https://doi.org/10.35219/efms.2023.2.07

AGE AND GENDER DIFFERENCES IN BODY COMPOSITION IN YOUNG ADOLESCENTS

Pavol Čech, Bibiana Vadašová, Jaromír Sedláček, Pavel Ružbarský, Laura Lacková

Faculty of Sports, University of Prešov, Slovakia
E-mail: jaromir.sedlacek@unipo.sk

Abstract: *At the age of 11-15 (the period of younger adolescents), there are significant changes in body composition due to pre-pubertal and pubertal development. In our paper, the differences in indicators of body composition of elementary school students in the context of age and gender were evaluated. Boys and girls from primary schools aged 10-11 years (n=32 and n=38), 12-13 years (n=36 and n=57) and 14-15 years (n= 38 and n=33) were examined. In addition to age, body height (BH), body weight (BW), Quetelet's index (BMI), body fat mass (BFM), body fat mass index (BFMI), skeletal muscle mass (SMM), percentage of body fat (PBF), waist-hip ratio (WHR) and visceral fat (VFA) were monitored. The data were obtained using the InBody 230 device using the multi-frequency bioimpedance method of measuring body composition. The measured data were processed using IBM SPSS Statistics, version 20.0. Since data were not normally distributed (Shapiro-Wilk test), they were processed using non-parametric methods through Kruskal-Wallis Anova (age differences) and multiple comparisons with the Mann-Whitney U test with the application of the Bonferonni adjustment. The most significant differences were only found in the intersex comparison of 14-15-year-old pupils, when in the relative values of fat representation (BFMI and PBF), girls achieved higher mean values, on the contrary, higher values of in the group of boys are visible in the indicators describing active body mass (FFM, FFMI and SMM).*

Key Words: Adolescents, Body Composition, Gender And Age Differences.

INTRODUCTION

Body composition during adolescence is a point of interest in many areas of medicine and population health assessment, particularly in light of persistent negative secular trends. These are noticeable not only in the adult population, but also increasingly in children, and in our focus on adolescents. World health organization defined adolescence as the phase of life between childhood and adulthood, from ages 10 to 19. In this defined period, the authors still specifically differentiate early adolescence or otherwise also called pubescence. In early adolescence (10 – 15 years), the dominant physical development characteristics include growth spurts, puberty, and neural change (Patton et al., 2016). Growth spurts, which are characteristic for this period, include significant increases in height, weight, internal organ size, and skeletal and muscular systems (Norris et al., 2022). In terms of the occurrence of hormonal imbalances and mental changes, there can also be abrupt changes in body composition.

The prevalence of obesity in the population is alarming and has been increasing over the last two decades. More than 340 million children and adolescents aged 5-19 years were overweight or obese in 2016, according to WHO (WHO, 2021a). The prevalence of overweight and obesity among children and adolescents aged 5-19 has risen dramatically from just 4% in 1975 to just over 18% in 2016 (WHO, 2021a). One in three children are living with overweight or obesity. The rise has occurred similarly among both boys (29%) and girls (27%) (WHO, 2021b). The social environment also plays a role in the prevalence of obesity and overweight. As research shows, the prevalence of overweight and obesity among children and adolescents is increasing in countries with low and middle income. The Slovak Republic can also be included among these countries. On the contrary, the increase in obesity prevalence in recent years has been slower than in the past and has reached a plateau in developed countries (Wabitsch et al., 2014). The next thing is that association between childhood obesity and obesity in adults (age ≥20 years) is strong, with obese children being more than five times more likely to be obese as adults than non-obese children (Simmonds et al., 2015).

Obesity prevention requires the implementation of surveys to monitor its evolution over time, knowledge of its determinants, research and implementation of interventions, necessarily in a multisector and multidisciplinary context, as well as a continuous process of evaluation (Nittari et al., 2020). All population-based epidemiological studies of this nature are based on BMI tracking, which is a simple and accessible method of assessment. Although it is an important epidemiologic and clinical tool, BMI does not distinguish between fat mass and fat-free mass; thus individuals of the same BMI show varying levels of fatness (Vadasova et al., 2016; Staatz et al., 2021).

Moreover, BMI fails to reflect the developmental changes in body fatness between boys and girls during adolescence (Nevill et al., 2021). Therefore, in the studies, it is inevitable to look for and evaluate indicators of the internal structure of the body. For this purpose, it is necessary to create a sufficiently large database of data describing the state of the adolescent population. Currently, the most commonly used method of the body composition monitoring is bioimpedance. In general, our observed period is characterised by an increase in fat in girls and a significant development of the skeleton and muscles in boys, which changes body proportions and appearance. This period is a kind of stage of development, which is characterized by a whole complex of somatic, functional and psychological changes that turn a child into an adult (Gáborová, Porubčanová, 2017). However, research results are not consistent. Age differences in the context of gender may not be clear, since the nature of the population, eating habits and local genotype may enter into the result as other factors.

Objectives

In this article, our aim was to contribute to reveal differences in body composition in young adolescents according age and gender.

MATERIAL AND METHODS

Nonrandomized cross-sectional observational study was performed in a Caucasian origin population. Research sample consisted of 234 school-aged children (girls, n = 128; boys, n = 106) between 10.0 and 15.9 years (mean 13.9±1.4 years) from the eastern part of the Slovak Republic (Prešov region). Research sample was divided to subgroups according to calendar age (S1 – 10-11 years, S2 – 12-13 years, S3 – 14-15 years old) and sex.

Table 1. Basic characteristics of subgroups divided according to age and sex (M±SD)

Sex	age group	age (year)	body height (cm)	body weight (kg)
boys	S1 *(n = 32)*	11.4±0.4	151.8±10.1	46.4±17.6
	S2 (*n = 36)*	13.0±0.6	160.4±10.4	54.0±17.8
	S3 (n = 38)	14.8±0.5	174.4±8.5	67.4±15.2
girls	S1 *(n = 38)*	11.4±0.3	152.6±7.3	44.0±11.0
	S2 *(n = 57)*	13.0±0.5	158.2±7.5	52.3±12.3
	S3 *(n = 33)*	14.8±0.5	161.9±5.4	54.9±12.0

Basic characteristics of subgroups are shown in Table 1. Only children who had no identified metabolic or musculoskeletal disorders at the time of measurement participated in the study. Characteristics of volume and intensity of physical activity were not measured. Participation in the study was fully voluntary and anonymous. A participant's legal guardian received a write description of the study procedures before testing. Written informed consent to participate in this study was provided by the participants' legal guardian.

Body height was measured using a portable stadiometer SECA 217 (Hamburg, Germany) with an accuracy of 0.1 cm. Body weight (with an accuracy of 0.1 kg) and body composition were measured via bioelectric impedance by InBody 230 device (Biospace Co., Ltd.; Seoul, Korea). This device use direct segmental multi-frequency bioelectric impedance analysis (DSM-BIA) based on measuring resistance and reactance of tissues. Resistance is determined by a tissue's conductivity defined as a ratio of voltage and current. Reactance is defined as a tissue's ability to slow down the current and cause a phase shift (Vadasova et al., 2016). The InBody 230 device uses for measurement 8-point tactile electrodes placed below each foot in anterior-posterior directions and in contact with the palm and thumb of each hand. Measurements were taken in the morning following the measurement standards described by Kyle et al. (2004) whereby participants were asked not to ingest food for at least two hours prior to measurement. In accordance with the manufacturer's guidelines, the participants held out their arms and legs so that they would not come into contact with any other body segments during the procedure (Vadasova et al., 2016). The measurements were processed using Lookinbody 120 software (Biospace Co., Ltd.; Seoul, Korea). Indirectly measurable parameters were calculated on the basis of software prediction equations for the given age category. Measurements were taken according to the ethical standards of the Declaration of Helsinki (Harriss, Atkinson, 2011).

The following indicators of body composition were analysed: absolute value of body fat mass (FM), skeletal muscle mass (SMM) and fat free mass (FFM), normalized value of body fat mass index (FMI) and fat free mass index (FFMI), percentage body fat (PBF) and visceral fat area (VFA). The FFMI and FMI indexes are equivalent concepts to the

BMI, and are defined as FFM/height2 (kg/m2) and FM/height2 (kg/m2), respectively (Baumgartner et al. 1998).

The Shapiro-Wilk test was used to test normality of data distribution as a means of selection of statistical tests. On the base of its results, to examine the differences between defined subgroups with respect to factors of age and sex, Kruskal-Wallis analysis of variance (K-W ANOVA) was used. To determine the significance of the differences among subgroups for non-normally distributed variables, Mann-Whitney test with Bonferroni's correction of p-value was used. Mann Whitney test was used for analysis of differences from the point of view of the gender factor The level of significance was set at 95 % for all statistical parameters ($p < 0.05$). Statistical analysis was performed using IBM SPSS statistical software, version 20.0.

RESULTS AND DISCUSSION

Based on the research data distribution assessed using the Shapiro-Wilk test, nonparametric characteristics and mathematical statistics procedures (unpublished data) were used for further analysis.

When comparing age differences, in terms of assessing year-to-year gains, in body composition indicators with respect to the gender of the pupils, we observed significant differences in the level of variables describing active body mass in boys by applying non-parametric analysis of variance (FFM - $H_{2,106} = 44.304$, $p = 0.001$; FFMI - $H_{2,106} = 25.671$, $p = 0.001$; SSM - $H_{2,106} = 44.545$, $p = 0.001$). In the context of changes in the median values, an increase with age was captured in all these variables. Multiple comparisons showed a significant year-to-year increase in all observed paired data in fat-free mass (FFM) representation and skeletal muscle mass (SMM) level. When comparing the subgroups in the normalized value of fat-free mass index (FFMI), a significant increase was detected only in the comparison of 12-13-year-old and 14-15-year-old boys (comparison S2 and S3). Body composition indicators describing adiposity of the examined boys did not show significant changes ($p>0.05$) in terms of year-to-year increases.

In the group of girls, the applied Kruskal-Wallis Analysis of Variance showed significant differences in the compared subgroups only in the variables assessing the proportion of active mass, similarly as in the groups of boys (FFM - $H_{2,128} = 21.545$, $p = 0.001$; FFMI - $H_{2,128} = 11.137$, $p = 0.004$; SSM - $H_{2,128} = 22.329$, $p = 0.001$). By multiple comparisons, only year-to-year differences in S1 and S2 groups were determined as significant. Based on the results of multiple comparisons and mean values, we can conclude that after the age of 13 years, a stagnation in the natural increases in these parameters was observed. In contrast to the groups of boys, in the groups of girls it is evident that the proportion of inactive mass increases with increasing age.

However, the observed trend was not sufficiently strong in the monitored age groups to be statistically significant. Comprehensive results of the age factor in monitored changes in body composition indicators are presented in Table 2.

As reported by Siervogel et al. (2003) during early adolescence or puberty, dramatic hormonal fluctuations as well as a rapid growth in body size occur and are accompanied by marked changes in body composition. Our results confirm this statement in the group of girls, as a trend of gradual increase in the vast majority of body composition indicators over the observed period of 10 - 15 years was found. The most commonly assessed parameter of adiposity is the percentage of body fat (PBF). In the group of girls, this indicator was manifested by a gradual increase in values with its significant slowing down (even stagnation) at the end of the observation period. On the contrary, in the group of boys, no trend was identified - in the first half there was an increase, in the second half the opposite decrease of this value. The described results of girls are in full agreement with the results of Myrtaj et al. (2018). López-Sánchez et al. (2019) monitored this indicator in a group of girls and boys aged 7-19 years. In the age groups equivalent to our research, they observed a gradual decrease in this parameter for the group of boys. For girls, they also described a decrease in PBF with a value plateau in mean values at the age of 13 - 15 years. The results are also supported by the research by Rodríguez et al. (2004), who, through anthropometric measurements (four skinfolds) for boys aged 13 - 15 years, captured a decline in PBF with respect to age as well as sexual maturity ratings (Tanner puberty stage). Durá-Travé et al. (2020) monitored groups of boys and girls in the age range 10-14 years. In terms of PBF and FMI values, they reported a gradual increase with respect to age in girls. On the contrary, in boys the age differences were accompanied by decrease in the mean values.

At the end of the assessed period (14-15-year-old girls), a decrease in the parameters of VFA in girls was identified. In boys, the decrease at the end of the period showed in all observed indicators assessing adiposity. This may be the result of changes in dietary habits. As reported by Bitar et al. (2000), there are significant increases in the energy requirements of boys (that are sex-dependent) in early stage of puberty. The increase in adiposity in the first part of puberty is attributed to the gradual processes of adaptation of the body to increased nutrient intake.

Table 2. Values of body composition indicators and their comparison between the subgroups in relation to age

sex	*variable*	*group*	*Me*	*QD*	*min*	*max*	*multiple comparison*
Boys	FM *(kg)*	S1	7.2 ns.	7.7	2.7	34.7	
		S2	10.2	5.6	2.9	51.4	
		S3	9.4	6.5	2.9	42.6	
	FMI *(kg.m^{-2})*	S1	2.9 ns.	3.1	1.3	12.8	
		S2	3.9	1.8	1.1	19.7	
		S3	2.9	1.8	0.9	13.2	
	PBF *(%)*	S1	17.4 ns.	10.9	9.6	41.9	
		S2	20.6	6.6	6.2	49.7	
		S3	14.0	5.4	5.6	42.1	
	VFA *(cm^2)*	S1	37.5 ns.	35.6	5.5	163.7	
		S2	46.3	20.9	12.1	212.0	
		S3	41.3	27.7	5.0	152.1	
	FFM *(kg)*	S1	33.1*	6.6	22.7	49.9	S1 vs. S2 S2 vs. S3
		S2	40.0	7.6	21.5	69.5	
		S3	54.5	5.8	32.8	71.2	
	FFMI *(kg.m^{-2})*	S1	13.8*	1.5	12.0	18.3	S2 vs. S3
		S2	15.5	1.6	10.7	23.3	
		S3	17.7	1.6	14.5	22.9	
	SMM *(kg)*	S1	17.8*	3.9	11.5	27.5	S1 vs. S2 S2 vs. S3
		S2	21.8	4.5	10.4	39.7	
		S3	30.7	3.4	17.6	41.1	
Girls	FM *(kg)*	S1	8.6 ns.	4.4	2.8	32.9	
		S2	12.1	5.0	2.1	43.1	
		S3	13.2	5.8	5.4	41.0	

FMI *(kg.m^{-2})*	S1	3.4 $^{ns.}$	2.2	1.3	15.2	
	S2	4.7	2.3	0.9	16.8	
	S3	4.9	1.9	2.1	14.6	
PBF *(%)*	S1	19.0 $^{ns.}$	7.9	9.3	47.7	
	S2	24.2	7.4	6.9	49.7	
	S3	24.6	5.6	13.7	45.1	
VFA *(cm^2)*	S1	36.3 $^{ns.}$	26.0	5.0	153.8	
	S2	53.2	24.7	5.0	192.5	
	S3	48.7	26.5	13.7	164.9	
FFM *(kg)*	S1	33.1*	4.5	25.7	44.7	S1 vs. S2
	S2	38.8	2.9	24.0	49.1	
	S3	39.6	4.7	29.7	50.1	
FFMI *(kg.m^{-2})*	S1	14.0*	1.1	11.7	17.2	S1 vs. S2
	S2	15.1	0.9	12.5	18.8	
	S3	14.8	1.2	12.1	18.2	
SMM *(kg)*	S1	17.5*	2.6	13.2	24.4	S1 vs. S2
	S2	21.0	1.7	12.2	27.0	
	S3	21.6	2.8	15.5	27.7	

Note: *Me* – median; *QD* – quartile deviation; * Kruskal-Wallis ANOVA significant differences p <0.05; *ns* - Kruskal-Wallis ANOVA non-significant differences

In the evaluation of FFM and FFMI, active mass indicators, an increase in these parameters with increasing age was observed, which is in agreement with the results of Durá-Travé et al. (2020). The result is in conformity to the well-known facts of ontogeny that puberty is characterized by the development of strength, when, for example, in boys there are 27-40% muscle gains (Malina & Bouchard, 1991).

To conclude, the results are consistent with Siervogel et al. (2003), who reported that pubertal development involves the chemical maturation of body tissues, including the amount and distribution of adipose tissue, and increases in bone mass and fat-free lean tissue mass.

The comparison of selected body composition indicators of pupils with respect to their gender in the selected age subgroups is shown in Table 3. In the groups of 10-11-year-old (S1) and 12-13-year-old children (S2), no significant differences in any of the studied variables (p>0.05) were observed. When analysing the median values of these subgroups, we see that in the indicators assessing adiposity (FM, FMI, PBF, VFA), girls always had a higher proportion compared to boys. Concerning the active mass parameters (FFM, FFMI and SMM), their representation with respect to sex was more or less the same. Thus, we can conclude that a higher representation of inactive components of body composition was found in girls at the age of 10-13 years. Significant differences, in terms of the gender factor, found using the statistical method of Mann-Whitney U test, were seen in most of the observed indicators in the age groups of 14-15-year-old pupils. Significantly higher proportion of relative values of fat (FMI and PBF) was found in the group of girls; on the contrary, significantly higher representation of active components of FFM, FFMI and SMM was measured in boys of this age group.

Table 3. Results of analysis of differences in body composition indicators between groups divided according to sex

group		FM (kg)	FMI ($kg.m^{-2}$)	PBF (%)	VFA (cm^2)	FFM (kg)	FFMI ($kg.m^{-2}$)	SMM (kg)
S1	M-W U	292.0	302.5	292.5	283.5	288.0	266.0	285.5
	p	0.754	0.914	0.762	0.632	0.696	0.411	0.660
S2	M-W U	873.0	848.5	806.5	998.0	879.0	896.5	878.0
	p	0.227	0.161	0.083	0.825	0.246	0.307	0.243
S3	M-W U	426.0	352.0	237.5	495.0	66.0	172.5	66.0
	p	0.075	0.007	0.001	0.354	0.001	0.001	0.001

Note: M-W U – Mann-Whitney U test criterion; p – statistical significance

Maynard et al. (2001) reported that the period of early adolescence typically presents significant sexual dimorphism, not only in the timing of pubertal events, but also in body composition. Consistent with our results, Tovar-Galvez et al. (2017) presented that girls had higher mean body fat levels. This dimorphism manifests in the form of higher subcutaneous fat values in girls compared with boys. Similarly, López-Sanchéz (2019) mentioned that girls showed higher medium values of fat mass than boys. The fat mass in the female gender was higher in all age groups, showing significant differences in adolescence time from 13 to 19 years of age. Our results are in line with the findings by Rosenfield (2002), who stated that the most obvious and most prominent differential effect of sex hormones at puberty is the stimulation of linear growth and development of muscle bulk in boys and fat accumulation and bone maturation in girls. Females experience lesser increment in stature and muscle mass, but a significant accumulation of body fat. Fat accumulation resumes in both sexes, but it is twice as rapid in girls (Goswami et al., 2014). However, Rodríguez et al. (2004) point out that adolescence is a particular period of life in which body composition change dramatically when puberty appears and, therefore, the amount of body fatness and its distribution pattern may be more strongly related to gender and pubertal development stage.

CONCLUSIONS

1. The results indicate that the age factor is more pronounced in boys compared to girls in terms of natural increases in active body mass. This is more remarkable across puberty, which was confirmed by significant increases found in the monitored groups.
2. In girls, the natural increase in active body mass is evident only in the first half of puberty and then slows down. In the case of inactive body mass, the trend of its increase across the observed period (age 10 - 15 years) is visible only in the group of girls.
3. No trend patterns are noticeable in boys. As can be inferred from the results, the gender factor produces significant differences only in the final phase of puberty, highlighting the predominance of adipose tissue in the body of girls with a predominance of active mass in boys.

REFERENCES

1. *Baumgartner, R.N., et al. (1998). Epidemiology of sarcopenia among the elderly in New Mexico. American Journal of Epidemiology, 147(8), 755–763. https://doi.org/10.1093/oxfordjournals.aje.a009520.*
2. *Bitar A., et al. (2000). Longitudinal changes in body composition, physical capacities and energy expenditure in boys and girls during the onset of puberty. European Journal of Nutrition, 39(4), 157–163. doi:10.1007/s003940070019.*
3. *Bridger Staatz, C., et al. (2021). Socioeconomic position and body composition in childhood in high- and middle-income countries: a systematic review and narrative synthesis.*

International Journal of Obesity, (45), 2316–2334. https://doi.org/10.1038/s41366-021-00899-y.

4. *Durá-Travé, T., et al. (2020). Reference values of fat mass index and fat-free mass index in healthy Spanish adolescents. Nutrición hospitalaria, 37(5), 902-908. doi: 10.20960/nh.03161.*
5. *Gáborová, Ľ., Porubčanová, D. (2017). Vývinová psychológia (Developmental psychology). Brno: Tribun, EU s.r.o.. ISBN 978-80-263-1332-8.*
6. *Goswami, B., et al. (2014). Impact of Pubertal Growth on Physical Fitness. American Journal of Sports Science and Medicine, 2(5A), 34-39. DOI: 10.12691/ajssm-2-5A-8.*
7. *Harriss, D. J., MacSween, A., Atkinson, G. (2019). Ethical Standards in Sport and Exercise Science Research: 2020 Update. International journal of sports medicine, 40(13), 813–817. https://doi.org/10.1055/a-1015-3123.*
8. *Kyle, U.G., et al. (2004). Bioelectrical impedance analysis-part I: review of principles and methods. Clinical Nutrition, (Edinburgh, Scotland), 23(5), 1226–1243. https://doi.org/10.1016/j.clnu.2004.06.004.*
9. *López-Sánchez, G.F., et al. (2019). Body Composition in Children and Adolescents Residing in Southern Europe: Prevalence of Overweight and Obesity According to Different International References. Frontiers in Physiology. 10. doi: 10.3389/fphys.2019.00130.*
10. *Malina, R.M., Bouchard, C. (1991). Growth, maturation, and physical activity, Champaign, IL: Human Kinetics.*
11. *Maynard, L.M., et al. (2001). Childhood body composition in relation to body mass index. Pediatrics, 107(2), 344–350. doi:10.1542/peds.107.2.344.*
12. *Mytraj, N., et al. (2018). Anthropometry and Body Composition of Adolescents in Macedonia. International Journal of Morphology, 36(4), 1398-1406. http://dx.doi.org/10.4067/S0717-95022018000401398.*
13. *Nevill, A.M., et al. (2021). BMI Fails to Reflect the Developmental Changes in Body Fatness between Boys and Girls during Adolescence. International Journal of Environmental Research and Public Health, 18(15), 7833. doi: 10.3390/ijerph18157833.*
14. *Nittari, G., et al. (2020). Epidemiology of obesity in children and adolescents. Teamwork in Healthcare. IntechOpen. doi: 10.5772/intechopen.93604.*
15. *Norris, S.A., et al. (2022). Nutrition in adolescent growth and development. Lancet (London, England), 399(10320), 172–184. https://doi.org/10.1016/S0140-6736(21)01590-7.*

16. *Patton, G.C., et al. (2016). Our future: A Lancet commission on adolescent health and wellbeing. The Lancet, 387(10036), 2423–2478. https://doi.org/10.1016/S0140-6736(16)00579-1.*
17. *Prentice, A.M. (2006). The emerging epidemic of obesity in developing countries. International Journal of Epidemiology, 35(1), 93-99. doi:10.1093/ije/dyi272.*
18. *Rodríguez, G., et al. (2004). Body composition in adolescents: measurements and metabolic aspects. International Journal of Obesity, 28(S3), 54–58. https://doi.org/10.1038/sj.ijo.0802805.*
19. *Rosenfield, R.L. (2002). Puberty in the female and its disorder. Pediatric endocrinology, M.A. Sperling, Philadelphia: Southern, 455-518.*
20. *Siervogel, R.M., et al. (2003). Puberty and Body Composition. Hormone Research, 60 (Suppl. 1), 36–45. https://doi.org/10.1159/000071224.*
21. *Simmonds, M., Llewellyn, A., Owen, C. G., & Woolacott, N. (2015). Predicting adult obesity from childhood obesity: a systematic review and meta-analysis. Obesity Reviews, 17(2), 95–107. doi:10.1111/obr.12334.*
22. *Tovar-Galvez, M.I. et al. (2017). Composición corporal en escolares: comparación entre métodos antropométricos simples e impedancia bioeléctrica. Endocrinología, Diabetes y Nutrición, 64(8), 424–431. doi:10.1016/j.endinu.2017.05.011.*
23. *Vadasova, B., et al. (2016). Overweight and obesity in Slovak high school students and body composition indicators: a non-randomized cross-sectional study. BMC Public Health 16, 808. https://doi.org/10.1186/s12889-016-3508-9.*
24. *Wabitsch, M., Moss, A., Kromeyer-Hauschild, K. (2014). Unexpected plateauing of childhood obesity rates in developed countries. BMC Medicine, 12, 17. https://doi.org/10.1186/1741-7015-12-17.*
25. *World Health Organization. (2021a, June 9). Obesity and Overweight. https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight.*
26. *World Health Organization. Regional Office for Europe. (2021). WHO European Childhood Obesity Surveillance Initiative (COSI) Report on the fourth round of data collection, 2015–2017. https://apps.who.int/iris/handle/10665/341189.*