An examination of growth acceleration trends within a male population in Bosnia and Herzegovina between the 19th and 21st centuries

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Abstract
In a transversal study that was conducted from October 2014 to March 2015, we analysed anthropometric measurements and height of young adults. The study included a cohort of 1010 individuals, 596 females and 416 males, who were born during the war period in Bosnia and Herzegovina (BH) (1992-1995) and were in an age range of 20-24. The average measured height of females was 167.37±6.00 cm and 182.77±6.57 cm of males. When these data were compared with measurements taken in 1895 of Bosnian soldiers who served in the Austro-Hungarian army (age 20 to 24), whose average height was 172.35 ± 5.54 cm, a difference of t=31.17 was observed (p<0.001). Our data showed that the average height of men born from 1992 to 1995 was 182.77 ± 6.56 cm. Furthermore, additional international comparisons with other European and European-descent nations showed that our studied population was one of the tallest. Based on the aforementioned it can be concluded that anthropometric attributes in BH follow a trend of acceleration, which is of particular significance for this part of the world as this anthropometric acceleration trend was observed in a cohort that was born and raised in sub-optimal conditions of war that lasted from 1992 to 1995. It is, therefore, safe to assume that, despite hardships, living conditions have overall improved over a period of 100 years as an increase in overall body height was observed.

KEYWORDS: anthropometry, growth acceleration, body height

ANTHROPOLOGICAL NOTEBOOKS 22 (2): 107–115.
ISSN 1408-032X

Introduction

Bosnia and Herzegovina (BH), covering a total of 51,209 km² of land, is located in the western part of the Balkan Peninsula, with the neighbouring Republic of Serbia and Republic of Montenegro to the east and the Republic of Croatia to the north, west, and south. According to preliminary results from the 2013 census, the population of this area numbered 3,791,662 inhabitants (Agency for Statistics of Bosnia and Herzegovina 2013).

Body height information is useful for many reasons. It serves as an accurate measure of body size, provides an assessment of nutritional status, and acts as an indicator of basic energy requirements. Precise evaluations not only enable the standardisation of measures of physical ability and assessments of children's growth progress, but they also serve as a prediction and standardisation of physiological variables such as lung volumes, muscle strength, glomerular filtration and metabolic rate, which in turn are helpful facts in the determination and adjustment of drug doses (Golshan, Amra & Hoghoghi 2003; Golshan, Crapo, Amra, Jensen & Golshan 2007; Mohanty, Babu & Nair 2001; Ter Goon, Toriola, Musa & Akusu 2011).

The growth and development of the human body are a basis for global anthropological research as they are fundamental units of individuality. Height is one of the most stable indicators of physical development, which speaks not only about the aging process but also about a certain level of maturity of the body (Ivanović 1985). However, the influence of growth and development changes during ontogenesis as a child's growth varies over time between progress and reversal. When a child grows in favourable conditions, his or her final height strongly correlates with the height of the parents, highlighting the child's genetic inheritance. Genetic factors are limiting the biological potential for body height development and, along with environmental (biological and social) factors, can cause some variations (Van Wieringen 1986). This is especially related to major endogenous (nervous, endocrine) and exogenous (climatic, nutritional, health and hygiene, psychological and socio-economic) determinants.

Factors that could affect the body height and mass of a generation can be monitored at various points in time, and these changes have to be monitored periodically to assess the state of health and wellbeing of the examined population. In countries with developed health care, even more than 100 years ago, relevant anthropometric data of school children and youth are available. Research is conducted that highlights the impact of the critical growth moment in the development of various conditions in adulthood, such as cardiovascular diseases, diabetes, metabolic disorders, etc. (Cameron 2002; Grasgruber, Cacek, Kalina & Sebera 2014). The background of these secular changes could be positive and/or negative, depending on the period of observation as well as the environment, but also historical and socio-economic situations as well as other differences between examined populations. Secular growth acceleration is defined by Bach, Jaeger, Zellner (1985) and Tanner (1966) as an acceleration of ontogenetic processes in a present population compared to previous generations, and results in an overall higher final body height that adults attain much sooner. Previous studies emphasised that the trend of growth acceleration is not necessarily present in all populations worldwide (Van Wieringen 1986).

Secular trend lives are specific for every population. Besides positive trends, negative movements are possible as well as the unequal intensity of specific development periods. Environmental, biological and social specifications require that the personal standards of physical development of children and youth are obtained and renewed every ten years to account for secular trends (Ivanović 1985). As an example, 20th-century military conflicts certainly presented a risk for nearly all exogenous factors of personal growth and development of the entire human civilization, and especially to those that were immediately affected by these historical events.

The very first known bio-anthropological survey of the BH population, conducted by Austro-Hungarian military physicians, may be considered an initial phase in determining the genetic structure of BH human population (Hadžiselimović 1984). In 1887, Austro-Hungarian military physician Himmel published the first data on heritable qualitative traits using data on average height, weight, eye colour, hair colour, and other anthropological (body) measures of a group of 180 Herzegovinian soldiers recruited by the Austrian Army. Almost one decade later, another Austrian physician performed a significant study, which is evident in the general approach and the large sample size (n = 3803) (Weisbach 1865).

Modern-day BH is a multinational and multi-religious country with a tumultuous recent past. The 20th century was marked by political justifications for the conflicts in the area (Marjanovic et al. 2005). Those conflicts had severe repercussions, such as forced migrations, destruction and infrastructure collapse, environmental deterioration, lack of ability to provide and protect food and water as well as reductions in health and socio-economic standards. Certainly, the conditions above also had strong impacts on the bio-anthropological characteristic of the entire BH population.

Continuity of accelerated growth and development should be considered to be an indicator of approaching optimal health conditions of examined populations (Susanne 1985; Malina 1979). Unfortunately, no comprehensive systematic and persistent scientific research of indicators of growth and development were conducted during the last 100 years in BH, which resulted in a significant lack of reliable information in this area of research in the region. The main goal was to analyse the average height of males of BH well as to assess the growth acceleration trend during the last 100 years.

Materials and methods

A transversal study was conducted from October 2014 to March 2015, in which the anthropometric measurements of the height of young individuals were analysed. The study included a cohort of 1010 individuals, 596 females and 416 males, who were born during the war period in Bosnia and Herzegovina (BH) (1992-1995) and thus were in the age range of 20-24 years.

Analysed individuals came from the following BH regions:

Unsko-sanski Canton (Bihać, Bosanska Krupa, Bosanski Petrovac, Bužim, Cazin, Sanski Most, Velika Kladuša), Srednje-bosanski Canton (Bugojno, Donji Valuf, Gornji Vakuf, Jajce, Novi Travnik, Travnik), Tuzlanski Canton (Gradačac, Lukavac, Srebrenik, Tuzla, Živinice), Hercegovačko-neretvanski Canton (Međugorje, Mostar, Prozor, Stolac,

Konjic, Jablanica), Bosansko-podrinjski kanton (Goražde), Zeničko-dobojski Canton (Doboj, Kakanj, Maglaj, Vareš, Visoko, Zavidovići, Zenica), Brčko District (Brčko), Sarajevski Canton (Sarajevo, Ilidža, Hadžići) (Figure 1).

Figure 1: Geographical map of the investigated area

The sample was chosen randomly and stratified by age categories. After anthropometric parameters had been collected, a database was formed using Microsoft Office Excel 2007. Parameters were statistically analysed, and the following statistical calculations were taken into consideration: minimal and maximal values, average, standard deviation and percentiles (P5, P25, P50, P75, P95). Student's t-test (for large independent samples) was used to determine a statistical significance of differences between sexes and compared to previous research from the same geographic area.

Results

Anthropometric measurements were performed on a cohort of 1010 individuals, 595 (58.91%) of which were females and 415 (41.09%) of which were males. The average measured height in females is 167.37±6.00 cm and in males 182.77±6.57 cm (Table 1), indicating that the average BH male body height is larger than that of the female group, and the difference is statistically significant.

Table 1: Statistical parameters of body height for females and males

Body height (cm)	Xmin - Xmax	Xavg ± SD
Females	150-183	167.37 ± 6,00
Males	167-204	182.77 ± 6,57

Additional statistical analyses of body height confirmed statistically significant differences between males and females in all age categories; the largest difference was observed in the category of 22 years of age (Table 2).

Table 2: Height differences between genders by age category (p-value; TDIST)

Age category	t	p
20 years of age	12.56	p<0.01
21 years of age	17.26	p<0.01
22 years of age	25.61	p<0.01
23 years of age	19.09	p<0.01
24 years of age	11.79	p<0.01

Obtained data were compared with first measurements that were obtained in 1895 from Bosnian soldiers that served in the Austro-Hungarian Army and that were of 20-24 years old at the time of measurement (Weisbach 1865). Our data show that the average height of males born from 1992-1995 is 182.77 ± 6.56 cm. The average height of Bosnian soldiers that served in the Austro-Hungarian Army was 172.35 ± 5.54 cm (Table 3), and the difference between the studied male population and the aforementioned was t=31.17 (p<0.01).

Table 3: Height comparisons between males born between 1992-1995 and Bosnian soldiers

Sample	N	Xmin - Xmax	-	S	S (-)	V
BH males	414	160-204	182.77	6.56	0.10	43.00
Bosnian males from 1895	3802	152-192	172.35	5.54	0.00	30.67

All anthropometric parameters of height are also illustrated via percentile distributions (Figures 2 and 3).

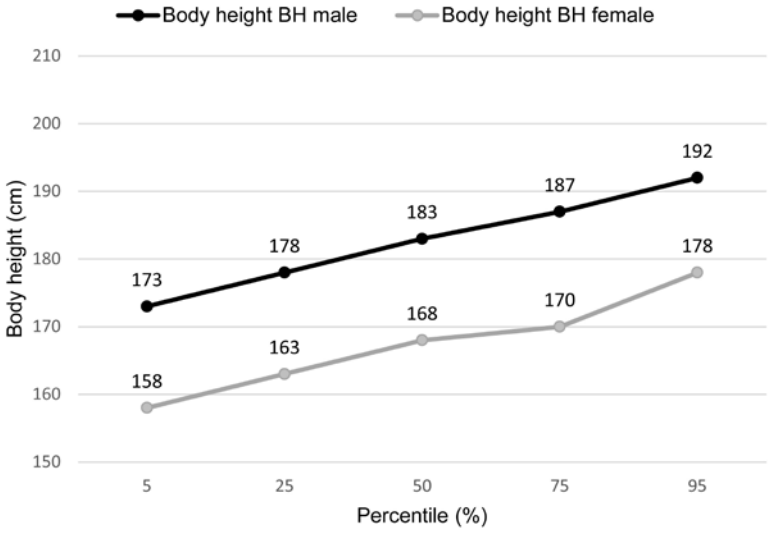

Figure 2: Percentile scale of body height based on gender

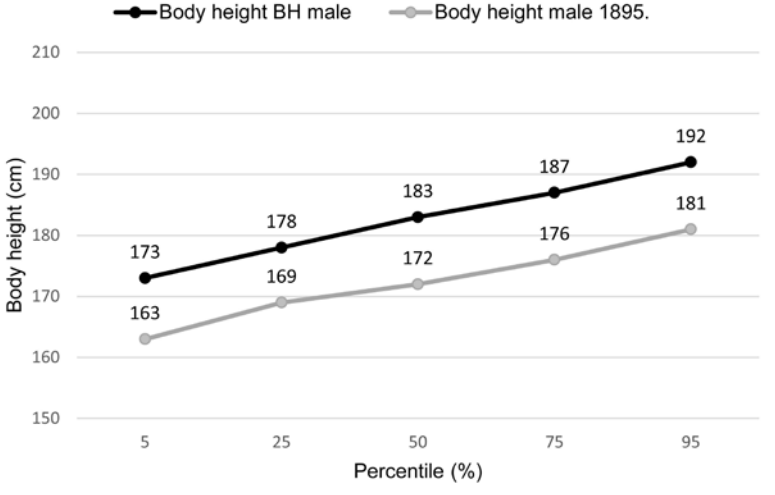

Figure 3: Percentile scale of body height of youth and male soldiers from 1895

Discussion

Growth acceleration is best estimated based on comparisons with other studies conducted in the same geographic area. It is difficult to obtain these comparison data for the whole of Bosnia and Herzegovina (BH), since there is a lack of available published data for this country. The very first anthropological analysis was conducted and published when Austro-Hungarian soldiers were subjected to anthropometric measurement in 1895 (Weisbach 1865). Those scientific studies were conducted in the region of present BH, at a time when it was considered five regions ("Kreis"), namely Sarajevo, Bihać, Mostar, Travnik, Banja Luka, Tuzla. Given the measurement results that were obtained in 1895 and considering that their average was lower than the average obtained in the current investigation, it is safe to conclude that the BH population underwent an overall positive acceleration trend to the year 2015.

Average height distributions result in a subdivision of individuals into the following categories (Smajkic 1997): *tall*, taller than 170 cm; *above midrange height*, 166-170 cm; *medium height*, 165 cm; *below average height*, 160-164 cm; *low*, less than 160 cm. According to previous studies, the population of the former Yugoslavia has an average body height of above 172 cm, and therefore belongs to the tall group (Smajkic 1997). Along the same lines, since the average body height in our research is found to be 182.77 cm, men from the investigated region can be classified into the tall category. The comparison data between parameters from 1895 and the current study strongly suggest a positive acceleration trend. This highlights improvements in living conditions over the last 100 years, including primarily dietary habits as well as the healthcare system, despite the sub-optimal conditions of war that afflicted the studied population. Furthermore, it may be safe to speculate that acceleration perhaps could have been even more pronounced if the studied population had not been exposed to the negative impact of exogenous factors.

A positive trend in the acceleration can also occur as a result of new combinations of genes as in response to increased migration and the emergence of more heterozygous genes that govern the dominant growth. This theory cannot be applied in the present study because this type of migration did not take place. It should, however, be mentioned that, according to expectation, men are on average taller than women in all conducted studies

With an average of 182.8 cm, Bosnian males are not the tallest population in Europe, but still considerably tall. The male Dutch population is documented to be 184.6 cm tall (Pineau, Delamarche & Božinović 2005) and, according to a different study, 183.8 cm (TNO 2010). Overall, it can be concluded that growth in the height of the population in BH is synchronised in comparison to European countries and nations of European descent (Grasgruber 2014).

Gradual growth and increase in the size of various body measures have been observed globally over the last century. Our data also enable us to conclude that anthropometric parameters in BH follow the trend of acceleration, regardless of the war that negatively affected conditions in which the studied individuals were born and raised. It is, therefore, safe to assume that, despite hardships, living conditions have overall improved during a period of 100 years as an increase in overall body height has been observed. A comparison between BH height parameters to the parameters of nations that

are either European and/or European decent also lead to the conclusion that BH can be classified among the tallest nations as only Netherlands supersedes it with its overall average height. Anthropometric measurements are therefore among the most useful parameters that enable assessments of living conditions nationally and internationally as well as interculturally.

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Povzetek

Presečna študija je potekala od oktobra 2014 do marca 2015, v njej pa smo analizirali antropometrijske mere in višino mladih odraslih. Študija je vključevala kohorto 1010 posameznikov, 596 žensk in 416 moških, ki so se rodili med vojno v Bosni in Hercegovini (BiH) (1992-1995) v času meritev pa so bili stari 20 do 24 let. Povprečna izmerjena višina pri ženskah je bila 167.37 ± 6.00 cm in 182.77 ± 6.57 cm pri moških. Ko smo te podatke primerjali z meritvami bosanskih vojakov (starost 20 do 24 let), ki so kot rekruti leta 1895 začeli služiti v avstro-ogrski vojski in katerih povprečna višina je bila 172.35 ± 5,54 cm, smo ugotovili statistično značilno razliko med obema skupinama ($t = 31.17$, $p < 0,001$). Naši podatki so pokazali, da je bila povprečna višina moških, rojenih od 1992 do 1995 182.77 ± 6.56 cm. Poleg tega je mednarodna primerjava z drugimi evropskimi narodi ali narodi evropskega porekla pokazala, da spada obravnavana skupina med najvišje. Glede na navedeno je mogoče sklepati, da antropometrijske lastnosti v BiH kažejo trend naraščanja, kar je za ta del sveta posebnega pomena, saj je trend pospeška rasti zaznan v kohorti, ki je rasla v pod-optimalnih pogojih vojne od leta 1992 do leta 1995. Zaradi naraščanja telesne višine sklepamo, da so se kljub stiski življenjske razmere v obdobju 100 let na splošno izboljšale.

KLJUČNE BESEDE: anthropometrija, pospeševanje rasti, telesna višina, Bosna in Hercegovina

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