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Changes in Stature, Weight and Body Mass Index in 3-6-Year-Old Bulgarian Children (2005 – 2016)

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The aim of the study is to follow up trends in the stature, weight and body mass index (BMI) in 3-6-year-old children from Sofia during the period 2005-2016 and to assess the prevalence of underweight, overweight and obesity.

From 2004 to 2005 and 2014 to 2016, two independent cross-sectional anthropological studies of children visiting kindergartens in Sofia were carried out. Stature and body weight were measured and BMI was calculated. The children were classified as underweight, normal, overweight and obese according to the International Obesity Task Force BMI cut-offs proposed by Cole and Lobstein.

The children measured during the period 2014-2016 have lower but similar values of the stature, body weight and BMI to those of children from the first survey (2004-2005). The statistically significant differences are not observed. An increase of frequencies of underweight and overweight and a decrease of the incidence of obesity in 3-6-year-old children are detected.

Key words: children, anthropometric measurements, BMI, underweight and overweight, secular changes

Introduction

The anthropological characteristic of the population of each country is an indicator of the specifics of the socio-economic living conditions during its historical development and in the present.

Secular trend presents changes in the consecutive generations, mostly observed in growth, development and maturation of children and adolescents, or in adult sizes [7].

The changes depend on both the genetic potential of the population and environmental factors, notably the level of socio-economic living conditions.

In some developed countries, secular changes slow down [4] or stabilize at a certain age and age of menarche, while in other ones it still continues [1, 2].

The absence of changes in the rate of growth and development in certain years shows that either living conditions stop improving or that they already allow the full expression of genetic potential [23].

Secular growth changes to higher stature, body weight and earlier maturation are also associated with improved nutrition and health care [4, 9, 15, 24, 25] and could be referred to the health status of a population with mostly positive, progressive tendencies. Unfortunately these positive trends lead to some negative consequences such as the increasing body fat content as one of the results of the modern way of living (reduced physical activity along with unfavorable changes in dietary habits) [18].

The risk of being overweight and obese during adolescence and adulthood begins in early childhood. Overweight and childhood obesity are a risk factor for a number of health problems (respiratory, cardiovascular, musculoskeletal, metabolic, endocrine, etc.) [10, 20].

A relative increase in the prevalence of overweight and obesity in early childhood are observed worldwide in the period 1990–2010 [6]. Along with being overweight in the current generation of children and adolescents in developed countries, a serious problem is the increased incidence of underweight, which, although to a lesser extent, also carries a risk of health complications [13, 27].

The frequency of overweight and obesity is constantly increased, but a number of studies have found slowed down or even stabilized percentage of overweight and obese children after the 2000s. This is observed mostly in the younger children (up to 7-10 years) [8, 22, 26].

The aim of the study is to follow up trends in the stature, weight and body mass index in 3-6-year-old children from Sofia during the period 2005-2016 and to assess the prevalence of underweight, overweight and obesity.

Materials and Methods

Two independent cross-sectional anthropological studies of children visiting kindergartens in Sofia were carried out during the periods 2004 - 2005 and 2014 - 2016. A total of 640 participants (320 boys and 320 girls) were included in the first study and 870 (451 boys and 419 girls) in the second one. Stature was measured in standing position with stadiometer to the nearest 0.1 cm by Martin-Saller's classical methods [12]. Body weight was measured using digital scale Tanita to the nearest 0.1 kg. Body mass index (BMI) was calculated by the formula: $BMI = \text{body weight (kg)}/\text{stature (m)}^2$. The participants were classified as underweight, normal, overweight and obese according to the International Obesity Task Force (IOTF) cut-offs of BMI proposed by Cole and Lobstein [5].

Written informed consent from the parents of each child who voluntarily participated in the studies was obtained. The investigations were approved by the Ethical Committee

of Institute of Experimental Morphology, Pathology and Anthropology with Museum – Bulgarian Academy of Sciences and were conducted in agreement with the principles of the Declaration of Helsinki for human studies of the World Medical Association [28].

The metrical data were analyzed by SPSS software, version 16. Student’s t-test was used to compare stature, weight and BMI between two investigated cohorts. The comparison of the frequency of underweight, overweight and obesity between the different years was performed with a chi-square test. Statistical significance was considered at $p \leq 0.05$.

Results and Discussion

The statistical data of basic anthropometric features and BMI in 3-6-year-old children are presented on **Table 1**.

The stature of the boys from the first sample (2004-005) varies between 101.20 cm at the age of 3 and 121.28 cm at the age of 6 years. In the boys from the second

Table 1. Statistical data for stature, weight and BMI in 3-6-year-old children (2005-2016)

Features	Age	Years	Boys					Girls				
			n	mean	SD	decade changes	p	n	mean	SD	decade changes	p
Stature (cm)	3y	2005	80	101.20	4.30	- 1.44	0.03*	80	98.99	3.89	- 0.6	0.37
		2016	103	99.76	4.66			102	98.39	4.92		
	4y	2005	80	107.70	4.13	- 0.99	0.18	80	106.52	5.39	- 0.07	0.94
		2016	100	106.71	5.20			100	106.45	5.39		
5y	2005	80	114.66	4.97	- 0.79	0.28	80	113.91	4.97	- 0.79	0.28	
	2016	128	113.87	5.18			111	113.12	4.95			
6y	2005	80	121.28	4.93	0.21	0.79	80	120.40	5.16	- 0.97	0.19	
	2016	120	121.49	5.74			106	119.43	4.80			
Body weight (kg)	3y	2005	80	16.33	2.11	- 0.55	0.07	80	15.48	1.79	- 0.33	0.24
		2016	103	15.78	1.93			102	15.15	1.98		
	4y	2005	80	18.35	3.09	- 0.32	0.53	80	17.96	2.68	- 0.24	0.55
		2016	100	18.03	3.60			99	17.72	2.59		
5y	2005	80	21.06	3.97	- 0.7	0.18	80	20.01	3.72	0.12	0.82	
	2016	127	20.36	3.16			110	20.13	3.68			
6y	2005	80	23.86	4.26	- 0.6	0.31	80	22.87	3.93	- 0.52	0.31	
	2016	120	23.26	4.0			106	22.35	3.09			
BMI (kg/m ²)	3y	2005	80	15.91	1.43	- 0.09	0.65	80	15.76	1.26	- 0.16	0.36
		2016	103	15.82	1.25			102	15.60	1.18		
	4y	2005	80	15.75	1.83	- 0.01	0.97	80	15.76	1.48	- 0.17	0.44
		2016	100	15.74	1.87			99	15.59	1.43		
5y	2005	80	15.92	1.87	- 0.28	0.23	80	15.38	1.42	0.26	0.33	
	2016	127	15.64	1.46			110	15.64	2.02			
6y	2005	80	16.14	2.04	- 0.46	0.08	80	15.72	2.04	- 0.09	0.75	
	2016	120	15.68	1.69			106	15.63	1.59			

* Statistically significant differences at $p \leq 0.05$

study (2014-2016) it is between 99.75 cm and 121.49 cm, respectively. The increment is higher in boys investigated during the period 2014-2016 (21.73 cm) compared to those investigated within 2004-2005 (20.08 cm). The body weight range is from 16.33 kg to 23.86 kg (2004-2005) and from 15.78 kg to 23.26 kg (2014-2016). The weight of boys from both cohorts increased between 3 and 6 years of age with 7.5 kg.

The stature of the girls from the first study ranged from 98.99 cm at 3 years to 120.40 cm at 6 years, as the increment is 21.41 cm. In the group of girls from second study, the stature increased from 3 (98.39 cm) to 6 (119.43 cm) years with 21.04 cm. The body weight of the girls measured in 2004-2005 ranged from 15.48 kg (at the age of 3) to 22.88 kg (at the age of 6), and girls measured in 2014-2016 weigh from 15.15 kg to 22.35 kg. Weight gain is 7.4 kg in the first sample and 7.2 kg in the second one.

The difference in stature of both boys and girls from each cohort is from a few millimeters to about 1.4 cm, and in body weight: from 0.100 kg to 0.700 kg.

In children investigated during the periods 2004-2005 and 2014-2016, the values of the indicator of nutritional status – BMI are within a normal range (18.5 kg/m² – 25.0 kg/m²) and remain relatively constant for a decade.

There are no significant differences in stature, weight and BMI in boys and girls in all age groups between 2005 and 2016, with the exception of 3-year-old boys, in which statistically significant differences are observed in stature (p=0.03).

For each age group in both genders, the mean values of stature, weight and BMI decreased slowly for a decade. The opposite trend is observed only in the stature of 6-year-old boys (0.21 cm) and in the weight and BMI of 5-year-old girls (0.12 kg and 0.26 kg/m² respectively).

Table 2 presents the incidence of underweight, normal weight, overweight and obesity in children studied in 2004-2005 and 2014-2016.

The frequency of underweight children in both genders investigated in 2004-2005 is 11.9%. The highest incidence of underweight is at the age of 3 (17.5%) in boys and

Table 2. Frequency of the categories nutritional status according BMI cut-offs of Cole and Lobstein

Boys											
Age	Years	n	Underweight		Normal weight		Overweight and obesity				χ^2 (df = 3)
							Overweight		Obesity		
			n	%	n	%	n	%	n	%	
3y	2005	80	14	17.5	60	75.0	4	5.0	2	2.5	1.56
	2016	103	17	16.5	76	73.8	9	8.7	1	1.0	
4y	2005	80	11	13.8	63	78.8	3	3.8	3	3.8	3.52
	2016	100	18	18.0	73	73.0	8	8.0	1	1.0	
5y	2005	80	7	8.8	62	77.5	8	10.0	3	3.8	2.82
	2016	127	21	16.6	90	70.9	13	10.2	3	2.4	
6y	2005	80	6	7.50	62	77.5	8	10.0	4	5.0	6.03
	2016	120	14	11.7	99	82.5	6	5.0	1	0.8	

Girls											
Age	Years	n	Underweight		Normal weight		Overweight and obesity				χ^2 (df = 3)
							Overweight		Obesity		
			n	%	n	%	n	%	n	%	
3y	2005	80	11	13.8	63	78.8	5	6.2	1	1.2	1.40
	2016	102	17	16.7	81	79.4	3	2.9	1	1.0	
4y	2005	80	11	13.8	53	66.2	16	20.0#	0	0.0	10.10#
	2016	99	14	14.1	76	76.8	6	6.10	3	3.0	
5y	2005	80	6	7.5	68	85.0	3	3.8	3	3.8	5.26
	2016	110	11	10.0	81	73.6	14	12.7	4	3.6	
6y	2005	80	10	12.5	56	70.0	11	13.8	3	3.8	6.79
	2016	106	7	6.6	87	80.2	12	11.3	0	0.0	

Statistically significant differences at $p \leq 0.05$

at the age of 3 and 4 (13.8%) in girls. The prevalence of underweight among preschool boys and girls studied in 2014-2016 is 15.7% and 11.9% respectively, as the highest frequency is observed at the age of 4 (18.0%) in boys and at the age of 3 (16.7%) in girls. The incidence of underweight decreased with age in both studies. Over 70% of the children from the investigated cohorts have normal weight and 3.0 to 20.0% are overweight. In children from the first study the incidents of overweight rise to 10% and 13.8% in 6-year-old boys and girls and in children from the second one – to 10% and 12.7% in 5-year-old boys and girls, after that the frequency decreases. In both studies the children with obesity are less than 5.0%. There are significant differences only in group of overweight girls at the age of 4 ($p \leq 0.05$).

Discussion

The periodic conduct of similar studies provides a possibility to follow the tendencies in children and adolescents' growth and development for certain periods of time in different socio-economic living conditions.

Our study demonstrates slow-down trends for stature, weight and BMI in 3-6-year-old children from Sofia. The comparative analysis of the data from the two studies shows that the children measured in the period 2014-2016 have lower values of the stature, weight and BMI, but close to those of the children from the first study (2004-2005). Statistically significant differences only in the group of 3-year-old boys are observed. Similar trends in basic anthropometric features are detected in some other populations as well [4, 16, 21]. The data from other countries are consistent in reporting a positive trend. In children under the age of 5 the secular changes in stature, weight and BMI are the smallest and increase with age and reach a maximum during the puberty [18, 19, 29]. Positive and negative changes are recorded for different ages and decades in Novi Sad sample between 1991 and 2001, and after 2001. A modest increase of height and weight during the investigated period, especially in preschool children are established. According to the authors, the changes in anthropometric characteristics reflect the changing socio-economic and political situation in the country after the 1990s [17].

An important aspect of monitoring of the children's health is the investigation of their nutritional status and determination of the frequency of its extreme forms – underweight and obesity.

Comparing the children in both studies an increase of the frequency of underweight is detected, with the exception of 3-year-old boys, and 6-year-old girls. The prevalence of overweight in boys also increases, except 6-year-olds, and decreases in girls, except 5-year-olds. The incidence of obese children decreases in boys, whereas in 3 and 5-year-old girls it remains relatively constant and decreases in 6-year-olds. Similar to our results for children from early childhood, preschool and school age are established in England, Netherlands, Czech Republic and others [11, 14, 22, 26]. Van Jaarsveld and Gulliford reported stabilization in the incidence of obesity in 2-10-year-old English children between 2004 and 2013, but not in older 11-15-year-old students [26]. A relatively constant incidence of obesity was also found by Sigmund et al. for Czech children for the period 2005-2015 [22]. Decrement of the frequency of overweight and obese children in 2002-2011 in Italy was reported by Brambilla et al. They also found an increase in prevalence of underweight children [3].

Conclusion

For the investigated period (2004/2005 – 2014/2016), detention in stature, body weight and BMI in early childhood and preschool children are established. An increase of the frequency of underweight and overweight and a decrease of the incidence of obesity is detected in 3-6-year-old children.

The information obtained could be used to assess the real health risks of children from early childhood and preschool age, and to develop adequate programs and policies to improve the living conditions and health of the younger generation in the country.

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References

1. **Ayatollahi, S. M. T., S. Pourahmad, Z. Shayan.** Trend in physical growth among children in southern Iran, 1988–2003. – *Ann. Hum. Biol.*, **33**(4), 2006, 510-514.
2. **Bodzsár, É. B., A. Zsákai, N. Mascie Taylor.** Secular Growth and Maturation Changes in Hungary in Relation to Socioeconomic and Demographic Changes. – *J. Biosoc. Sci.*, Cambridge University Press, **48**(2), 2016, 158-173.
3. **Brambilla, P., M. Vezioni, R. Lucchini, L. Acerbi, A. Brambilla, G. Brandolini, P. Rogari, G. Cassavia.** Is the prevalence of overweight reducing at age 5-6 years? Ten years data collection in ASL Milano 2. – *Ital. J. Pediatr.*, **38**, 2012, 24.
4. **Cole, T. J.** The secular trend in human physical growth: a biological view. – *Econ. Hum. Biol.*, **1**, 2003; 161-168.
5. **Cole, T. J., T. Lobstein.** Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. – *Pediatric Obesity*, **7**, 2012, 284-294.
6. **De Onis, M., M. Blössner, E. Borghi.** Global prevalence and trends of overweight and obesity among preschool children. – *Am. J. Clin. Nutr.*, **92**, 2010, 1257-1264.

7. **Farkas, A., M. Szmodis.** About the Secular Growth Trend. – *Biomed. J. Sci. & Tech. Res.*, **17**(4), 2019. BJSTR. MS.ID.003043.
8. **Franssen, S. J., M. F. van der Wal, P. Jansen, M. van Eijsden.** Thinness and overweight in children from Amsterdam: a trend analysis and forecast. – *Ned. Tijdschr. Geneesk.*, **159**, 2015, A8967.
9. **Hovels, O.** Growth, maturation and environment. – *Fortschritte der Kieferorthopädie*, 1990, **51**(2), 61-69.
10. **Kirchengast, S.** Biocultural aspects of gender differences in body composition and obesity during childhood and adolescence. – *Anthrop. Anz.*, **66** (3), 2008, 337-348.
11. **Lateva, M., S. Galcheva, W. de Witte, V. Iotova.** Preschool children – obesity and risk behaviours. Trends from 2009 to 2013. – *Scripta Scientifica Medica*, **45**(3), 2013, 39-42.
12. **Martin, R., K. Saller.** Textbook of Anthropology. – Stuttgart, Gustav Fischer Verlag, Band I, 1957. (Lehrbuch der Anthropologie) [in German].
13. **Martinez-Vizcaíno, V., M. S. López, P. M. Martínez, M. S. Martínez, B. N. Pacheco, F. S. Aguilar, F. Rodríguez-Artalejo.** Trends in excess weight and thinness among Spanish schoolchildren in the period 1992-2004: the Cuenca study. – *Public Health Nutr.*, **12**(7), 2008, 1015-8.
14. **Mitova, Z., R. Stoev, L. Yordanova.** Nutritional Status in 9-15-years-old Schoolchildren from Sofia, Bulgaria /1984-2002/. – *Acta morphol. anthropol.*, **19**, 2012, 246-249.
15. **Murata, M., I. Hibi.** Nutrition and the secular trend of growth. – *Horm. Res.*, **38**(1), 1992, 89-96.
16. **Oprîşescu, I., L. C. Gherghel, C. Minculescu.** Secular Trend of Growth in Height, Weight and Body Mass Index in Young Romanians Aged 18-24 Years. – *Procedia - Social and Behavioral Sciences*, **117**, 2014, 622-626.
17. **Pavlica, T. M, R. S. Rakić, B. K. Popović, V. P. Puškaš, V. S. Božić-Krstić.** Secular trend in height and weight among children from Novi Sad (Serbia), 1971–2017 – *Glasnik*, **53**, 2018, 131-140.
18. **Photiou, A., J. H. Anning, J. Mészáros, I. Vajda, Z. Mészáros, A. Sziva, A. Prókai, N. Ng.** Lifestyle, body composition, and physical fitness changes in Hungarian school boys (1975-2005). – *Res. Q Exerc. Sport*, **79**(2), 2008, 166-73.
19. **Pop, R.M., A. Tenenboum, M. Pop.** Secular Trends in Height, Body Mass and Mean Menarche Age in Romanian Children and Adolescents, 1936-2016. – *Int. J. Environ. Res. Public Health*, **18**(2), 2021, 490.
20. **Reilly, J. J., E. Methven, Z. C. McDowell, B. Hacking, D. Alexander, L. Stewart, C. J. H. Kelnar.** Health consequences of obesity. – *Arch. Dis. Child*, **88**, 2003, 748-752.
21. **Sedlak, P., J. Pařízková, D. Samešová, M. Musálek, H. Dvořáková, J. Novák.** Secular Changes in Body Build and Body Composition in Czech Preschool Children in the Context of Latent Obesity. – *Children*, **8**, 2021, 18, <https://doi.org/10.3390/children8010018>
22. **Sigmund, E., D. Sigmundová, P. Badura, L. Trhlíková, A. M. Gecková.** Time trends: a ten-year comparison (2005–2015) of pedometer-determined physical activity and obesity in Czech preschool children. – *BMC Public Health*, **16**, 2016, 560.
23. **Susanne, Ch., E. Bodzsar.** Patterns of secular changes of growth and development. – In: *Secular growth changes in Europe* (Eds. E. B. Bodzsar, C. Susanne), Eötvös Univ. Press, Budapest, 1998, 5-26.
24. **Tanner, J. M.** The secular trends towards earlier physical maturation. - *Tijdsch. Soc. Geneesk.*, **44**, 1966, 524-538.
25. **Tanner, J. M.** Growth as a measure of the nutritional and hygienic status of a population. – *Horm. Res.*, **38** (1), 1992, 106-115.
26. **van Jaarsveld, C. H. M., M. C. Gulliford.** Childhood obesity trends from primary care electronic health records in England between 1994 and 2013: population-based cohort study. – *Arch. Dis. Child*, **100**, 2015, 214-219.

27. **Vignerova, J., L. Humeníková, M. Paulová, J. Riedlová.** Prevalence of overweight, obesity and low weight in the Czech child population up to 18 years of age in the last 50 years., – *J. Public Health*, **16**, 2008, 413-420.
28. **World Medical Association.** Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects. – *WMJ*, **54**(4), 2008, 122-125.
<https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/>
29. **Zhang, Y. Q., H. Li, H. H. Wu, X. N. Zong.** Secular trends in weight, height and weight for height among children under 7 years in nine cities of China, 1975-2015: results from five repeated cross-sectional surveys. – *BMJ Open*, **9**(10), 2019, e029201.