ORIGINAL SCIENTIFIC PAPER

Local Geographical Differences in Adult Body Height in Montenegro

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ABSTRACT The purpose of this research study is to examine body height in both Montenegrin sexes and map local geographical differences within both groups. A total of 2088 individuals (981 boys and 1107 girls) participated in this research study, and anthropometrical data were collected from 23 municipalities throughout the country. The anthropometric measurements were taken according to the ISAK protocol. Means and standard deviations were calculated for ages and anthropometric variable (body heights) as well as frequencies for the calculation of density of very short and very tall subjects. The results revealed that Montenegrin boys are 183.36±6.89 cm tall, while Montenegrin girls are 169.38±6.37 cm tall. The results of this study confirmed our assumption that both men and women in Montenegro are among the tallest people on the planet. However, the regional variation is considerable: from 181.25 cm in the municipality of Cetinje to 185.51 cm in the municipalities of Kolasin and Savnik for males and from 162.53 cm in the municipalities of Plav and Andrijevica to 170.86 cm in the municipality of Niksic for females. The measured values of body heights in Montenegro are currently one of the highest in the world, while the secular trend might increase it in the upcoming decades.

KEY WORDS Standing Height, Stature, Montenegro.

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ADULT HUMAN HEIGHT IN MONTENEGRO
http://mjssm.me/?sekcija=article&artid=135

Introduction

Over the course of the 20th century, adult body heights dramatically increased in Montenegro, in parallel to most industrialized countries (Schonbeck et al., 2013); it was about 5 centimeters on average. This trend is apparently caused by much better lifestyles that improved from decade to the decade, and it is reflected in better living conditions and the increased nutritional, hygienic, economic, and health status of the people studied (Hauspie, Vercauteren & Susanne, 1996).

Trends in men's body height have been analyzed in Europe, the USA and Japan for up to 250 years (cited in NCD Risk Factor Collaboration, 2016). There are fewer historical data for women and for children, because the focus was historically directed towards men, while the adult data tend to be cross-sectional or cover short periods (cited in NCD Risk Factor Collaboration, 2016). Nevertheless, the unusual height of Montenegrin highlanders was a fact recognized by European anthropologists more than a century ago (Bjelica et al., 2012). The widely recognized researcher Robert Ehrich conducted research at the beginning of the 20th century and measured 800 male Montenegrins (Coon, 1975) and proclaimed them to have the highest average height in all of Europe (177 cm), with some districts approaching 178 centimeters. In contrast, the same study stated that their counterparts in Herzegovina (geographically close) reached 175–176 centimeters. It is noteworthy that the majority of European countries barely reached 170 cm in this period (Coon, 1939). Generally, the entire population living in the Dinaric Alps has historically been renowned for the unusually large body size of its inhabitants (Coon, 1939; Coon, 1970). However, the problem is that unlike most Western countries, this region keeps poor records and any initiative that explores this area is of significance for anthropological research in general.

Accepted after revision: August 29 2016 | First published online: March 01 2017

Conflict of interest: None declared.

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More recently, several research studies (Bjelica et al., 2012; Popovic, Bjelica, Georgiev, Krivokapic & Milasinovic, 2016; Bubanja, Vujovic, Tanase, Hadzic & Milazinovic, 2015; Vujovic, Bubanja, Tanase & Milasinovic, 2015; Milasinovic, Popovic, Matic, Gardasevic & Bjelica, 2016a; Milasinovic, Popovic, Jaksic, Vasilejvic & Bjelica, 2016b) that dealt with the adult body heights in Montenegro (more or less directly) have confirmed that Montenegrins are one of the tallest nations (both sexes) on the planet. However, none of these studies analyzed the local variation in adult body heights within the municipalities, which is also of interest, due to the various geographic characteristics. Therefore, the results of such studies would provide beneficial knowledge, due to the geographical diversity throughout Montenegro, and the scientific fact that tallest people live in the mountains (Pineau, Delamarche, & Bozinovic, 2005).

FIGURE 1 Municipalities in Montenegro

It is well-known in scientific literature that the measurement of adult body heights is important in many settings (cited in Popovic, Bjelica, Tanase & Milasinovic, 2015): it is a relevant measure of body size and gives an assessment of nutritional status, and a meaningful measure of determination of basic energy requirements, standardization of measures of physical capacity and adjusting drug dosage, evaluation of children's growth, prediction and standardization of physiological variables and talent identification, etc. (Golshan, Amra & Hoghoghi, 2003; Mohanty, Babu & Nair, 2001; Ter Goon, Toriola, Musa & Akusu, 2011; Popovic, Bjelica, Molnar, Jaksic & Akpinar, 2013; Popovic, Bjelica & Hadzic, 2014). Taller people might have enhanced longevity, have a lower risk of adverse pregnancy outcomes and cardiovascular and respiratory diseases, but have a higher risk of some cancers (cited in NCD Risk Factor Collaboration, 2016; Quanjer et al., 2014). There

UDC 572.512-053.8(497.16)

is also evidence that being taller is associated with higher level of education, higher monthly incomes, as well as higher level of position in its societies (cited in NCD Risk Factor Collaboration, 2016). Finally, adult body heights can also significantly influence success in sports.

With regard to the ongoing lack of representative anthropological research on the territory of Montenegro, the author of this study used the data from the conducted national survey, which was carried out in 2013, and analyzed local geographical differences. It covered a very large sample and enabled a detailed mapping of the local geographical differences within adult body heights among both genders. In this paper, the author has pooled Montenegrin population-based data to estimate body heights in adulthood for men and women living in available municipalities throughout Montenegro.

Methods

The nature and scope of this study qualifies 2088 final year students (981 males and 1107 females) from the secondary schools in Montenegro to be subjects. The sampling method is chosen parallel to the fact that the growth of both genders individual ceases by this age, while the age-related loss in body heights at this age is not recognized in the previous studies. The average male Montenegrins were between 17 and 20 years old (18.37±0.61), while the average female Montenegrins were between 17 and 20 years old (18.30±0.61). The exclusion criteria in this study were having physical deformities that could affect body heights and not having informed consent. The author also could not accept students who were non-Montenegrins.

The protocol of the International Society for the Advancement of Kinanthropometry (ISAK) was employed Marfell-Jones, Olds, Stew & Carter (2006), and the body height measurements were taken accordingly. The age of the study subjects was determined directly from their reported date of birth, while the trained measurers whose quality of performance had been evaluated against the prescribed "ISAK Manual" prior to the study performed these measurements. The frequencies of shorter (less than 170 and 160 centimeters) and taller individuals (above than 190 and 200 centimeters) are analyzed and presented separately (in percentages).

The analysis was carried out using SPSS version 20.0. Means and standard deviations were obtained for both genders from all available municipalities from all around of Montenegro.

Results

A summary of the body height measurements in the male population is shown in Table 1. The mean of the body heights for male subjects was 183.36±6.89 centimeters, while the tallest subjects live in central (183.58±6.95), the medium ones in northern (183.01±6.44) and the shortest in the southern regions (182.55±7.53) of Montenegro.

TABLE 1. Descriptive Statistics among Male Subjects

Municipality*	N	Age		Body Heights		
		Mean	SD	Mean	SD	Range
Bar & Ulcinj	50	18.28	0.64	182.13	7.47	163.6-199.0
Berane** & Rozaje	52	17.96	0.19	182.86	6.54	171.0-196.0
Plav*** & Andrijevica	25	17.60	0.50	181.26	6.98	170.2-195.2
Budva & Tivat	13	18.77	0.44	182.99	5.89	170.0-190.7
Kotor & Herceg Novi	24	18.04	0.55	183.17	8.62	170.2-198.2
Cetinje	74	18.26	0.76	181.25	6.06	165.1-202.0
Pljevlja	78	18.08	0.45	182.56	5.81	164.3-193.0
Danilovgrad	51	18.31	0.71	184.36	7.39	167.5-203.3
Podgorica	341	18.57	0.56	182.04	7.45	160.9-204.2
Niksic	168	18.63	0.49	184.57	6.57	166.1-200.9
Pluzine & Zabljak	28	17.71	0.60	184.88	5.78	172.0-196.5
Kolasin & Savnik	30	18.17	0.38	185.51	6.90	170.1-197.0
Mojkovac & Bijelo Polje	47	17.98	0.39	183.77	7.25	163.0-198.0
Northern Region	230	17.93	0.45	183.01	6.44	163.0-198.0
Central Region	664	18.53	0.58	183.58	6.95	160.9-204.2
Southern Region	87	18.29	0.63	182.55	7.53	163.6-199.0
Total	981	18.37	0.61	183.36	6.89	160.9-204.2

Legend: *- small municipalities are merged with the first neighboring municipality; **-Petnjica municipality is included; ***- Gusinje municipality is included.

A summary of the body height measurements in the female population is shown in Table 2. The mean of the body heights for female subjects was 169.38±6.37 centimeters, while the tallest subjects live in the central (169.70±6.27), the medium ones in the northern (168.84±6.36) and the shortest in the southern regions (168.76±6.79) of Montenegro.

TABLE 2 Descriptive Statistics among Female Subjects

Municipality*	N	Age		Body Heights		
		Mean	SD	Mean	SD	Range
Bar & Ulcinj	52	18.42	0.67	168.84	6.77	156.5-189.5
Berane** & Rozaje	37	18.08	0.28	169.24	5.15	160.0-179.0
Plav*** & Andrijevica	22	17.59	0.50	162.53	6.06	152.8-173.0
Budva & Tivat	40	18.90	0.38	168.95	7.42	153.8-187.7
Kotor & Herceg Novi	47	17.96	0.36	168.49	6.40	157.2-181.7
Cetinje	70	18.07	0.69	167.98	6.13	154.7-184.0
Pljevlja	108	18.09	0.38	169.54	6.24	155.5-183.3
Danilovgrad	49	18.33	0.66	168.37	6.60	151.5-182.2
Podgorica	362	18.50	0.57	168.54	6.33	150.2-193.4
Niksic	204	18.48	0.57	170.86	5.96	153.4-197.7
Pluzine & Zabljak	34	17.50	0.56	170.14	6.57	154.5-181.9
Kolasin & Savnik	26	18.15	0.37	169.82	7.09	151.0-183.0
Mojkovac & Bijelo Polje	56	17.91	0.29	168.90	6.11	156.0-185.6
Northern Region	257	17.93	0.45	168.84	6.36	152.8-185.6
Central Region	711	18.42	0.60	169.70	6.27	150.2-197.7
Southern Region	139	18.40	0.62	168.76	6.79	153.8-189.5
Total	1107	18.30	0.61	169.38	6.37	150.2-197.7

Legend: *- small municipalities are merged with the first neighboring municipality; **-Petnjica municipality is included; ***- Gusinje municipality is included.

Discussion

This research contributes to a beneficial update of adult human heights among both sexes in Montenegro, mostly because the reason the recent study conducted by NCD Risk Factor Collaboration (2016) did not adequately analyze the trends in adult human heights in Montenegro. The aforementioned study was a largest study ever in this area, analyzing 1472 populations in 200 countries and over 18.6 million participants to estimate adult human heights for people born between 1896 and 1996. However, this research excludes the current data from Montenegro, while the importance of its inclusion is established in the findings of Robert Ehrich, proving that Montenegrin males were the tallest population throughout Europe at the beginning of the 20th century (Coon, 1975), with an average height of 177 centimeters (the female population was not measured). Consequently, it is reasonable to assume the average adult human height in Montenegro is also currently among the highest (including females because they have the same genetic backgrounds as male population).

The results of this research study reveal that Montenegrin males are very tall, with an average of 183.4 centimeters and are one of the tallest nations in Europe and the entire world. Montenegrin males are shorter than Bosnian and Herzegovinian males measured in the Republic Srpska entity (183.9 centimeters) in 2013 (Popovic et al., 2015) and the Federation of BH Entity (183.8 centimeters) in 2015 (Gardasevic et al., 2017) as well as the Dutch male population (183.8 centimeters) measured in the last nationwide survey in 2010 (TNO, 2010). In contrast, Montenegrin males are taller than the 182 centimeters of the Serbian male population measured in 2012 (Popović et al., 2013), the 181.3 centimeters of Lithuanians (Tutkuviene, 2005), the 180.6 centimeters of Icelanders (Dagbjartsson, Thornórsson, Pálsson & Arnórsson, 2000), 180.5 centimeters of Croats (Juresa, Musil & Tiljak, 2012), 180.4 centimeters of the Swedes (Werner & Bodin, 2006), the 180.3 centimeters of Slovenes (Starc & Strel, 2011), Danes (Statistics Denmark, 2011), Czechs (Vignerová, Brabec & Bláha, 2006) et cetera.

The average height of Montenegrin females in this study is 169.4 centimeters, and this result proved that this population is also one of the tallest nations in the entire planet. Montenegrin females are shorter than females from Bosnia and Herzegovina with 171.8 centimeters (Popovic et al., 2015), the Netherlands with 170.7 centimeters (TNO, 2010), while this population is taller than females in Lithuania with 167.5 centimeters (Tutkuviene, 2005), Slovenia with 167.4 centimeters (Starc & Strel, 2011), Iceland and Czech Republic with 167.2 centimeters (Dagbjartsson et al., 2000; Vignerová at al. 2006), Latvia with 167.1 centimeters (Gerhards, 2005), Sweden with 167 centimeters (Werner & Bodin, 2006), etc.

However, there is an assumption that both genders of Montenegrins have not yet reached their full genetic potential yet regarding height, since they have been influenced by various environmental factors (wars, poor economic situation, etc.) in recent decades. Therefore, it is reasonable to assume these circumstances had a negative bearing on the secular trends in Montenegro. Consequently, the secular changes affecting adult human heights might rise in the following decades. It is interesting to add that this trend has already completed in the developed countries and it is confirmed that one of the world's tallest nations (the Dutch population)

UDC 572.512-053.8(497.16)

has stopped growing taller (Schonbeck et al., 2013) and this fact might push Western Balkan populations back among the tallest nations.

In contrast to the recent and the largest study in this area "A century of trends in adult human height", conducted by NCD Risk Factor Collaboration (2016), the results of this study confirmed our assumption that both male and female subjects from Montenegro are one of the tallest populations on the planet, the same as at the beginning of 20th century. However, the regional variation is considerable: from 181.25 cm in the municipality of Cetinje to 185.51 cm in the municipalities of Kolasin and Savnik for male and from 162.53 cm in the municipalities of Plav and Andrijevica to 170.86 cm in the municipality of Niksic for female subjects.

The density of very tall subjects appears to be characteristic of the Montenegrin males since 18.2% measured 190 centimeters or more in adult human heights. If the 18.2% in Montenegro compare to the 28% in Dinaric Alps (Pineau et al., 2005), the 20.2% in Bosnia and Herzegovina (Popovic et al., 2015), the 20% in the Netherlands (Pineau et al., 2005), the 14% in Serbia (Popović et al., 2012) and the mere 1.5% in France (Pineau et al., 2005), the of fact the density of very tall subjects in Montenegrin males is apparent. However, the density of very tall subjects in Montenegro did not reach the density of the Dinaric Alps population from Pineau et al.'s study (2005). Although all nations from Dinaric Alps were measured and did not individually reach the density of its summary, this fact leads to the assumption that individuals living in mountains might have a higher percentage of subjects with 190 centimeters or more in adult human heights (at the expense of those living in low-lying regions). However, the considerable regional variation in this study did not amplify this assumption, mostly due to the reason some mountain areas showed opposite results. It is also interesting to note that just 0.7% of subjects are taller than 200 centimeters, while no subjects were shorter than 160 centimeters and a low percentage of subjects was shorter than 170 centimeters (just 2.4%).

TABLE 3 Density of Very Short and Very Tall Male Subjects

Municipality*	Below 160 cm (%)	Below 170 cm (%)	Above 190 cm (%)	Above 200 cm (%)
Bar & Ulcinj	0	4.0	22	0
Berane** & Rozaje	0	0	21.5	0
Plav*** & Andrijevica	0	0	26	0
Budva & Tivat	0	0	25.4	0
Kotor & Herceg Novi	0	0	29.2	0
Cetinje	0	1.4	22.2	1.4
Pljevlja	0	2.6	9.0	0
Danilovgrad	0	2.0	25.5	2.0
Podgorica	0	4.8	23.1	1.2
Niksic	0	2.1	22.6	0.9
Pluzine & Zabljak	0	0	21.4	0
Kolasin & Savnik	0	0	33.3	0
Mojkovac & Bijelo Polje	0	6.4	21.3	0
Northern Region	0	2.2	14.3	0
Central Region	0	2.6	19.7	1.1
Southern Region	0	2.3	17.2	0
Total	0	2.4	18.2	0.7

Legend: *- small municipalities are merged with the first neighboring municipality; **-Petnjica municipality is included; ***- Gusinje municipality is included.

In contrast, the density of very tall subjects did not appear to be characteristic of the Montenegrin females, since just more than 5% measured 180 centimeters or more in adult human height. It is also noteworthy that just 0.2% of subjects taller than 190 centimeters, while there are no subjects shorter than 150 centimeters and a low percentage of subjects shorter than 160 centimeters (just 6.6%).

For better observation, the authors have prepared Table 3 and Table 4 to present an overview of the density of very short and very tall subjects among male and female populations in Montenegro. These results are significant for society, mostly because adult human height can significantly influence success in various sports disciplines, and this can help sport trainers to in talent identification when disciplines are linked to the specific heights (both shortness and height), as well as all other practitioners from other areas who need to enhance human longevity, to prevent the risk of adverse pregnancy outcomes and cardiovascular and respiratory diseases as well as some cancers, etc.

The overall perspective, based on the wide literature regarding adult human height, directs us to a more precise estimation of the average adult human heights in Europe and the entire world, since most previous studies did not include adequate study samples. Therefore, larger samples from various nations are required

TABLE 4 Density of Very Short and Very Tall Female Subjects

Municipality*	Below 150 cm (%)	Below 160 cm (%)	Above 180 cm (%)	Above 190 cm (%)
Bar & Ulcinj	0	5.8	7.7	0
Berane** & Rozaje	0	0	0	0
Plav*** & Andrijevica	0	31.8	0	0
Budva & Tivat	0	15.0	5.0	0
Kotor & Herceg Novi	0	8.5	6.4	0
Cetinje	0	14.3	2.9	0
Pljevlja	0	5.6	6.5	0
Danilovgrad	0	12.2	4.1	0
Podgorica	0	6.9	2.9	0.5
Niksic	0	3.3	5.5	0.3
Pluzine & Zabljak	0	5.9	5.9	0
Kolasin & Savnik	0	3.8	5.4	0
Mojkovac & Bijelo Polje	0	3.6	5.4	0
Northern Region	0	6.6	4.7	0
Central Region	0	6.0	4.8	0.3
Southern Region	0	9.4	6.5	0
Total	0	6.6	5.0	0.2

Legend: *- small municipalities are merged with the first neighboring municipality; **-Petnjica municipality is included; ***- Gusinje municipality is included.

and much more standardized procedures with sufficient geographical and social heterogeneity. Perhaps national surveys that measure whole populations shall be considered for this kind of comparison in the future.

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