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ORIGINAL ARTICLE

Prevalence of overweight/obesity among 7-year-old children—WHO Childhood Obesity Surveillance Initiative in Slovakia, trends and differences between selected European countries

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Abstract

The objectives of this study were (1) to assess the prevalence and time trends of overweight/obesity in Slovak children by applying WHO, IOTF, and the national criteria; (2) to compare the prevalence between selected European countries; and (3) to evaluate the central obesity by the waist-to-height ratio. The survey was performed within the WHO European Childhood Obesity Surveillance Initiative. The weight, height, waist, and hip were measured in 2795 children at the age of 7–7.99 years (50.1% boys; 55.5% in rural areas). The prevalence of overweight/obesity was determined using the LMS Growth. In boys, the prevalence of overweight/obesity was 17.1/14.9% according to WHO, 13.8/8.8% according to IOTF, and 9.9/8.8% according to the national criteria. Among girls, the prevalence reached 15.1/11.1%, 12.6/8.1%, and 7.5/9.5%, respectively. These rates corresponded to the average of the European countries. Central obesity was identified in 76.9% of overweight/obese, but also in 5.9% normal-weight subjects.

Conclusion: While overweight has increased by 3% the prevalence of obesity has doubled since 2001. The rise culminated approximately 6 years ago and has not increased since then. The body constitution differences should be considered when comparing the prevalence of overweight/obesity between populations and/or individuals.

What is Known:

- *Knowledge of the prevalence of overweight/obesity is seminal for effective implementation of programs focusing on the reduction of incidence and prevalence of obesity in early childhood.*

What is New:

- *The most numerous and representative study on the prevalence of overweight/obesity in 7-year-old children involving 2795 (5%) of peers living in Slovakia.*
- *The prevalence of obesity in Slovakia falls within the range of average rate of the European countries. Central obesity was identified in almost 20% subjects.*

Keywords Overweight/obesity · Children · Prevalence and trends in European countries

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Abbreviations

BMI	Body mass index
COSI	Childhood Obesity Surveillance Initiative
IOTF	International Obesity Task Force
NAS	National Anthropometric Survey
PHA	Public Health Authorities
SD	Standard deviation
WHtR	Waist-to-height ratio
WHO	World Health Organization

Introduction

Childhood obesity is one of the most serious public health problems of the twenty-first century. More and more young people in Europe are affected, with evidence suggesting that up to one in three boys and one in five girls aged 6–9 years are now overweight or obese [35]. Monitoring a prevalence of obesity is relevant for the public health programs focusing on prevention and reduction of obesity. In contrast to adults, there exists no uniform definition of overweight/obesity in children. According to the World Health Organization (WHO), the criteria for children aged between 5 and 19 years, overweight is defined as age- and gender-adjusted body mass index (BMI) > 1 standard deviation (SD) and obesity as > 2 SD above the WHO Growth Reference median [9]. The International Obesity Task Force (IOTF) aimed to link adult cutoff points of overweight/obesity (25 and 30 kg/m^2, respectively) to BMI centiles for children and adolescents. The calculated average curves provide age- and sex-specific cutoff points for overweight/obesity for 2 to18 years [8]. The national Slovak references define overweight/obesity as BMI exceeding the 90th and 97th percentiles for age and gender, respectively [24].

The WHO European Childhood Obesity Surveillance Initiative (COSI) is considered the largest WHO/Europe study carried out in children, involving 35 countries and almost 300,000 children. Specific aim of the cross-sectional COSI study in Slovakia was to collect new data on the body weight and body height of the 7- to 7.99-year-old (herein after referred to as 7 year old) Slovak school children, to calculate BMI, and to estimate the prevalence of thinness, normal weight, overweight, and obesity in accordance with the WHO protocol during the Fourth COSI implementation round in 2015/2016. Since different criteria for the assessment of childhood obesity achieved disparate results, herein, we aimed to assess the prevalence and trend of overweight/obesity in Slovak children using different criteria: WHO, IOTF, and national (Slovak). In addition to this, we compared the prevalence of obesity between certain selected European countries. Since measures of central adiposity have been more accurate compared to cardiometabolic risk regardless of gender or ethnicity [1, 2, 5, 18], waist-to-height ratio (WHtR) was calculated as a proxy measure of central obesity, by weight categories in both genders.

Material and methods

Within the "National Action Plan for the Prevention of Obesity" coordinated by the Ministry of Health, the Children's Hospital of the Comenius University in Bratislava was appointed as the principal investigator of the Fourth COSI data collection round in Slovakia. The study was carried out according to the WHO recommendations and was approved by The Ethical Committee of Children's Hospital in Bratislava. Parents were fully informed about all study procedures, and informed consent was obtained on a voluntary basis.

Sampling design

The COSI project was implemented by 36 Public Health Authorities (PHA) covering the entire territory of Slovakia. The minimum final effective sample size of approximately 2800 children per age group was required [26]. To select the nationally representative sample, cluster sampling was employed. The cluster primary sampling unit was the primary school. Primary schools were selected randomly from the list of all primary schools, stratified by region and level of urbanization. Approximately 80 children in urban and rural schools were selected by each of PHA. The final studied sample consisted of 2795 children at the age of 7, attending 123 different schools, including 55% of rural and 38% of urban provenience; only 7% came from larger cities with the population of more than 50,000.

Anthropometric data (weight, height, waist, and hip) were assessed by trained personnel of the PHA directly at schools during November and December 2015. According to the protocol of the WHO COSI project, measurements were performed in bare-foot children wearing either underwear or gym clothes (e.g., shorts and t-shirt only) or light clothing (such as a t-shirt, cotton trousers, or skirt) without any heavy objects (phone, wallet, belt, etc.). In each child, date of birth, gender, geographic location of residence, school grade, date of measurement, clothes worn during measurement, and school codes were recorded. Prior to the data analyses, body weight was corrected for the average weight of the clothes worn, e.g., 115 g in case of wearing gym clothing, 185 g in case of wearing light clothing.

Statistical analysis

In Excel, data were checked for obvious keying mistakes and they were compared with the age- and gender-specific BMI national standards [24]. The source of the BMI data was the sixth National Anthropometric Survey (NAS) conducted in the year 2001. The original data were cleaned, revised, and recalculated by the recommended LMS method [7]. The prevalences of overweight/obesity as well as of the grades of thinness and severe thinness according to the WHO (2007) [9], the IOTF definition [8], and the Slovak national standards [24] were determined by applying the LMS Growth software. To assess central obesity, WHtR was computed and the limit values were set at WHtR > 0.5 because this value is considered to be a reliable indicator of increased cardiometabolic risk in individuals aged ≥ 6 years [2, 5, 18]. Proportions of WHtR > 0.5 were estimated with respect to the gender and BMI categories. Between-gender prevalence of obesity and central obesity was compared by applying the chi-square test. The *P* value < 0.01 was considered significant.

Results

Basic descriptive outputs

Two thousand seven hundred ninety-five children aged 7–7.99 years were evaluated: 1402 (50.1%) boys and 1393 (49.9%) girls; 1525 (55.5%) of rural and 1270 (44.5%) of urban provenience. The cohort characteristics are given in Table 1. Boys were significantly taller (128.2 ± 6.2 vs. 127.5 ± 6.1 cm, $p < 0.001$) and heavier (27.7 ± 6.6 vs. 27 ± 6 kg, $p = 0.002$) and had higher waist circumference (59.9 ± 8 vs. 58.6 ± 7.2 cm, $p < 0.001$) and WHtR (0.47 ± 0.05 vs. 0.46 ± 0.05, $p < 0.001$) compare to girls. The gender differences of BMI values were of less significance: (16.8 ± 2.9 vs. 16.5 ± 2.7 kg/m^2, $p = 0.02$). The boys and girls did not differ significantly by hip (68.6 ± 7.3 vs. 68.3 ± 6.7, ns).

The mean height of our children corresponded with the WHO 2007 reference values for 8 years old [9], as only 55% of children were within the limits of normal height, 39% were higher than the level of *Z*-score ≥ 1. Among them, 12% exceeded *Z*-score ≥ 2 and 5.5% were lower than *Z*-score ≤ − 1 (Table 2). Compared with Slovak data from NAS (2001), only 8% children were higher than the median + 1 SD.

Prevalence of overweight/obesity by different standards of BMI with respect to gender

Distribution of children in BMI categories according to the WHO (2007) [9], the IOTF [8], and the (Slovak) national reference values [24] is shown in Fig. 1.

In boys, the prevalence of severe thinness reached 0.6% according to the WHO criteria, 0.7% using the IOTF, and 1.9% employing the national criteria. The thinness reached 2.6, 1.9, and 3.9%; that of overweight 17.1, 13.8, and 9.9%; and 14.9, 8.8, and 8.8%, respectively, presented obesity. According to the WHO, the IOTF, and the national criteria, 64.8, 74.8, and 75.5% of boys respectively were within the normal weight.

In girls, the prevalence of severe thinness reached 0.5% according to the WHO criteria, 1.1% by applying the IOTF, and 1.7% employing the national criteria. The thinness reached 2.4, 2.4, and 2.8%; 15.1, 12.6, and 7.5%, respectively, were overweight; and 11.1, 8.1, and 9.5%, respectively, were obese. According to the WHO, the IOTF, and the national criteria, 71.0, 75.4, and 78.4% of girls were within the normal range.

The gender differences in proportions of overweight or obesity were significant ($p < 0.001$) only when the WHO standards were applied. WHO limits for obesity in boys (*Z*-score = 2) represent in boys the value of BMI lower by 0.8 kg/m^2 than in girls, but the median is higher in boys. The data on the median BMI in children aged 7 years and the cutoff values defining obesity in selected European countries are given in Table 3. According to IOTF and almost all of the national standards based on LMS method and percentile distribution [6, 15, 19, 24, 25, 31], the cutoffs of BMI to define obesity, as well as medians, were higher in boys (Table 3). All nation-specific standards set the definition of obesity at the 97th percentile. In addition to Slovakia and the Czech Republic, in other four countries, the BMI value indicating obesity in boys was by 2–3 kg/m^2 higher compared to the WHO limits. The Slovak cutoffs for both genders are similar those of IOTF.

Consequently, in each country, the prevalence of obesity according to the WHO criteria seemed to be systematically higher in boys *(the average 15%)* and consistently almost two times higher than the prevalence *(the average 7.7%)* indicated by the IOTF criteria (Fig. 2). The respective percentage in girls reached *10.8% (WHO) and 8% (IOTF)*. In 9 of 15 countries participating in the COSI [35], the prevalence of obesity was higher in girls than in boys, when applying the IOTF limits. Among those countries, where obesity was more frequent in boys, it was maximum by 1.3% higher than in girls (Macedonia). Two criteria achieved dissimilar results of prevalence of obesity among the genders in Ireland, Lithuania, Latvia, Belgium, Czech Republic, Hungary, Portugal, and Greece: the prevalence in girls was higher by the IOTF criteria, but when applying the WHO limits, it was higher in boys. Generally, the presented obesity rates in Slovakia were approximately at the level of an average of the COSI members.

Table 1 Mean values and standard deviations for body height, weight, body mass index, waist, and hip circumferences and waist-to-height ratio in children (aged 7–7.99 years)

	Height cm	Weight kg	BMI kg/m^2	Waist cm	Hip cm	WHtR
Boys	128.2 ± 6.2	27.7 ± 6.6	16.8 ± 2.9	59.9 ± 8	68.6 ± 7.3	0.47 ± 0.05
Girls	127.5 ± 6.1	27 ± 6	16.5 ± 2.7	58.6 ± 7.2	68.3 ± 6.7	0.46 ± 0.05
p	0.001	0.002	0.02	0.001	NS	0.001

BMI body mass index, *WHtR* waist-to-height ratio, *NS* not significant

Prevalence of overweight/obesity according to the place of residence and time trends

For local comparison within the country, we consider the national standards to be more appropriate. The prevalence of overweight/obesity in rural and urban residents is shown in Fig. 3. The rate of overweight was not affected by the place of residence, but obesity slightly prevailed ($p = 0.04$) in rural or small urban areas (urban I < 50,000 inhabitants).

Time trends of overweight/obesity

While the prevalence of overweight has increased since 2001 by 3%, the prevalence of obesity has doubled (Fig 4). The rising trend in obesity is more abrupt compared with that of overweight. However, during the last 5 years, the prevalence of both seems to be stabilized or not changed/increased.

Prevalence of central/abdominal obesity assessed by WHtR

Central obesity (WHtR ≥ 0.5) was identified overall in 18.6% subjects without significant gender differences. (Table 4). Forty-nine percent overweight girls and 32% boys did not present central obesity, while 97% obese boys and 87% obese girls were also centrally obese. Moreover, central obesity was found even in normal weight children, and that was more frequent in girls (6.6 vs. 5.2%). Except for 3 boys (0.3%) in thin children, adequate fat distribution was displayed.

Discussion

In former Czechoslovakia, anthropometric surveys of secular trends were carried out regularly in each decade since 1951. This schedule remained continuously implemented even after splitting of Czechoslovakia into two independent states, Slovak Republic and the Czech Republic in 1993. Thus, Slovakia belongs to the few countries with very well-monitored children's growth characteristics, with available long-term data on anthropometric parameters (body height, weight, head, bust, and abdomen), up to the age of 18 years, on the developmental trends of children and youth, as well as of the national BMI standards.

Comparison of the median BMI values in our cohort with the data of COSI Round 2 [35] has shown that they are very similar to those from several other countries like Czech Republic, Hungary, Slovenia, Macedonia, Portugal, and Serbia [11]. Paradoxically, there is no similarity in overweight/obesity rates. This discrepancy might stem from substantial differences in body height. The mean height of the Slovak children, as well as of the children in Latvia, Lithuania, Greece, Slovenia, and Serbia, is about 4–5 cm higher than the values of the WHO 2007 standards [9]. On average, the Slovak children are even higher (by about 2 cm) compared with the Czechs—which is the population very similar genetically, and by the socio-economic and environmental conditions. This finding is rather surprising as in all of the former nationwide anthropometric surveys the differences were opposite [16].

Among the countries participating in COSI [35], the position of Slovak children is approximately in the middle of the ranks of obesity. Notable disagreements between obesity definitions according to the WHO and the IOTF related to gender differences in the prevalence of obesity, resulted in

Table 2 Mean values, standard deviations for *Z*-score, and the prevalence of subjects exceeding *Z*-score ≥ 1 or *Z*-score ≥ 2 for body height according to the World Health Organization (WHO, 2007) [9] and national Slovak references (NAS) [24] in children (aged 7–7.9 years)

	Boys			Girls		
	Z-score	Prevalence		*Z*-score	Prevalence	
Reference	Mean	*Z* ≥ 1 (%)	*Z* ≥ 2 (%)	Mean	*Z* ≥ 1 (%)	*Z* ≥ 2 (%)
WHO (2007)	0.71 ± 1.01	27.62	12.35	0.70 ± 1.10	27.23	11.49
NAS (2001)	0.18 ± 0.97	8.13	1.68	0.24 ± 0.97	8.84	2.11
WHO vs. NAS	0.001	0.001	0.001	0.001	0.001	0.001

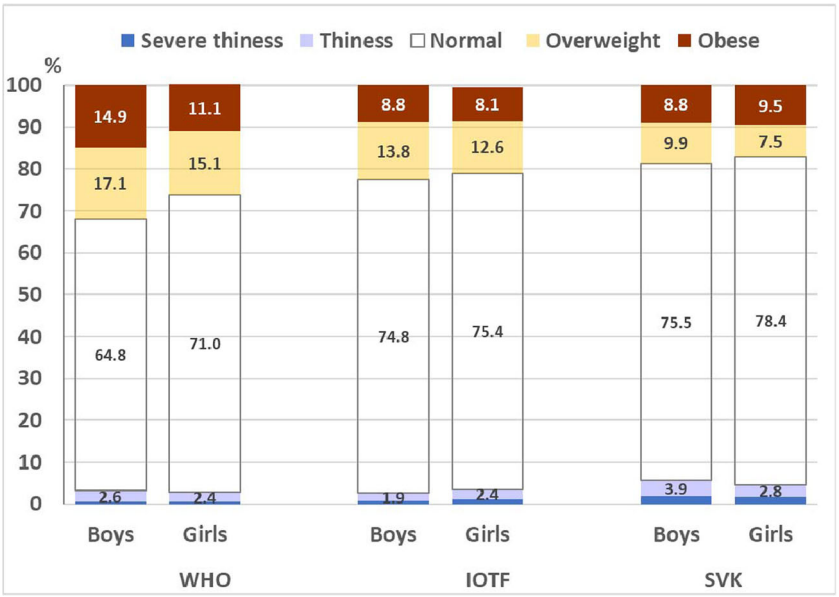

Fig. 1 Prevalence of children (aged 7–7.9 years) in BMI categories according to the WHO (2007) [9], the IOTF [8], and national Slovak references [24]

systematically, and sometimes strikingly higher prevalence in boys compared with girls according to the WHO. According to the IOTF, in most of the countries (9 of 15), higher prevalence was found in girls, but overall gender differences did not exceed 1.7%. According to the WHO 2007 standards [9], in European populations, the mean body height at the age of 7 years is by 0.5 to 1.3 cm higher in boys than in girls [6, 15, 16, 19, 25, 31, 35], so there is no reason to employ the lower BMI cutoffs for boys than for girls. Furthermore, in many children, their biological age does not correspond to their calendar age. The current generation is by about 5 cm taller and by 3.5 kg heavier than their peers 40 years ago. The median body height of the children in our sample corresponds to the 85th percentile of their peers or to the median of 8- to 9-year-old children in Slovakia in the year 1981. Similarly, it corresponds to the 75th percentile of WHO 2007 body height standards or median of 8 years old [9]. However, mean/median weight agreed with the 90th percentile in boys and the 85–90th percentile in girls in NAS 1981 and with the 85th percentile of the WHO 2007 data. Thus, the weight of average population increases nearly proportionally to body height.

Among many other European national BMI limits for obesity [6, 15, 19, 25, 31], the Slovak cutoffs [24] are the second lowest, so they are "strict" enough, and at the same time avoid misclassification of some healthy boys with accelerated growth and/or robust physical constitution and increased lean body mass as overweight (false positive). However, it is increasingly clear that BMI is rather a poor indicator of a percent of body fat [14, 22, 34]. BMI would be greater in those individuals who are advanced by development and are presumably taller and heavier (with more lean body mass) at the given age [12, 13, 29]. Studies applying the BMI to identify overweight/obesity in children based on the percentage of body fat showed high specificity (95–100%), but low sensitivity (36–66%) in this classification [17].

Different studies recommend waist [28] or WHtR [2, 5, 18] as a surrogate marker of abdominal obesity.

Table 3 Comparison of medians of body mass index and the cutoff values defining obesity in boys and girls in selected European countries. Nation-specific standards set the definition of obesity at the 97th percentile of body mass index

		Median BMI (kg/m^2)		Obesity BMI (kg/m^2)	
	Age (y.)	Boys	Girls	Boys	Girls
CZE 1999 [31]	7–7.99	15.6	15.5	19.5	19.6
POL	7	15.8	15.5	21.5	21
2007–2009 [15]	7.5	16	15.7	22.2	21.6
GER	7	15.8	15.7	20.8	20.6
2003–2006 [25]	7.5	16	15.9	21.6	21.2
AUT	7	16	15.8	22.0	21.4
2009–2011 [19]	7.5	16.2	16.1	22.9	22.1
ITA	7	16.4	16.6	22.7	22.9
1994–2000 [6]	7.5	16.6	16.8	23.2	23.2
SVK	7	15.5	15.3	20.7	20.3
2001 [24]	7.5	15.6	15.4	21.0	20.6
WHO	7	15.5	15.4	19.0	19.8
1977 [9]	*7.5*	*15.6*	*15.5*	*19.3*	*20.1*
IOTF	*7*	–	–	*20.63*	*20.51*
1963–1993 [8]	*7.5*	–	–	*21.09*	*21.01*

For each country, the period of the data collection is indicated

Abbreviations: *AUT* Austria, *CZE* Czech Republic, *GER* Germany, *ITA* Italy, *POL* Poland, *SVN* Slovenia, *SVK* Slovakia, *WHO* World Health Organization, *BMI* body mass index, *y.* years

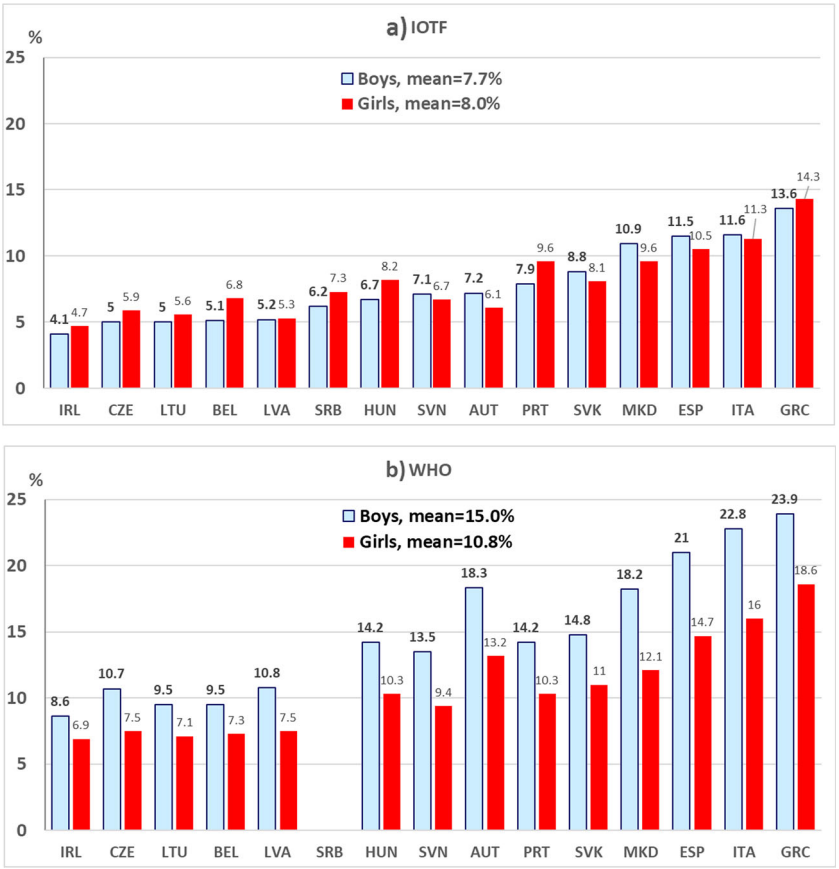

Fig. 2 Prevalence of obesity according to the IOTF (**a**) and to the WHO (**b**) standards. Figures represent respective population at the aged of 7 to 7.9 years examined in the frame of the COSI project round 2 (2009/2010), only Italian data refer to 8-year-old children [35]. Serbian data were collected later, in 2015 within the same project [11]. Austrian population relates to the age group of 6–9 years [19]. Countries are listed in order by their prevalence of obesity from the smallest to the highest according IOTF cutoffs. Abbreviations: AUT Austria, BEL Belgium (Flanders), CZE Czech Republic, GRC Greece, HUN Hungary, IRL Ireland, ITA Italy, LVA Latvia, LTU Lithuania, MKD Macedonia, PRT Portugal, SVN Slovenia, ESP Spain, SRB Serbia, SVK Slovakia

Unfavorable body fat distribution (prevailing at the upper part of the trunk) is associated with increased cardio-metabolic risk already at an early age [10]. There is a tendency to greater increase of the ratio of individuals with central obesity compared to the overall fatness, implying that the number of metabolic complications in children and adolescents may intensify in the future [30]. In our study, 5.9% of normal weight/BMI children presented increased waist, but as we did not investigate their other cardio-metabolic characteristics, it is not possible to assess whether they were actually at higher risk. On the other hand, a great proportion of overweight children did not present central obesity.

In Slovak children, the onset of "obesity epidemics" started approximately on the threshold of the new millennium with a delay of approximately 15–20 years compared with other industrial and economically developed

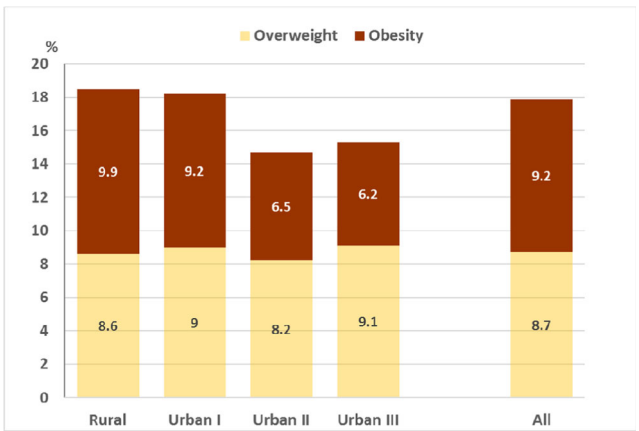

Fig. 3 Prevalence of overweight and obesity in 7- to 7.9-year-old children residing in rural or urban areas (urban I < 50,000 inhabitants; urban II 50,000–70,000 inhabitants; urban III > 70,000 inhabitants)

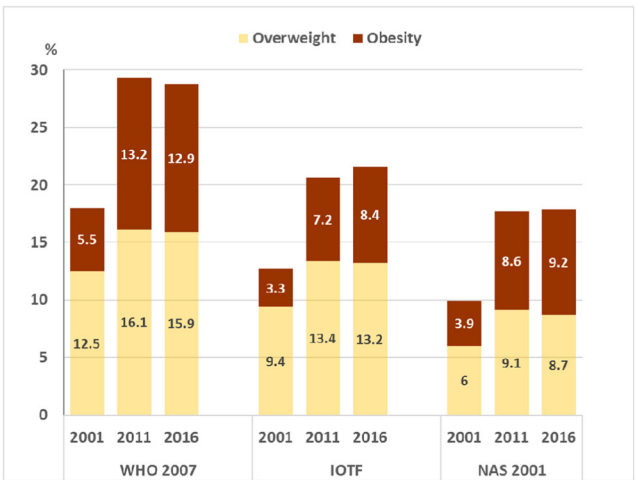

Fig. 4 Prevalence of overweight and obesity in Slovakia according to the WHO 2007 [9], IOTF [8], and national Slovak references (NAS) [24]

Table 4 Percentage rate of central obesity (waist-to-height ratio > 0.5) in different categories of body mass index in boys and girls

Normal		*p*	Overweight		*p*	Obese		*p*	All		*p*
Boys	Girls		Boys	Girls		Boys	Girls		Boys	Girls	
5.2	6.6	NS	68.3	51.4	0.001	94.8	87.2	0.001	19.5	17.7	NS

NS not significant

European countries. However, regardless the references applied, this initially only slightly rising obesity trend became more abrupt later, during the next decade (2001–2011). During the following 5 years, the overweight/obesity rates have not changed. Plateauing of the obesity was observed also in other European countries, already earlier—at the time when obesity has risen in Slovakia [3, 4, 20, 21, 23, 27, 33].

The general public, especially the younger people, in Slovakia are well informed and educated about many aspects of obesity, mainly the related health risks. There are several projects like "Action Plan of Prevention of Obesity," "Protection and Support of Children's Health," etc., aiming to educate the general public and from time to time also inventing campaigns accompanied by activities which support sports and healthy nourishment. Unfortunately, we were not able to obtain data on eating preferences, physical and sedentary activities, etc. for this study. However, the lifestyle factors of Slovaks are traditionally very well documented by internal surveys [32]. The most detailed analysis on the energy intake and essential nutrients within the nationwide project coordinated by PHA "Monitoring of Food and Nutrition Preferences" (2010) shows higher protein, fat, and salt intake than that recommended for this age, although the daily overall caloric intake was ad optimum. The energy balance was positive, because of the prevailing duration of sedentary over physical activities. The risk behavior has only minor effect on obesity in younger school age, as it is less frequent, but it may backfire later. In the second round of the COSI study, only four of the 13 health-risk behaviors were found to be positively associated with obesity, and three were even found to be negatively associated with obesity or overweight [35]. On the other hand, the combination of health-risk behaviors shows more consistent findings towards the prevalence of overweight/obesity. The relationship between childcare and childhood overweight/obesity is multi-faceted with many aspects linked to childhood adiposity [1]. Significant positive associations found between the physical activity-risk scores and obesity, as well as between the health-risk scores and obesity underline particularly the importance of promoting physical activity-related behaviors and discouraging sedentary lifestyle among school children.

Conclusions

The results of the representative study on the prevalence of overweight/obesity in 7-year-old children in Slovakia suggest that the trend in the growth of obesity in children at younger school-age culminated around 6 years ago and has not grown since then. Our findings point to differences of body constitution as well as the rate of growth and development between European countries. These factors should be taken into account if comparing BMI values and the prevalence of overweight or obesity among populations as well as by the assessment of appropriate weight at the individual level. Whereas the concomitant feature of obesity is almost always the increased waist to body height, the overweight category is more heterogeneous in this respect. In quite a large part (1/2 girls, 1/3 boys), it is not associated with central obesity. On the other hand, unfavorable body fat distribution was detected even in some normal weight children. Evaluation of the body constitution and structure, although indirectly measured, may contribute to the better estimation of health risk.

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Authors' contributions Ľubica Tichá - 40%, Valéria Regecová - 25%, Katarína Šebeková - 20%, Darina Sedláková - 5%, Jana Hamade -5%, Ľudmila Podracká - 5%

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Compliance with ethical standards

Conflict of interest Darina Sedláková is an employee of the World Health Organization, Jana Hamade is an employee of the Public Health Authorities, and participation of Ľubica Tichá at the fourth round COSI kick-off meetings was sponsored by WHO. The other authors declare that they have no conflict of interest. The funding organizations played no role in the analysis and interpretation of data, in writing of the manuscript, or in the decision to submit it for publication.

Informed consent Written informed consent was obtained from the parents/caregivers of all participating children.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and later amendments thereto or the comparable ethical standards.

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