Article

Trends and correlates of excessive body weight in Czech adolescents in relation to family socioeconomic status over a 16-year study period (2002-2018)

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Abstract: The main objective of the study is to analyse time trends in excessive body weight (obesity, overweight) of Czech adolescents between 2002 and 2018 with regard to the socioeconomic status (SES) of adolescents' families and to find SES-mediated correlates of adolescents' obesity. A nationally representative sample of 29,879 adolescents (49.6% of them boys) aged 10.5-16.5 years was drawn from the Health Behaviour in School-aged Children cross-sectional, self-reported questionnaire surveys conducted in 2002, 2006, 2010, 2014, and 2018 in the Czech Republic. Across the quadrennial surveys from 2002 to 2018, we observed a clear increase in the prevalence of excessive body weight (overweight/obesity) in all SES categories of adolescents, which was most striking ($p<0.05$) in adolescents with low SES (boys: +5.2/+7.5 percent points (p.p.); girls +6.3/+2.4 p.p.). When all the survey cycles were compared, the highest prevalence of overweight/obesity was evident in the low-SES adolescents in 2018, both in girls (14.9%/5.1%) and boys (20.4%/12.0%). The lower odds of obesity were significantly ($p<0.05$) associated with regular vigorous physical activity, participation in organized sport. An unreasonable increase in the prevalence of obesity in adolescents with low SES suggests that national health-related and sports programmes have the least impact on children from low-SES families.

Keywords: obesity; overweight; socioeconomic status; Health Behaviour of School-aged Children (HBSC) Study; trends

1. Introduction

The epidemic of obesity in every segment of the population is a serious public health problem in the high-income as well as low- and middle-income countries of the world [1–3]. The prevalence of obesity is generally lower but is increasing faster in low- and middle-income countries than in high-income countries [4,5], but the evidence from, for example, the former Communist Bloc countries in Europe is still limited [6]. On the evidence of the existing prevalence and trend data [1,7–

9] and the epidemiological evidence linking obesity with long-term cardiovascular, metabolic, and other health consequences [10], it is necessary to describe obesity as a public health crisis with serious negative impacts on the quality of life of people and imposing a considerable burden on national health-care budgets [11,12].

To simplify, obesity is the result of a long-term positive energy balance between food intake and expenditure, with its rate being mediated by the complex interaction of multiple behavioural, biological, and environmental factors [13–16]. Lifestyle behaviour is strongly associated with obesity in school-aged children, regardless of country or continent [13,15,16]. Everyday physical activity of moderate-to-vigorous intensity (MVPA) and longer sleep duration have been associated with lower odds of overweight or obesity in school-aged children [16], while shorter sleep duration and longer outside-of-school screen time (ST – watching television and playing video/computer games) have been associated with higher odds of obesity [15,16]. The consumption of sugar-sweetened beverages as an example of unhealthy food intake has been shown to be one of the key contributors to the risk of child overweight/obesity [17]. Although the consumption of sugar-sweetened beverages has declined over the last 15 years, it is still high among children and adolescents, with a negative impact on health – a higher incidence of obesity, insulin resistance, and dental caries [17]. Many of the energy balance-related behaviours in children and young people vary considerably with regard to the socio-economic status (SES) of their families [6,16,18,19].

One of the major social determinants of child and adolescent obesity is the SES of their families [7,9,20]. Only a few of the trend-related publications that exist reveal a growing socioeconomic gradient in high-income countries – a stabilized or slight decreasing trend in the prevalence of obesity in children and adolescents from high-SES families, as opposed to a steady increase in the prevalence of obesity among their peers from low-SES families [7,9,20]. Between 2003 and 2014, active participation in the Special Supplemental Nutrition Program for Women, Infants, and Children in Los Angeles [20] was first accompanied by an increase in childhood obesity (2003-2005), followed by a stagnation of obesity (2005-2010), and then a final decline in childhood obesity (2010-2014), with significant differences between children from different SES backgrounds. In most years, the incidence of childhood obesity was highest in the families with the lowest SES [20]. Bann et al. [21] point to a diametric change in the relationship between SES and body weight in a longitudinal survey. In the cohorts before 2001, lower SES was associated with lower weight and inequalities did not differ systematically with age until the 2001 cohort, in which weight and BMI inequalities widened at older ages. Nevertheless, critical information gaps persist in relation to the impact of childhood and life course SES on obesity in low- and middle-income countries [22], as well as an analysis of the impact of health-related programmes on the prevalence of obesity regarding SES [5].

Low- and middle-income European countries (including the countries of Central and Southern Europe from the former Communist bloc) appear to tend to replicate the 'negative' health-related behaviour patterns – a decrease in MVPA, an increase in ST [6,23,24] – which had previously been witnessed in high-income countries [25]. The rapid increase in childhood and adolescent obesity in low- and middle-income countries underlines the fact that these countries have failed to learn from the development of obesity in high-income countries. The Czech Republic is one of the most economically developed European countries in the former Communist bloc [26]. Since 2006, it has been implementing a number of national health-related and sports programmes (such as "The Olympic Flag of Versatility", "School Fruit and Vegetable Scheme ", and "School Milk Scheme") for children and adolescents, supported by the Ministry of Education, Youth, and Sports [27]. However, the effect of these programmes on the health and health-related behaviour of children and adolescents is not monitored and evaluated to an adequate extent.

The present study attempts to bridge the gap between the national health-related and sports programmes that have been implemented and the lack of evidence of their effectiveness in terms of their impact on the prevalence of excessive body weight. Therefore, the main objective of the study is to analyse time trends in excessive body weight (obesity, overweight) among Czech adolescents between 2002 and 2018 with regard to the SES of adolescents' families and to find SES-mediated correlates of adolescents' obesity.

2. Materials and Methods

2.1. Study design

This study is based on five cycles of the Czech "Health Behaviour in School-aged Children" (HBSC) cross-sectional study. The HBSC study is a World Health Organization (WHO) collaborative cross-national study conducted in 48 countries across Europe, North America, and Asia. The HBSC study focuses on the description of adolescents' health and health-related behaviours to inform policy makers, professionals, and practitioners to improve adolescents' lifestyle [28]. An international standardized questionnaire and research protocol were used across all the participating countries to ensure the consistency of survey instruments, data collection, and processing procedures [28,29]. As HBSC is a school-based survey, data is collected through self-completion questionnaires administered in the classroom.

2.2. Sample and data collection

Nationally representative samples of Czech adolescents in the age range 10.5-16.49 years were recruited during the 2002 (n=4912; 47.7% boys), 2006 (n=4629; 50.4% boys), 2010 (n=4121; 48.7% boys), 2014 (n=4588; 47.6% boys), and 2018 (n=11,629; 50.4% boys) school years by using multistage stratified designs, with census regions, ratio of primary vs. multi-year grammar schools, and grades as strata, with schools acting as the primary sampling units (Table 1). The school response rate among the survey cycles varied from 75% to 99% and the adolescent participants' response rate exceeded 80%. The participating teenagers were predominantly white Caucasian (>96.5%), which corresponds to the very homogeneous ethnic demography of the Czech Republic [30].

Table 1. Descriptive characteristics of the samples, HBSC study, Czech Republic 2002-2018.

	2002		2006		2010		2014		2018†	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
n=	(2345)	(2567)	(2332)	(2297)	(2008)	(2113)	(2183)	(2405)	(5856)	(5773)
	%	%	%	%	%	%	%	%	%	%
Age category§										
11 years	34.1	33.1	31.4	31.2	32.6	30.6	29.9	30.3	32.7	32.8
13 years	32.5	33.8	33.5	33.9	31.4	35.2	33.9	34.4	34.5	34.4
15 years	33.4	33.1	35.0	34.9	36.0	34.2	36.2	35.3	32.8	32.8
Family affluence										
Low	34.2	40.5	25.7	30.3	13.1	17.0	32.4	34.4	23.7	27.2
Medium	56.5	53.0	54.9	55.9	54.2	53.3	44.3	45.4	45.3	44.6
High	9.3	6.5	19.4	13.8	32.7	29.7	23.3	20.2	31.0	28.2
Weight status*										
Non-overweight	81.6	91.7	77.9	83.8	73.7	88.1	74.8	87.9	73.2	84.7
95% CI	80.0-83.2	90.6-92.7	76.2-79.6	82.3-85.3	71.8-75.7	86.7-89.5	73.0-76.6	86.6-89.2	72.1-74.4	83.8-85.7
Overweight	14.5	6.5	14.2	11.8	18.7	9.5	18.1	9.3	17.9	11.9
95% CI	13.1-16.0	5.6-7.4	12.8-15.6	10.5-13.1	17.0-20.4	8.3-10.7	16.5-19.7	8.2-10.5	16.9-19.0	11.0-12.7
Obesity	3.9	1.8	7.9	4.4	7.6	2.4	7.1	2.8	8.8	3.4
95% CI	3.1-4.7	1.3-2.3	6.8-9.0	3.6-5.3	6.4-8.8	1.7-3.1	6.0-8.2	2.1-3.5	8.1-9.6	2.9-3.9

§11 years (13 years and 15 years) includes adolescents in the age range 10.5-12.49 years (12.50-14.49 years and 14.50-16.49 years); † in the 2018 data analyses, the weights for strata (administrative regions) were applied; *obesity and overweight were represented by the >97th percentile and 85th-97th percentile, respectively, on gender-specific Body Mass Index-for-age growth charts [31,32]; CI – 95% confidence interval.

Trained researchers collected the data during a single morning lesson in the classroom using pen-and-paper questionnaires between 2002 and 2014 and in the IT classroom using online questionnaires in 2018. The participation of the adolescents in the quadrennial surveys was voluntary, and the respondents were assured of anonymity and the confidentiality of their responses. To ensure anonymity, the participants were instructed to put the questionnaire in an envelope, which they sealed and handed over to the researchers (2002-2014) after the survey was completed. In 2018, during the online data collection, each participant received a unique application code to access a questionnaire from the researcher. All the survey procedures for each data collection cycle were stored and can be downloaded from [33]. This trend-related study was approved by the Institutional Research Ethics Committee of the Faculty of Physical Culture, Palacký University Olomouc, with the reference No. 9/2016.

2.3. Survey items

2.3.1. Excessive body weight

The adolescents' self-reported actual body weight (kg), body height (cm), and chronological age were used to calculate the weight status of the participants. The Body Mass Index (BMI) was calculated as body weight (kg) divided by body height (m) squared. Body weight status (non-overweight, overweight, obesity) was determined in accordance with the WHO's gender-specific BMI-for-age growth charts [32]. Obesity and overweight were represented by the >97th percentile and 85th-97th percentile, respectively, on the gender-specific BMI-for-age growth charts [31,32] (Table 1). The BMI calculated from the self-reported body height and weight demonstrated good diagnostic ability to identify excessive body weight in children and adolescents (sensitivity, specificity, and positive and negative predictive values ranged from 0.83 to 0.98) [34]. Self-reported body height and weight show high agreement with the values measured in the laboratory, thus making it possible to identify excessive body weight in children and adolescents in epidemiological studies substantially [34–36].

2.3.2. Socio-demographic variables

Because of repeatedly detected gender and socio-economically related differences in the prevalence of excessive body weight [18,37] of adolescents, all the analyses were stratified according to the gender of the participants and family SES. An estimate of family SES was provided by the Family Affluence (FA) Scale. The FA scale comprised several simple-to-answer age-appropriate questions created to quantify material assets in the family [38,39]. Between 2002 and 2010, four questions were included to determine FA: *having one's own bedroom* (No=0; Yes=1), *number of computers* (None=0; One=1; Two=2; Three or more=3), *car ownership* (No=0; One=1; Two or more=2), and *family holidays in the past year* (Never=0; Once=1; Twice=2; Three or more times=3) [38]. In 2014, an updated version of the FA scale was used to compensate for the changing social environment [23,28]. Two new FA-related items – *dishwasher ownership* (No=0; Yes=1) and *number of bathrooms* (None=0; One=1; Two=2; Three or more=3) were added to the existing FA scale. The response codes to these items were summed and treated as a composite sum score. For the analyses, three categories of FA ("low", "medium", and "high") were created from the composite sum score. Between 2002 and 2010 the FA categories correspond to tertiles of the sum score ("low"=0-3; "medium"=4-6, "high"=7-9) and in 2014 and 2018 as follows: "low"=0-6, "medium"=7-9, and "high"=10-13 [18]. High validity (kappa coefficient 0.41-0.74; 76.2-88.1 agreement) and moderate reliability (Cronbach's α=0.58) between children's and parents' responses on the FA scale-related items have been documented repeatedly [40–44].

2.3.3. Energy balance-related behaviours

The energy balance-related behaviours covered physical activity patterns (daily MVPA, weekly vigorous physical activity (VPA), and participation in organized sport), sedentary behaviour (daily entertainment screen time), dietary patterns (daily consumption of fruits, vegetables, sweets, and

sweetened soft drinks; daily breakfast on school and weekend days, and frequency of fast food meals).

Among all the survey cycles MVPA was examined by a single question, '*Over the past seven days, on how many days were you physically active for a total of at least 60 minutes per day?*' A definition of MVPA was provided as any activity that usually increases your heart rate and makes you get out of breath some of the time, with examples of activities that produce such an effect. The response categories were consistent among all the survey cycles and ranged from '*0 days*' to '*7 days*'. For the analyses of current MVPA recommendations (≥60 min per day [45]) a dichotomous outcome variable was created. The weekly participation in VPA was determined by the question '*How often do you usually exercise in your free time so much that you get out of breath or sweat?*' with seven response categories: '*Every day*', '*4 to 6 times a week*', '*2 to 3 times a week*', '*Once a week*', '*Once a month*', '*Less than once a month*', and '*Never*'. In line with existing precedents [46], the outcome variable for VPA was dichotomized as follows: ≥4 days of the week vs. less frequent VPA. The assessment of self-reported MVPA and VPA during the past seven days in adolescents was originally developed and validated against seven-day continuous measurement with an accelerometer (r_{MVPA}=0.40 p<0.01; r_{VPA}=0.36 p<0.01) [47]. A recent study supports the validity of self-reported past-seven-days MVPA (r=0.49 p<0.01 correlation with seven-day continuous monitoring with an Actigraph accelerometer) [48], with almost perfect test-retest stability of the MVPA item in Polish (ICC=0.98) and Chinese (ICC=0.82) 11-15-year-old adolescents [49,50]. The VPA-related question in the HBSC questionnaire demonstrated moderate stability (ICC=0.68) [50].

Participation in organized sport was investigated using the question on involvement in organized activities (six activities including team sports, individual sports): '*In your free time, do you do any of these organized activities? We mean activities you do in a sports or other club or organization*' with the dichotomous response 'yes'/'no' [51,52]. The participating adolescents were categorized as *'active'* (involved in organized team and/or individual sport) or *'inactive'* (not involved in any organized sport). The scale of participation in organized sport has an acceptable level of agreement (ICC=0.64), indicating good reliability [52].

In 2002, two items related to ST in free time were assessed. The adolescents were asked the following questions: '*About how many hours a day, in your free time, do you usually spend watching television (including DVDs and videos) in your free time?*' and '*About how many hours a day, in your free time, do you usually spend using a computer (for playing games, emailing, chatting, or surfing on the internet)?*' In all the other data collection cycles, the question related to computer use was subdivided into two questions to better reflect the changes in screen-based activities. The first sub-question, '*About how many hours a day, in your free time, do you usually spend using electronic devices such as computers, tablets (such as an iPad) or smartphones for other purposes, for example, homework, emailing, tweeting, Facebook, chatting, or surfing the internet?*', represents the non-gaming part of computer use. The second sub-question, '*About how many hours a day, in your free time, do you usually spend playing games on a computer, games console, tablet (such as an iPad), smartphone, or other electronic device (not including moving or fitness games)?*', represents the gaming part of computer use [53]. Each ST-related question was asked for weekdays and weekend days separately. For each ST-related question, the same response options were provided '*None at all*', '*About half an hour a day*', '*About 1 hour a day*', '*About 2 hours a day*', '*About 3 hours a day*', '*About 4 hours a day*', '*About 5 hours a day*', '*About 6 hours a day*', and '*About 7 or more hours a day*'. The validity of self-reported ST-related questions for the past seven days has been proved in comparison with 7-day 24-hour diaries both on weekdays (r=0.39-0.46, p<0.001) and at weekends (r=0.37-0.47, p<0.001) [54,55]. At least 7-day test-retest stability of the ST-related questions (computer use (PC) and television viewing (TV)) have been repeatedly verified among adolescents aged 11-15 for weekdays (ICC_{PC}=0.33–0.82, ICC_{TV}=0.54–0.72) and weekends (ICC_{PC}=0.33–0.66, ICC_{TV}=0.58–0.68) [49,50,54,56]. The daily ST outcome variable comprised the sum of three (two in 2002) ST-related questions. In accordance with previous ST-related studies [57,58], the cutoff point for the dichotomization of daily ST was set at *'2 or more hours daily'* vs. *'less than 2 hours daily'*.

As part of the validated brief food frequency questionnaire, adolescents were asked: '*How many times a week do you consume fruit/vegetables/sweetened soft drinks/sweets?*', with seven response categories: '*Never*', '*Less than once a week*', '*Once a week*', '*Two to four times a week*', '*Five to six times a week*', '*Once a day*', and '*More than once a day*' and '*How often do you usually have breakfast (more than a glass of milk or fruit juice)?*' with six response categories for weekdays ('*Never*', '*One day*', '*Two days*', '*Three days*', '*Four days*' and '*Five days*'), and three for weekends ('*Never*', '*Only on one day*', and '*On both days*') [19]. In line with previous trend-related studies [19,59] the response options were recorded into dichotomous outcome variables, *'daily'* vs. *'less than daily'*. The last question investigated the frequency of eating in fast food restaurants: '*How many times a month do you eat in fast food restaurants?*', with seven response categories: '*Never*', '*Rarely*', '*Once a month*', '*Two to three times a month*', '*Once a week*', '*Two to four days a week*', and '*Five days a week or more*'. The outcome variable for eating in fast food restaurants was dichotomized as follows: *'at least twice a month'* vs. *'less often'*.

2.3.4. Sleep time

Sleep time was calculated from the participants' reports of bedtimes and wake-up times separately for school days and weekends. Bedtimes were asked about by a single question, '*When do you usually go to bed if the next morning is a school day (weekend day)?*' Self-reported alternatives for bedtimes ranged at half-hour intervals from '*at least 9 pm*' to '*2 am or later*' for school days and '*at least 9 pm*' to '*4 am or later*' for weekend days. Wake-up times were asked about as follows: '*When do you usually wake up on school (weekend) mornings?*' The response categories ranged at half-hour intervals from '*5 am at the latest*' to '*8 am or later*' for school days and '*7 am at the latest*' to '*2 pm or later*' for weekends [60]. Finally, sleep time was calculated as the difference between bedtime and wake-up time, separately for weekdays and weekend days. The outcome variable for sleep time was categorized in relation to the age-related recommendation for hours of sleep [61] as follows: *'enough sleep'* vs. *'not enough sleep'* for school days and *'enough sleep'*, *'not enough sleep'*, and *'excessive sleep'* for weekends. The sleep-related items demonstrated at least substantial reliability, especially for the item on when the participants wake up at weekends, for which the reliability is almost perfect (ICC=0.83) [50].

2.4. Data analysis

All data processing and statistical analyses were performed in the Statistical Package for the Social Sciences (SPSS) for Windows v.22 software (IBM Corp. Released 2013. Armonk, NY, USA). Descriptive data are presented as percentages, including 95% confidence intervals (CI) in the case of weight status, for each survey cycle and gender separately. Chi-square (χ^2) tests were performed to assess trend-related differences in the prevalence of overweight/obesity in each gender and SES categories of adolescents between 2002 and 2018, and SES category-related differences in the prevalence of overweight/obesity in 2018 separately for boys and girls. The chi-square (χ^2) tests were also used to analyse the differences in the proportion of participants involved in organized sports and engaging in VPA in relation to SES categories of adolescents and to test the statistical significance of differences in the prevalence of obesity by adolescents' VPA level, participation in organized sport, and frequency of consumption of sweets. Multiple logistic regression analysis was used for examining the correlates of adolescents' obesity in the 2018 data collection. Given the larger sample, which was supposed to be representative of the whole country and individual administrative regions, strata-specific weights were used for the 2018 data. The regression parameters were based on the odds ratio (OR) with a 95% CI. A minimum alpha level of 5% was set for all the statistical procedures.

3. Results

3.1. Trends of excessive body weight

There is an evident increasing trend in the prevalence of excessive body weight (overweight – Figure 1 and obesity – Figure 2) in adolescents of both genders from low-SES backgrounds between 2002 and 2018.

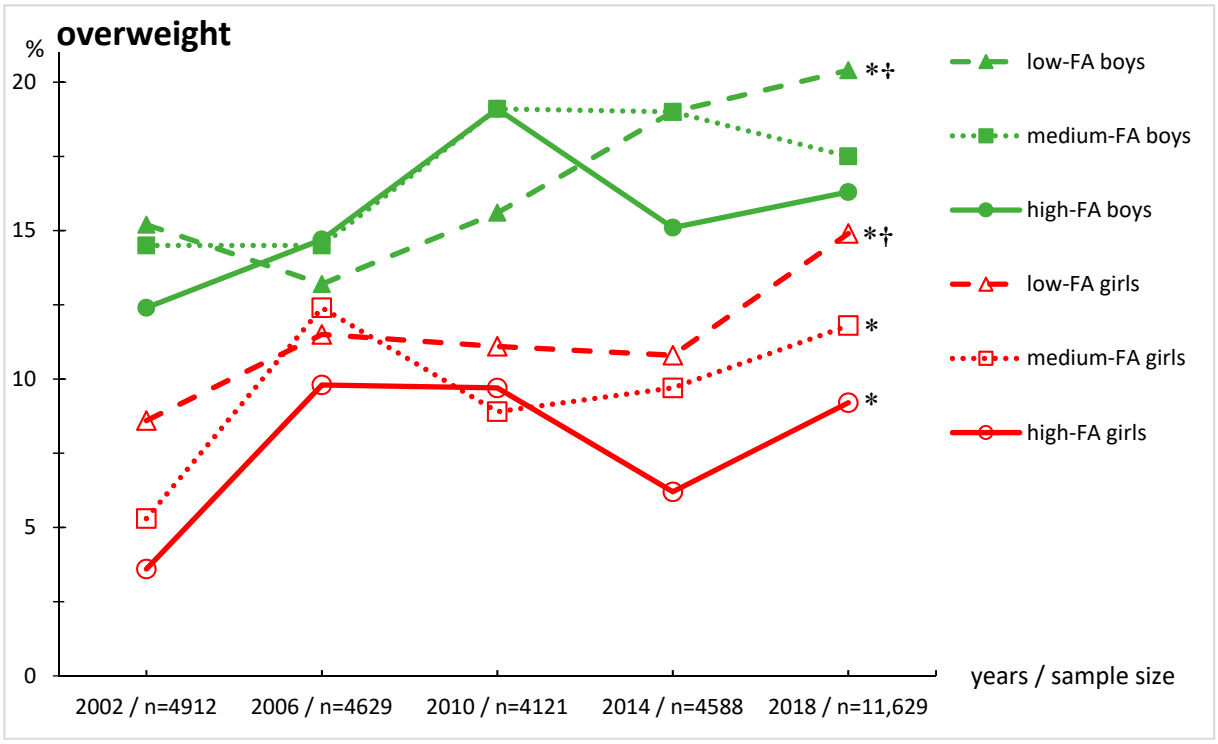

Figure 1. The trend-related prevalence of overweight in a randomized sample of Czech adolescents aged 11-15 years between 2002 and 2018. n – Number; FA – Family affluence; *chi-square tests – differences ($p<0.05$) in the prevalence of overweight between 2002 and 2018 in each gender and FA category; †chi-square tests – differences ($p<0.05$) in the prevalence of overweight between low- and high-FA categories of boys and girls separately in 2018.

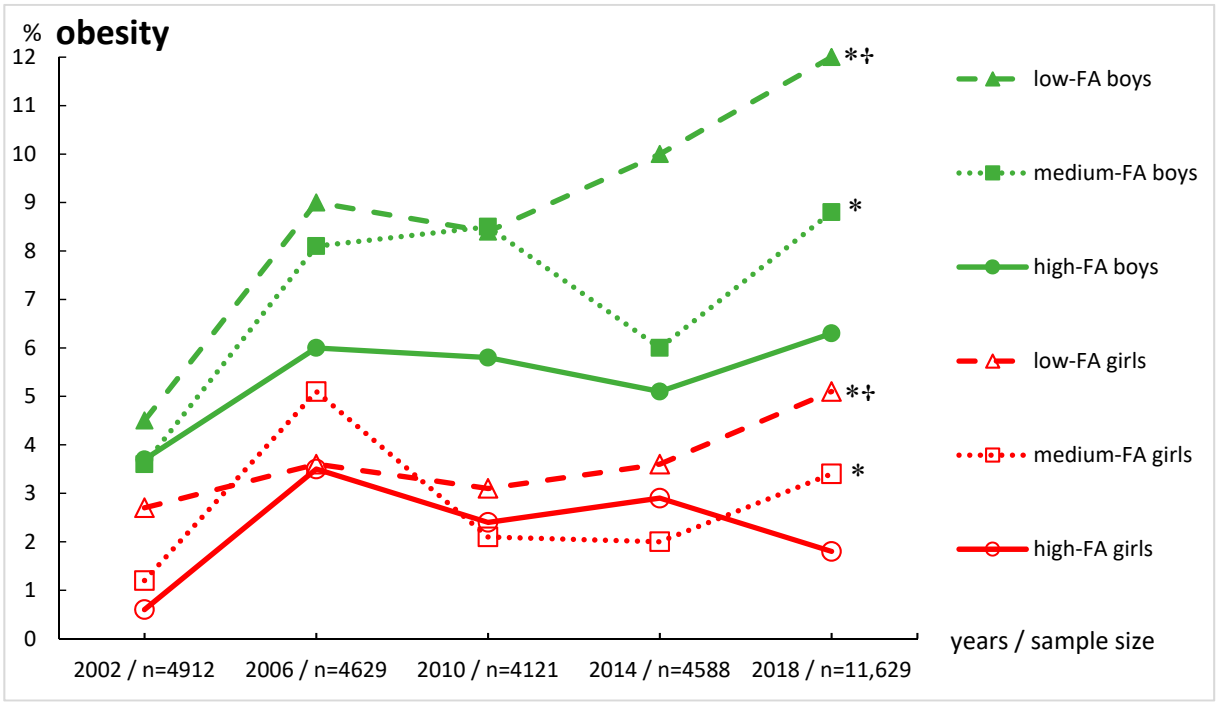

Figure 2. The trend-related prevalence of obesity in a randomized sample of Czech adolescents aged 11-15 years between 2002 and 2018. n – Number; FA – Family affluence; *chi-square tests – differences ($p<0.05$) in the prevalence of obesity between 2002 and 2018 in each gender and FA category; †chi-square tests – differences ($p<0.05$) in the prevalence of obesity between low- and high-FA categories of boys and girls separately in 2018.

A significant increase in overweight between 2002 and 2018 was also registered in girls in the medium-/high-SES category (Figure 1). A significant increase in obesity between 2002 and 2018 was also uncovered in adolescents in the medium-SES category (Figure 2). The 'up-stairs' effect in the prevalence of obesity (i.e. the sharp increase between 2002 and 2006 was replaced by stagnation/decline between 2006 and 2014, with a subsequent increase between 2014 and 2018) in the 2002-2018 period was typical for all SES categories of adolescents except for girls from the high-SES category. In addition, between 2014 and 2018, there was apparently not only an increase in the prevalence of obesity but also a widening of the difference in the prevalence of obesity between the low and high adolescent SES categories (Figure 2).

Table 2. This is a table. Tables should be placed in the main text near to the first time they are cited.

	Obesity								
	Low FA			Medium FA			High FA		
			95% CI			95% CI			95% CI
	%[a]	OR	lower-upper	%[a]	OR	lower-upper	%[a]	OR	lower-upper
Gender									
Girls	5.1	Ref.		3.4	Ref.		1.8	Ref.	
Boys	12.0	2.11‡	1.70-2.61	8.8	2.29‡	1.93-2.72	6.3	2.39‡	1.89-3.03
Age Category									
15 years	8.7	Ref.		5.5	Ref.		3.3	Ref.	
13 years	7.2	1.38*	1.07-1.76	6.7	1.35†	1.11-1.63	3.8	1.20	0.93-1.55
11 years	9.0	1.39*	1.06-1.81	6.2	1.17	0.95-1.46	5.4	1.18	0.88-1.58
60 min of MVPA									
0-6 days	8.8	Ref.		6.2	Ref.		4.7	Ref.	
7 days	5.5	0.67*	0.47-0.96	5.8	0.98	0.77-1.24	2.1	0.63†	0.46-0.86
Vigorous PA									
<4 times a week	9.1	Ref.		6.7	Ref.		4.6	Ref.	
≥4 times a week	6.7	0.73*	0.57-0.93	5.3	0.76†	0.63-0.91	3.6	0.78*	0.62-0.99
Participation in sport									
Inactive (no participation)	9.9	Ref.		7.4	Ref.		5.6	Ref.	
Team and/or individual	7.0	0.66‡	0.53-0.81	4.8	0.69‡	0.58-0.82	3.5	0.75*	0.58-0.96
Screen time on weekdays									
≥2 h per weekday	8.6	Ref.		6.5	Ref.		4.3	Ref.	
<2 h per weekday	4.9	0.91	0.59-1.39	2.9	0.47‡	0.32-0.68	2.0	0.70	0.43-1.12
Breakfast on weekdays									
less than daily	8.8	Ref.		7.4	Ref.		4.3	Ref.	
daily	7.6	0.84	0.68-1.05	5.1	0.81*	0.68-0.96	3.9	1.07	0.85-1.35
Consumption of sweets									
less than daily	8.9	Ref.		6.5	Ref.		4.6	Ref.	
daily	5.4	0.58‡	0.44-0.78	4.1	0.53‡	0.42-0.67	2.0	0.58‡	0.42-0.79
Eating fast food									
less often	8.4	Ref.		6.3	Ref.		4.3	Ref.	
at least twice a month	8.0	0.81	0.60-1.09	5.3	0.77*	0.61-0.97	3.3	0.57‡	0.43-0.77
Sleep time at weekends									
enough sleep	7.9	Ref.		5.9	Ref.		4.4	Ref.	
not enough sleep	14.0	1.15	0.87-1.53	8.9	1.33*	1.05-1.69	5.5	1.48*	1.09-2.00
too much sleep	6.0	0.79	0.61-1.03	4.8	0.82	0.67-1.01	3.0	0.89	0.67-1.17

[#]significant in at least one of the adolescent FA categories; FA – family affluence; CI – 95% confidence interval; %[a] – proportion of obese; OR – odds ratio (logistic regression Enter method); Ref. – Reference group; PA – physical activity; MVPA – moderate-to-vigorous PA; *p<0.05, †p<0.005, ‡p<0.001.

3.2. Correlates of obesity

Given the significant differences in the prevalence of obesity between the low- and high-SES categories of adolescents in 2018, obesity correlates are presented separately for all SES categories (Table 2). In all the cycles of data collection, girls in all SES categories reported having a lower prevalence of obesity than boys. Regardless of the adolescent SES category, the lower odds of obesity were significantly ($p<0.05$) associated with regular VPA, participation in organized sport, and daily consumption of sweets (Table 2). However, the lowest proportion of participants involved in organized sports ($p<0.001$) and regularly engaging in VPA is among the low-SES adolescents ($p<0.001$). Additional analysis confirms a significantly lower prevalence of obesity in adolescents with regular participation in VPA compared with those with less frequent participation (5.0% vs. 6.8%, $p<0.001$), active participants in sports compared with non-participating adolescents (5.0% vs. 8.1%, $p<0.001$), and daily consumers of sweets compared with those who consume sweets less often (3.8% vs. 6.6, $p<0.001$). At least 60 minutes of MVPA daily generally reduce the odds of obesity in adolescents, but the finding was only significant in adolescents from low-SES and high-SES categories. Paradoxically, eating in fast food restaurants more frequently is associated with lower odds of obesity in adolescents (significantly in adolescents from the medium- and high-SES categories) (Table 2).

In the cohort of 11-year-old adolescents, we found the highest prevalence of obesity compared to 13- and 15-year-old adolescents (11 yrs. – 6.8%, 13 yrs. – 5.9%, and 15 yrs. – 5.6%), with the difference being significant between the cohorts of 11- and 15-year-old adolescents ($p<0.05$). In adolescents with at least two hours of ST daily on school/weekend days we revealed a significantly higher prevalence of obesity than in adolescents with less than two hours of ST per day (6.4%/6.3% vs. 3.4%/3.5% $p<0.001$). However, in the case of the SES categorization of adolescents, non-excessive ST at weekends is significantly associated with lower odds of the occurrence of obesity only in adolescents from the medium-SES category (Table 2). In adolescents who reported not getting enough sleep on school/weekend days, we found a significantly higher prevalence of obesity than among adolescents meeting the sleep recommendation (5.5%/5.9% vs. 6.9%/9.5% $p<0.01$). A lack of sleep at weekends was significantly associated with higher odds of obesity in adolescents from the medium- and high-SES categories.

4. Discussion

The key findings of the trend analysis between 2002 and 2018 include the revelation of an 'up-stairs' effect in the prevalence of obesity in all adolescents except for girls from the high-SES category and increasing differences in the prevalence of obesity between gender-separated low- and high-SES categories of adolescents.

It turns out that the Czech Republic is repeating a similar development in child and adolescent obesity to economically more advanced countries (e.g. Australia, England, France, Germany, Netherlands, and the USA) 10-15 years ago, where the increase in obesity reached a plateau, with a subsequent increase in obesity among low-SES adolescents [7,62]. After a sharp increase in obesity among Czech adolescents between 2002 and 2006, a number of national health-related and sports programmes (such as "The Olympic Flag of Versatility", "Fruit and Vegetables in Schools", and "Milk to Schools") were introduced for children and adolescents with support from the Ministry of Education, Youth, and Sports [27]. A new compulsory subject called "Health Education" was also established at primary schools. This course focuses on healthy eating habits, non-risky behaviour (avoidance of drug use and smoking) and nature and environmental friendliness. These health-promoting activities may have contributed to the stabilization (plateau) of the prevalence of overweight/obesity among adolescents between 2006 and 2014. However, after the restriction of some national programmes between 2013 and 2015, a rebound of overweight/obesity among adolescents was registered in the 2018 national data collection. The subsequent increase in overweight/obesity is most pronounced in adolescents with a low-SES background. The possible subsequent effect of national health and sport programmes is most noticeable in adolescents from high-SES families. In addition, significantly higher odds of obesity in the age categories of 11 and 13 years from low-SES

families than among 15-year-olds indicated an expected rise in obesity in older low-SES adolescents in the near future. The trend patterns of excessive body weight, especially obesity in adolescents with a low-SES background and in the youngest age category examined between 2002 and 2018, indicate an urgent need for improvement.

Special attention is therefore paid to the subsequent analyses of obesity correlates in adolescents from various SES backgrounds. Despite the differences in SES, three correlates of energy balance-related behaviours were identified as being associated with significantly lower rates of obesity in all SES groups of adolescents: i) regular VPA (≥4 times a week), ii) active participation in sport, and iii) daily consumption of sweets. Moreover, in adolescents from low- and high-FA families, engagement in MVPA for at least 60 minutes a day also significantly reduces the risk of obesity. In adolescence, behaviour associated with more pronounced energy expenditure (PA of at least moderate intensity, participation in sport) appears to have a stronger anti-obesity effect than the absence of unhealthy eating habits. However, the energy expenditure required for adolescents must also include the energy required for bodily growth and development. Unlike other studies [63–65], more frequent eating (at least twice a month) in fast food restaurants in Czech adolescents with medium and high SES was associated with a significantly lower risk of obesity than in adolescents with lower rates of eating in fast food restaurants. On the other hand, regular breakfast is, in line with Marlatt et al. [65], associated with lower rates of obesity. These eating patterns are "more typical" for adolescents who regularly participate in sports than for non-participating adolescents. The participation of 11-15-year-old adolescents in sport was related to more frequent eating at fast food restaurants but less frequent snacking in front of the computer and intake of crisps than in non-sporting participants [66]. In addition, in the context of TV, it has been found that adolescents who watched TV for a longer time were more likely to consume sweets and soft drinks daily and less likely to consume fruit and vegetables [55]. However, a more significant obesity-related problem can occur when an adolescent ceases to participate in sports or is not regularly involved in MVPA and does not change his or her eating habits, because unhealthy eating habits adopted in adolescence tend to persist into adulthood and represent a crucial factor in the development of obesity [67–69].

Another explanation for the results that the daily consumption of sweets and eating more frequently in fast food restaurants are related to a lower likelihood of the prevalence of obesity is that non-obese adolescents do not have to care about unhealthy eating habits as much as their obese classmates, as evidenced by previous findings [70,71]. Better eating habits in the obese category may have been influenced by the "social desirability" factor in addressing dietary habits in the HBSC questionnaire [72]. Undervaluation of responses to unhealthy and socially undesirable foods has proved to be commonplace in questionnaire surveys of overweight and obese participants [73]. The results could also be influenced by the current tendency among overweight or obese adolescents to reduce weight [74].

Excessive body weight is not only associated with long-term cardiovascular and metabolic health complications [10], but also with social complications [75]. Overweight/obese 11-to-15-year-old girls spend less time with friends after school, and overweight/obese boys report less frequent e-communication compared to normal-weight adolescents. In addition, the overweight/obese weight status of adolescents is associated with not perceiving a best friend as a confidant [75]. This finding is perhaps also one of the reasons why there are more individuals with normal body weight among the participants in organized team or individual sports. In addition, adolescents from low-SES backgrounds have been significantly more likely to fall behind their peers in terms of life satisfaction [70]. In addition to the financial and logistical demands of adolescents' participation in organized leisure-time sport, this finding may contribute to explaining why the lowest proportion of participants in organized sport and regularly engaging in VPA is among adolescents with low SES.

Short sleep duration is generally associated with increased obesity in European adolescents [76] as well as in adolescents from Canada and the United States [77,78]. In addition, a positive relationship between shorter sleep duration and obesity appears to be related to both sides of energy balance-related behaviours as a result of a combination of increased food intake and more sedentary habits [76]. However, in our study, short sleep duration at weekends is associated with a significantly

higher risk of obesity only in adolescents with medium and high SES, although differences in obesity among adolescents with sufficient sleep and lack of sleep are also significant in the low-SES category.

A higher prevalence of obesity also appears to be related to the environments that children and adolescents reside in and in the neighbourhood of the schools they attend [64]. Fast food restaurants are more frequently present in low-quality neighbourhoods. The availability of fast food restaurants near the place of residence or schools is associated with lower consumption of fruits and vegetables, higher consumption of soft drinks, and increased odds of childhood obesity being diagnosed [64]. However, improving public open spaces in low-SES areas by installing play spaces for recreational PA [79] or expanding school-related PA [80] has an impact on increasing day-to-day PA [79] and reducing children's obesity [80,81].

Strengths and limitations

The large sample size, with high response rates in all the survey cycles, strict adherence to the international standardized questionnaire and research protocol, and the same well-trained research team responsible for data collection are major strengths of this study.

The primary limitation of this study is that the data is based on self-reported assessment. However, the self-reported measures of body weight and height have been validated, and other studies have revealed high correlations between self-reported and laboratory measurements of BMI, making it suitable for epidemiological studies to identify excessive body weight in children and adolescents [36]. Although every attempt was made to minimize bias, the self-reported measures applied in this study are subject to recall and social desirability bias, which may have affected the responses. The cross-sectional design of this study does not allow us to interpret the results on the relationship between responses and explanatory variables causally. However, previous longitudinal studies point to the beneficial effects of additional school physical activity on reducing obesity in school-age children [80,81].

5. Conclusions

The results of this study pointed out the rising trends of excessive body weight (obesity and overweight), especially in adolescents from low-SES families. Additionally, significantly higher odds of obesity in 11- and 13-year-old adolescents from low-SES families, compared with their peers aged 15, indicated an expectable rise in obesity in older low-SES adolescents in the near future. It seems that association energy expenditure behaviours (participation in individual or team sports, regular vigorous PA, and daily moderate-to-vigorous PA) with weight status in adolescents are stronger than is the case for unhealthy eating habits (daily consumption of sweets or occasional meals at fast food restaurants). We highlight the importance of prevention and the need for more effective strategies/programmes to prevent excessive body weight in children and adolescents with a low-SES background.

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References

1. Ford, N.D.; Patel, S.A.; Narayan, K.M.V. Obesity in low- and middle-income countries: Burden, drivers, and emerging challenges. *Annu. Rev. Public Health* 2017, *38*, 145–164.
2. Hruby, A.; Hu, F.B. The epidemiology of obesity: A big picture. *Pharmacoeconomic* 2015, *33*, 673–689.
3. Mitchell, N.; Catenacci, V.; Wyatt, H.R.; Hill, J.O. Obesity: Overview and epidemic. *Psychiatr. Clin. North Am.* 2012, *34*, 717–732.
4. Ng, M.; Fleming, T.; Robinson, M.; Thomson, B.; Graetz, N.; Margono, C.; Mullany, E.C.; Biryukov, S.; Abbafati, C.; Abera, S.F.; Abraham, J.P.; Abu-Rmeileh, N.M.; Achoki, T.; AlBuhairan, F.S.; Alemu, Z.A.; Alfonso, R.; Ali, M.K.; Ali, R.; Guzman, N.A.; Ammar, W.; Anwari, P.; Banerjee, A.; Barquera, S.; Basu, S.; Bennett, D.A.; Bhutta, Z.; Blore, J.; Cabral, N.; Nonato, I.C.; Chang, J.C.; Chowdhury, R.; Courville, K.J.; Criqui, M.H.; Cundiff, D.K.; Dabhadkar, K.C.; Dandona, L.; Davis, A.; Dayama, A.; Dharmaratne, S.D.; Ding, E.L.; Durrani, A.M.; Esteghamati, A.; Farzadfar, F.; Fay, D.F.; Feigin, V.L.; Flaxman, A.; *et al.* Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *Lancet*, 2014, *384*, 766–781.
5. Seidel, J.C.; Halberstadt, J. The global burden of obesity and the challenges of prevention. *Ann. Nutr. Metab.* 2015, *66*, S7–S12.
6. Inchley, J.; Currie, D.; Jewell, J.; Breda, J.; Barnekow, V. *Adolescent obesity and related behaviours: Trends and inequalities in the WHO European Region, 2002-2014*, 1st ed.; WHO Regional Office for Europe: Copenhagen, Denmark, 2017; pp. 1–98.
7. Frederick, C.B.; Snellman, K.; Putnam, R.D. Increasing socioeconomic disparities in adolescent obesity. *Proc. Nation. Acad. Sci. Unit. Stat. Am.* 2014, *111*, 1338–1342.
8. Hamřík, Z.; Sigmundová, D.; Pavelka, J.; Kalman, M.; Sigmund, E. Trends in overweight and obesity in Czech schoolchildren from 1998 to 2014. *Cent. Eur. J. Public Health* 2014, *25*, S10–S14.
9. Hardy, L.L.; Mihrshahi, S.; Gale, J.; Drayton, B.A.; Bauman, A.; Mitchell, J. 30-year trends in overweight, obesity and waist-to-height ratio by socioeconomic status in Australian children, 1985 to 2015. *Int. J. Obes. (Lond).* 2017, *41*, 76–82.
10. Kelly A.; Barlow, S.E.; Rao, G.; Inge, T.H.; Hayman, L.L.; Steinberger, J.; Urbina, E.M.; Ewing, L.J.; Daniels, S.R. Severe obesity in children and adolescents: Identification, associated health risks, and treatment approaches: A scientific statement from the American Heart Association. *Circulation* 2013, *128*, 1689–1712.
11. Cawley, J.; Meyerhoefer, C. The medical care costs of obesity: An instrumental variables approach. *J. Health Econ.* 2012, *31*, 219–230.
12. Tremmel, M.; Gerdthem, U.G.; Nilsson, P.M.; Saha, S. Economic burden of obesity: A systematic literature review. *Int. J. Environ. Res. Public Health* 2017, *14*, E435.
13. Dumuid, D.; Olds, T.; Lewis, L.K.; Martin-Fernández, J.A.; Barreirea, T.; Broyles, S.; Chaput, J.P.; Fogelholm, M.; Hu, G.; Kuriyan, R.; Kurpad, A.; Lambert, E.V.; Maia, J.; Matsudo, V.; Onywera, V.O.; Sarmiento, O.L.; Standage, M.; Tremblay, M.S.; Tudor-Locke, C.; Zhao, P.; Katzmarzyk, P.; Gillison, F.; Maher, C.; ISCOLE research group. The adiposity of children is associated with their lifestyle behaviours: A cluster analysis of school-aged children from 12 nations. *Pediatr. Obes.* 2016, *13*, 111–119.
14. Huang, T.T.; Drewnowski, A.; Kumanyika, S.K.; Glass, T.A. A systems-oriented multilevel framework for addressing obesity in the 21st century. *Prev. Chronic Dis.* 2009, *6*, A82.
15. Ren, H.; Zhou, Z.; Liu, W.; Wang, X.; Yin, Z. Excessive homework, inadequate sleep, physical inactivity and screen time are major contributors to high paediatric obesity. *Acta Paediatr.* 2016, *106*, 120–127.
16. Wilkie, H.J.; Standage, M.; Gillison, F.B.; Cumming, S.P.; Katzmarzyk, P.T. Multiple lifestyle behaviours and overweight and obesity among children aged 9-11 years: Result from the UK site of the International Study of Childhood Obesity, Lifestyle and the Environment. *BMJ Open* 2016, *6*, e010677.
17. Bleich, S.N.; Vercammen, K.A. The negative impact of sugar-sweetened beverages on children's health: An update of the literature. *BMC Obes.* 2018, *5*, 6.
18. Sigmund, E.; Badura, P.; Sigmundová, D.; Voráčová, J.; Zacpal, J.; Kalman, M.; Pavelka, J.; Vokacová, J.; Hobza, Jr.V.; Hamrik, Z. Trends and correlates of overweight/obesity in Czech adolescents in relation to family socioeconomic status over a 12-year study period (2002-2014). *BMC Public Health* 2018, *18*, 122.
19. Voráčová, J.; Sigmund, E.; Sigmundová, D.; Kalman, M. Family affluence and the eating habits of 11- to 15-year-old Czech adolescents: HBSC 2002 and 2014. *Int. J. Environ. Res. Public Health* 2016, *13*, 1034.

20. Nobari, T.Z.; Whaley, S.E.; Prelip, M.L.; Crespi, C.M.; Wang, M.C. Trends in socioeconomic disparities in obesity prevalence among low-income children aged 2-4 years in Los Angeles county, 2003-2014. *Child. Obes.* 2018, *14*, 248–258.
21. Bann, D.; Johnson, W.; Li, L.; Kun, D.; Hardy, R. Socioeconomic inequalities in childhood and adolescent body-mass index, weight, and height from 1953 to 2015: an analysis of four longitudinal, observational, British birth cohort studies. *Lancet Public Health* 2018, *3*, e194–e203.
22. Newton, S.; Braithwaite, D.; Akinyemiju, T.F. Socio-economic status over the life course and obesity. Systematic review and meta-analysis. *PLoS One* 2017, *12*, e0177151.
23. Bucksch, J.; Sigmundova, D.; Hamrik, Z.; Troped, P.J.; Melkevik, O.; Ahluwalia, N.; Borraccino, A.; Tynjälä, J.A.; Kalman, M.; Inchley, J. International trends in adolescent screen-time behaviors from 2002 to 2010. *J. Adolesc. Health* 2016, *58*, 417–425.
24. Kalman, M.; Inchley, J.; Sigmundova, D.; Iannotti, R.J.; Tynjälä, J.A.; Hamrik, Z.; Haug, E.; Bucksch, J. Secular trends in moderate-to-vigorous physical activity in 32 countries from 2002 to 2010: A cross-national perspective. *Eur. J. Public Health* 2015, *25*, S37–S40.
25. Iannotti, R.J.; Wang, J. Trends in physical activity, sedentary behavior, diet, and BMI among US adolescents, 2001-2009. *Pediatrics* 2013, *132*, 606–614.
26. OECD Data. Available online: https://data.oecd.org/czech-republic.htm (accessed on 17. 4. 2019).
27. MSMT. Available online: http://www.msmt.cz/?lang=2 (accessed on 17. 4. 2019).
28. Currie, C.; Nic Gabhainn, S.; Godeau, E.; International HBSC Network Coordinating Committee. The health behaviour in school-aged children: WHO collaborative cross-national (HBSC) study: Origins, concept, history and development 1982-2008. *Int. J. Public Health* 2009, *54*, S131–S139.
29. Roberts, C.; Freeman, J.; Samdal, O.; Schnohr, C.W.; Looze, M.; Nic Gabhainn, S.; Iannotti, R.; Rasmussen, M.; International HBSC Study Group. The Health Behaviour in School-aged Children (HBSC) study: Methodological developments and current tensions. *Int. J. Public Health* 2009, *54*, 140–150.
30. Bilík, J. *Demographic yearbook of districts of the Czech Republic – 2008-2017*, 1st ed.; Code: 130056-18; Czech Statistical Office: Praque: Czech Republic, 2018; pp. 1–145.
31. de Onis, M.; Lobstein, T. Defining obesity risk status in the general childhood population: Which cut-offs should we use? *Int. J. Pediatr. Obes.* 2010, *5*, 458–460.
32. de Onis, M.; Onyango, A.W.; Borghi, E.; Siyam, A.; Nishida, C.; Siekmann, J. Development of a WHO growth reference for school-aged children and adolescents. *Bull. World Health Organ.* 2007, *85*, 660–667.
33. http://www.hbsc.org/methods/index.html (accessed on 17. 4. 2019).
34. Chan, N.P.T.; Choi, K.C.; Nelson, E.A.S.; Sung, R.Y.T.; Chan, J.C.N.; Kong, A.P. S. Self-reported body weight and height: An assessment tool for identifying children with overweight/obesity status and cardiometabolic risk factors clustering. *Matern. Child Health J.* 2013, *17*, 282–291.
35. Fonseca, H.; Silva, A.M.; Matos, M.G.; Esteves, I.; Costa, P.; Guerra, A.; Gomes-Pedro, J. Validity of BMI based on self-reported weight and height in adolescents. *Acta Paediatr.* 2010, *99*, 282–291.
36. Aasvee, K.; Rasmussen, M.; Kelly, C.; Kurvinen, E.; Giacchi, M.V.; Ahluwalia, N. Validity of self-reported height and weight for estimating prevalence of overweight among Estonian adolescents: The Health Behaviour in School-aged Children study. *BMC Res. Notes* 2015, *8*, 606.
37. Ahluwalia, N.; Dalmasso, P.; Rasmussen, M.; Lipsky, L.; Currie, C.; Haug, E.; Kelly, C.; Damsgaard, M.T.; Due, P.; Tabak, I.; Ercan, O.; Maes, L.; Aasve, K.; Cavallo, F. Trends in overweight prevalence among 11-, 13- and 15-years-olds in 25 countries in Europe, Canada and USA from 2002 to 2010. *Eur. J. Public Health* 2015, *25*, S28–S32.
38. Currie, C.; Molcho, M.; Boyce, W.; Holstein, B.; Torsheim, T.; Richter, M. Researching health inequalities in adolescents: The development of the health behaviour in school-aged children (hbsc) family affluence scale. *Soc. Sci. Med.* 2008, *66*, 1429–1436.
39. Currie, C.; Inchley, J.; Molcho, M.; Lenzi, M.; Veselak, Z.; Wild, F. *Health Behaviour in School-Aged Children (HBSC) Study Protocol: Background, Methodology and Mandatory Items for the 2013/2014 Survey*, 1st ed.; CAHRU: St. Andrews, United Kingdom, 2014; pp. 1–48.
40. Andersen, A.; Krølner, R.; Currie, C.; Dallago, L.; Due, P.; Richter, M.; Örkényi, Á.; Holstein, B.E. High agreement on family affluence between children's and parents' reports: International study of 11-year-old children. *J. Epidemiol. Community Health* 2008, *62*, 1092–1094.
41. Boyce, W.; Torsheim, T.; Currie, C.; Zambon, A. The family affluence scale as a measure of national wealth: Validation of an adolescent self-reported measure. *Soc. Indic. Res.* 2006, *78*, 473–487.

42. Hartley, J.E.K.; Levin, K.; Currie, C. A new version of the HBSC family affluence scale – FAS III: Scottish qualitative findings from the international FAS development study. *Child Indic. Res.* 2016, *9*, 233–245.
43. Liu, Y.; Wang, M.; Villberg, J.; Torsheim, T.; Tynjälä, J.; Lv, Y.; Kannas, L. Reliability and validity of family affluence scale (FAS II) among adolescents in Beijing, China. *Child Indicat. Res.* 2012, *5*, 235–251.
44. Molcho, M.; Gabhainn, S.N.; Kelleher, C.C. Assessing the use of the family affluence scale (fas) among Irish schoolchildren. *Ir. Med. J.* 2007, *100*, S37–S39.
45. Jansen, I.; LeBlanc, A.G. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int. J. Behav. Nutr. Phys. Act.* 2010, *7*, 40.
46. Inchley, J.; Currie, D.; Young, T.; Samdal, O.; Torsheim, T.; Augustson, L.; Mathison, F.; Aleman-Diaz, A.; Molcho, M.; Weber, M.; Barnekow, V. *Growing up unequal: gender and socioeconomic differences in young people's health and well-being. Health Behaviour in School-Aged children (HBSC) Study: International report from the 2013/2014 survey. Health Policy for children and adolescents, No. 7.*, 1st ed.; WHO Regional Office for Europe: Copenhagen, Denmark, 2016; pp. 1–292.
47. Prochaska, J.J.; Sallis, J.F.; Long, B. A physical activity screening measure for use with adolescents in primary care. *Arch. Pediatr. Adolesc. Med.* 2001, *155*, 554–559.
48. Ridgers, N.D.; Timperio, A.; Crawford, D.; Salmon, J. Validity of a brief self-report instrument for assessing compliance with physical activity guidelines amongst adolescents. *J. Sci. Med. Sport* 2012, *15*, 136–141.
49. Bobakova, D.; Hamrik, Z.; Badura, P.; Sigmundova, D.; Nalecz, H.; Kalman, M. Test-retest reliability of selected physical activity and sedentary behavior HBSC items in the Czech Republic, Slovakia and Poland. *Int. J. Public Health* 2015, *60*, 59–67.
50. Liu, Y.; Wang, M.; Tynjälä, J.; Lv, Y.; Villberg, J.; Zhang, Z.; Kannas, L. Test–retest reliability of selected items of Health Behaviour in School-aged Children (HBSC) survey questionnaire in Beijing, China. *BMC Med. Res. Methodol.* 2010, *10*, 73.
51. Badura, P.; Sigmund, E.; Geckova, A.M.; Sigmundova, D.; Sirucek, J.; van Dijk, J.P.; Reijneveld, S.A. Is participation in organized leisure-time activity associated with school performance in adolescence? *PLoS One* 2016, *11*, e0153276.
52. Bosakova, L.; Kolarcik, P.; Bobakova, D.; Sulcova, M.; Van Dijk, J.P.; Reijneveld, S.A.; Geckova, A.M. Test-retest reliability of the scale of participation in organized activities among adolescents in the Czech Republic and Slovakia. *Int. J. Public Health* 2016, *61*, 329–336.
53. Sigmundová, D.; Sigmund, E.; Bucksch, J.; Baďura, P.; Kalman, M.; Hamřík, Z. Trends in screen time behaviours in Czech schoolchildren between 2002 and 2014: HBSC Study. *Cent. Eur. J. Public Health* 2017, *25*, S15–S20.
54. Schmitz, K.H.; Harnack, L.; Fulton, J.E.; Jacobs, D.R.Jr.; Gao, S.; Lytle, A.L.; Coevering, P.V. Reliability and validity of a brief questionnaire to assess television viewing and computer use by middle school children. *J. Sch. Health* 2004, *74*, 370–377.
55. Vereecken, C.A.; Todd, J.; Roberts, C.; Mulvihill, C.; Maes, L. Television viewing behaviour and associations with food habits in different countries. *Public Health Nutr.* 2006, *9*, 244–250.
56. Rey-López, J.P.; Vicente-Rodriguez, G.; Ortega, F.B.; Ruiz, J.R.; Martinez-Gómez, D.; De Henauw, S.; Manios, Y.; Molnar, D.; Polito, A.; Verloigne, M.; Castillo, M.J.; Sjöström, M.; De Bourdeaudhuij, I.; Moreno, L.A.; HELENA Study Group. Sedentary patterns and media availability in European adolescents: the HELENA study. *Prev. Med.* 2010, *51*, 50–55.
57. Salmon, J.; Campbell, K.J.; Crawford, D.A. Television viewing habits associated with obesity risk factors: a survey of Melbourne schoolchildren. *Med. J. Aust.* 2006, *184*, 64–67.
58. Tremblay, M.S.; LeBlanc, A.G.; Janssen, I.; Kho, M.E.; Hicks, A.; Murumets, K.; Colley, R.C.; Duggan, M. Canadian sedentary behavior guidelines for children and youth. *Appl. Physiol. Nutr. Metab.* 2011, *36*, 59–64.
59. Vereecken, C.; Pedersen, T.P.; Ojala, K.; Krølner, R.; Dzielska, A.; Ahluwalia, N.; Giacchi, M.; Kelly, C. Fruit and vegetable consumption trends among adolescents from 2002 to 2010 in 33 countries. *Eur. J. Public Health* 2015, *25*, S16–S19.
60. Leger, D.; Beck, F.; Richard, J.B.; Godeau, E. Total sleep time severely drops during adolescence. *PLoS One* 2012, *7*, e45204.
61. Paruthi, S.; Brooks, L.J.; D'Ambrosio, C.; Hall, W.A.; Kotagal, S.; Lloyd, R.M.; Malow, B.A.; Maski, K.; Nichols, C.; Quan, S.F.; Rosen, C.L.; Troester, M.M.; Wise, M.S. Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. *J. Clin. Sleep Med.* 2016, *12*, 785–786.

606 62. Wabitsch, M.; Moss, A.; Kromeyer-Hauschild, K. Unexpected plateauing of chilhddo obesity rates in
607 developed countries. *BMC Med.* 2014, *12*, 17.
608 63. Braithwaite, I.; Stewart, A.W.; Hancox, R.J.; Beasley, R.; Murphy, R.; Mitchel, E.A.; ISAAC Phase Three
609 Study Group. Fast-food consumption and body mass index in children and adolescents: An international
610 cross-sectional study. *BMJ Open* 2014, *4*, e005813.
611 64. Hamano, T.; Li, X.; Sundquist, J.; Sundquist, K. Association between childhood obesity and neighbourhood
612 accessibility to fast-food outlets: A nationwide 6-year follow-up study of 944,487 children. *Obes. Facts* 2017,
613 *10*, 559–568.
614 65. Marlatt, K.L.; Farbakhsh, K.; Dengel, D.R.; Lytle, L.A. Breakfast and fast food consumption are associated
615 with selected biomarkers in adolescents. *Prev. Med. Rep.* 2016, *3*, 49–52.
616 66. Voráčová, J.; Badura, P.; Hamrik, Z.; Holubčíková, J.; Sigmund, E. Unhealthy eating habits and
617 participation in organized leisure-time activities in Czech adolescents. *Eur. J. Pediatr.* 2018, *177*, 1505–1513.
618 67. Emmett, P.M.; Jones, L.R. Diet, growth, and obesity development throughout childhood in the Avon
619 Longitudinal Study of Parents and Children. *Nutr. Rev.* 2015, *73*, S175–S206.
620 68. León-Muñoz, L.M.; García-Esquinas, E.; Soler-Vila, H.; Guallar-Castillón, P.; Banegas, J.R.; Rodríguez-
621 Artalejo, F. Unhealthy eating behaviors and weight gain: A prospective study in young and middle-age
622 adults. *Obesity (Silver Spring)* 2016, *24*, 1178–1184.
623 69. Mikkilä, V.; Räsänen, L.; Raitakari, O.T.; Pietinen, P.; Viikari, J. Longitudinal changes in diet from childhood
624 into adulthood with respect to risk of cardiovascular diseases. The Cardiovascular Risk in Young Finns
625 Study. *Eur. J. Clin. Nutr.* 2004, *58*, 1038–1045.
626 70. Chzhen, Y.; Moor, I.; Pickett, W.; Toczydlowska, E.; Stevens, G. Family affluence and inequality in
627 adolescent health and life satisfaction: Evidence from the HBSC study 2002-2014. *Innocenti Working Paper*
628 2016, No.2016-10, 1–26.
629 71. Sigmundová, D.; Sigmund, E.; Hamrik, Z.; Kalman, M. Trends of overweight and obesity, physical activity
630 and sedentary behaviour in Czech schoolchildren: HBSC study. *Eur. J. Public Health* 2014, *24*, 210–215.
631 72. Bel-Serrat, S.; Julian-Almarcegui, C.; Gonzalez-Gross, M.; Mouratidou, T.; Bornhorst, C.; Grammatikaki, E.;
632 Kersting, M.; Cuenca-García, M.; Gottrand, F.; Molnár, D.; Hallström, L.; Dallongeville, J.; Plada, M.;
633 Roccaldo, R.; Widhalm, K.; Moreno, L.A.; Manios, Y.; De Henauw, S.; Leclercq, C.; Vandevijvere, S.; Lioret,
634 S.; Gutin, B.; Huybrechts I. Correlates of dietary energy misreporting among European adolescents: the
635 Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Br. J. Nutr.* 2016, *115*, 1439–
636 1452.
637 73. Hebert, J.R.; Hurley, T.G.; Peterson, K.E.; Resnicow, K.; Thompson, F.E.; Yaroch, A.L., Ehlers, M.; Midthune,
638 D.; Williams, G.C.; Greene, G.W.; Nebeling, L. Social desirability trait influences on self-reported dietary
639 measures among diverse participants in a multicenter multiple risk factor trial. *J. Nutr.* 2008, *138*, S226–
640 S234.
641 74. Ojala, K.; Vereecken, C.; Välimaa, R.; Currie, C.; Vilberg, J.; Tynjälä, J.; Kannas, L. Attemps to lose weight
642 among overweight and non-overweight adolescents: A cross-national survey. *Int. J. Behav. Nutr. Phys. Act.*
643 2007, *4*, 50.
644 75. Kjelgaard, H.H.; Holstein, B.E.; Due, P.; Brixval, C.S.; Rasmussen, M. Adolescent weight status: association
645 with structural and functional dimensions of social relations. *J. Adolesc. Health* 2017, *60*, 460–468.
646 76. Garaulet, M.; Ortega F.B.; Ruiz, J.R.; Rey-López, J.P.; Béghin, L.; Manios, Y.; Cuenca-García, M.; Plada, M.;
647 Diethelm, K.; Kafatos, A.; Molnár, D.; Al-Tahan, J.; Moreno, L.A. Short sleep duration is associated with
648 increased obesity markers in European adolescents: Effect of physical activity and dietary habits. The
649 HELENA study. *Int. J. Obes. (Lond).* 2011, *35*, 1308–1317.
650 77. Miller, M.A.; Kruisbrink, M.; Wallace, J.; Ji, C.; Cappuccio, F.P. Sleep duration and incidence of obesity in
651 infants, children, and adolescents: A systematic review and meta-analysis of prospective studies. *Sleep* 2018,
652 *41*, 1–19.
653 78. Sluggett, L.; Wagner, S.L.; Harris, R.L. Sleep duration and obesity in children and adolescents. *Can. J.*
654 *Diabetes* 2019, *43*, 146–152.
655 79. Lal, A.; Moodie, M.; Abbott, G.; Carver, A.; Salmon, J.; Giles-Corti, B.; Timperio, A.; Veitch, J. The impact
656 of a park refurbishment in a low socioeconomic area on physical activity: a cost-effectiveness study. *Int. J.*
657 *Behav. Nutr. Phys. Act.* 2019, *16*, 26.

80. Sigmund, E.; El Ansari, W.; Sigmundová, D. Does school-based physical activity decrease overweight and obesity in children 6-9 years? A two-year non-randomized longitudinal intervention study in the Czech Republic. *BMC Public Health* 2012, *12*, 570.
81. Sigmund, E.; Sigmundová, D. Longitudinal 2-year follow-up on the effect of a non-randomised school-based physical activity intervention on reducing overweight and obesity of Czech children aged 10–12 years. *Int. J. Environ. Res. Public Health* 2013, *10*, 3667–3683.