



SECULAR CHANGES IN MAIN ANTHROPOMETRIC INDICATORS FOR THE EVALUATION OF THE PHYSICAL DEVELOPMENT OF CHILDREN AT THE AGE BETWEEN 3-6 YEARS FROM SMOLYAN REGION, BULGARIA (1996/98- 2017/19)

Silviya Mladenova

Department of Natural-Mathematical and Economical Sciences, Branch Smolyan at Plovdiv University "Paisii Hilendarski", Bulgaria.

SUMMARY

The purpose of the present study is to investigate the secular changes in the body height, weight, chest and head circumferences in preschool children (3-6 years) from the Smolyan region, Bulgaria, during the past 20 years.

Material and methods. A transversal anthropometric study of 330 clinically healthy children, aged between 3 to 6 years from Smolyan region, Bulgaria, was performed in the period 2017-2019 (Sample B). For the aims of the analysis, earlier anthropometric data, collected by the author for 406 preschool children from the Smolyan region, aged between 3-6 years, transversally studied in the period 1996-1998 (Sample A) were also used. The height, weight, chest and head circumference have been measured for each child, as per Martin-Saller's methods. The data have been processed through the statistical package Statistica 12.0 by using analysis of variance. The Student's T-test was used a check the significance.

Results. Our results show the significant increase of height and weight of boys at the age of 3 and 5 years and the weight of girls at the age of 3 and 6 years. A statistically reliable reduction in the chest and head circumferences among boys at the age of 6 years. On the grounds of these negative secular changes, the modern girls at the age of 3 years have a reliably larger chest and head circumference in comparison to their peers 20 years ago. At the same time the girls at the age of 5 years are with chest circumference, which is almost 2 cm smaller in comparison to their peers.

Conclusions. Our results once again show the multidimensional character of the secular changes, which are presented, to various extents, in the various morphological systems of the body during the different stages of the ontogenesis and are different for the two genders.

Keywords: secular changes, height, weight, chest and head circumference, preschool children,

INTRODUCTION

It is known that the different stages in the ontogenesis of humans are a real reflection of the chain of events in the process of individual growth and development. Each of these stages is characterized by a unique and specific combination

of biological features which are influenced by a complex of various environmental and genetic factors, and the influence of these factors changes during different ages. The environmental influences manifest with territorial, ethnic, sex and age peculiarities and morphometric differences in basic anthropometric features, like height, weight, BMI, some indicators of width and circumferences, features of body composition and nutritional status and other features and draw the determining role of the different endo- and exogenic factors in growth processes [1, 2, 3, 4].

A direct reflection of the increased ecosensitivity of the child's organism to the environmental factors is the secular changes in the basic dimensions of the children's and adolescent's bodies observed in the second half of the 20th century in most parts of the world. These positive secular changes occur in different periods of growth and are related to an increase of height, weight, BMI and other somatic features [5, 6, 7, 8] with earlier puberty [9]. Also, the secular changes in the ratio between the individual anthropometric features [10] and also the biggest differences in the terminal body height in early childhood have been reported [11].

Due to the fluctuating character of the secular changes, the periods of acceleration take turns with periods of stabilization. Such changes and stabilization of the secular processes were observed in the 80s-90s of the 20th century in many countries around the world in different age and territorial groups [12, 13, 14, 15]. Some authors reported gracilization [16] about astenization of body composition [14] and for debrachycephalization as part of the general "tendency of the century" [12].

At the beginning of the new 21 century, reports started to appear in the scientific literature in relation to positive secular changes in nutritional status, leading to the increasing spread of overweight and obesity among the children as a result of an increase of fat mass [17, 18]. Also in scientific literature reports for a decrease of skeletal robustness [7] and for a decrease of the age of appearance of overweight and obesity [19], and its increased occurrence among preschool children [6, 20, 21].

The above requires continuous monitoring of the growth and development processes in order to update the

growth standards, to provide correct and adequate evaluation of the physical development in the modified social and economic conditions of living and to ensure early diagnosis of the deviations in physical development. In relation to that, the studies of the processes of growth in the early age of children, in all their aspects and dimensions, are especially current and valuable both for science and pediatricians.

The **PURPOSE** of the present study is to investigate the secular changes in the body height, body weight, head and chest circumferences of children between the ages of 3-6 years from the Smolyan region, Bulgaria, during the past 20 years.

MATERIALS AND METHODS:

A transversal anthropometric study of 330 children (161 boys and 169 girls), aged between 3 to 6 years from the district of Smolyan, Bulgaria, was performed in the period 2017-2019 (Sample B). All studied children are clinically healthy and are of Bulgarian origin. The children were distributed into eight age-gender groups (4 groups per gender) - three-years-old, four-years-old, five-years-old and six years old. The average age of the children is 3.5, 4.5, 5.5 and 6.5 years. For example, 4-years-old are considered children at the age between 4.0 to 4.99 years. The data of the number of investigated children from two samples are presented in table 1.

Table 1. Characteristics of the sample by age and sex.

Age (years)	Sample IA (1996-1998) Number			Sample B (2017-2019) Number			Total N
	Boys	Girls	All	Boys	Girls	All	
3 y.	69	46	115	23	28	51	166
4 y.	41	25	66	36	44	80	146
5 y.	50	53	103	49	53	102	205
6 y.	56	69	125	53	44	97	222
Total	216	193	409	161	169	330	739

The height, weight, chest and head circumferences have been measured for each child, as per the classical anthropometrical methods of Martin-Saller [22] by original instruments GPM (Siber-Hegner Company, Swiss).

During the study, all ethical norms and requirements have been adhered to and informed written consent was collected by the parents in relation to the participation of the children in the study. The study has been approved by the Ethics Committee of the Branch of Plovdiv University at Smolyan.

For the performance of the analysis of the secular changes, anthropometric data for 406 children from the

Smolyan region, aged between 3-6 years, transversally studied in the period 1996/98 (Sample A) were used [23].

The data have been processed through the statistical software package Statistica 12.0 (StatSoft Inc.) by using analysis of variance. The Student's T-test, with a level of significance of $p < 0.05$, was used to check the reliability of the group averages.

RESULTS

The results of the secular changes in the studied anthropometric indicators such as height, weight, chest and head circumferences at preschool boys are presented in table 2.

Table 2. Comparison of basic anthropometric parameters in Bulgarian preschool boys in two generations (Sample A – 1996/1998; Sample B -2017/2019).

Age (years)	3 y.			4 y.			5 y.			6 y.		
	S _A	S _B	p≤0.05									
	Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Height (cm)	98.4 (3.9)	100.8 (5.9)	0.045*	105.8 (6.3)	106.6 (3.9)	0.524	112.8 (5.1)	115.4 (4.2)	0.006*	120.1 (5.2)	120.3 (5.7)	0.836
Weight (kg)	15.0 (1.5)	16.1 (2.0)	0.011*	17.4 (3.2)	18.1 (2.4)	0.284	19.8 (2.9)	21.7 (3.4)	0.004*	23.1 (3.8)	24.3 (6.2)	0.199
Chest circumference (cm)	52.9 (2.1)	52.5 (2.7)	0.463	54.3 (4.0)	54.5 (2.6)	0.798	57.0 (2.8)	57.0 (3.5)	0.970	59.6 (4.0)	58.1 (3.8)	0.046*
Head circumference (cm)	50.3 (1.2)	50.3 (1.4)	0.972	51.5 (1.5)	51.1 (2.1)	0.344	52.0 (1.4)	51.6 (1.5)	0.102	53.1 (1.5)	52.2 (3.8)	0.003*

In relation to **height**, our results show that the contemporary **boys** (Sample B) are taller in comparison to their peers before 20 years, in all age periods, but the differences have statistical significance only among the children at the age 3 and 5 years, where they reach values, respectively of 2.4 cm and 2.6 cm ($p \leq 0.05$).

The results for **weight** show that the modern generation of 3-6-years-old boys from the studied region is heavier than their peers at the same age two decades ago, in all age groups. For the modern boys at the age of 3 years, for two decades, the weight has increased by 1 kg, for 5-years-old by 1.8 kg, and for 6-years-old by 1.2 kg, where the differences have statistical significances for the boys, aged at 3 and 5 years ($p \leq 0.05$).

The data about the secular changes in **chest circumference** show that the values of the chest circumference in the present generation of **boys** from the Smolyan re-

gion, at the age of 3 years, are insignificantly smaller in comparison to their peers from 20 years ago, where in the modern boys at the age of 6 years a significant negative trend is observed as well, which is in the range of 1.5 cm ($p \leq 0.05$).

The results for the secular changes in the **head circumference** show that the modern boys at the age of 3 years are with the same size of the head circumference as their peers from the end of the last century. Among the boys aged between 4-6 years, the size of the head circumference is reduced, where the differences reach 0.9 cm in the 6 years, which differences have statistical significance ($p \leq 0.05$).

The results of the secular changes in the studied anthropometric indicators at preschool **girls** are presented in table 3.

Table 3. Comparison of basic anthropometric parameters in Bulgarian preschool girls of two generations (Sample A – 1996/1998; Sample B -2017/2019).

Age (years)	3 y.			4 y.			5 y.			6 y.		
	S _A	S _B		S _A	S _B		S _A	S _B		S _A	S _B	
	Mean (SD)	Mean (SD)	$p \leq 0.05$	Mean (SD)	Mean (SD)	$p \leq 0.05$	Mean (SD)	Mean (SD)	$p \leq 0.05$	Mean (SD)	Mean (SD)	$p \leq 0.05$
Height (cm)	97.3 (3.1)	97.5 (4.8)	0.882	107.2 (6.4)	105.7 (5.5)	0.338	111.9 (5.4)	112.2 (5.7)	0.675	119.7 (4.9)	120.8 (4.7)	0.229
Weight (kg)	13.5 (1.6)	15.3 (2.2)	0.000*	17.4 (3.2)	17.5 (3.7)	0.913	19.6 (3.3)	20.0 (4.0)	0.526	22.1 (3.4)	25.2 (7.0)	0.001*
Chest circumference (cm)	50.3 (2.9)	51.9 (2.2)	0.014*	54.2 (4.2)	52.9 (3.7)	0.172	56.2 (3.5)	54.1 (5.9)	0.033*	58.0 (4.0)	59.0 (7.5)	0.359
Head circumference (cm)	48.9 (1.5)	49.8 (1.3)	0.008*	51.0 (1.7)	50.3 (2.3)	0.194	51.1 (1.2)	50.6 (1.3)	0.111	51.8 (1.5)	51.5 (1.3)	0.530

As opposed to the boys, the **height** of the studied **girls** (Sample B) at the age between 3-6 years has not significantly changed for the last two decades. No differences in height were established among the girls of the two generations at the age of 3 years. The differences grow among the girls at the age of 5 and 6 years but remain statistically insignificant ($p \leq 0.05$).

The body **weight** of modern girls in preschool age also presents positive secular changes in all age groups. For the girls at the age of 3 years, the weight values have increased, on average base, by 1.8 kg ($p \leq 0.05$), for the girls at the age of 4 years, it is similar for the two studied groups. For the girls at the age of 5 years, the differences are insignificant and are in the range of 0.4 kg ($p \leq 0.05$), but the highest differences, which are statistically significant, are observed in the weight of modern 6- years- old girls, who are reliably heavier, on average base by 3.1 kg in comparison to their peers from the end of the previous century ($p \leq 0.05$).

The secular changes in **chest circumference** in girls are with multidirectional character. Positive secular

trend is observed only among the girls at the age of 3 and 6 years, while at the age of 4 and 5 years, the secular changes are negative. The modern girls at the age of 3 years are with reliably bigger chest circumference in comparison to their peers from 20 years ago, while the girls at the age of 5 years are with chest circumference, which is almost 2 cm smaller in comparison to their peers ($p \leq 0.05$).

The results for the **head circumference** for girls are similar to the results of the boys. Positive secular changes are observed only among the modern girls at the age of 3 years, whose head circumference is 1 cm larger in comparison to their peers 20 years ago ($p \leq 0.05$). Insignificant negative secular changes are observed among the girls at the age of 4, 5 and 6 years, which are getting smaller with age.

DISCUSSION

The present study provides, for the first time, data about the main anthropometric indicators of physical development – height, weight, chest and head circumfer-

ences of the modern generation of children from Smolyan region, Bulgaria, at the age between 3-6 years, as well as data in relation to secular trends of these indicators for the last 20th years.

In this relation, our results show a positive secular trend for height and weight for children at the age between 3-6 years, despite the fact that the increase is not evenly presented in all ages and is different for the two genders.

Among the **boys** (table 2) at preschool age, body height has increased for the past two decades (1996-2019). The results show minor positive secular changes in the height of the boys at the age of 3 and 5 years and stabilization at the age of 6 years during the first two decades of the 21 century. For the boys at the age of 3 years, the increase in height for two decades is with 2.4 cm or on average by 1.2 cm per decade and for the boys at the age of 5 years, respectively 2.3 cm or 1.3 cm per decade. The increase is lowest and insignificant for boys at the age of 6 years, where, practically, the height shows stabilization and lack of secular changes. Our results for that indicator are different from the data of some authors who do not observe significant secular differences in the 25-years period (1990-2016) studied by them [15, 24].

No significant secular changes in body height are observed among the **girls** (table 3). Weak and insignificant acceleration processes are established during the 3, 5 and 6 years and deceleration processes, which are also insignificant, at the age of 4 year ($p > 0.05$). In fact, our data about the secular changes in the height of girls at that age correspond to the data provided by Sedlak et al. [24], according to which there are no significant secular changes in the height, including of girls, in the period 1990-2016. Negative secular changes in the height of Bulgarian children of two genders at age 3-6 years for the period 1980-2004 are reported earlier by Yankova and Zhecheva for Bulgarian preschool children from Sofia [25].

In relation to **secular changes in weight** the results show positive secular changes among children at age 3-6 years from both genders during the first two decades of the 21st century, which are well presented and significant among the boys at the age of 3 and 5 years and among girls at the age of 3 and 6 years. Most probably, our data outline a new positive secular tendency in the weight of Bulgarian children at the age between 3-6 years at the beginning of the 21st century, on the base of earlier data from Yankova and Zhecheva [25], who reported about deceleration changes in the weight in both genders after the 70s of the last century up to the year 2005.

But at the same time, our results confirm the observations of other authors [24], who report an increase in the weight of Czech boys at the age of 3, 5 and 6 years and Czech girls at the age of 6 years for the period 1990-2016. In the previous papers, other authors also report similar positive secular changes in weight [6,17].

In relation to **chest circumference**, the results show that for the last 20 years, it has been going down among

the boys at the age of 3 and 6 years and girls at age 4 and 5 years. At the same time, its secular increase is observed only among girls at the age of 3 and 6 years, where the differences have statistical significance only for the girls at the age of 3 years from the two generations. These results are close to the data of other authors, who also report stabilization or reduction of the chest circumference, about processes of astenization in body composition among urban preschool child etc. [14].

According to **head circumference**, the results show negative secular changes for the boys, especially well expressed among children at the age of 6 years, as well as slight deceleration processes in that indicator among girls at the age between 4 to 6 years. A positive trend is present only among girls at the age of 3 years. These results confirm earlier published data of many authors about the absence of acceleration processes and about the deceleration of the head circumference after the 80s of 20 century [25].

Our results confirm the statements of other authors that the intensity of the secular changes in the somatic dimension of the children, to a great extent, is the “result” of the period of ontogenesis to which the studied population is related [8].

CONCLUSION

In summary, the results of the study of the secular changes of the studied main anthropometric features show that there are secular changes in the main features in the physical development and nutritional status among the children of Smolyan region at age 3-6 years during the last 20 years (1998-2019), which are different for the two genders. They are expressed in a significant increase of height and weight of boys at the age of 3 and 5 years and the weight of girls at the age of 3 and 6 years. A statistically reliable reduction in the chest and head circumference among boys at the age of 6 years and a smaller chest circumference of 5-years-old girls are observed. On the grounds of these negative changes, the modern girls at the age of 3 years have a reliably larger chest and head circumference in comparison to their peers 20 years ago.

The results of the secular changes in these main features show the multidimensional character of the secular changes, which are presented, to various extents, in the various morphological systems of the body during the different stages of the ontogenesis and are different for the two genders. Most probably, these differences are related to the influence of the specific hereditary factors, dominating the growth of the studied indicators in that age, as well as with the different ecosensitivity of the body to environmental factors in the earlier stages of the development, which will be a subject of our future studies.

ACKNOWLEDGEMENTS

This manuscript was developed with the financial support of the Fund “Scientific Research” at Plovdiv University “Paisii Hilendarski”, Bulgaria, Grants No. FP 19-FS 004 and No. FP 21-FS 003.

REFERENCES:

1. Wolanski N. Genetic and ecological factors in human growth. *Hum Biol.* 1970 Sep;42(3):349-68. [[PubMed](#)]
2. Mladenova S, Nikolova M. Intragroup differences in morphological characteristics in children and adolescents from Smolyan region based on social and economic factors. *Journal of Anthropology. BAS.* 2003; 4:55-58.
3. Mladenova S, Nikolova M, Godina E. Socioeconomic factors and their role in the processes of intragroup differentiation of certain morphological characteristics in children and adolescents from the Smolyan region (Bulgaria). Proceedings from Conference Anthropology on the Threshold of the III Millennium". Moscow. 2005 (2):686-697.
4. Nikolova M, Godina E, Mollova D. A Comparison of Plovdiv and Moscow Children's Height, Weight and BMI Values. *Acta morphologica et anthropologica.* 2010; 15:212-216. [[Internet](#)]
5. Pavlov S, Petrov I, Tzirovski M, Geshev A, Matev T, Nikolova M, et al. [On the changes in the body growth of the children from the kindergartens in Plovdiv for the period 1953/1956-1977.] *Pediatrics.* XIX, 1980 (1): 58-63. [in Bulgarian].
6. Karklina H, Krumina D, Ebela I, Valeinsis J, Knipse G. A cross sectional research on the height, weight and body mass index of children aged 5-6 years in Latvia and its secular changes during the last century. *Centr Eur J Public Health.* 2013; 21 (1):3-7. [[PubMed](#)]
7. Nikolova M, Mladenova S, Boyadzhiev D, Paskaleva T. Changes in body composition and skeletal robustness in 7-17 year old children and adolescents from Plovdiv, Bulgaria (1998-2008). *Anthropol Res Stud.* 2019; 9:41-53. [[Crossref](#)]
8. Fedotova T, Gorbacheva A. [Time trend of somatic measures of children in the periods of the first and second childhood (based on materials from the Russian Federation and the former Soviet Union).] [in Russian] *Moscow University Anthropology Bulletin. Anthropology.* 2019 (2): 26-39. [[Crossref](#)]
9. Stoev R., Mladenova S. [Secular changes in the terms of puberty in Smolyan (1986-2001).] Proceedings of National Scientific Conference: "The Rhodopes and Man". Union of Scientists in Bulgaria-Smolyan, 2008: 244-251. [In Bulgarian].
10. Godina E, Khomyakova I, Zadorozhnaya L. Secular changes in body dimensions and sexual maturation in children of Arkhangelsk city. *Anthropol Anz.* 2016; 73(1):45-59. [[PubMed](#)]
11. Cole TJ, Mori H. Fifty years of child height and weight in Japan and South Korea: Contrasting secular trend patterns analyzed by SITAR. *Am J Hum Biol.* 2018 Jan;30(1):e23054. [[PubMed](#)]
12. Stoev R, Yordanov Y. Secular Growth Changes in Europe. Eds. By E. Bodzsar and C. Susanne. *Budapest. Eötvös Univ. Press;* 1998. Secular changes in Bulgaria; p. 65-73.
13. Godina E. Secular Growth Changes in Europe. Eds. By E. Bodzsar and C. Susanne. *Budapest. Eötvös Univ. Press;* 1998. Secular changes in Russia and the former Soviet Union; p. 351-367.
14. Gurbo T. [Regularities in the variability of the physical development in children from Belarus in the period of the first childhood (from 4 of 7 years).] [PhD Thesis]. [Minsk]. 2005. 22 p. [in Russian].
15. Pavlica T, Rakiæ R, Popoviæ B, Puškaš V, Boïæ-Krstiæ V. Secular trends in height and weight among children from Novi Sad (Serbia), 1971-2017. *Glas Antropol druš Srb.* 2018; 53(1-2):131-140. [[Crossref](#)]
16. Nacheva A, Zecheva Y, Yankova I, Filcheva Z, Mitova Z, Yordanov Y. [Physical development of children and adolescents in the borderline between XX and XXI century]. [Monographs]. *Academic Publishing House. BAS. "Prof. Marin Drinov"*. 2012. 417 p. [in Bulgarian].
17. Nagel G, Wabitsch M, Galm C, Berg S, Brandstetter S, Fritz M, et al. Secular changes of anthropometric measures for the past 30 years in South-West Germany. *Eur J Clin Nutr.* 2009 Dec;63(12):1440-3. [[PubMed](#)]
18. Mitova Z, Stoev R, Yordanova L. Nutritional Status in 9-15-years old Schoolchildren from Sofia, Bulgaria (1984-2002). *Acta Morphologica et Anthropologica. BAS.* 2012; 19: 246-249. [[Internet](#)]
19. Kowal M, Kryst L, Woronkiewicz A, Brudecki J, Sobiecki J. Time trends in BMI, body fatness, and adiposity rebound among boys from Kraków (Poland) from 1983 to 2010. *Am J Hum Biol.* 2015 Sep-Oct;27(5):646-53. [[PubMed](#)]
20. Cattaneo A, Monasta L, Stamatakis E, Lioret S, Casteblon K, Frenken F et al. Overweight and obesity in infants and preschool children in the European Union: a review of existing data. *Obesity Reviews,* 2010 May;11(5):389-98. [[PubMed](#)]
21. Alper Z, Ercan I, Uncu Y. A Meta-Analysis and an Evaluation of Trends in Obesity Prevalence among Children and Adolescents in Turkey: 1990 through 2015. *J Clin Res Pediatr Endocrinol.* 2018 Mar 1;10(1):59-67. [[PubMed](#)]
22. Martin R, Saller K. [Lehrbuch der Anthropologie] [in German] *Stuttgart: Gustav Fisher Verlag;* 1957. 661p.
23. Mladenova S. [Anthropological characteristics of the growth and development of children and adolescents from Smolyan region in modern living conditions.] [dissertation]. Plovdiv University "Paisii Hilendarski"; 2003. 199 p. [in Bulgarian]
24. Sedlak P, Parizkova J, Prochazkova L, Cvrckova L, Dvorakova H. Secular Changes of Adiposity in Czech Children Aged from 3 to 6 Years: Latent Obesity in Preschool Age. *Biomed Res Int.* 2017;2017:2478461. [[PubMed](#)]
25. Yankova I, Zecheva Y. Secular changes in basic anthropometrical features of neonates and children in early childhood from Sofia. *Acta Morphologica and anthropologica.* 2012 (19):279-283. [[Internet](#)]

Please cite this article as: Mladenova S. Secular changes in main anthropometric indicators for the evaluation of the physical development of children at the age between 3-6 years from Smolyan region, Bulgaria (1996/98- 2017/19). *J of IMAB*. 2022 Jan-Mar;28(1):4270-4275. DOI: <https://doi.org/10.5272/jimab.2022281.4270>

Received: 31/07/2021; Published online: 11/03/2022



Address for correspondence:

Assoc. Prof. Silviya Mladenova, PhD
Department of Natural-Mathematical and Economical Sciences, Filial Smolyan
at Plovdiv University "Paisii Hilendarski"
32, Dicho Petrov Str, 4700 Smolyan, Bulgaria
E-mail: silviamladenova.sm@uni-plovdiv.bg