SUGAR-SWEETENED BEVERAGES AND CHILDHOOD ABNORMAL ADIPOSITY IN THE CZECH REPUBLIC – NARRATIVE LITERATURE REVIEW

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SUMMARY

Objectives: In Czech children, the burden related to the high body-mass index is rising. In the last three decades, Western eating patterns have influenced Czech children's diet, including the high consumption of sugar-sweetened beverages. This narrative review aims to evaluate evidence of the trend of sugar-sweetened beverages consumption in Czech children and its impact on the prevalence of childhood abnormal adiposity.

Methods: A comprehensive literature review in MEDLINE (PubMed) and a hand search using references in identified articles were performed. The inclusion criteria were population-based studies of randomly selected samples of children from 0 to 18 years old, data involving the Czech population, published from 1990 to 2021. The results were organized into three sections – childhood abnormal adiposity, SSBs consumption, and the association between SSBs consumption and abnormal adiposity.

Results: The studies showed a significant increase in abnormal adiposity in both genders and all age categories. The highest prevalence of abnormal adiposity was observed in boys and younger children. On the contrary, sugar-sweetened beverages showed a significant decline in daily consumption among Czech children of both genders and all age categories. No results were found for consequences of abnormal adiposity concerning sugar-sweetened beverages consumption.

Conclusion: Findings from this review could serve public health experts to detect the areas of a gap in research and establish potential interventions in vulnerable groups. Observation of potential obesogenic contributors – including sugar-sweetened beverages – should be an integral part of effective action against the obesity pandemic.

Key words: sugar-sweetened beverages, soft drinks, abnormal adiposity, children

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INTRODUCTION

Most people live in countries where abnormal adiposity kills more people than the underweight (1). The epidemic related to abnormal adiposity is currently extended to childhood, affecting most high-income countries but also children in low- and middle-income countries (1, 2). The high prevalence of childhood abnormal adiposity predicts a generation growing up at a higher risk of noncommunicable diseases, including cardiovascular disease, type 2 diabetes, and some cancers (1, 3). In Czech children, the burden related to the high body mass index (BMI) is on the rise; from 1990 to 2019, the number of disability-adjusted life years (DALYs) related to high BMI increased by 45.65% in children under five years, by 39.69% in children between 5 to 14 years, and by 38.37% in adolescents aged 15 to 19 years (4).

The consumption of sugar-sweetened beverages (SSBs) continues to grow globally (5–9). In 2021, Czechia's per capita consumption of SSBs (defined as lemonades) was 87.7 litres (10). SSBs provide a higher intake of energy, calibrate people to a high level of sweetness that generalizes preferences in other sweet food (8), promote imprecise and incomplete compensation for energy in liquid form (7, 9) by decreasing satiety with calorie intake from liquids (8), and are positively related to higher BMI. In children, the consumption of SSBs is associated with energy-dense food, low nutrient quality, lower levels of physical activity, and high screen time, altogether leading to abnormal adiposity (1, 2).

In the last three decades, Western eating patterns have influenced Czech children's diet, including the high consumption of SSBs (11), which could contribute to the increasing burden of abnormal adiposity in Czech children. This narrative review aims to evaluate evidence of the trend of SSBs consumption in Czech children and its impact on the prevalence of childhood abnormal adiposity.

MATERIALS AND METHODS

A comprehensive literature review in MEDLINE (PubMed) was performed by one researcher (MK) in March–May 2021 using the following keywords: (soft* OR sweet* OR sugar*) AND (drink* OR beverage* OR juic* OR tea*) AND (child* OR adoles* OR pediatr* OR kid*) AND (obes* OR fat* OR corpulen*).

Additionally, a hand search using references in identified articles was performed. The inclusion criteria were population-based studies of randomly selected samples of children from 0 to 18 years old, data involving the Czech population, published from 1990 to 2021. The extra filter was the language of publication – Czech or English. The exclusion criteria were clinical trials, case report studies, reviews, and studies that included only adults (19 years and older). The results were organized into three sections – childhood abnormal adiposity, SSBs consumption, and the association between SSBs consumption and abnormal adiposity.

Table 1. *Prevalence of childhood abnormal adiposity in Czechia*

Author/year (study)	Goals and outcomes	Design/year of data collection	Method of measurements	Sample	Results/conclusion
Inchley (14) 2020 (HBSC study)	To provide information about the health, well-being, social environment, and health behaviour of 11-, 13- and 15-year-old boys and girls.	Cross-sectional study Setting: public schools 2017/2018	Self-report questionnaire	13,377 Czech children (11, 13, and 15 years)	About 15% of children belonged to the overweight category, 6% had obesity. Boys had a higher risk of overweight/obesity.
Kratěnová (16) 2017 (Children's Health 2016)	To describe the incidence of allergic diseases, obesity, risk factors for cardiovascular disease, and musculoskeletal disorders in children.	Cross-sectional study Setting: 46 paediatrics units of preventive medical check-up 2016	Medical examination using BMI percentile chart ratings for children.	5,132 children (5, 9, 13, 17 years)	The frequency of overweight and obesity were 7.5% and 10.3%, respectively. The percentage of overweight/obese increased the most from 5 to 9 years, followed by a steady decline in girls. In boys, the increase continued until the age of 13.
Hamřík (13) 2017 (HBSC study)	To analyse trends in the prevalence of overweight and obesity in adolescents by gender and age groups between 1998 and 2014.	Cross-sectional study Setting: public schools 1998, 2002, 2006, 2010, and 2014	Self-report questionnaire	19,103 children (11, 13, 15 years)	Prevalence of overweight and obesity increased among boys and 15-year-old girls. Between 2010 and 2014, stabilization in overweight rates was observed in all age and gender groups.
Sigmund (2) 2015 (HBSC study)	To determine the prevalence of overweight and obesity and evaluate the cut-off point for BMI references.	Cross-sectional study Setting: public schools, paediatrics units of preventive medical check-ups in 2008 1951, 1981, 1991, 2001, and 2008	Self-report questionnaire	16,701 children (7 years)	Between 1951 and 2001, the prevalence of overweight/obesity increased from 13% to 26.8% in boys, and from 10.9% to 22.9% in girls. In 2008, it was 23.5% in boys, and 19.5% in girls.
Humeníková (11) 2007	To determine dietary intakes in terms of energy, fat, fibre, and fruit and vegetable servings. To evaluate the amount and intensity of physical activity and to identify important predictors of BMI.	Cross-sectional, correlational study Setting: public elementary schools 2006	The height and weight of children were measured at each school by primary investigator or research assistant using the Czech reference cut-offs and the 2000 CDC reference cut-offs of BMI percentile charts.	97 children (11.0 ± 1.03 years) 92 parents	The prevalence of overweight/obesity was estimated between 11.3% (based on the Czech standards) to 14.4% (based on the 2000 CDC reference values). Boys had a higher risk of overweight/obesity.

BMI – body mass index; HBSC – Health Behaviour in School-aged Children Study

RESULTS

Studies Included

A total of 137 articles were retrieved from the database. After excluding studies not performed on the Czech population, nine were included: six reported the prevalence of childhood abnormal adiposity (Table 1), two reported the prevalence of SSB consumption, and one study reported both topics (Table 2). The articles included were based on five studies or databases: the Health Behaviour in School-aged Children study (HBSC) (2, 12–14), the national anthropological surveys, the Europe Childhood Obesity Surveillance Initiative (COSI) (15), surveys in public elementary schools (11), and during preventive medical check-ups in healthcare centres (16).

The HBSC study was a cross-sectional, nationally representative survey implemented in public schools, evaluating children aged 11, 13 and 15 years, from 1998 to 2018, with four years intervals. The HBSC study aimed to describe health behaviours, well-being and social determinants (17). Overweight and obesity were defined according to World Health Organization (WHO) values (overweight as 85–97%, obesity > 97% on age-differentiated BMI charts). Six articles included were based on this study (2, 12–14).

The "Children's Health 2016" study was a cross-sectional survey implemented in 2016 in 17 cities of Czechia, in collaboration with paediatricians, including children of 5, 9, 13, and 17 years, evaluated in healthcare centres. The study aimed to describe the presence of allergic diseases, obesity, risk factors for cardiovascular disease, and musculoskeletal disorders. The presence of overweight and obesity was assessed using Czech reference values (overweight 90th–97th percentile, obesity ≥ 97th percentile on BMI charts) (16).

In 2006, a cross-sectional study was implemented in public elementary schools in Pilsen and Prague including 97 children aged 11.0 ± 1.03 years. The study aimed to assess dietary intake, physical activity levels, and identify predictors of BMI. To determine the presence of overweight and obesity, the Czech reference values and the 2000 CDC (Center for Disease Control and Prevention in the USA) reference values (risk for overweight ≥ 85th to < 95th percentile, overweight ≥ 95th percentile on BMI-for-age charts) were used (11).

In 2011 was published an analysis using data from the national anthropological surveys conducted in public schools in 1951, 1981, 1991, and 2001, and from the Europe Childhood Obesity Surveillance Initiative obtained in preventive medical check-ups in 2008. The analysis aimed to evaluate the change in the prevalence of overweight and obesity in 7 years old children. Overweight and obesity were classified based on the Czech reference values, reference data of the International Obesity Task Force, and WHO criteria (15).

Concerning SSBs consumption, only data from the HBSC surveys were available. The HBSC reports from 1997/1998 (17) and 2017/2018 (14) were included. Additionally, one study complied data from 2002, 2006, 2010, and 2014 HBSC surveys (18).

Prevalence of Childhood Abnormal Adiposity in Czechia

From 1951 to 2001, data from the national anthropological surveys showed that the combined prevalence of overweight and obesity in 7-year-old children increased by 13.8% in boys (from 13.0% to 26.8%), and by 12% in girls (from 10.9% to 22.9%). From 2001 to 2008, results showed a decrease in the combined prevalence of overweight and obesity by 3.3% in boys (from 26.8% to 23.5%) and by 3.4% in girls (from 22.9% to 19.5%) (15).

From 2002 to 2010, in the HBCS surveys, the prevalence of overweight and obesity increased in both genders and all age groups. In boys, the highest increase was in the 13-year-old group, by 9.9% (from 17.0% to 26.9%), and the age group with

Table 2. *Prevalence of sugar-sweetened beverages consumption in Czechia*

Author/year (study)	Goals and outcomes	Design/year of data collection	Method of measurements	Sample	Results/conclusion
Inchley (14) 2020 (HBCS study)	To provide information about the health, well-being, social environment, and health behaviour of 11-, 13- and 15-year-old boys and girls.	Cross-sectional study Setting: public schools 2017/2018	Self-report questionnaire	13,377 Czech children (11, 13, and 15 years)	Boys drank SSBs more often. SSBs consumption increased with age.
Voráčová (18) 2015 (HBCS study)	To provide an insight into dietary changes among Czech children and adolescents aged 11–15 years concerning their age and gender between 2002 and 2014.	Cross-sectional study Setting: public schools 2002, 2006, 2010, and 2014	Self-report questionnaire	16,537 children (11, 13, 15 years)	Daily SSBs consumption was more prevalent in boys and older children.
Currie (17) 2000 (HBCS study)	To provide information about the health, well-being, social environment, and health behaviour of 11-, 13- and 15-year-old boys and girls.	Cross-sectional study Setting: public schools 1978/1998	Self-report questionnaire	3,703 children (11, 13, 15 years)	Boys drank SSBs more often. SSBs consumption increased with age.

HBSC – Health Behaviour in School-aged Children Study; SSBs – sugar-sweetened beverages

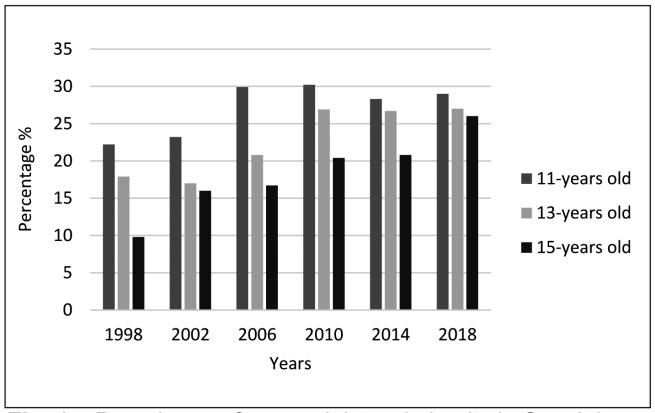

Fig. 1a. *Prevalence of overweight and obesity in Czech boys.*

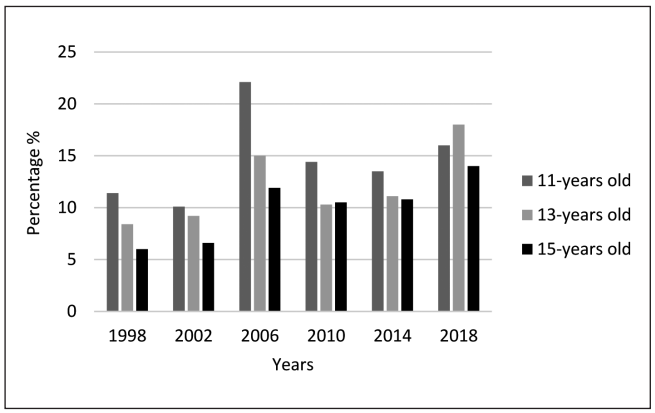

Fig. 1b. *Prevalence of overweight and obesity in Czech girls.*

the highest prevalence of overweight/obese was the 11-year-old group (from 23.2% to 30.2%). In girls, the highest increase was in the 11-year-old group, by 4.3% (from 10.1% to 14.4%). This age group had the highest prevalence of overweight/obese (Table 3, Fig. 1a, 1b) (13).

In parallel, a study conducted in 2006 in a public elementary school with 11.0 ± 1.03 years old children reported a prevalence of overweight/obesity between 11.9% to 16.7% for boys, and 10.9% to 12.7% for girls, using Czech and 2000 CDC reference values (11).

Between 2010 and 2014, a plateau in overweight and obesity prevalences was observed in the HBSC survey in all age and gender groups. A slight decrease was present in the category of 11-year-old boys – by 1.9% (from 30.2% to 28.3%). In other categories, the change was less than one percent (Table 3, Fig. 1a, 1b) (13).

Between 2014 and 2018, there was an increase in the prevalence of overweight and obesity in both genders and all age groups in the HBSC study, with the most significant increase in the 15-year-old group in boys with 5.2% (from 20.8% to 26%) and the 13-year-old group in girls with 6.9% (from 11.1% to 18%) (Table 3, Fig. 1a, 1b) (13, 14).

In the "Children's Health 2016" study, in boys, the highest prevalence of overweight/obesity was observed in older age categories – 25.1% for the 13-year-old group and 23.3% for the 17-year-old group. For girls was noted transition of high prevalence towards younger categories – 21.8% for 9-year-old group and 19.9% for 13-year-old group (16).

According to the last HBSC survey conducted in 2017/2018, about 15% of children presented as overweight and 6% as obese. In boys, the highest prevalences were in the youngest age groups, with a prevalence of 29% in the 11-year-old group. In girls, the highest prevalence was in the category of 13-year-old, with 18% (Table 3, Fig. 1a, 1b) (14).

Sugar-sweetened Beverages Consumption in Czechia

From 1998 to 2018, a significant reduction in daily SSBs consumption was observed among children of both genders and all age categories. In boys, SSBs consumption decreased by 34% (from 49.7% to 15.7%), and in girls, by 30% (from 40% to 12%) (17). Boys and older children reported more frequent daily intake (Table 4, Fig. 2a, 2b) (18).

Association between SSBs and Childhood Abnormal Adiposity in Czech Population

No studies were found to evaluate the association between abnormal adiposity and SSBs consumption in Czech children.

DISCUSSION

This review compiles the studies reporting the trend in the prevalence of childhood abnormal adiposity and SSBs consumption in Czechia. The data shows a significant increase in the prevalence of abnormal adiposity in both genders and all age categories of children. The HBSC study showed the transition

Table 3. *Prevalence of overweight/obesity in Czech children – HBSC data (12, 13)*

	1998 %	2002 %	2006 %	2010 %	2014 %	2018 %
Boys						
11 years old	22.2	23.2	29.9	30.2	28.3	29
13 years old	17.9	17.0	20.8	26.9	26.7	27
15 years old	9.8	16.0	16.7	20.4	20.8	26
Girls						
11 years old	11.4	10.1	22.1	14.4	13.5	16
13 years old	8.4	9.2	15.0	10.3	11.1	18
15 years old	6.0	6.6	11.9	10.5	10.8	14

Table 4. *Sugar-sweetened beverages consumption in Czech children*

	1998[a] %[c]	2002[b] %[c]	2006[b] %[c]	2010[b] %[c]	2014[b] %[c]	2018[a] %[c]
Boys	–	30.4	34.3	24.6	17.2	–
11 years old	48	27.9	35.0	18.7	15.3	13
13 years old	49	29.0	34.4	26.6	18.9	16
15 years old	52	34.2	33.8	28.5	17.3	18
Girls	–	26.1	27.1	19.9	14.2	–
11 years old	44	22.5	26.4	15.5	13.2	10
13 years old	46	29.1	31.1	23.2	15.3	13
15 years old	36	26.8	23.9	20.9	14.0	13

[a]Data from an international report (14)
[b]Data processed by Voráčová et al. (18)
[c]Percentage of children who performed SSBs consumption at least daily.

in childhood abnormal adiposity to the younger age categories (2, 12, 13, 19). Boys had a higher prevalence of overweight and obesity (2, 11–14, 16) and consumed SSBs more often than girls (14, 17, 18).

Abnormal adiposity in children is mainly driven by unhealthy behaviours, including excessive screen time, low physical activity, and unhealthy eating patterns characterized by high consumption of ultra-processed food products, including SSBs (20). These behaviours affect children heterogeneously and influence the physical and non-physical environment, affecting more dramatically those with lower parental education levels, parental abnormal adiposity, children without siblings, and those with non-traditional family structures (20–22). A positive association also exists with parents' tobacco consumption, decreasing residence community size (under 10,000 population) and older maternal age (22–25). Socioeconomic status is linked with eating habits, physical activity, sedentary behaviour, screen time, and other health-related behaviours (26, 27). The HBSC surveys showed that from 2002 to 2014, socioeconomic status, reported as family affluence, a measure of material family property developed as an indicator of the absolute level of socioeconomic status (28), was a strong determinant of related changes in children's weight (12). At the turn of 2013/2014, the most overweight/obese individuals were observed in the category of low-family affluence. On the contrary, the lowest prevalence was found in the high-family affluence category. In the low-family affluence category, increased excessive daily screen time was accompanied by decreased physical activity (12). An additional potential explanation for the transition in the prevalences observed in Czech children is that between 2002 to 2014, Czechia had an economic transformation characterized by foreign direct investment focusing on highly processed food which contributed to adopting Western unhealthy behaviours (2).

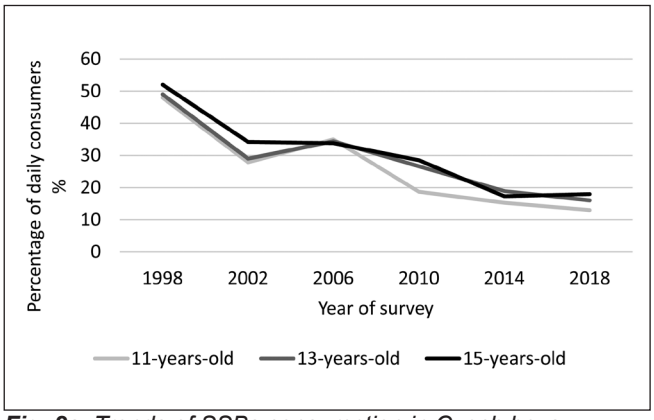

Fig. 2a. *Trends of SSBs consumption in Czech boys.*

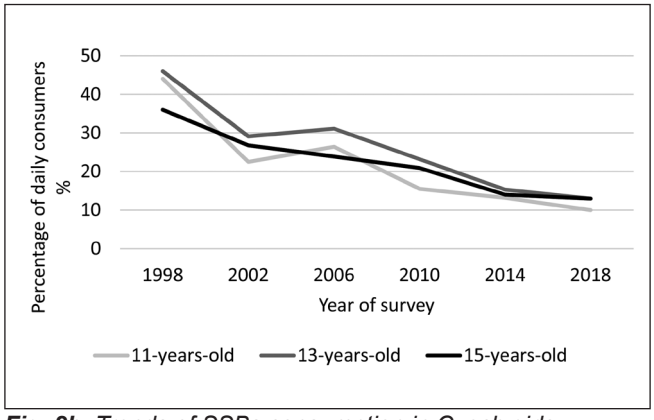

Fig. 2b. *Trends of SSBs consumption in Czech girls.*

In Europe, most adolescents consume products with high amounts of sugars (94%), defined as products with a percentage of energy from free sugars above 10% (29). SSBs are the main contributor to free sugars (26%) (30). In the studies included, boys and older children reported a more frequent daily intake of SSBs (14, 17, 18). This behaviour could be explained by higher autonomy for older children, free choice when choosing beverages, and more frequent opportunities to eat/drink outside the home (18). However, between 1998 to 2018, data from HBSC surveys showed a reduction in the trend of SSBs consumption in Czech children, by 34.% for boys and 30% for girls (14, 17, 18). The explanation could be a policy on unhealthy foods that sets out the requirements for food, including beverages, that can be offered for sale and sold in schools and educational establishments that started in 2016 (31).

There is strong evidence reporting the association between SSBs consumption and abnormal adiposity. An excessive intake of free sugars, especially from SSBs, adversely affects dental impairment (6), bone mineral density (32), visceral fat accumulation, and due to abnormal adiposity, increased risk of type 2 diabetes and cardiovascular disease (33, 34). Subjects with abnormal

adiposity have lower levels of high-density lipoprotein (HDL) cholesterol and higher levels of triglycerides, fasting insulin (35, 36), high serum uric acid levels, systolic blood pressure (16, 37), and Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) (35, 38, 39). The high consumption of SSBs also affects taste preferences in other food rich in sweetness. It is also associated with an inadequate intake of essential nutrients, such as iron, magnesium, vitamin A, vitamin C, and folic acid. Low intake of proteins and calcium may be affected by reduced consumption of milk and dairy products (3, 33, 40). Despite this knowledge, there is no epidemiological information evaluating the impact of SSBs on the prevalence of abnormal adiposity in Czech children.

In most children with abnormal adiposity overweight/obesity persist even in adulthood (1, 3, 5, 11). SSBs consumption in adolescence and changes in SSBs consumption from childhood to adolescence are predictors of the incidence of abnormal adiposity in early adulthood. Participants of the European Youth Heart Study who consumed more than one portion of SSBs daily at 15 years had more significant BMI and waist circumference increases in early adulthood compared to non-consumers. Participants who increased their SSBs consumption between 9–15 years of age also had more significant BMI and waist circumference increases in adulthood (9). A similar trend was described in the infancy period (5).

Several optional tools can be used as effective public health interventions to decrease the consumption of SSBs. These tools include labelling products with a traffic-light system or colour-coded scale, promoting healthier beverages in supermarkets, implementing government food benefit programmes that prohibit the purchase of SSBs, launching multicomponent community campaigns that target SSBs, and making low-calorie drinks more readily available in the home environment (41). Implementing efficient taxation on sugar-sweetened beverages, as recommended by the World Health Organization's Best Buys report (42), has been shown to effectively decrease sugar consumption, with the implementation of the soft drink industry levy resulting in a 50% reduction in the sales of taxable SSBs in the United Kingdom (43). Model-based analysis conducted in Germany, which involved implementing a 20% tax on SSBs, suggested that this approach could significantly reduce rates of overweight and obesity (44). Highlighting the health risks associated with SSBs can be a powerful motivator for parents to reduce their family's consumption, as children's nutrition is a top priority for parents; therefore, placing warning signs on food packaging that target lesser-known health threats (infertility, gout, arthritis) may be effective, but frequent updates may be necessary as the impact of warnings can diminish over time (45). These strategies could be vital to a comprehensive approach to addressing the obesity epidemic.

The main limitation of a narrative literature review could be an inadequate systematic selection of included studies leading to a biased interpretation of results. However, an extensive search was conducted that assessed the current state of research on this topic and identified key components necessary for further investigation. Most of the results were from the HBSC studies. Despite the cross-national design and representative sample, the HBSC methodology has some limitations that need to be mentioned – the self-reported questionnaire and collected data did not provide information about portion size or amounts of consumed food. Due to limited space in the questionnaire, some food items, including SSBs, were not precisely specified and could be misunderstood (46). Furthermore, the WHO defines SSBs as all beverages containing free sugars, i.e., carbonated or non-carbonated soft drinks, 100% fruit/vegetable juices and drinks, liquid and powder concentrates, flavoured water, energy and sports drinks, ready-to-drink tea, ready-to-drink coffee, and flavoured milk drinks (47). Comparing studies due to the different definitions of SSBs could be difficult. Most studies define SSBs as beverages with sugars added during processing, such as carbonated and non-carbonated lemonades; some studies do not even have an exact definition. Most studies excluded beverages with naturally occurring sugars, such as 100% fruit juices. Although WHO guidelines specify that 100% fruit juices provide free sugars, children's parents could perceive these drinks as healthier choices. However, contain as much sugar (naturally present) and energy as carbonated beverages (48). Another limitation is the non-inclusion of energy drinks in the analysis, as most studies need to indicate whether they were also included in the definition of sweetened beverages. Consumption of energy drinks has become widespread and frequent among adolescents across Europe (49). Due to the comparable amount of sugar and the addition of stimulant ingredients, there are concerns that these drinks may harm children and adolescents. According to the analysis of HBSC data from 2014 in Slovakia (results for Czechia not found), the prevalence of regular energy drink consumption in adolescents aged 11–15 years was 20.6%, with a higher prevalence among boys and older adolescents (49).

CONCLUSION

Czechia is facing an increase in the burden related to childhood abnormal adiposity. Although there has been a plateau in the prevalence of overweight and obesity over the past decade, data from recent studies showed an increase again in both genders and all age categories. Contrarily, the HBSC surveys reported a decreasing trend in the consumption of SSBs, suggesting a potentially small role of SSBs in the current trend of abnormal adiposity. Boys were more prone to both – a higher prevalence of overweight and obesity and more frequent consumption of SSBs. However, there is still a lack of research addressing this topic in Czechia. Despite the strong cover of health care structure and public health policy, there is a window for improvement to reinforce an organized effort to health promotion.

Findings from this review could serve public health experts to detect the areas of a gap in research and establish potential interventions in vulnerable groups. Observation of potential obesogenic contributors – including SSBs – should be an integral part of effective action against the obesity pandemic. The education and attitude of parents on the eating habits and health behaviour of their offspring have a significant influence. In addition to interventions targeting specific child populations, awareness-raising events should be organized to educate their parents. From the public health perspective, the effort of an effective strategy should be accompanied and supported by key stakeholders in this area – government, healthcare professionals, schools, and insurance companies.

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Conflict of Interests

None declared

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Authors' Contributions

MK, JPG-R – conceptualization, methodology; MK, JPG-R and GAMN – methodology, writing, original draft preparation; MK – writing, original draft preparation; MK, JPG-R, and GAMN – writing, review and editing. All authors have read and agreed to the published version of the manuscript.

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