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RESEARCH ARTICLE

Changes in the adiposity level and prevalence of overweight/obesity among children from Kraków (Poland) within the last decade (from 2010 to 2020)

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Abstract

The aim of this study was to assess the changes in the prevalence of overweight, obesity and high adiposity in children and adolescents from Krakow (Poland), between the years 2010 and 2020. Two cross-sectional series of anthropometric measurements were carried out in 2010 and 2020. Analysed characteristics included: body height and weight, BMI (Body Mass Index), body adiposity (%BF). The subjects were categorised according to their BMI (underweight, normal weight, overweight, obesity), as well as %BF (low, normal, high body fat).The research was conducted in randomly selected primary schools in Krakow (Poland). Studied cohorts (8-15 years of age), which represented four of the traditional residential districts: Śródmieście, Podgórze, Krowodrza and Nowa Huta. Among the girls, there was a negative secular trend regarding the prevalence of underweight and obesity. On the other hand, there also was a positive trend concerning the prevalence of overweight and low and high body fat. In boys, there was a negative secular trend regarding the prevalence of underweight and low adiposity. There was also a generally positive secular trend regarding the prevalence of overweight, obesity as well as high adiposity in boys. The findings of this study are particularly significant because detailed knowledge of the prevalence of overweight/obesity in childhood and adolescence is crucial for the future health of entire populations. Further studies should also take into account the levels of physical fitness and activity of the examined population.

Keywords: overweight; obesity; adiposity; children

Introduction

Sensitivity of human growth and development to environmental factors, and thus also to socio-economic modifiers, has been demonstrated in many studies (Eveleth & Tanner, 1976; Komlos & Baten, 2004; Perkins et al., 2016). Thus, different environmental factors are mirrored in changing proportions, size and tissue composition of the body of children and adolescents, in subsequent generations. They are therefore also reflected in the form of secular trends regarding Body Mass Index (BMI) and adiposity (Kowal et al., 2014; Kryst et al., 2012; Marques-Vidal et al., 2008).

Regrettably, considerable progress of civilisation, and thus improvement of the living conditions, is also one of the primary causes of the growing prevalence of overweight and obesity, as well as excess adiposity (Hales et al., 2017; Johansson et al., 2020; Kalies et al., 2002; Skinner et al., 2016; Vijayakumar et al., 2018; Wedderkopp et al., 2004; World Health Organisation [WHO], 2017). This problem was documented in many countries and concerned also the Polish population. Unfortunately, Poland, in comparison to other European countries, was recently characterised

as having moderate to high levels of overweight and obesity among children and adolescents (Huang et al., 2020; Kułaga et al., 2016). Mentioned secular increase in the prevalence of excess body mass was also noted, for example, in a population of 14-17-year-olds from New Delhi. Importantly, in the same group, there was also a decrease in the prevalence of underweight (Gupta et al., 2011). Furthermore, a similar tendency was noted among Chinese children and adolescents, where the prevalence of overweight increased from 4.3% in 1995 to 18.4% in 2014. It should also be mentioned, that this change coexisted with a secular increase in the incidence of high blood pressure (Dong et al., 2018). Continued, linear, intergenerational increase of the prevalence of excess body mass was noted also in three states of Australia, with the highest observed percentages of 30.2% and 24.3% for overweight and obesity respectively (Ho et al., 2017). Additionally, in Italy, across 20 years, there was a positive trend regarding the body weight of children (Costa de Miranda et al., 2019).

At the same time, in a recent study regarding intergenerational changes in the prevalence of excess body mass and adiposity among preschoolers from Kraków, there was a secular decrease in the prevalence of both of the mentioned problems. Moreover, the prevalence of underweight and low adiposity was also reduced in the more contemporary cohort. Described tendencies were also mirrored by a secular increase in the percentage of preschoolers in the category of normal BMI and body fat ratio (Żegleń et al., 2019). Obviously, such phenomena seem to be extremely favourable, thus, it will be beneficial to investigate, if they are present also in older age groups. Especially, as the secular trends noted in preschoolers often differ, either in size or direction, from those noted for in older children and adolescents (Pavlica et al., 2018).

Additionally, studies concerning issues of body mass and tissue composition among children and adolescents are crucial. It is due to the fact, that excess body mass, as well as adiposity, is associated with an increased risk of dyslipidemia, hypertension, non-alcoholic fatty liver disease, obstructive sleep apnea, polycystic ovarian syndrome, and psychological problems in childhood (Kim & Moon, 2020). Moreover, the presence of excess weight as well as body fat can have a significant influence on the pubertal development in girls, as well as boys, which adds to the importance of exploring mentioned topics among adolescents (Colmenares et al., 2014; Huang et al., 2020).

Similar studies are also crucial for assessing the effectiveness of prevention and intervention programs that, in recent years, were applied in many countries, to battle or prevent the incidence of excess body mass and adiposity among youth (Salanave et al., 2009; Shirasawa et al., 2015; Xiao et al., 2015). In 2016 such program was introduced also in Poland. The "National Health Program" has the main goal of fighting against overweight and obesity in children and adolescents by focusing mainly on the promotion of physical activity and a healthy lifestyle (Ministry of Health, 2016).

The aim of this study was to assess the changes in the prevalence of overweight and obesity, as well as high adiposity in children and adolescents (8-15 years of age) from Kraków (Poland), between the years 2010 and 2020.

Material and methods

Children and adolescents included in the study group were examined during two cross-sectional surveys carried (in 2010 and 2020). Both of the surveys were carried out in randomly selected primary schools in Kraków (Poland), located in four of the traditional residential districts: Śródmieście, Podgórze, Krowodrza and Nowa Huta, with the consent of the school's management. Inclusion to the study group was based on the written consent of the parents/legal guardians as well as verbal consent of the participants themselves.

The range of the exact calendar age of the subjects was7.50 to 15.49 years. It was calculated as a difference between the date of the survey and the birth date and expressed as a decimal fraction.

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The exact calendar age was a basis for classifying each participant into one of 8 age groups (i.e. the category of 11-year-olds included children whose calendar age ranged from 10.50 to 11.49 years).

The 2010 series consisted of 1926 individuals (990 boys and 936 girls) and the one from 2020 included 1850 children and adolescents (886 boys and 964 girls) (Tab.1). Data for the project was collected between 2019-20 and the measurements were completed before the lockdown associated with COVID-19 pandemic began. Similarly, earlier data was collected in 2009-10.

Body height was obtained using an anthropometer (accuracy 1 mm; GPM, Switzerland) and body weight was measured with an electronic scale manufactured by Tanita (Japan) (accuracy 0.1 kg, model BC-418, with adiposity measurement corrected for age). BMI (Body Mass Index) was calculated according to the following formula: body weight /body height^2, where body weight was expressed in kilograms and body height in meters. Participants were categorised as having underweight, normal weight, overweight or obesity according to Cole's cut off points (Cole et al., 2000, 2007).

The percentage of body fat was measured by the bioimpedance method, using the previously mentioned electronic scale (Tanita; Japan; accuracy 0.1%). The subjects were then categorised according to their body fat ratio, as characterized by low ($\leq$ -1 z-score), normal (-1-1 z-score) or high ($\geq$ 1 z-score) adiposity.

Intergenerational changes regarding the prevalence of each bodyweight and adiposity category, within the age groups, were analyzed by using the Chi^2 test.

Statistical analyses were performed using Statistica 13.0 and StatsDirect 3.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Bioethics Committee of the Regional Medical Association in Kraków (5/KBL/OIL/2019).

Results

Girls

Among girls, there was a decrease in the prevalence of underweight in all of the age categories, as well as the entire group (Table 2). However the change was only statistically significant for the whole group, regardless of age. On the other hand, in the majority of the age groups, except for 9 and 13-year-olds, there was an increase in the prevalence of overweight. In half of the age groups, there also was a decrease in the prevalence of obesity, but there was an increase among 8, 10, 11 and 14-year-olds. In the case of adiposity, besides the youngest age category, there was an increase in the prevalence of low body fat. The observed change differences was statistically significant among 10-year-olds, as well as in the whole group, regardless of age. Contemporary girls were also generally characterised by a slightly higher prevalence of high adiposity, in comparison to their peers examined in 2010. Exceptions to this tendency were noted at 8, 9 and 13 years of age.

Boys

Similarly to what was observed among girls, contemporary boys were overall characterised by a lower prevalence of underweight than their counterparts from 2010 (Table 3). The change was statistically significant only at 11 years of age. Once again, there was also an increase in the prevalence of overweight, which concerned all age groups apart from 9, 10 and 14-year olds. However there was a substantial and statistically significant decrease in the prevalence of overweight at age 10. In the majority of the boys' age categories, there was a decrease in the prevalence of obesity. The same tendency was also noted regardless of age. However there was an increase among 12 year olds. There was an increase in the prevalence of low adiposity among 8, 11, 13 and 14 year old boys (as well as overall), and a decrease in the prevalence of high adiposity among 10, 12 and 13 year old boys (as well as overall).

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Table 1. Selected characteristics of the examined group

		♀			♂		
Age category [yrs.]	Cohort	Number of individuals	Mean (range) body mass [kg]	Mean (range) percentage of body fat [%]	Number of individuals	Mean (range) body mass [kg]	Mean (range) percentage of body fat [%]
8	2010	102	27.7 (19.0–47.9)	22.4 (16.5–35.9)	128	19.8 (20.5–48.2)	20.9 (12.4–42.6)
	2020	130	28.1 (17.5–49.1)	20.1 (8.2–38.9)	106	28.9 (20.4–45.9)	18.0 (5.0–34.6)
9	2010	111	31.7 (19.9–58.5)	23.4 (15.2–35.0)	134	33.6 (19.8–73.1)	21.9 (13.0–37.1)
	2020	115	30.7 (21.0–53.8)	19.6 (7.4–34.0)	123	32.0 (19.7–53.7)	17.5 (9.5–35.9)
10	2010	98	35.0 (21.1–56.6)	23.9 (16.4–42.8)	94	36.7 (25.2–62.5)	20.9 (12.5–39.1)
	2020	162	35.6 (21.8–65.5)	20.7 (8.9–42.8)	145	35.4 (19.4–67.2)	16.7 (7.2–41.2)
11	2010	96	38.8 (25.5–62.6)	23.2 (16.3–37.2)	81	38.6 (25.7–108.9)	19.6 (10.1–51.0)
	2020	170	38.8 (24.4–74.4)	19.9 (8.9–38.2)	115	40.5 (24.4–70.8)	16.9 (5.7–38.8)
12	2010	81	44.9 (27.3–76.9)	23.0 (14.3–40.8)	82	42.8 (26.2–67.2)	19.3 (11.6–34.2)
	2020	107	44.8 (30.4–66.3)	21.4 (9.5–35.9)	110	46.3 (23.6–81.0)	16.5 (5.0–42.9)
13	2010	101	51.0 (34.2–82.3)	24.5 (13.6–41.0)	95	52.3 (34.2–98.5)	19.2 (10.1–41.6)
	2020	87	49.3 (34.4–84.5)	21.8 (6.1–38.7)	115	51.4 (32.3–89.6)	14.9 (5.0–45.0)
14	2010	186	53.5 (31.9–94.5)	25.5 (14.7–40.4)	221	60.0 (32.5–111.0)	18.4 (10.0–44.8)
	2020	93	55.2 (35.0–76.5)	24.3 (8.3–45.5)	79	57.9 (36.7–105.2)	12.7 (5.0–26.2)
15	2010	161	55.0 (40.5–92.8)	25.8 (15.7–37.9)	155	61.7 (40.7–108.7)	16.9 (9.9–38.7)
	2020	100	57.8 (38.7–89.3)	24.3 (8.3–45.5)	93	63.9 (42.7–116.0)	13.0 (5.0–41.5)

Table 2. Percentages of children of each BMI and adiposity statuses in 2010 and 2020 cohorts and their differences (girls)

		BMI						Adiposity			
Age category	Cohort	Underweight n [%]	Change overtime (2020 vs 2010) [%]	Overweight N [%]	Change overtime (2020 vs 2010) [%]	Obesity n [%]	Change overtime (2020 vs 2010) [%]	Low n [%]	Change overtime (2020 vs 2010) [%]	High n [%]	Change overtime (2020 vs 2010) [%]
8	2010	17 [16.7]	−5.9	19 [18.6]	1.4	3 [2.9]	2.4	16 [16.0]	−7.7	15 [15.0]	−3.9
	2020	14 [10.8]		26 [20.0]		7 [5.4]		18 [8.3]		24 [11.1]	
9	2010	13 [11.7]	−0.4	19 [17.1]	−1.5	7 [6.3]	−5.4	13 [11.8]	4.8	22 [20.0]	−0.7
	2020	13 [11.3]		18 [15.7]		1 [0.9]		19 [16.7]		22 [19.3]	
10	2010	12 [12.2]	−4.2	15 [15.3]	2.0	2 [2.0]	1.7	8 [8.2]	17.0 ($p < 0.001$)	15 [15.3]	2.0
	2020	13 [8.0]		28 [17.3]		6 [3.7]		32 [25.2]		22 [17.3]	
11	2010	12 [12.5]	−3.1	9 [9.4]	2.4	2 [2.1]	0.3	11 [11.6]	8.2	13 [13.7]	4.8
	2020	16 [9.4]		20 [11.8]		4[2.4]		32 [19.8]		30 [18.5]	
12	2010	12 [14.8]	−8.3	10 [12.3]	7.3	3 [3.7]	−3.7	10 [12.3]	7.3	11 [13.6]	6.0
	2020	7 [6.5]		21 [19.6]		0 [0.0]		21 [19.6]		21 [19.6]	
13	2010	11 [10.9]	−2.7	14 [13.9]	−6.8	5 [5.0]	−2.6	14 [14.0]	2.3	17 [17.0]	−1.9
	2020	7 [8.2]		6 [7.1]		2 [2.4]		14 [16.3]		13 [15.1]	
14	2010	17 [9.1]	−2.7	24 [12.9]	7.5	7 [3.8]	−0.5	22 [12.0]	3.3	30 [16.3]	0.0
	2020	6 [6.5]		19 [20.4]		3 [3.2]		14 [15.2]		15 [16.3]	
15	2010	20 [12.4]	−2.4	16 [9.9]	4.1	2 [1.2]	4.8	24 [15.2]	0.0	24 [15.2]	1.0
	2020	10 [10.0]		14 [14.0]		6 [6.0]		15 [15.2]		16 [16.2]	
Total	2010	114 [12.2]	−3.2 ($p < 0.05$)	126 [13.5]	2.3	31 [3.3]	−0.3	118 [12.7]	3.7 ($p < 0.001$)	147 [15.9]	0.4
	2020	86 [8.9]		152 [15.8]		29 [3.0]		165 [16.5]		163 [16.3]	

Table 3. Percentages of children of each BMI and adiposity statuses in 2010 and 2020 cohorts and their differences (boys)

		BMI						Adiposity			
Age category	Cohort	Underweight [%]	Change overtime (2020 vs 2010) [%]	Overweight [%]	Change overtime (2020 vs 2010) [%]	Obesity [%]	Change Overtime (2020 vs 2010) [%]	Low [%]	Change overtime (2020 vs 2010) [%]	High [%]	Change overtime (2020 vs 2010) [%]
8	2010	11[8.6]	−3.9	16 [12.5]	4.5	10 [7.8]	−3.1	9 [7.1]	5.4	19 [15.0]	1.4
	2020	5 [4.7]		18 [17.0]		5 [4.7]		13 [12.5]		17 [16.3]	
9	2010	11 [8.2]	1.5	33 [24.6]	−9.2	10 [7.5]	−2.6	23 [17.2]	−2.5	22 [16.4]	0.7
	2020	12 [9.8]		19 [15.4]		6 [4.9]		18 [14.6]		21 [17.1]	
10	2010	5 [5.3]	5.0	26 [27.7]	−13.9 ($p < 0.01$)	5 [5.3]	−0.5	15 [16.0]	−3.5	17 [18.1]	−5.0
	2020	15 [10.3]		20 [13.8]		7 [4.8]		18 [12.4]		19 [13.1]	
11	2010	16 [19.8]	−11.9 ($p < 0.05$)	13 [16.0]	2.2	3 [3.7]	0.6	7 [8.6]	3.5	10 [12.3]	5.0
	2020	9 [7.8]		21 [18.3]		5 [4.3]		14 [12.2]		20 [17.4]	
12	2010	14 [17.1]	−9.8	13 [15.9]	2.3	0 [0.0]	5.5 ($p < 0.05$)	13 [15.9]	−4.9	18 [22.0]	−9.2
	2020	8 [7.3]		20 [18.2]		6 [5.5]		12 [10.9]		14 [12.7]	
13	2010	8 [8.4]	−0.7	18 [18.9]	6.1	4 [4.2]	−0.8	9 [9.5]	6.5	16 [16.8]	−4.5
	2020	9 [7.8]		29 [25.0]		4 [3.4]		18 [15.9]		14 [12.4]	
14	2010	11 [5.0]	−1.2	52 [23.5]	−2.0	14 [6.3]	−3.8	24 [10.9]	1.8	36 [16.3]	0.2
	2020	3 [3.8]		17 [21.5]		2 [2.5]		10 [12.7]		13 [16.5]	
15	2010	10 [6.5]	0.0	21 [13.5]	2.6	6 [3.9]	1.5	15 [9.7]	−2.1	19 [12.3]	0.8
	2020	6 [6.5]		15 [16.1]		5 [5.4]		7 [7.6]		12 [13.0]	
Total	2010	86 [8.7]	−1.1	192 [19.4]	−1.5	52 [5.3]	−0.7	115 [11.6]	0.9	157 [15.9]	−1.1
	2020	67 [7.6]		159 [17.9]		40 [4.5]		110 [12.5]		130 [14.8]	

Discussion

In the present study, there was a generally increasing secular trend regarding the prevalence of overweight for girls, which was slightly higher in children and adolescents examined in 2020 in comparison to their peers measured in 2010. In the case of boys, however, there was a reduction in the prevalence of overweight. There was a trend towards decreasing prevalence of obesity in the case of both girls and boys, though, it should also be mentioned that observed differences, for the most part, were not statistically significant. This may suggest stabilization of intergenerational changes previously noted among children and adolescents from Kraków (Kowal et al., 2013, 2015). This, at least to some extent, is in line with secular changes observed recently among preschoolers (3-7 years of age) from the same population (Żegleń et al., 2019). This is an interesting observation, especially considering the fact that it has been suggested in the literature, that secular trends observed among preschool children usually have different magnitude and directions in comparison to older age categories (Pavlica et al., 2018; Żegleń et al., 2020).

The stabilisation of secular trends regarding the prevalence of excess body weight was noted also in the USA (Ryu et al., 2019). The intergenerational decrease in childhood overnutrition, which particularly corresponds to the presently noted declining secular trend in the prevalence of obesity, was observed also in the Mediterranean area of Southeast Spain (Pastor-Fajardo et al., 2020). Moreover, similar findings were presented in other European countries participating in the Childhood Obesity Surveillance Initiative (COSI), as well as the Spanish ALADINO study (Ministerio de Sanidad, 2016; Pastor-Fajardo et al., 2020; Spinelli & Nardone, 2018; WHO, 2018; Wijnhoven et al., 2014).

These findings are in line with results of other studies, where the overnutrition was more prevalent in boys, in comparison to girls (NCD RiskFactor Collaboration, 2017; Miqueleiz et al., 2016; Ministerio de Sanidad, 2016; Ng et al., 2014; Pastor-Fajardo et al., 2020; Wijnhoven et al., 2014). In literature, the occurrence of such a phenomenon has been attributed to differences in body composition, particularly in muscle mass. Additionally, said discrepancies have been suggested to be influenced by a different perception of weight observed in both sexes (Ramiro-González et al., 2017; Salcedo et al., 2010).

Presently noted trends regarding the body mass, especially those observed for underweight and overweight, were mirrored in the intergenerational changes regarding the prevalence of high and low adiposity. However, similarly to what was observed in the case of body mass, said discrepancies between both cohorts were, for the most part, statistically insignificant, which may suggest stabilization of prior trends (Kowal et al., 2013, 2014; Kryst et al., 2018). Conversely, in recent years, in other studies concerning the Polish population, there was a significant tendency toward an increasing prevalence of high adiposity, which was particularly evident among girls (Durda-Masny et al., 2019; Saczuk et al., 2018).A secular increase of adiposity, especially in the waist area, has also been noted in a population from the United Kingdom. Interestingly, it was observed independently of the changes noted for the BMI. However, it is also worth noting that it coexisted with the rise in low high-density lipoprotein cholesterol prevalence (Johnson et al., 2020). Additionally, similar tendencies, also regarding especially the subcutaneous fat tissue allocated in the abdominal area, were also observed among adolescents from Russia (Godina et al., 2016).

It has been suggested in the literature that stabilization of previous, increasing secular trends regarding the prevalence of excess body mass and adiposity may be associated with the implementation of public health measures aimed to prevent pediatric obesity (Ministerio de Sanidad, 2016; Pastor-Fajardo et al., 2020; Salanave et al., 2009; Shirasawa et al., 2015; Xiao et al., 2015). In 2016 such program has been introduced also in Poland by the Ministry of Health. The National Health Program focuses mainly on the promotion of physical activity among children and adolescents (Ministry of Health, 2016). Thus, it is quite possible that currently noted secular changes may be among the benefits of said program. Other possible explanations of the mentioned stabilisation of intergenerational trends may be associated with saturation levels and reaching the population

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balance (Bygdell et al., 2017). On the other hand, it should also be stressed, that current findings may be a part of the transitory phase which can be the beginning of a future trend. Especially, as the presence of alternating phases of decrease, stabilization and increase concerning particular features has been demonstrated in previous research (Pastor-Fajardo et al., 2020; Salcedo et al., 2010). Lastly, presently noted results may be associated with socioeconomic changes occurring over the last decade in Polish society. Between the years 2010 and 2020, there was a decrease in the unemployment rate (from around 9% to about 6%) as well as in the at-risk-of poverty rate (from 20.5% in 2005 to 17.3%). Moreover, there was an increase in average salaries, GDP (Gross Domestic Product), as well as general education rate in society (Główny Urząd Statystyczny, 2018).

The findings of this study are particularly significant due to the fact, that detailed knowledge of the prevalence of overweight/obesity in childhood and adolescence is crucial for the future health of entire populations. It is due to the fact, that excess body mass and adiposity at an early age significantly increase the risk of developing disorders related to excessive weight in adulthood (de Onis et al., 2010; Dietz, 1998; Epstein, 1996; Piekorz et al., 2016; WHO, 2017). It should also be stressed, that changes regarding body mass, occurring in subsequent generations, should be investigated in the context of body composition. Further studies should also take into account the levels of physical fitness and activity of the examined population

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Conflicts of Interest. The authors have no conflicts of interest to declare.

Ethical Approval. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving research study participants were approved by the Bioethics Committee of the Regional Medical Association in Kraków (5/KBL/OIL/2019). Written informed consent was obtained from parents/ legal guardians of the subjects.

References

NCD Risk Factor Collaboration (NCD-RisC) (2017) Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128 million children, adolescents, and adults. *The Lancet* **390**, 2627–2642. https://doi.org/10.1016/S0140-6736(17)32129-3

Bygdell M, Ohlsson C, Célind J, Saternus J, Sondén A & Kindblom JM (2017) The rise and the recent decline of childhood obesity in Swedish boys: The BEST cohort. *International Journal of Obesity* **41**(5), 807–813. https://doi.org/10.1038/ijo.2017.23

Cole TJ, Bellizzi MC, Flegal KM & Dietz WH (2000) Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* **320**(7244), 1240–1243. https://doi.org/10.1136/bmj.320.7244.1240

Cole TJ, Flegal KM, Nicholls D & Jackson AA (2007) Body mass index cut offs to define thinness in children and adolescents: international survey. *BMJ* **335**(7612), 194. https://doi.org/10.1136/bmj.39238.399444.55

Colmenares A, Gunczler P & Lanes R (2014) Higher prevalence of obesity and overweight without an adverse metabolic profile in girls with central precocious puberty compared to girls with early puberty, regardless of GnRH analogue treatment. *International Journal of Pediatric Endocrinology* **2014**(1), 5. https://doi.org/10.1186/1687-9856-2014-5

Costa de Miranda R, Di Renzo L, Cupertino V, Romano L, De Lorenzo A, Salimei C & De Lorenzo A (2019) Secular trend of childhood nutritional status in Calabria (Italy) and the United States: the spread of obesity. *Nutrition Research* **62**, 23–31. https://doi.org/10.1016/j.nutres.2018.10.008

de Onis M, Blössner M & Borghi E (2010) Global prevalence and trends of overweight and obesity among preschool children. *The American Journal of Clinical Nutrition* **92**(5), 1257–1264. https://doi.org/10.3945/ajcn.2010.29786

Dietz WH (1998) Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics* **101**(3 Pt 2), 518–525. http://www.ncbi.nlm.nih.gov/pubmed/12224658

Dong Y, Ma J, Song Y, Ma Y, Dong B, Zou Z & Prochaska JJ (2018) Secular trends in blood pressure and overweight and obesity in Chinese boys and girls aged 7 to 17 years from 1995 to 2014. *Hypertension* **72**(2), 298–305. https://doi.org/10.1161/HYPERTENSIONAHA.118.11291

Durda-Masny M, Hanć T, Czapla Z & Szwed A (2019) BMI at menarche and timing of growth spurt and puberty in Polish girls – longitudinal study. *Anthropologischer Anzeiger* **76**(1), 37–47. https://doi.org/10.1127/anthranz/2019/0920

Epstein LH (1996) Family-based behavioural intervention for obese children. *International Journal of Obesity and Related Metabolic Disorders* **20** *Suppl* 1, S14-21. http://www.ncbi.nlm.nih.gov/pubmed/8646260

Eveleth PB & Tanner JM (1976) *Worldwide variation in human growth* (8th ed.). CUP Archive.

Główny Urząd Statystyczny (2018) *100 lat Polski w liczbach, 1918-2018.*

Godina EZ, Khomyakova IA& Zadorozhnaya LV (2016) Secular changes in body dimensions and sexual maturation in children of Arkhangelsk city. *Anthropologischer Anzeiger* **73**(1), 45–59. https://doi.org/10.1127/anthranz/2015/0599

Gupta DK, Shah P, Misra A, Bharadwaj S, Gulati S, Gupta N, Sharma R, Pandey RM & Goel K (2011) Secular Trends in Prevalence of Overweight and Obesity from 2006 to 2009 in Urban Asian Indian Adolescents Aged 14-17 Years. *PLoS ONE* **6**(2), e17221. https://doi.org/10.1371/journal.pone.0017221

Hales CM, Carroll MD, Fryar CD & Ogden CL (2017) Prevalence of Obesity Among Adults and Youth: United States, 2015-2016. *NCHS Data Brief* **288**, 1–8. http://www.ncbi.nlm.nih.gov/pubmed/29155689

Ho N-T-V S, Olds T, Schranz N & Maher C (2017) Secular trends in the prevalence of childhood overweight and obesity across Australian states: A meta-analysis. *Journal of Science and Medicine in Sport* **20**(5), 480–488. https://doi.org/10.1016/j.jsams.2016.09.014

Huang A, Reinehr T & Roth CL (2020) Connections between obesity and puberty. *Current Opinion in Endocrine and Metabolic Research* **14**, 160–168. https://doi.org/10.1016/j.coemr.2020.08.004

Johansson L, Brissman M, Morinder G, Westerståhl M & Marcus C (2020) Reference values and secular trends for cardiorespiratory fitness in children and adolescents with obesity. *Acta Paediatrica, International Journal of Paediatrics* **109**(8), 1665–1671. https://doi.org/10.1111/apa.15163

Johnson W, Norris T & Hamer M (2020) Secular changes in mid-adulthood body mass index, waist circumference, and low HDL cholesterol between 1990, 2003, and 2018 in Great Britain. *European Journal of Clinical Nutrition*. https://doi.org/10.1038/s41430-020-00758-5

Kalies H, Lenz J & von Kries R (2002) Prevalence of overweight and obesity and trends in body mass index in German pre-school children, 1982–1997. *International Journal of Obesity* **26**(9), 1211–1217. https://doi.org/10.1038/sj.ijo.0802013

Kim JH & Moon JS (2020) Secular Trends in Pediatric Overweight and Obesity in Korea. *Journal of Obesity & Metabolic Syndrome* **29**(1), 12–17. https://doi.org/10.7570/jomes20002

Komlos J & Baten J (2004) Looking Backward and Looking Forward: Anthropometric Research and the Development of Social Science History. *Social Science History* **28**(2), 191–210. https://doi.org/10.1215/01455532-28-2-191

Kowal M, Kryst Ł, Sobiecki J & Woronkowicz A (2013) Secular trends in body composition and frequency of overweight and obesity in boys aged 3–18 from Krakow, Poland, within the last 30 years (from 1983 to 2010). *Journal of Biosocial Science* **45**, 111–134. https://doi.org/10.1017/S0021932012000284

Kowal M, Kryst Ł, Woronkowicz A, Brudecki J & Sobiecki J (2015) Time trends in BMI, body fatness, and adiposity rebound among boys from Kraków (Poland) from 1983 to 2010. *American Journal of Human Biology* **27**(5), 646–653. https://doi.org/10.1002/ajhb.22704

Kowal M, Kryst Ł, Woronkowicz A & Sobiecki J (2014) Long-term changes in body composition and prevalence of overweight and obesity in girls (aged 3-18 years) from Kraków (Poland) from 1983, 2000 and 2010. *Annals of Human Biology* **41**(5), 415–427. https://doi.org/10.3109/03014460.2013.878394

Kryst Ł, Kowal M, Woronkowicz A, Sobiecki J & Cichocka BA (2012) secular changes in height, body weight, body mass index and pubertal development in male children and adolescents in Krakow, Poland. *Journal of Biosocial Science* **44**(04), 495–507. https://doi.org/10.1017/S0021932011000721

Kryst Ł, Woronkowicz A, Kowal M & Sobiecki J (2018) Long-term changes in fat distribution in children and adolescents aged 3-18 from Krakow (Poland), within the last 30 years (from 1983 to 2010). *Anthropological Rreview* **81**(2), 146–157. https://doi.org/10.2478/anre-2018-0013

Kułaga Z, Grajda A, Gurzkowska B, Wojtyło M, Góźdź M & Litwin M (2016) The prevalence of overweight and obesity among Polish school-aged children and adolescents. *Epidemiological Review* **70**(4), 641–651.

Marques-Vidal P, Madeleine G, Romain S, Gabriel A & Bovet P (2008) Secular trends in height and weight among children and adolescents of the Seychelles, 1956–2006. *BMC Public Health* **8**(1), 166. https://doi.org/10.1186/1471-2458-8-166

Ministry of Health (2016) *Narodowy Program Zdrowia*. https://www.gov.pl/web/zdrowie/narodowy-program-zdrowia1

Miqueleiz E, Lostao L & Regidor E (2016) Stabilisation of the trend in prevalence of childhood overweight and obesity in Spain: 2001-11. *European Journal of Public Health* **26**(6), 960–963. https://doi.org/10.1093/eurpub/ckw087

Ministerio de Sanidad (2016) *Estudio ALADINO 2015*. Ministerio de Sanidad, Servicios Sociales e Igualdad. https://www.aesan.gob.es/AECOSAN/docs/documentos/nutricion/observatorio/Estudio_ALADINO_2015.pdf

Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany EC, Biryukov S, Abbafati C, Abera SF, Abraham JP, Abu-Rmeileh NME, Achoki T, Albuhairan FS, Alemu ZA, Alfonso R, Ali MK, Ali R, Guzman NA, … **Gakidou E** (2014) 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. *The Lancet* **384**(9945), 766–781. https://doi.org/10.1016/S0140-6736(14)60460-8

Pastor-Fajardo MT, Bosch-Giménez VM, Larqué E, Solano Navarro C, Fuentes-Castelló MÁ & Pastor-Rosado J (2020) Prevalence and secular trend of childhood overweight and obesity in a Mediterranean area of Southeast Spain. *Child and Adolescent Obesity* **3**(1), 136–149. https://doi.org/10.1080/2574254x.2020.1784640

Pavlica TM, Rakić RS, Popović BK, Puškaš VP & Božić-Krstić VS (2018) Secular trends in height and weight among children from Novi Sad (Serbia), 1971-2017. *Journal of the Anthropological Society of Serbia Niš53*(05). https://doi.org/10.5937/gads53-18722

Perkins J M, Subramanian SV, Smith GD & Zaltin EO (2016) Adult height, nutrition, and population health. *Nutrition Reviews* **74**(3), 149–165. https://doi.org/10.1093/nutrit/nuv105

Piekorz Z, Lewandowski A, Goch A, Radzimińska A, Strojek K, Bułatowicz I, Siedlaczek M & Zukow W (2016)Nadwaga a poziom gibkości dzieci szkolnych – raport z badań = Obesity and the level of flexibility in primary school pupils – a research report. *Journal of Education, Health and Sport* **6**(9), 451–459. https://doi.org/10.5281/zenodo.154197

Ramiro-González MD, Sanz-Barbero B & Royo-Bordonada MÁ (2017) Exceso de peso infantil en España 2006-2012. Determinantes y error de percepción parental. *Revista Espanola de Cardiologia* **70**(8), 656–663. https://doi.org/10.1016/j.recesp.2016.11.017

Ryu S, Frith E, Pedisic Z, Kang M & Loprinzi PD (2019) Secular trends in the association between obesity and hypertension among adults in the United States, 1999–2014. *European Journal of Internal Medicine* **62**, 37–42. https://doi.org/10.1016/j.ejim.2019.02.012

Saczuk J, Wasiluk A & Wilczewski A (2018) Body height and age at menarche of girls from eastern Poland in the period of political transformation. *Anthropological Review* **81**(2), 130–145. https://doi.org/10.2478/anre-2018-0010

Salanave B, Peneau S, Rolland-Cachera MF, Hercberg S & Castetbon K (2009) Stabilization of overweight prevalence in French children between 2000 and 2007. *International Journal of Pediatric Obesity* **4**(2), 66–72. https://doi.org/10.1080/17477160902811207

Salcedo V, Gutiérrez-Fisac JL, Guallar-Castillón P & Rodríguez-Artalejo F (2010) Trends in overweight and misperceived overweight in Spain from 1987 to 2007. *International Journal of Obesity* **34**(12), 1759–1765. https://doi.org/10.1038/ijo.2010.96

Shirasawa T, Ochiai H, Nanri H, Nishimura R, Ohtsu T, Hoshino H, Tajima N & Kokaze A (2015) Trends of Underweight and Overweight/Obesity Among Japanese Schoolchildren From 2003 to 2012, Defined by Body Mass Index and Percentage Overweight Cutoffs. *Journal of epidemiology* **25**(7), 482–488. https://doi.org/10.2188/jea.JE20140144

Skinner AC, Perrin EM& Skelton JA (2016) Prevalence of obesity and severe obesity in US children, 1999-2014. *Obesity* **24**(5), 1116–1123. https://doi.org/10.1002/oby.21497

Spinelli A & Nardone P (2018) *WHO European Childhood Obesity Surveillance Initiative: overweight and obesity among 6-9-year-old children.: Report of the third round of data collection 2012-2013*. https://moh-it.pure.elsevier.com/en/publications/who-european-childhood-obesity-surveillance-initiative-overweight

Vijayakumar P, Wheelock KM, Kobes S, Nelson RG, Hanson RL, Knowler WC & Sinha M (2018) Secular changes in physical growth and obesity among southwestern American Indian children over four decades. *Pediatric Obesity* **13**(2), 94–102. https://doi.org/10.1111/ijpo.12199

Wedderkopp N, Froberg K, Hansen HS& Andersen LB (2004) Secular trends in physical fitness and obesity in Danish 9-year-old girls and boys: Odense School Child Study and Danish substudy of the European Youth Heart Study. *Scandinavian Journal of Medicine and Science in Sports* **14**(3), 150–155. https://doi.org/10.1111/j.1600-0838.2004.00365.x

WHO (2017) WHO | Childhood overweight and obesity. *WHO*. http://www.who.int/dietphysicalactivity/childhood/en/

WHO (2018) *Childhood Obesity Surveillance Initiative (COSI) Factsheet. Highlights 2015-17 (2018)*. https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/publications/2018/childhood-obesity-surveillance-initiative-cosi-factsheet.-highlights-2015-17-2018

Wijnhoven T M, Van Raaij JM, Spinelli A, Starc G, Hassapidou M, Spiroski I, Rutter H, Martos É, Rito AI, Hovengen R, Pérez-Farinós N, Petrauskiene A, Eldin N, Braeckevelt L, Pudule I, Kunešová M & Breda J (2014) WHO European Childhood Obesity Surveillance Initiative: Body mass index and level of overweight among 6-9-year-old children from school year 2007/2008 to school year 2009/2010. *BMC Public Health* **14**(1), 1–16. https://doi.org/10.1186/1471-2458-14-806

Xiao Y, Qiao Y, Pan L, Liu J, Zhang T, Li N, Liu E, Wang Y, Liu H, Liu G, Huang G & Hu G (2015) Trends in the Prevalence of Overweight and Obesity among Chinese Preschool Children from. *PLoS ONE* **10**(8), 134466. https://doi.org/10.1371/journal.pone.0134466

Żegleń M, Kryst Ł, Kowal M & Woronkowicz A (2020) Changes in physical fitness among preschool children from Kraków (Poland) from 2008 to 2018. *Journal of Physical Activity and Health* **17**(10), 987–994. https://doi.org/10.1123/jpah.2020-0199

Żegleń M, Kryst Ł, Kowal M, Woronkowicz A & Sobiecki J (2019) Changes in the prevalence of overweight/obesity and adiposity among pre-school children in Kraków, Poland, from 2008 to 2018. *Journal of Biosocial Science*. https://doi.org/10.1017/S0021932019000853

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