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Dynamics of Growth in 9–14-year-old Bulgarian Boys and Girls

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Abstract: The physical development of the human body is used as an objective indicator of the health status and work capability of the population. Height and weight are the main anthropometric traits which vary and change significantly during the growth period and are used as a base for the development of anthropometric standards at different ages. The aim of this study is to assess the basic anthropometric traits in adolescent boys and girls in Bulgaria in order to establish age- and sex-specific variation in growth. During the period 2016–2018, a transversal anthropometric study in five secondary schools in Sofia, Bulgaria was conducted. A total of 424 adolescents (211 boys and 213 girls) aged 9 to 14 years were studied. Anthropometric measurements were performed according to the classic 1957 methodology of Martin-Saller. Statistically significant sex differences ($p<0.05$) were indicated for height and weight in the age periods: 10–11 years, with priority for girls and 13–14 years, with priority for boys. Age-related differences ($p<0.001$) in the age period 9–14 years were also observed. Physical development of adolescent Bulgarian students follows the general trends of the postnatal ontogenesis, reflected in increasing the sizes of anthropometric features highlighted in 10–11-year-olds girls and 13–14-year-olds boys. These new data for height, weight, and BMI in 9–14-year-old Bulgarian students might be a practical addition in the pediatric practice of monitoring of children's health.

Keywords: adolescents, height, weight, body mass index

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Introduction

Physical development is an objective indicator for the health status and work capability of the population. Anthropometric measurements are the most preferred clinical tool for screening normal child growth and predicting disease risk factors from childhood (Freedman et al. 1999; Revenga-Frauca et al. 2009; Nagy et al. 2014; Andaki et al. 2018). Height and weight are the main anthropometric traits that exhibit great adaptive potential and which change significantly during the growth period. Their metric characteristics are used as a base for developing anthropometric standards at different ages and vary significantly in populations of different climatic and geographical areas (Theis et al. 1993; Honigman et al. 1993; Алексеева 1998; Roach and Hackett 2001; Malkoç et al. 2012). According to Eveleth (1987), children of different nationalities differ in both size and shape of the body and rate of their growth (Eveleth 1987). Following the physical development of children from the Northern part of Russia, Kozlov and Vershubskaya (1999) found that they are characterized by lower height and body weight compared to their peers from the central parts of Russia. It has been established that these peculiarities are due to the ethnicity of individuals and are not the result of the adverse climatic conditions in which they live (Kozlov and Vershubskaya 1999).

Body mass index (BMI) is used to assess nutritional status in children and adolescents as well as adults. Elevated BMI in childhood is related to adult obesity and a high risk of various diseases. Other, more direct ways of measuring adiposity are known to correlate well with BMI, and consistent links are known between BMI and comorbidities associated with obesity and overweight. Body mass index is thus still regularly implemented as a child's measure of weight. Elis et al. (1999) declared a close relation between BMI and percent body fat (%BF) assessing 438 Caucasian, 283 African, and 258 Hispanic children and adolescents aged 3–18 years, and confirmrd the suggestion for relation with the age and ethnicity.

The standards for height and weight used in pediatric practice in Bulgaria are based on international or national data collected more than fifty years ago, and they may be out of date due to secular trends. This highlights the need to create newer and more competitive norms for assessing body weight, body height and BMI in children and adolescents. Thus, the aim of this study was to assess the basic anthropometric traits in adolescent Bulgarian boys and girls in order to establish age- and sex-related variation in adolescent growth.

Materials and Methods

Study design and participants

The present transversal anthropometric study was carried out in the period 2016–2018 and included 424 (211 boys and 213 girls) children and adolescents from Sofia, Bulgaria, aged 9 to 14 years. Anthropometric measurements were performed according to the classic methodology of Martin Saller (1957). Body height and weight were measured by standard anthropometric equipment. For BMI calculations, weight in kgs was divided by height in m^2. The ethics protocol for this study was reviewed and approved by the Ethical Committee of the Institute of Experimental Morphology, Pathology, and Anthropology with Museum – Bulgarian Academy of Sciences (Protocol No

3/11.04.2018). The study was conducted in agreement with the principles stated in the Declaration of Helsinki for human studies and researches (WHO 2008). All participants and their parents gave a completed informed consent for voluntary participation in the study.

Statistical analysis

The statistical data processing was carried out using the Statistical Package for the Social Sciences 16.00 (SPSS 16.00) software. Student t-tests at $p<0.05$ were performed to detect sex-related differences in the above outlined variables. To establish age-related differences, one-way ANOVA with Tukey's post hoc tests at $p<0.05$, $p<0.01$, $p<0.001$ was applied.

Results

The linear growth of the body increases significantly throughout the assessed age period. The average body height of 9–year-old boys (140.37 cm) has greater values than than of girls (138.48 cm) of the same age. Between 10 and 12 years, girls are taller than boys and their peak height velocity occurs at about 11 years. The maximum increase in boys' height is between 11–12 years (Figure 1).

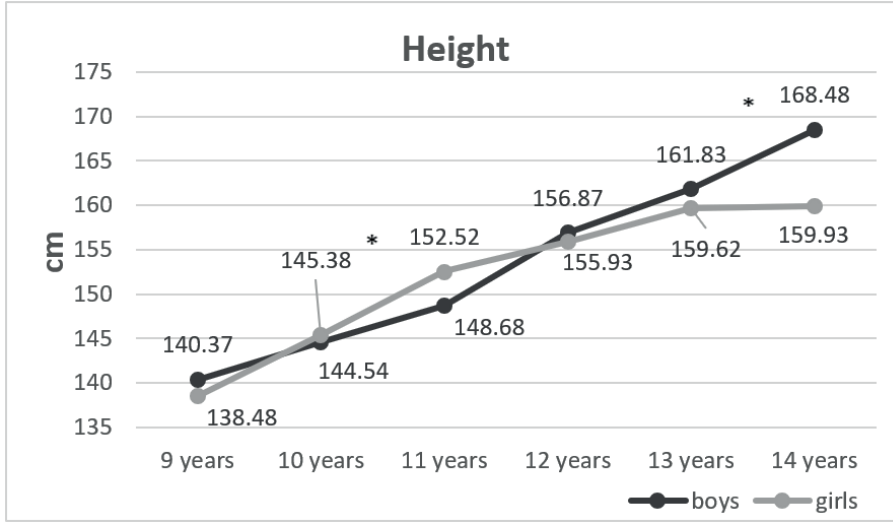

Figure 1. The average values of height in 9–14-year-olds Bulgarian children and adolescents

The average value of weight in girls varies from 33.26 kg at the age of 9 to 53.63 kg at the age of 14 years. The girls' weight increased significantly between 9 and 10 years. The boys' mean weight values range from 35.04 kg to 59.41 kg in the age period from 9 to14 years. Their peak weight velocity occurs two years later, than the girls – between 11 and 12 years (Figure 2).

Statistically significant sex differences ($p<0.05$) for height and weight in the age periods 10–11 years with priority for girls, and 13–14 years for boys,

were observed. Age-related differences for height and weight ($p<0.001$) in the period 9–14 years were also established. The assessed age period is characterized by a slight increase of the values of BMI in both sexes: from 17.78 kg/m^2 to 20.77 kg/m^2 in boys and from 17.28 kg/m^2 to 21.03 kg/m^2 in girls. Incremental change in BMI in both sexes follows the trend determined by height and weight, but there were no statistically significant sex- and age-related differences (Figure 3).

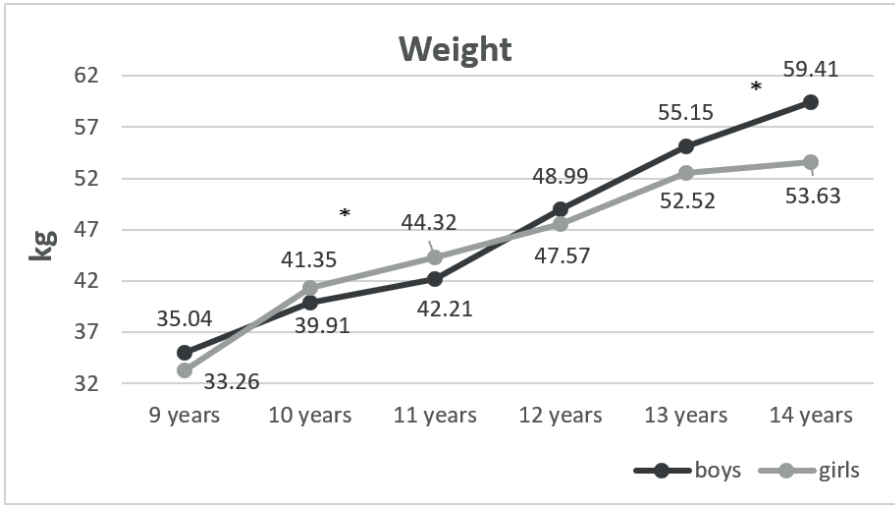

Figure 2. The average values of weight in 9–14-year-olds Bulgarian children and adolescents

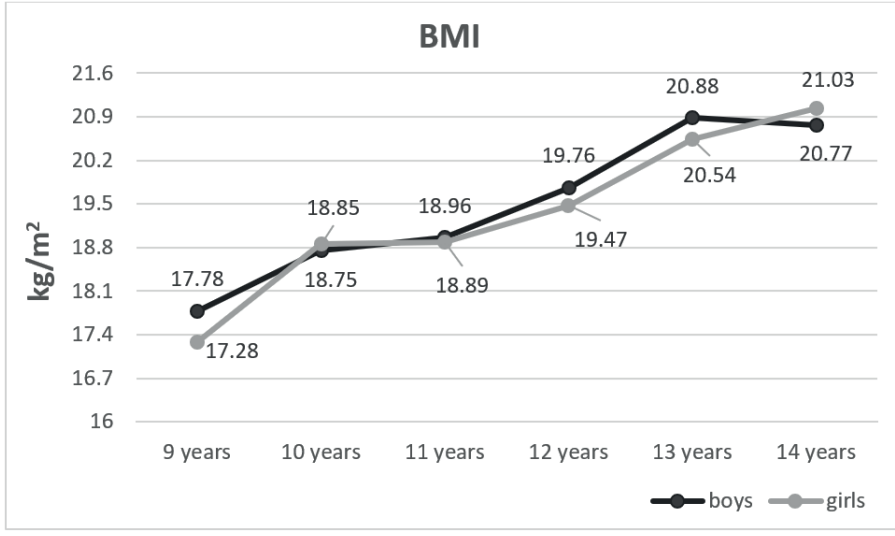

Figure 3. The average values of body mass index (BMI) in 9–14-year-olds Bulgarian children and adolescents

Discussion

The present study emphasizes the specifics of the physical development of 9–14-year-old healthy Bulgarian boys and girls. The results of our study confirmed that 9–14-year-old boys and girls grow up significantly when it comes to their height and weight. The increment of change in boys' and girls' height is 28.11 cm, and 19.56 cm, respectively. Reaching their maximum occurs in different age periods according to sex. The girls reached their peak height and weight velocity earlier than boys (between 10 and 11 years) and also have earlier onset of puberty. The largest absolute year alteration for this period was observed: 7.14 cm in girls' height and 8.09 kg in their weight. Puberty in boys occurs between the ages of 13–14 when height and weight reach values of 168.48 cm and 59.41 cm, respectively. The maximal year alteration in boys' height and weight is 8.19 cm and 8.09 kg at the age of 12 when the line of growth is crossed and the boys are ahead of girls in terms of the assessed anthropometric traits (Table 1).

Sex differences in the age periods 10–11 and 13–14 years are the most pronounced. Assessing the anthropometric characteristic of children and adolescents from the Smolyan region (Bulgaria), Mladenova (2003) determined close to our results. Analysis of the data shows that the first peak of linear growth was observed between 4 and 7–8 years. The second peak height velocity is established in the period of 9–10 years in girls, while in boys it occurs about three years later (Mladenova 2003). Earlier data for Bulgarian children and adolescents showed that between 9 and 12 years girls gradually outstrip the boys but at 14 years they nearly stopped their growth in height and weight. Contrary, boys continue to grow significantly after 14 years (Nacheva et al. 2012). The data from a transversal study of 9–16-year-olds students from Sofia, Bulgaria showed a spurt in their morphological development, with a peak between 10 and 11 years, and 13 years with girls. For boys aged 13–14 years, the author registered a puberty growth spurt peak, and the beginning of post-puberty between ages of 15–16 is an exception (Mitova 2009).

Table 1. Heigth, weight, and body mass index (BMI) data for 9–14-year-old Bulgarian boys and girls

Age period (years)	Absolute Year Alteration (AYA)	
	♂	♀
	HEIGHT (cm)	
9–10	4.17*	6.88*
10–11	4.14*	7.14*
11–12	8.19*	3.41
12–13	4.96*	3.69
13–14	6.65*	0.31
	WEIGHT (kg)	
9–10	4.87	8.09*
10–11	2.30	2.97
11–12	6.78*	3.25
12–13	6.16*	4.95
13–14	4.26	1.11
	BMI (kg/m^2)	
9–10	0.97	1.57
10–11	0.21	0.04
11–12	0.80	0.58
12–13	1.12	1.07
13–14	0.00	0.49

*$p<0.05$ – statistically significant age differences

Overweight and obesity have been noted as a pandemic of the 21st century (Popkin and Doak 1998; Moreno et al. 2000). Obesity has been known as a risk factor for the development of type 2 diabetes, cardiovascular and other health

disorders (Pischon et al. 2008; Di Angelantonio et al. 2016; Bluher 2019). In developed countries, part of overweight and obese individuals increased from 16.9% of males and 16.2% of females in 1980 to 23.8% of males and 22.6% of females in 2013 (Ng et al. 2014). Aranceta-Bartrina et al. (2016) declared that in Spain, the prevalence of overweight in the adulthood reaches 39.3%, and the global prevalence of obesity in 2014–2015 was estimated at 21.6% (Aranceta-Bartrina et al. 2016). An anthropometric assessment of Bulgarian 8–15-year-old students from the Smolyan region showed they have higher BMI values than girls in all ages, with statistically insignificant differences between the sexes (Mladenova and Andreenko 2015). Over last decade, an increament in overweight and obesity prevalence among Bulgarian pupils from Smolyan region was registered by Mladenova and Andreenko (2015).

Assessing BMI is the most popular method to track the changes in nutritional status from childhood to adulthood. Whereas in adult age only, the thresholds that define BMI in terms of overweight and obesity are not associated with age or sex. In growing children, however, BMI links with sex and age. In accordance with the standards of the International Obesity Task Force (IOTF) and the World Health Organisation (WHO), Cole et al. (2000; 2007) developed specific BMI cut-offs for children and adolescents under 18 years. According to the IOTF BMI thresholds, all 9–14-year-old boys and girls who took part in the present study fall in the category of normal weight status. In further studies, we are going to present reference standards of BMI-for-age in Bulgarian children and adolescents (WHO 1987; Cole 2000, 2007).

Conclusion

Physical development of Bulgarian children and adolescents follows the general tendency of the postnatal ontogenesis, shown in increasing the sizes of anthropometric features highlighted in 10–11-year-old girls and 13–14-year-old boys. These new data for height, weight, and BMI in 9–14-year-old Bulgarian students might be a practical addition in the pediatric practice to the monitoring children's health. Despite the benefits observed, a limitation in this study is the small sample size when separated by age and sex, especially in the last age group.

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Author contributions

AD designed the study, collected the data, oversaw the statistical analysis/interpretation and agree to be accontable for all aspect of the work.

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None to declare.

Conflict of interests

No conflict of interests were declared by the author.

Ethics statement

Ethical approval was issued by the Ethics Committee of the Institute of Experimental Morphology, Pathology, and Anthropology with Museum – Bulgarian Acade-

my of Sciences (Protocol № 3/11.04.2018) and was conducted in agreement with the principles stated in the Declaration of Helsinki for human studies (2008).

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