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Changes in body mass index-z scores in 3-year-old children during the COVID-19 pandemic: a 2-year retrospective cohort study

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SUMMARY

OBJECTIVE: Given how dramatically the pandemic has affected food systems, the economy, and the daily lives of children over the past 2 years, the potential impact of the pandemic on childhood obesity requires careful investigation. The aim of this study was to investigate the change in body mass index z-score in 3-year-old children and the inducing factors during the pandemic period.

METHODS: The body mass index z-scores of all children participating in the study were calculated at the beginning of the pandemic (3-year-old body mass index z-score) and in its second year (5-year-old body mass index z-score).

RESULTS: This study, conducted during the 2-year pandemic period, found a strong association between the body mass index z-scores of children aged 3 and 5 years. The mean body mass index z-score increased between these time points for both boys and girls (p=0.013; p=0.034). In two different linear regression models created for the change in body mass index z score, gestational weight gain was found to be related. The regression coefficients (95% confidence intervals) and corresponding p-values were 0.580 (0.217–0.944) and p=0.002 for model 1, whereas they were 0.585 (0.217–0.961) and p=0.002 for model 2.

CONCLUSION: This study showed an increase in body mass index z-scores in early childhood period during the COVID-19 pandemic. To prevent this increase, new strategies should be developed by considering the changes brought by the pandemic period.

KEYWORDS: Childhood obesity. COVID-19. Body mass index. Pandemic.

INTRODUCTION

Childhood obesity is one of the most serious public health problems of the 21st century and it requires immediate preventive measures[1]. The prevalence of overweight and obesity among children under 5 years of age has continued to rise, increasing from an estimated 30.3 million (4.9%) children in 2000 to 38.3 million (5.6%) children in 2019, according to the United Nations Children's Fund, World Health Organization (UNICEF/WHO), and The World Bank Group report[2]. The substantial annual increases in body mass index (BMI) among adolescents with obesity occur between the ages of 2 and 6 years.

The global pandemic declared by WHO in March 2020 has led to significant changes in daily life for children, youth, and their families, with specific recommendations and restrictions varying between countries[3]. Similar to other countries, Turkey also restricted crowded areas, social gatherings, sports activities, and playgrounds and closed schools[4]. This situation caused a lack of physical activity, sleep disorders, and changes in eating habits, which are among the important risk factors for early childhood obesity[5].

Although a few recent studies[6,7] have shown that the pandemic period creates a risk for obesity by causing lifestyle changes in children, there is no study that measures the BMI z-scores in children. Many variables can contribute to childhood obesity, including behavioral, genetic, and environmental factors. Studies show that factors such as maternal BMI, maternal smoking, gestational weight gain (GWG), and gestational diabetes have an impact on early childhood obesity[8]. While there are studies dealing with lifestyle changes during the pandemic period in the literature, there is a lack of comprehensive research that includes other risk factors.

In this study, which is, to the best of our knowledge, the first to show the changes in BMI in early childhood during the COVID-19 pandemic period, we investigated the change in BMI z-scores during the 2-year pandemic period and the factors affecting it.

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METHODS

Study population

This extensive retrospective cohort study was conducted in 42 family medicine centers located in Rize, Turkey. Data collection centers are spread over a wide geographical area, both urban and rural. This study included 289 children aged 3 years (born between January 1, 2017 and March 31, 2017) at the onset of the pandemic. The data of 266 children were analyzed, excluding the children who did not want to share data, had missing follow-up information, or could not be reached.

Children included in this study were evaluated regularly according to the official monitoring protocol of the Family Medicine Practice of Turkey until the age of 5 years. According to the protocol, children aged 3–5 years were monitored regularly at least 12 times. Family Medicine Information Systems (FMIS) are programs in which the follow-up information of pregnant women and children is recorded during face-to-face interviews in accordance with the authority and responsibilities of Family Physicians in Family Medicine.

Potential confounding variables

Potentially confounding variables measured were child's gender, age in months, birth weight, birth height, birth week, nutrition in the first 6 months, maternal gestational age, mode of delivery, maternal weight gained during pregnancy, maternal pre-pregnancy body mass index, smoking status during pregnancy, educational status of parents, and socioeconomic status.

Weight gained during pregnancy

Gestational weight gain is calculated by subtracting pre-pregnancy weight from maternal weight at the time of delivery and categorized according to the recommendations of the National Research Council and the Institute of Medicine[9]. Underweight, normal weight, overweight, and obese mothers who gained 12.7–18.1, 11.3–15.9, 6.8–11.3, and 5.0–9.1 kg, respectively, were regarded as adequate GWG, whereas those gaining weight above or below specified values were categorized as excessive or inadequate, respectively.

Children's body mass index z-score analysis

The BMI z-score is based on the WHO growth standards, which are age- and sex-standardized measures of adiposity in children, and it represents the optimal growth of children. The BMI z-scores of all children participating in this study were calculated at the beginning of the pandemic (3-year-old BMI z-score) and in its second year (5-year-old BMI z-score)[10]. We categorized the pre-pandemic children according to their BMI z-scores (BMI-for-age z-score cutoff points of <-2.0, >1.0, >2.0 and >3.0 are recommended by WHO to classify children aged 0–5 years as wasted, risk of overweight, overweight, and obese, respectively).

Height and weight were used to calculate BMI (kg/m^2), which was converted to BMI z-scores using the US Centers for Disease Control and Prevention growth reference.

Statistical analysis

The distribution of the mothers' sociodemographic characteristics and some clinical characteristics of the children were calculated alongside the 3-year-old and 5-year-old BMI z-scores of the children. The categorical variables were expressed in numbers and percentages, and the numerical variables were expressed as mean, standard deviation, median, and interquartile range (IQR). Linear regression analysis was used to determine the factors affecting the BMI z-score, and two models were designed for the analysis. In the first model, a set of confounding variables consisted of the child's gender, type of feeding in the first 6 months, mode of delivery, educational status of parents, socioeconomic status, and GWG. By including COVID-19 status (positive), kindergarten attendance, screen time, and fast-food nutrition variables to the previous confounding set, the second model was created. Data were analyzed using the SPSS 22.0 software package, and 0.05 is used as the significance level for all analyses.

Ethical procedure

Necessary written approvals were obtained from the local ethics committee (dated 09.05.2022, with decision number 2022/106). Patient informed consent forms providing all details of the study were given to patients, and their relatives were informed in detail about the study and their written consent was obtained.

RESULTS

Parent and child characteristics

The birth weight of the children included in the study was 3,373.15(±475.88) g. Of note, 60.2% (n=160) of the children were only breastfed for the first 6 months and 49.6% (n=132) of them were born through vaginal delivery. During the pandemic period, 27.8% (n=74) of them had COVID. The mean age of mothers was 30.74±5.54 years, and their average pre-pregnancy BMI was 25.96±4.48 kg/m^2.

When we calculated the mean BMI z-scores of all the children participating in the study, we determined a significant increase in these scores from 3 to 5 years of age, regardless of gender (p=0.034; p=0.013). While analyzing the nutrition of children, we also ascertained that BMI z-scores increased significantly during the pandemic period for those who started to receive supplementary food before 6 months. In contrast, the BMI z-score increased substantially for both the COVID and non-COVID groups (Table 1).

In Table 2, we utilized odds ratios from a multinomial linear regression model that enabled adjustment for the possible influence of potentially important covariates. In two

Table 1. Relationship of 3-year-old body mass index z-score and 5-year-old body mass index z-score with risk factors.

	3-year-old BMI z-score	5-year-old BMI z-score	p*
All group	0.38±1.23	0.68±1.50	**<0.001**
Gender			
Female	0.26±1.01	0.49±1.30	**0.034**
Male	0.50±1.41	0.88±1.66	**0.013**
Infant nutritional status (First 6 months)			
Exclusive breastfeeding	0.57±1.34	0.80±1.51	0.152
Not exclusive breastfeeding	0.25±1.14	0.61±1.49	**0.002**
Type of birth			
Vaginal delivery	0.25±1.22	0.65±1.47	**0.003**
Cesarean section	0.51±1.23	0.71±1.53	0.106
History of COVID-19			
Yes	0.45±1.29	0.81±1.66	**0.031**
No	0.35±1.21	0.63±1.43	**0.011**
Kindergarten attendance			
Yes	0.63±1.26	0.78±1.50	0.331
No	0.29±1.21	0.65±1.50	**0.002**
Possibility of outdoor activities			
Yes	0.40±1.18	0.73±1.43	**0.006**
No	0.34±1.30	0.62±1.58	0.065
Gestational weight gain status			
Excessive	0.47±1.15	1.06±1.43	**<0.001**
Adequate-inadequate	0.29±1.30	0.33±1.47	0.823
Smoking during pregnancy			
Yes	0.70±1.39	1.04±1.53	0.283
No	0.37±1.22	0.67±1.50	**0.002**
Mother's educational status			
Middle school or below	0.15±1.25	0.54±1.47	**0.012**
High school or above	0.49±1.20	0.76±1.51	**0.024**
Father's educational status			
Middle school or below	0.33±1.25	0.52±1.35	0.234
High school or above	0.39±1.22	0.73±1.54	**0.002**
Socioeconomic status			
Low	0.38±1.38	0.49±1.51	0.681
Normal/high	0.38±1.21	0.71±1.49	**0.001**

*Wilcoxon test. Bold indicates statistically significant values.

Table 2. Linear regression predictors of follow-up body mass index z-score change for 3–5 years.

	BMI z-score change					
	Model 1			Model 2		
	b	95%CI	p	b	95%CI	p
Gender (male)	0.075	-0.284–0.434	0.681	0.124	-0.238–0.486	0.500
Infant nutritional status (first 6 months) (not exclusive breastfeeding)	-0.139	-0.512–0.234	0.465	-0.127	-0.502–0.248	0.505
Type of birth (Cesarean section)	-0.243	-0.607–0.121	0.190	-0.245	-0.613–0.123	0.192
Mother's educational status (high school or above)	-0.167	-0.571–0.236	0.415	-0.155	-0.561–0.251	0.453
Father's educational status (high school or above)	0.151	-0.294–0.596	0.504	0.138	-0.310–0.585	0.545
Socioeconomic status (normal/high)	-0.020	-0.673–0.633	0.951	0.029	-0.628–0.686	0.931
Gestational weight gain status (excessive)	0.580	0.217–0.944	**0.002**	0.585	0.217–0.961	**0.002**
History of COVID-19 (yes)	–	–	–	0.103	-0.298–0.503	0.615
Kindergarten attendance (yes)	–	–	–	-0.242	-0.656–0.171	0.250
Screen time (increased)	–	–	–	-0.050	-0.420–0.320	0.789
Sleep duration (decreased)	–	–	–	-0.103	-1.024–0.817	0.825
Fast-food nutrition (increased)	–	–	–	-0.462	-0988–0.063	0.085

Bold indicates statistically significant values.

different linear regression models created for the change in BMI z-score, weight gain during pregnancy was found to be related. Regression coefficients (95% confidence intervals) and corresponding p-values were 0.580 (0.217–0.944) and p=0.002 for model 1, whereas they were 0.585 (0.217–0.961) and p=0.002 for model 2. No relationship was found in terms of gender, nutrition in the first 6 months, mode of delivery, educational status of parents, socioeconomic status, having COVID, kindergarten attendance, screen time, sleep duration, and fast-food nutrition.

In Figure 1, we showed the changes in weight category of 3-year-old children when they reached the age of 5 years. We observed that out of 182 normal-weight children, 36 were at risk for overweight, 15 were overweight, and 4 were obese. Other transitions between groups are shown in Figure 1.

DISCUSSION

This study, conducted during the 2-year pandemic period, found a strong association between BMI z-scores of children aged 3 and 5 years. The mean BMI z-score increased between these time points for both boys and girls.

The pandemic period brought about many problems for children in physical, social, and psychological aspects. Factors affecting early childhood obesity introduced by the pandemic period, such as an increase in screen time, decrease in sleep duration, and change in eating habits, added to the factors already presented in the literature, such as genetic factors, socioeconomic status of the mother, maternal pre-pregnancy BMI, GWG, age, and birth weight.

Recent studies[3,6] have shown that screen time increased, physical activity decreased, sleep time decreased, and fast-food nutrition increased in children during the pandemic period. Conversely, some studies[11] have shown that the pandemic period also posed a risk for childhood obesity. Measurement-based values were not used in any of these studies and no confounding factors were considered. This is the first retrospective cohort study based on anthropometric measurements to investigate early childhood obesity during the 2-year pandemic period.

In this study, while investigating the possible reasons for the abovementioned increase in BMI z-score averages during the pandemic period, we analyzed the variables introduced by this period and the risk factors that are not specific to it.

One of the most relevant issues for children during the pandemic was the decreased physical activity and increased sedentary time during the COVID-19 quarantine. The increase in screen time was remarkable in 48.4% (n=129) of the children participating in this study. This finding is mainly due to less time spent outside and online activity engagements in some countries. Other factors could be the use of electronic media devices for keeping the children busy by remote working parents.

Contrary to school-age children and teenagers having longer sleep durations during quarantine, as expressed in some studies[3], there was no change in total sleep duration of children in

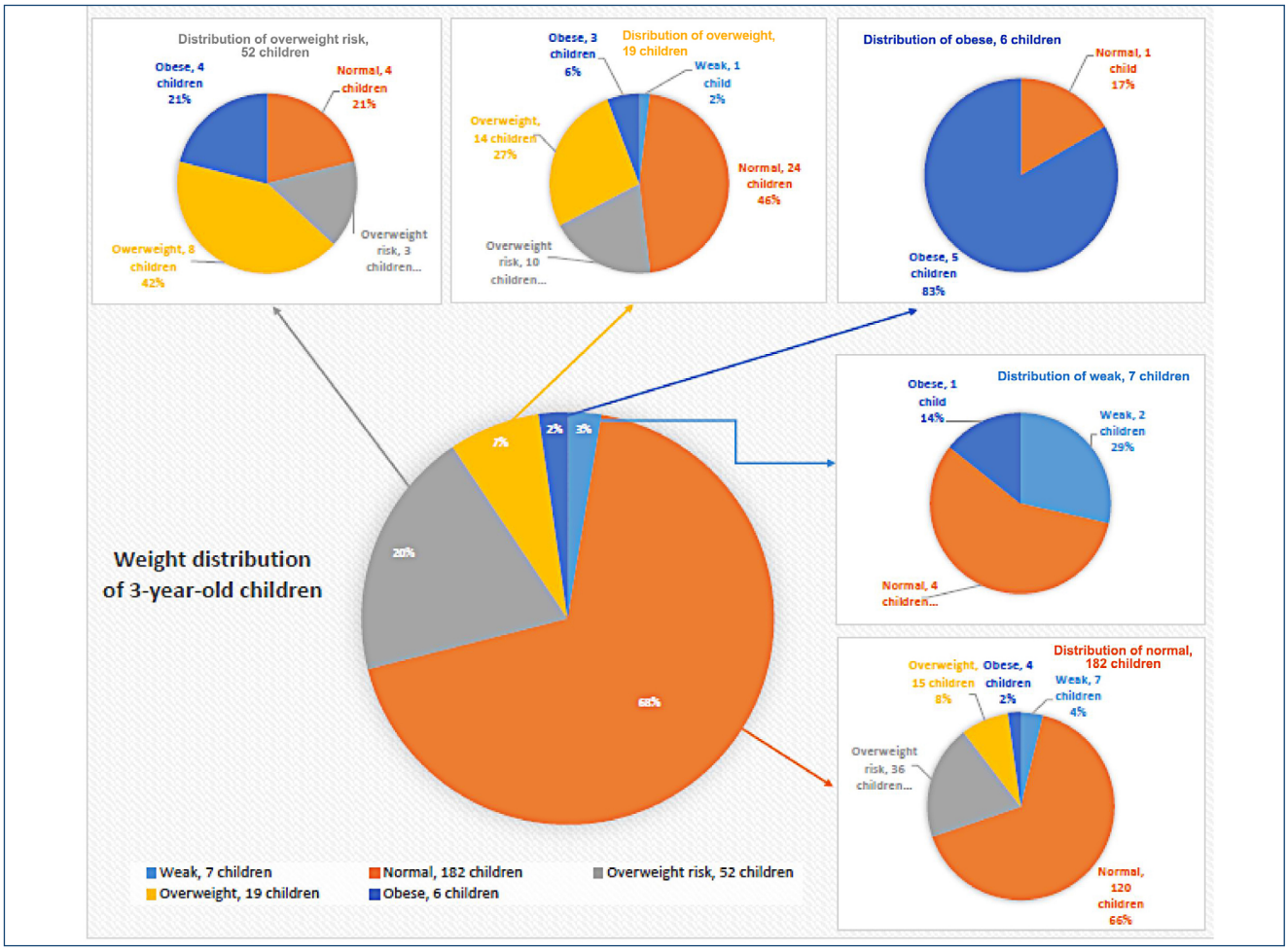

Figure 1. Changes in 3-year-old children's weight categorization at the age of 5 years.

this study. This indication may be the result of the change in bedtimes and wake-up times of children rather than total sleep duration during the pandemic period. Studies have reported a delay in bedtimes and wake-up times than usual for children[12].

There are many studies indicating the effect of GWG on childhood obesity[13]. In this study, we determined that 48.5% of the mothers gained excessive weight according to the criteria of the Institute of Medicine and the National Research Council. In reference to previous studies[14], this high rate of GWG can be explained by the sedentary lifestyle and the change in eating habits induced by the pandemic period. In the linear regression analysis, we found that the increase in BMI z-scores of children (from 3 to 5 years of age) during the pandemic period was the effect of excessive weight gain during pregnancy.

Our study, being the first based on anthropometric measurements in early childhood during the pandemic period, had several strengths. First, it was predicated mostly on quantitative data. Second, the data gathering procedure (anthropometric measurements) was performed by trained research assistants using a standard protocol, thereby reducing probable errors associated with the usage of measurements obtained during clinical care visits and the recall bias from parent-reported measurements. Additionally, data on independent variables were collected both prenatally and postnatally. Thus, reducing recall bias, and especially collecting data in the context of a cohort study that did not focus on obesity reduced the potential for acceptance bias.

There were some limitations in this study. One of the weaknesses of this study was the dependence of the sleep duration data on solely parental feedback. Also, data on dietary intake and physical activity were not quantitative. In addition, the difficulties in both determining screen time exposure and the current validity of screen time measurements were other weaknesses[15].

CONCLUSION

To the best of our knowledge, this is the first study on the assessment of BMI z-scores in early childhood which showed

an increase in these scores for both boys and girls during the COVID-19 pandemic period. Related variables other than GWG were found ineffective via the regression analysis. An increase in research analyzing different confounding variables introduced by the pandemic period will be beneficial for in-depth understanding of the topic.

ETHICS COMMITTEE APPROVAL

Ethics committee approval for this study was taken from the Ethics Committee of Recep Tayyip Erdoğan University Faculty of Medicine with protocol number 2022/106. Date: 09.05.2022.

AUTHORS' CONTRIBUTIONS

CA: Conceptualization, Data curation, Formal Analysis, Methodology, Software, Supervision, Writing – original draft, Writing review & editing. **KU:** Data curation, Project administration, Resources, Software, Visualization. **AK:** Data curation, Methodology, Validation, Visualization. **SK:** Data curation, Formal Analysis, Software.

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