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14-Months Follow-Up in 8- to 11-year-old Primary School Children from Vienna: Effects of the COVID-19 Pandemic on Weight and Body Mass Index

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Abstract

Introduction: Changes in children's daily schedules, such as during the COVID-19 pandemic, may affect nutritional status. Our aim was to track changes in body weight and Body Mass Index (BMI) in Viennese school children during the COVID-19 pandemic. To our knowledge this is one of the first studies analyzing these changes during a year of the COVID-19 pandemic in Europe.

Materials and Methods: Observational prospective analysis (December 2019 to February 2021) of repeated anthropometric measurements (body weight and height, BMI), in 8- to 11-year-old children from a Viennese Primary School. Subgroup analyses by sex and weight status were conducted.

Results: 37 children [median age 9; 20 boys] were included. At baseline 15 (40.5%) children were overweight/obese. Average change in weight was 8.28 (CI 95%: 7.02-9.55) kg. Within the first period of follow-up (t_0 to t_1), including the strictest lockdown in Austria, the BMI of the whole sample increased more compared to the second (t_1 to t_2) (1.50 v. 0.61 kg/m^2 units, p=0.038), with boys increasing more weight than girls [1.67 (CI 95%: 0.20-3.15) kg, p=0.028]. Overall BMI in boys increased more than in girls (2.41 v. 1.27 kg/m^2 units, p=0.032). Children with obesity at baseline gained more weight than normal weight children (11.6 v. 7.63 kg, p=0.014).

Conclusion: During the COVID-19 pandemic, prevalence of excessive weight in this Viennese pediatric sample increased. Thus, maintaining steady daily routines and healthy interventions for children is essential, along with tailored interventions for those who are already obese.

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Introduction

Overweight and obesity has grown to an epidemic extent over the last decades and the prevalence of children and adolescents with obesity has multiplied by the factor 11 in just 42 years (1975 to 2016) [1,2]. In 2021 data of the childhood obesity surveillance initiative showed that 30% of the boys and 22% of the girls in Austria between 6 and 9 years old were overweight and/or obese [3]. As obesity implies serious health consequences, healthy eating during childhood is important not only to assure optimal growth but also to reduce the risk of unhealthy weight gain [4]. Also data has shown that the physical fitness is crucial for children's health and has a negative correlation with Body Mass Index (BMI), blood lipids and risk for cardiovascular diseases in later life [5,6]. Due to the fact that treating obesity during childhood is extremely ineffective, experts propose evolving preventative obesity programs preferentially addressing children under the age of 11 [7-9]. Childhood education settings such as schools pose an ideal setting for health promotion and implementation of obesity prevention interventions. School-based prevention interventions have been shown to be most effective when diet and physical activity components are jointly addressed [4,10,11]. Recently, a study reported the positive changes in body composition in elementary school children after combining daily 45 min of physical activity and healthy diet [12].

Since the outbreak of COVID-19 the world has changed rapidly and the daily routines of

people have been impacted drastically. Children and adolescents are especially affected by the closure of schools and the limited access to indoor and outdoor activities. Social distancing measures and stay at home orders may have exposed children to reduced physical activity and a food environment that could exacerbate rapid weight gain [13-15]. The impact of COVID-19 and its consequences are multifactorial, comprising, among others, a reduced physical, psychological and emotional health status. In particular, social isolation stress is positively associated with an increased food intake [15]. An environment of structured school days has been suggested as an opportunity to protect children from obesogenic behaviors [16]. Thus, increasing time out of school may lead to an increase in childhood overweight and obesity [13].

Previous data from our group reported the dramatic increase in body weight of children participating in the EDDY study during the first stage of the COVID-19 pandemic when schools were temporary closed and no obesity prevention intervention could take place [17]. In Turkey, a study reported a 25% increase in percentile of weight in young children after 3 months of extreme quarantine measures [18]. Moreover, to our knowledge no study in Europe has analyzed changes in anthropometric variables in children during the COVID-19 pandemic for more than a year. The aim of this study was to evaluate changes in body weight and BMI in children from the EDDY study, during 14 months of follow-up in the context of the COVID- 19 pandemic.

Materials and Methods

Study population

For the present analysis, we included 8 to 11 year-old kids from the EDDY study of a Viennese primary school that completed all three anthropometric measurements during the COVID-19 pandemic. Briefly, the EDDY study is an intervention study that aims to prevent obesity by affecting the lifestyle and nutrition habits of children, with nutrition and physical activity training intervention. Details of the EDDY study were previously published [19]. Usually, anthropometric measurements are taken before and after the intervention, along with two additionally follow-up measurements. Considering the context of the COVID-19 pandemic, the nutrition and physical activity intervention was interrupted due to temporary closure of schools. However, anthropometric measurements (body weight and height) were performed and BMI was calculated.

Study design

A total of n=37 primary school children were observed over a period of 14 months, including 12 months of the COVID-19 pandemic starting in March 2020. The observation consisted of 3 measurement points: December 2019 (t_0), June 2020 (t_1), February 2021 (t_2). Therefore, three follow-up periods were considered: Whole follow-up period (t_0-t_2), first follow-up period (t_0- t_1), and second follow-up period (t_1-t_2). At all 3 time points the body weight and the body height were evaluated, and the BMI calculated. At baseline (t_0) and middle-point testing (t_1), the body weight was measured with the bioelectrical impedance analysis scale (Tanita MC-780MA), wearing light indoor clothing without shoes. Body height was evaluated with a stadiometer (Seca, Hamburg, Germany) with the kid standing and maintaining the head in the Frankfort Horizontal Plane position, without shoes. All measurements were performed by a trained team. Due to COVID-19 mitigation measurements, the last-point testing (t_2) measurements were performed by the teachers. In order to obtain accurate measures, the EDDY team standardized the measurement procedures among teachers, by giving measuring instructions *via* video. The anthropometric equipment was also provided.

Afterwards, the BMI was calculated as weight (kg) divided by square height (m^2) and classified according to age and sex [20]. For our analysis, low weight was classified <3rd percentile, normal weight ≥ 3rd percentile and overweight ≥ 90th percentile, according to Kromeyer- Hauschild. The obesity category was considered as the sum of the obesity (≥ 97th percentile) and extreme obesity (≥ 99.5th percentile) original categories.

Statistical analysis

SPSS Software (IBM SPSS Statistics v.26, New York) was used for statistical analysis. Continuous variables were expressed as the mean (CI 95%) or (min-max), and categorical variables were expressed as absolute number and proportions. Sex differences and anthropometric continuous variables were assessed using two-sample Student's t-tests. Means and proportions were compared using a Student's t-test (or ANOVA) and a Chi squared test, respectively. Statistical significance was considered when $p<0.05$.

Results

Overall, n=37 kids [median age 9 (min-max: 8.3 to 11.0) years old; n=20 boys] were followed-up during 14 months. Nutritional status according to BMI classification is shown in Table 1. At baseline (t_0), n=15 kids (40.5%) were classified with excessive BMI for their age and sex. According to sex, n=10 (50%) boys and n=5 (29.5%) girls were classified as overweight/obese. After 6 months of follow-up (t_1), n=20 kids (54%) were classified as overweight or obese according to age and sex; according to sex 14 boys (70%) were classified with excessive BMI for their age; n=9 (45%) with obesity. Among girls, overweight and

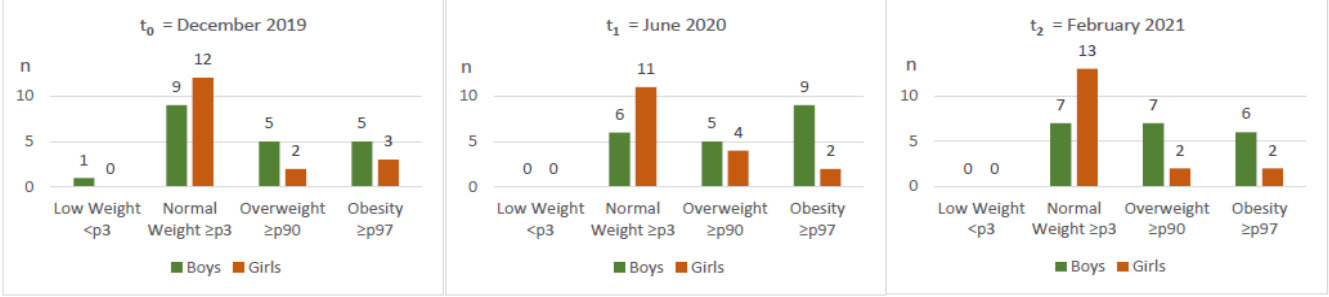

Figure 1: Distribution of children according to body mass index categories, sex and time testing.
Low weight was classified <3rd percentile, normal weight ≥ 3rd percentile and overweight ≥ 90th percentile, according to Kromeyer-Hauschild. Obesity category was considered obesity (≥ 97th percentile) and extreme obesity (≥ 99.5th percentile).

Table 1: Nutritional classification according to body mass index categories by sex and time testing.

	t_0 December 2019			t_1 June 2020			t_2 February 2021		
BMI category n (%)	**Boys n=20 (54.1%)**	**Girls n=17 (45.9%)**	**Total n=37**	**Boys n=20 (54.1%)**	**Girls n=17 (45.9%)**	**Total n=37**	**Boys n=20 (54.1%)**	**Girls n=17 (45.9%)**	**Total n=37**
Low weight	1 (5.0)	0	1 (2.7)	0	0	0	0	0	0
Normal	9 (45.0)	12 (70.6)	21 (56.8)	6 (30.0)	11 (64.7)	17 (46.0)	7 (35.0)	13 (76.4)	20 (54.1)
Over weight	5 (25.0)	2 (11.8)	7 (18.9)	5 (25.0)	4 (23.5)	9 (24.3)	7 (35.0)	2 (11.8)	9 (24.3)
Obesity[1]	5 (25.0)	3 (17.7)	8 (21.6)	9 (45.0)	2 (11.8)	11 (29.7)	6 (30.0)	2 (11.8)	8 (21.6)

[1]includes obesity and extreme obesity (≥ p97). Chi square test t_0 p= 0.45; t_1 p = 0.055; t_2 p =0.042
Reference: BMI: Body Mass Index; t_0: Baseline; t_1: Middle-point testing; t_2: Last-point testing

Table 2: Changes in weight and body mass index by sex and time testing.

	First follow-up period (t_0-t_1)	**Second follow-up period (t_1-t_2)**	**p value[1]**
All			
Weight (kg)	4.59 (3.81-5.36)	3.69 (2.71-4.68)	0.16
BMI (kg/m^2)	1.50 (1.13-1.86)	0.61 (-0.04-1.3)	0.038
Boys			
Weight (kg)	5.36 (4.14-6.57)*	4.02 (2.44-5.59)	0.18
BMI (kg/m^2)	1.85 (1.29-2.40)‡	0.98 (-0.15-2.10)	0.22
Girls			
Weight (kg)	3.68 (2.84-4.52)	3.32 (2.05-4.58)	0.63
BMI (kg/m^2)	1.09 (0.66-1.52)	0.18 (-0.45-0.81)	0.042

Values indicate mean difference (CI 95%). [1]Paired student's t-test between first and second follow-up
Reference: BMI: Body Mass Index; First follow-up period [changes from December 2019 (t_0) to June 2020 (t_1)]; Second follow-up period [changes from June 2020 (t_1) to December 2020 (t_2)]. Difference between sexes: ‡p=0.033 *p=0.028

Table 3: Changes in weight and body mass index by nutritional status at baseline during the follow-up period.

BMI category at t_0 (December 2019)	**All**		**Boys**		**Girls**	
	Weight (kg)	**BMI (kg/m^2)**	**Weight (kg)**	**BMI (kg/m^2)**	**Weight (kg)**	**BMI (kg/m^2)**
Low weight (n=1)	3.0	0.55	3.0	0.55	-	-
Normal (n=21)	7.63 (3.0-12.5)	2.02 (-0.52-5.48)	9.19 (3.1-12.5)	2.90 (0.06-5.48)	6.46 (3.0-12.2)	1.37 (-0.52-3.23)
Overweight (n=8)	7.75 (3.0-15.5)	1.02 (-1.84-5.02)	8.14 (4.2-15.5)	1.54 (-0.83-5.02)	7.1 (3.0-10.9)	0.15 (-1.84-1.58)
Obesity[1] (n=7)	11.6 (7.5-18.6)‡	2.66 (1.63-4.68)	12.2 (7.5-18.6)	2.77 (2.07-4.68)	10.1 (9.5-10.7)	2.38 (1.63-3.13)

Values indicate mean difference change (min max). **Reference:** BMI body mass index
[1]includes obesity and extreme obesity (≥p97)
‡p=0.014 comparing to those with normal weight at baseline

obesity at t_1 was present in n=6 (35.3%) (p=0.055). At the last-point testing (t_2), n=17 (45.9%) of the kids were classified as overweight/obese; n=13 (65%) boys and n=4 (23.6%) girls (p=0.042). Figure 1 shows the distribution of children according to BMI categories, sex and time testing.

During the entire follow-up period (t_0-t_2), average change in weight was 8.28 (CI 95%: 7.02-9.55) kg. Boys increased 9.37 (CI 95%: 7.39-11.35) kg, while girls increased 7.00 (CI 95%: 5.56-8.44) kg (p=0.057). BMI increased 1.89 (CI 95%: 1.34-2.43) units during the 14-month follow- up period, with the increase being higher in boys [2.41 (CI 95%: 1.59-3.23) kg/m^2] than in girls [1.27 (CI 95%: 0.63-1.92) kg/m^2] (p=0.032). Changes in weight and BMI according to sex and period of time testing are shown in Table 2.

The overall increase in weight during the first follow-up period (t_0-t_1) was 4.59 (CI 95%: 3.81-5.36) kg and during the second follow-up period (t_1-t_2) 3.69 (CI 95%: 2.71-4.68) kg (p=0.16). During the first follow-up period (t_0-t_1), boys increased significantly more weight than girls [1.67 (CI 95%: 0.20-3.15) kg p=0.028)]. No difference was observed in weight changes by sex during the second follow-up period (t_1-t_2). Regarding BMI, in the whole sample the increase during the first follow-up period (t_0-t_1) was significantly higher than during the second follow-up period (t_1-t_2) [0.88 (CI 95%: 1.7-0.05) kg/m^2 units, p=0.038]. Only in girls, the increase in BMI was higher in the first follow-up period (t_0-t_1) than in the second follow-up period (t_1-t_2) [0.90 (CI 95%: 0.04-1.8) kg/m^2 units, p=0.042] (Table 2).

When observing changes in weight and absolute BMI according to BMI categories at baseline (t_0) (Table 3), those children classified as obese at baseline increased significantly more weight during the whole follow-up period (t_0-t_2) than normal weight children (11.6 v. 7.63 kg, p=0.014).

Discussion

During 14-months of follow-up in a Viennese sample of primary school children during the COVID-19 pandemic, our study showed that excessive weight for age and sex increased. During the first stage of the pandemic, characterized by the outbreak of SARS-CoV-2 and very strict mitigation measures (home confinement, movement restrictions), gain in weight was higher in boys than in girls. Overall, children classified as obese increased significantly more weight than those who were normal weight for age. To our knowledge this is one of the first studies that analyses changes in children's weight and BMI during the COVID-19 pandemic for more than a year in Europe.

It is reasonable to hypotethize that the large scale lockdown under the COVID-19 pandemic would predispose in increase in weight, as it has been described that during holidays (e.g. summer recess, involving shorter periods off school) children tend to gain weight [13,16]. Our results showed that overall, percentage of overweight and obesity during the follow-up period increased approximately 5%, with an outstanding increase during the first stage of the pandemic. Moreover, during this time the increase in weight and BMI was more important. It should be taken into consideration that the pandemic year in Austria was characterized by different mitigation measures that may have impacted differently the children daily routines. During the first period, schools were closed, public circulation was not allowed and shops and recreation centers were closed. While in the second period of the pandemic, mitigation measures were gradually loosened; parents and children returned back to their daily routines little by little, just interrupted by short periods of stricter lockdown. During this period schools were open most of the days; however, physical activity inside was not allowed, which may partially explain our results.

Recently, a review reported that during the ongoing pandemic, children and adolescents increased weight and food preferences for potatoes, meat and sugary drinks [14]. Moreover, another study showed that the prevalence of physical inactivity during the first 2 months of the pandemic has more than doubled [21], and total screen time increased. More time spend at home during the lockdown somehow posits children to less opportunities of engaging in physical activities, less regulation of screen time and sleeping schedules, as well as disruptive meal patterns [16]. Replicating such lifestyle patterns in a more extensive period of time (e.g. if the pandemic continues) may further impact negatively on children's weight and health status. Moreover, our results showed that those children who already had excessive weight at the beginning of the pandemic, gained more weight than those with normal weight.

Accordingly, it has been previously described that children already overweight were more susceptible to excessive weight gain during school breaks (e.g. summer holidays), compared to normal weight children [22]. In school-aged children with obesity in Spain, an increase of 7.5 ± 3.2 kg in weight was registered after the COVID-19 lockdown period [23]. Another study addressed a significant weight gain of 2.8 ± 3.7 kg in adolescents with obesity [24]. Accordingly to our findings, these authors also reported gender differences in weight gain, towards a higher increase in boys [24].

Sticking to a healthy lifestyle while falling out of their routine structures seems to be particularly challenging for children who already carry excessive weight. A recent report from Italy observing lifestyle changes of children and adolescents with obesity, reported as main disturbances the increase of time spent in a sedentary position and the perception of feeling hungry [25]. Anxiety experienced during this period, related to changes in the daily routine (online lessons, being at home all day, less socialization, disturbance in meal patterns, and less opportunity to move) may turn mood into a stimulus for food intake and exacerbate calorie intake without feeling hungry [26]. On the contrary, we found one study also conducted in schools that reported that children with overweight or obesity did not experience acceleration in BMI change compared to children with normal weight [27]. The authors speculated that children with excessive weight are already engaged in an obesogenic environment therefore increase in weight may have been less dramatic [27]. This posits the challenge of addressing all children, independently of their nutritional status, in the goal of changing the tendency towards increase in weight during periods of confinement.

Moreover, young children are dependent on their parent's choices. Thus, preventive efforts to reduce weight gain are more likely to have optimal effects if they involve parents [28,29]. During the second wave of the pandemic, a study assessed dietary changes in adults in 3 European countries, including Austria [30]. Overall, Austrian participants reported an increase in frequency of daily consumption of dairy, grains, fats, vegetables and sweets; and alcohol intake increased. When asked about perception of change in body weight, the largest percentage of Austrian participants reported no changes in weight, however; more than 30% acknowledged having increased their weight [30]. A study conducted in 3 countries (Saudi Arabia, United Kingdom, and Turkey) assessed, from the perspective of parents, whether their children's weight changed during the pandemic. 63% of parents indicated that children did not gain weight [31]. Therefore, combined home-strategies involving the whole family are desirable if changes in children are expected. A recent systematic review addressed that most effective school-based interventions to prevent obesity had parental involvement [32].

Strengths of this study include the extensive follow-up period that allowed addressing the long-lasting effects of the restrictive lifestyle patterns in weight and BMI. Moreover, we assessed anthropometric variables under direct measurements in 2 of the 3 time-points. Several of the studies published recently assessing the effects of the COVID-19 pandemic have relied on self-reported weight status and questionnaires. Some limitations however should be addressed. First, the small number of children involved; therefore, our findings may not be generalizable to the entire pediatric population of Austria. Second, the lack of complementary measures (behavioral, food intake, physical activity) beyond anthropometrics that would have allowed us to examine possible factors associated with these changes in weight.

The long-term repercussions of the pandemic on children's health is important, as excessive weight during childhood has been associated with higher BMI and fat mass during adulthood [33]. As early puberty is a period characterized by rapid changes in body composition and movement behaviors, interventions focusing on healthy eating and physical activity behaviors to successfully prevent excessive weight gain are necessary, particularly within and after the course of the pandemic.

Moreover, since approximately 1 of 4 children in Austria is already overweight or obese, some consideration should be put on preventing progression of childhood obesity in school settings [3]. Alternatives to generic teacher-led curriculum interventions, such as computer- tailored personalized education in the classroom [10], and increasing the quantity of physical activity may be approaches to achieve better results [34].

Conclusion

This study shows an increase in weight in a sample of a Viennese pediatric population in the context of the COVID-19 pandemic, with boys being affected more than girls. These results urge for the immediate implementation of prevention strategies, such as combined online nutrition and physical activity interventions during lockdowns. Because of the increased time spent at home with family during the pandemic (school closures, lockdown, etc.) the parental involvement might be more important. Also schools and teachers

might have a substantial role because of the continuous contact to the parents. Moreover, as obese children are even more affected by the pandemic, targeted interventions (e.g. weight management programs to reduce excessive weight gain) are necessary to help them reduce weight sustainably through a multidisciplinary approach (e.g. doctors, psychotherapy, dietitians, etc). Overall the implementation of adapted online physical activity and nutrition interventions for children in a pandemic, especially during school-closures, is essential to stay in contact with children and help them maintain steady and healthy daily routines during this period.

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