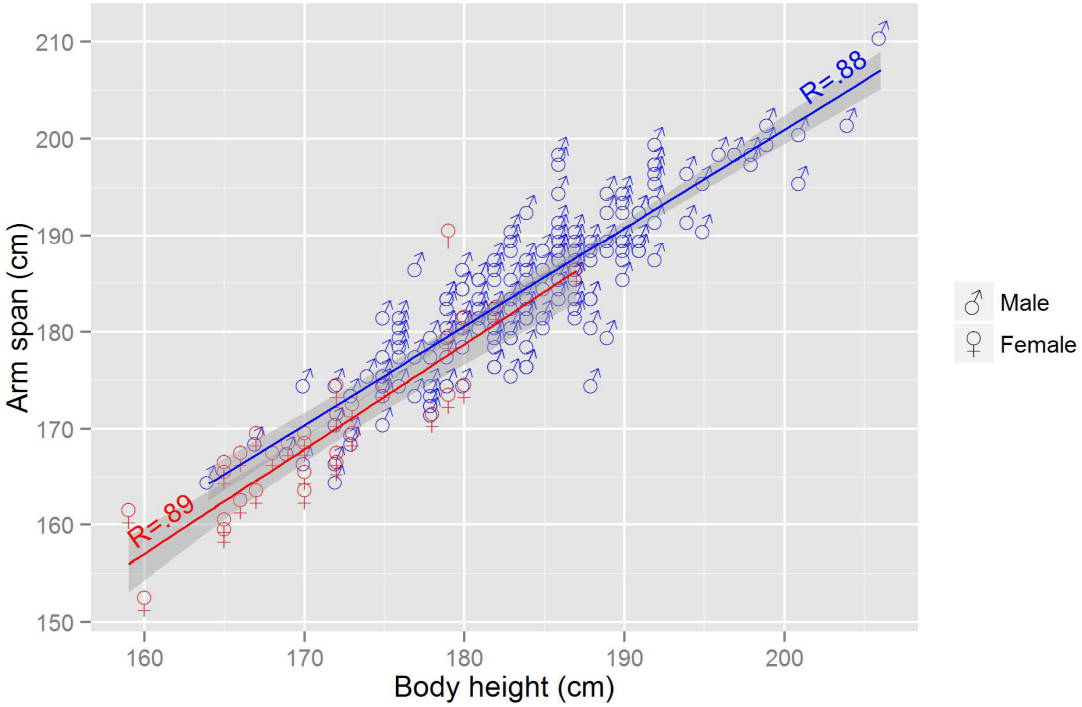

Figure 1. Scatter Diagram and Relationship between Arm Span Measurements and Body Height among Both Genders

Discusion

This study contributes to a very important update of average body heights among Bosnian and Herzegovinian males and females. The results proved that Bosnian and Herzegovinian males are very tall with an average of 183.87 centimeters and it is a little bit more comparing to the tallest nations in the Europe: 183.8 centimeters of the Dutch male population measured in the last nationwide survey in 2010 (TNO, 2010), 183.74 centimeters of the Montenegrin male population measured in 2013 (Popović, Bjelica & Hadžić, 2014) and 182 centimeters of the Serbian male population measured in 2012 (Popović et al., 2013). Consequently, the average height of Bosnian and Herzegovinian men is also taller than 181.3 centimeters of the Lithuanians (Tutkuviene, 2005), 180.6 centimeters of the Icelanders (Dagbjartsson, Thornórsson, Pálsson & Arnórsson, 2000), 180.5 centimeters of the Croats (Juresa, Musil & Tiljak, 2012), 180.4 centimeters of the Swedes (Werner & Bodin, 2006), 180.3 centimeters of the Slovenes (Starc & Strel, 2011), Danes (Statistics Denmark, 2011) and Czechs (Vignerová, Brabec & Bláha, 2006) and 141.7 centimeters of the shortest ethnic group in the whole World, Mbuti Pygmies (cited in Froment, 1993), which made Bosnian and Herzegovinian males the tallest nation on the earth. On the other hand, the average body height of Bosnian and Herzegovinian females was 171.8 centimeters on average and this result proved that Bosnian and Herzegovinian females are much taller than the tallest nations that were measured so far, such as the Netherlands with 170.7 centimeters (TNO, 2010), Montenegrins with 169.5 centimeters (Popović et al., 2014), Lithuanians with 167.5 centimeters (Tutkuviene, 2005), the Slovenes with 167.4 centimeters (Starc & Strel, 2011), the Icelanders and Czechs with 167.2 centimeters (Dagbjartsson et al., 2000; Vignerová at al. 2006), the Letts with 167.1 centimeters (Gerhards, 2005), and the Swedes with 167 centimeters (Werner & Bodin, 2006). However, there is a hypothesis that both genders of Bosnian and Herzegovinians 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. Therefore, the authors believe that these circumstances had a negative bearing on the secular trend in Bosnia and Herzegovina as well as surrounding countries such as Serbia, Montenegro and Macedonia (Bjelica et al., 2012; Popović et al., 2013, Popović et al., in press;), while it is expected that the secular changes affecting height will go up in the following two decades, comparing it to developed countries where this trend has already completed.

For better viewing of the tallest nations around the World,

the authors have prepared Table 4 to present an overview of the top 10 tallest male populations on the earth, while the overview of the data from the female population is sorted in Table 5 (the most of them are data from the national surveys).

Table 4. Top 10 Tallest Male Nations on the Earth

#	Country	Average Body Height	Source
1	Bosnia and Herzegovina	183.9	Current study
2	Netherland	183.8	TNO, 2010
3	Montenegro	183.7	Popović et al., 2014
4	Serbia	182.0	Popović et al., 2013
5	Lithuania	181.3	Tutkuviene, 2005
6	Iceland	180.6	Dagbjartsson et al., 2000
7	Croatia	180.5	Juresa et al., 2012
8	Sweden	180.4	Werner & Bodin, 2006
9	Slovenia	180.3	Starc & Strel, 2011
10	Denmark	180.3	Statistics Denmark, 2011

Table 5. Top 10 Tallest Female Nations on the Earth

#	Country	Average Body Height	Source
1	Bosnia and Herzegovina	171.8	Current study
2	Netherland	170.7	TNO, 2010
3	Montenegro	169.5	Popović et al., 2014
4	Lithuania	167.5	Tutkuviene, 2005
5	Slovenia	167.4	Starc & Strel, 2011
6	Iceland	167.2	Dagbjartsson et al., 2000
7	Czech Republic	167.2	Vignerová et al., 2006
8	Latvia	167.1	Gerhards 2005
9	Sweden	167.0	Werner & Bodin, 2006
10	Serbia	166.8	Popović et al., 2013

It is also interesting to mention that the density of very tall subjects appears to be characteristic of the Bosnian and Herzegovinian males, since 20.2% measured 190 centimeters or more in body height. If 20.2% in Bosnia and Herzegovina would be compared to 28% in Dinaric Alps (Pineau et al., 2005), 20% in the Netherlands (Pineau et al., 2005), 14% in Serbia (Popović et al., 2012), 13% in Montenegro (Bjelica et al., 2012) and only 1.5% in France (Pineau et al., 2005), it would imply that the density of very tall subjects in Bosnian and Herzegovinian males appears, but not frequently like in the Dinaric Alps in general that reached in Pineu and collaborator's study. On the other hand, the density of very tall subjects also appear to be characteristic of the Bosnian and Herzegovinian females, since mora than 14% measured 180 centimeters or more in body height.

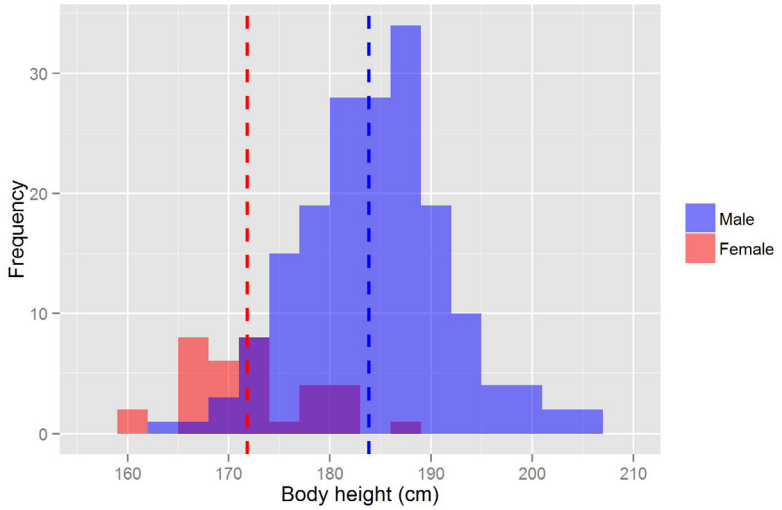

Figure 2. Density of Body Height among Both Genders

The estimation of body height using various anthropometric measurements are quite the age-old investigations over the past centuries and it has been attempted by many authors. As it is already mentioned, all of them estimated body height from vario-

us anthropometric measurements, but it is important to emphasize that the arm span has been derived the most reliable body indicator for predicting body height of an individual (Mohanty et al., 2001; Ter Goon et al., 2011). However, it must be underlined that the individual and ethnic variations in respect of body height and its relation with arm span were already observed in European (Reeves et al., 1996) and African populations (De Lucia et al., 2002), while Mohanty et al. (2001) have stated that the estimating equation varies from race to race, and ethnic group to ethnic group. In Steele and Chenier's study (1990), the arm span was nearly 8.3 centimeters more than the body height for black population (105.36% body height), whereas for white population this difference was only 3.3 centimeters (102.04% body height). Mohanty et al. (2001) have noted in their study that the arm span was nearly 2.5 centimeters more than the body height in South Indian females (101.4% body height), which is similar to that noted in the white population. In Ter Goon et al.'s study (2011), arm span was 5.8 centimeters more than body height for Nigerian males (103.3% body height), whereas for Nigerian females this difference was only 4 centimeters (102.5% body height) which is similar to that noted in the white population, although they are black. The most recent studies conducted by Bjelica et al. (2012) that showed that arm span was 2.5 centimeters more than body height for Montenegrin males (101.4% body height), whereas for Montenegrin females this difference was only 0.24 centimeters but in favor of body height (99.9% body height) and Popovic at al. (2013) that showed that arm span was 2.8 centimeters more than body height for Serbian males (101.5% body height), whereas for Serbians females this difference was only 0.15 centimeters but in favor of body height (98.7% body height), while Quanjere et al. (2014) have highlighted the body height estimated from the predicted arm span/height ratio may differ by up to 10% from actual stature. All mentioned have confirmed again the necessity for developing separate height models for each population on account of ethnic differences. Therefore, the main goal of the current study was to find out if these facts are true for the Bosnian and Herzegovinian population, since it is known that the estimating equation varies from race to race, and ethnic group to ethnic group (Mohanty et al., 2001). Hence, in the present study it is observed that the arm span was 0.73 centimeters more than the body height in males (100.3% body height), while it was 1.97 centimeters less than the body height in female population (98.9% body height). The arm span/height ratio in Bosnian and Herzegovinian males is extremely low when compared with other Europeans but it is quite close to the data that were reached in the measurement of Montenegrin and Serbian population (Bjelica et al., 2012; Popović et al., 2013), while the arm span/height ratio in Bosnian and Herzegovinian females is corresponding to Montenegrin and Serbian population as well as other Europeans.

The results of the above mentioned studies are also very similar to the correlation obtained in the present study (men: r=0.876; women: r=0.887). For example, Mohanty et al. (2001) reported that the correlation was r=0.82, while in Hickson and Frost's study (2003) correlation was r=0.86, in Zverev's study (2003) correlation was r=0.87 for males and r=0.81 for the female population. In the most recent studies, Ter Goon et at. (2011) reported that correlation was r=0.83, while Bjelica et al. (2012) reported that the correlation was r=0.861 for males and r=0.809 for female population and Popović et al. (2013) reported that the correlation was r=0.814 for males and r=0.822 for female population. As the correlation between arm span and body height was so high and significant in both Bosnian and Herzegovinian genders, the arm span measure therefore seems to be a reliable indirect anthropometric measurement for estimating body height in Bosnian and Herzegovinian adults.

Even though these relations are similar, the estimation equations which are obtained in Bosnian and Herzegovinian population, if the authors exclude Montenegrin and Serbian population, are substantially different from other populations, especially in Bosnian and Herzegovinian female population. Although this confirms the necessity for developing separate height models for each population on account of ethnic differences, it must be emphasized that further researches has to use larger samples for the prediction of body height utilizing arm span measurement, mostly due to the reason this study as well as some other studies that has been attempted in the past (Aggrawal et al., 2000; Bjelica et al., 2012; Hickson & Frost, 2003; Kwok & Whitelaw, 1991; Popović et al., 2013; Steele & Chenier, 1990; Ter Goon et al., 2011; Zverev 2003) used quite small samples. A more precise estimation of the average body height and its prediction utilizing arm span measurements in Bosnian and Herzegovinian adults would require a large sample with sufficient geographical and social heterogeneity or a national survey that measures the whole population. Moreover, next to the small sample, especially in female population (n=34), the obvious limitation of this research study was the composition of the measured sample that consisted of university students. Since university-educated persons, according to Bjelica et al. (2012) have been taller than the general population in Poland (Kułaga et al., 2011; Wronka & Pawliñska-Chmara, 2009), and Hungary (Bodzsár & Zsákai, 2008; Eiben & Tóth, 2000; Szöllősi, 1998), the authors cannot exclude the possibility that the body height of the students somewhat overestimates the average body height of contemporary Bosnian and Herzegovinians. On the other hand, this fact wasn't the case in Montenegro and might not be the case in Bosnia in Herzegovina too, mostly due to the reason the results from the study (sample that consisted of university students) conducted by Bjelica et al. (2012) correspond with the results reached in the national survey (Popović, et al., 2014).

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