

Impact of the COVID-19 Pandemic and Related Lockdown Measures on Lifestyle Behaviors and Well-Being in Children and Adolescents with Severe Obesity

Mila S. Welling^{a, b} Ozair Abawi^{a, b} Emma van den Eynde^{a, b}
Elisabeth F.C. van Rossum^{a, c} Jutka Halberstadt^d Annelies E. Brandsma^e
Lotte Kleinendorst^{a, f} Erica L.T. van den Akker^{a, b} Bibian van der Voorn^{a, b, c}

^aObesity Center CGG, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands; ^bDivision of Endocrinology, Department of Pediatrics, Erasmus MC-Sophia Children's Hospital, University Medical Center Rotterdam, Rotterdam, The Netherlands; ^cDivision of Endocrinology, Department of Internal Medicine, Erasmus MC, University Medical Center Rotterdam, Rotterdam, The Netherlands; ^dDepartment of Health Sciences, Amsterdam Public Health Research Institute, Faculty of Science, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; ^eDivision of Endocrinology, Department of Pediatrics, Obesity Center CGG, Maasstad Ziekenhuis, Rotterdam, The Netherlands; ^fDepartment of Clinical Genetics, Amsterdam UMC location AMC, University of Amsterdam, Amsterdam, The Netherlands

Keywords

Pediatric obesity · Coronavirus · Quarantine · Qualitative study · Eating behavior

Abstract

Introduction: COVID-19 lockdown measures have large impact on lifestyle behaviors and well-being of children. The aim of this mixed-methods study was to investigate the impact of COVID-19 lockdown measures on eating styles and behaviors, physical activity (PA), screen time, and health-related quality of life (HRQoL) in children (0–18 years) with severe obesity. **Methods:** During the first COVID-19 wave (April 2020), validated questionnaires were completed and semi-structured telephone interviews were conducted with parents of children with severe obesity (adult body mass index [BMI]-equivalent $\geq 35 \text{ kg/m}^2$) and/or with the children themselves. Changes in pre-pandemic versus lockdown scores of the Dutch Eating Behavior Questionnaire Children, Pediatric

Quality of Life Inventory, and Dutch PA Questionnaire were assessed. Qualitative analyses were performed according to the Grounded Theory. **Results:** Ninety families were approached of which 83 families were included. Characteristics of the included children were: mean age 11.2 ± 4.6 years, 52% female, mean BMI SD-score $+3.8 \pm 1.0$. Emotional, restrained, and external eating styles, HRQoL, and (noneducational) screen time did not change on group level (all $p > 0.05$). However, weekly PA decreased (mean difference -1.9 h/week , $p = 0.02$) mostly in adolescents. In the majority of children, mean weekly PA decreased to $\leq 2 \text{ h/week}$. Children with high emotional or external eating scores during lockdown or pre-existent psychosocial problems had the lowest HRQoL ($p < 0.01$). Qualitative analyses revealed an increased demand for food in a significant proportion of children ($n = 21$), mostly in children < 10 years (19/21). This was often attributed to loss of daily structure and perceived stress. Families who reported no changes ($n = 15$) or improved eating behaviors ($n = 11$) attributed this to already existing strict

eating schemes that they kept adhering to during lockdown. **Conclusion:** This study shows differing responses to COVID-19 lockdown measures in children with severe obesity. On group level, PA significantly decreased and in substantial minorities eating styles and HRQoL deteriorated. Children with pre-existent psychosocial problems or pre-pandemic high external or emotional eating scores were most at risk. These children and their families should be targeted by health care professionals to minimize negative physical and mental health consequences.

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Introduction

It has been suggested that the impact of the COVID-19 lockdown measures on lifestyle behaviors and general well-being of children and adolescents is larger than that of the infection itself [1]. In most countries, lockdown measures of varying duration and stringency included closing of schools and sports clubs and social distancing measures. Population-based studies in children and adolescents across the world have shown overall decreases in physical activity (PA) and increases in screen time and sedentary behavior [2–7]. Moreover, equivocal changes in food choices are described, with both increased intake of healthy foods such as fruit and vegetables as well as increased intake of unhealthy food categories reported [6, 8–10]. Children and adolescents with obesity are thought to be at even larger risk for lifestyle changes and weight gain due to lockdown measures [11].

In pre-pandemic circumstances, children and adolescents with obesity already are found to have differing scores for restrained, emotional, and external eating and poorer health-related quality of life (HRQoL) than children and adolescents without obesity [12–14]. Moreover, we recently reported our first findings during the COVID-19 pandemic in children and adolescents with severe obesity, which revealed the presence of COVID-19-related anxiety in a significant minority of families, resulting in additional self-imposed quarantine measures [15]. This might further exacerbate the negative impact of COVID-19 lockdown in this patient population.

To date, few studies investigated the impact of COVID-19-related lockdown measures on lifestyle factors in pediatric patients with obesity, reporting similar results as the abovementioned studies with regard to PA, screen time, and consumption of unhealthy foods [16–18]. It is unknown whether this is caused by changed eating styles,

such as external or emotional eating. For example, external eating could be affected by the presence of food stimuli at home or the closure of food establishments, while emotional eating could be increased by negative emotions during lockdown.

Therefore, the aim of this study was to investigate the impact of COVID-19-related lockdown measures on eating styles and behaviors, PA, screen time, and HRQoL in children (including adolescents up to 18 years) with severe obesity, using a combined quantitative and qualitative approach. This information can help caregivers in minimizing the short- and long-term negative consequences of these COVID-19-related lockdown measures.

Materials and Methods

This mixed-methods study was performed within a larger observational study [19] investigating diagnostic and therapeutic aspects of severe pediatric obesity (defined by a body mass index [BMI] above the age- and sex-specific *International Obesity Task Force* cut-off values that correspond to a BMI of ≥ 35 kg/m² at age 18 years) [20]. The presented data were prospectively collected for health care purposes according to standardized protocols and were recorded in the patients' medical records.

Study Setting

In the Netherlands, school closures were established from March 16, 2020, onwards as part of selective lockdown measures, including closings of, e.g., sports clubs and food establishments, followed by urgent governmental advices on March 23, 2020, to stay at home.

Study Participants

During the first month of the lockdown (April 2–23, 2020), we contacted all parents of children (including adolescents up to 18 years) who were under treatment at the Obesity Center CGG at the academic center Erasmus MC-Sophia Children's Hospital (online suppl. Fig. 1; see www.karger.com/doi/10.1159/000520718 for all online suppl. material). Children are referred for diagnostics, e.g., due to early-onset obesity or signs of insatiable behavior, or for multidisciplinary treatment advices [19]. We approached parents of children who had completed our diagnostic workup and whose last visit was in 2019 or early 2020 (pre-pandemic). We did not approach parents of children with severe intellectual disabilities or children who lived in residential care settings, as their families' experiences during the lockdown might not be representative for a patient population with severe obesity. Twenty children were lost to follow-up, i.e., did not continue their treatment at our obesity center (online suppl. Fig. 1).

Telephone Interviews

A treating physician (O.A., B.v.d.V., or M.S.W.) conducted a semi-structured telephone interview to evaluate and explore the effects of the lockdown measures on the children's lifestyle behaviors and HRQoL. Parents were interviewed as proxy for their chil-

dren in most cases, depending on their age and cognitive abilities. None of the included children were siblings within the same family. A structured format with 37 predefined multiple-choice and 20 open-ended questions was used. After conducting the interviews, the comprehensive physicians' records were used for qualitative analyses. Additionally, in-depth semi-structured interviews were conducted with 8 children between ages 10 and 14 years using video-calls (details in online suppl. material).

Qualitative Analysis

All interviews were independently coded by 2 physicians (O.A., M.S.W.) according to the Grounded Theory using a deductive, theory-driven approach followed by an inductive, data-driven approach [21]. Further details are provided in the online supplementary material. As this study was conducted in the context of patient care, all eligible study participants were included even after we had achieved data saturation. Importantly, the qualitative analyses were conducted before the quantitative analyses to avoid any biases through prior knowledge of the quantitative outcomes. Qualitative data were analyzed using MAXQDA 2018 (VERBI Software) following best practice methods and reported following the Consolidated Criteria for Reporting Qualitative Research checklist [22, 23].

Quantitative Assessments and Analysis

Pre-pandemic height and weight were measured by trained personnel. BMI was converted to age- and sex-specific standard deviation scores (SDS) using Dutch reference charts [24]. Ethnicity, socio-economic status (SES) z-score, whether subjects lived in urban or rural areas (both based on postal code), signs of insatiable behavior, autism (DSM-V diagnosis), intellectual disability/developmental delay (DSM-V diagnosis), and/or psychosocial problems (DSM-V diagnosis or involvement of psychosocial health care professionals) were assessed pre-pandemic; exact definitions are presented in the online supplementary Methods. Three validated questionnaires were completed by the children and/or their parents both at baseline as well as during lockdown:

- The Dutch Eating Behavior Questionnaire – Child version (DEBQ-C) assesses 3 eating styles: restrained eating (eating less than desired to lose or maintain body weight), emotional eating (eating in response to negative emotions), and external eating (eating in response to food cues). Percentile scores ranging from 0 to 100 were calculated based on population norms [25], and were recoded into low (<p20), average (p20–p80), or high (>p80) scores.
- The Dutch PA Questionnaire assesses weekly time spent on PA, including school transfers, sports at school or sport clubs, and playing outside [26]. Furthermore, it was assessed whether the child fulfills the WHO Global Recommendations on Physical Activity for Health criterion of ≥ 1 h of moderate- to high-intensity daily PA [27]. We compared the proportion of children fulfilling these recommendations pre-pandemic and during lockdown to the general Dutch population, adjusting for age categories and year of assessment [28]. Furthermore, daily sedentary screen time (excluding digital education) was assessed. From this, the proportion of children adhering to the 2016 American Academy of Pediatrics recommendations for screen time, i.e., <1 h/day for children aged 2–5 years and <2 h/day for children aged ≥ 6 years, was calculated [29].

Table 1. Characteristics of the study population at their most recent visit to the hospital pre-pandemic

Characteristic	All patients (n = 83)
Age, years, mean (SD)	11.2 (4.6)
Sex, female, n (%)	43 (52)
Ethnicity, Dutch, n (%)	56 (68)
Socioeconomic status z-score, mean (SD)	−0.1 (1.2)
Living conditions, urban, n (%)	65 (78)
BMI SDS, mean (SD)	+3.8 (1.0)
Signs of insatiable behavior, n (%)	38 (46)
Intellectual disability/developmental delay, n (%)	26 (31)
Autism, n (%)	14 (17)
Psychosocial problems, n (%)	46 (55)

BMI, body mass index; SD, standard deviation; SDS, standard deviation score.

- The Pediatric Quality of Life inventory™ 4.0 (parents proxy-report version) (PedsQL) questionnaire assesses HRQoL on 4 domains: physical, emotional, social, and educational functioning. Sub- and total scores were converted to percentile scores ranging from 0 to 100, with higher scores indicating better HRQoL [30]. In our center, we use the cutoff value <p60 to identify clinically relevant low scores, based on a large study in children with obesity in which this percentile reflects approximately mean −1 SD [31].

Quantitative data are given as mean (SD) or number (percentage). For our primary quantitative analyses, we compared differences between questionnaire outcomes during lockdown versus pre-pandemic. Additionally, we performed drop-out analyses in which we analyzed differences in baseline characteristics between included and excluded patients, as well as patients who participated in the telephone interviews or completed each of the questionnaires versus those who did not. The following statistical tests were used: for unpaired data, *t* tests for normally distributed continuous variables, Mann-Whitney tests for non-normally distributed continuous data, and χ^2 tests/Fisher's exact tests for categorical data, as appropriate. For paired analyses, paired-sample *t* tests were used for normally distributed continuous variables, Wilcoxon signed-rank tests for non-normally distributed continuous variables, and McNemar tests for categorical variables. Furthermore, it was evaluated whether baseline characteristics (i.e., age, sex, ethnicity, SES z-score, living in urban vs. rural areas, signs of insatiable behavior, autism, intellectual disability/developmental delay, or psychosocial problems) influenced the results of our qualitative and quantitative analyses using χ^2 tests or linear regression. Finally, we examined whether scores on the DEBQ-C and Dutch PA questionnaire influenced PedsQL scores during lockdown using linear regression analyses. In the qualitative data analyses, we categorized children based on qualitative outcomes (e.g., increased demand for food of the child reported by parents) and quantitatively evaluated differences in baseline characteristics using the appropriate statistical tests. Quantitative data were analyzed using SPSS version 25.0 (IBM Statistics) with a 2-sided α of 0.05.

Table 2. Identified themes and illustrative quotes from the qualitative analysis

Theme 1: changes in eating styles and behaviors during lockdown	
Theme 1.1: increased demand for food	<i>R1, girl, 10 yr: "Well, I am craving pancakes way more, because the pancake-mix is standing there [in the kitchen]. (...) I want those the whole time, for breakfast or for lunch, I think: I want pancakes."</i>
Theme 1.2: no changes in eating behaviors in families who already had strict schedules regarding food	<i>Mother of R4, boy, 13 yr: "Well, I try, we try together to keep the daily structure. We start with school on time and eat normal snacks, so it won't become a feeding frenzy. Which actually does happen in the weekends a bit."</i>
Theme 1.3: positive changes in eating behaviors due to decreased external eating stimuli	<i>R4, boy, 13 yr: "Actually, yes, it is easier. Because my mother is at home the whole time. Sometimes you think, I can take something and then... Yes, so it is easier to eat healthy." Father of R6, boy, 10 yr: "He really is managing very good. He indicates well when he is full. I think it is even better than when he's at school."</i>
Theme 2: changes in physical activities during lockdown	
Theme 2.1: decreased physical activities related to lockdown measures and/or anxiety	<i>R3, girl, 10 yr: "Sometimes it is difficult, if we are playing tag and we can't touch each other." R1, girl, 10 yr: "We bike less, we almost never walk and we watch a lot more movies, well, I watch a lot more movies. I watched a whole series in 2 days."</i>
Theme 2.2: important role of parents and peers in motivating children to engage in PA	<i>R3, girl, 10 yr: Before COVID we had an exercise club, with 2 other girls. (...) It's a pity that stopped, because those girls were fun to exercise with." Father of R7, boy, 11 yr: "I take him outside sometimes, I say to him: Come on, go outside for an hour or half an hour. (...) But I can't take him to the park every day, because sometimes he is scared. Then he says, he doesn't want to, because he'll get COVID."</i>
Theme 3: changes in emotional well-being of child and family dynamics during lockdown	
Theme 3.1: deteriorated emotional well-being of child and worsened family dynamics	<i>R4, boy, 13 yr: "Well, [I miss] my grandma, we do see her but only outside and on 1.5 m distance." R7, boy, 11 yr: "I find it hard that I can't talk with my friends or play outside. We can't do that. We play video games and talk on the phone, but that's boring to do the whole time."</i>
Theme 3.2: increased demands on parents due to different parenting roles	<i>Father of R7, boy, 11 yr: "It is really tough, it is very boring now. Life went almost down the drain because of that disease. Not just mine, but of the whole of humanity. (...) I find it very difficult; I can't see my colleagues; I can't do anything, you know. I can't go outside, I can't see my friends, for me it is also tough. But I can handle it, I can cope with it, but for children, it is difficult."</i>
Theme 3.3: improved family dynamics due to increased family time and space for children's emotions	<i>Mother of R4, boy, 13 yr: We are doing quite well, we can just endure each other well."</i>
Theme 4: impact of lockdown on daily structure of children	
Theme 4.1: difficulties in adapting to changes in daily structure	<i>R8, boy, 10 yr: "Today I woke up at 11:00 a.m. and yesterday I also woke up at 11:00 a.m."</i>
PA, physical activity.	

Results

In total, 116 patients visited the Obesity Center CGG during the study period, of which 90 families were approached (exclusion criteria presented in online suppl. Fig. 1). Of these families, 83 participated in the quantitative analyses and 75 in the telephone interviews. The mean age of the 83 included children was 11.2 ± 4.6 years; 43 (52%) were females; and mean BMI SDS was 3.8 ± 1.0 , indicating severe obesity (Table 1).

Baseline characteristics did not differ between children who were included in this study ($n = 83$) versus those who were not ($n = 33$, all p values >0.05 , online suppl.

Table 1). Similarly, baseline characteristics did not differ between children who participated in the telephone interviews ($n = 75$) versus those who did not ($n = 8$, all p values >0.05 , online suppl. Table 2). A thematic summary of main findings and illustrative quotes are presented in Table 2.

Theme 1: Changes in Eating Styles and Behaviors during Lockdown

Dutch Eating Behavior Questionnaire – Child Version The DEBQ-C was completed in 59/83 (71%) families during lockdown. Their children's baseline characteristics did not differ from those that did not complete the

Table 3. Dutch eating behavior questionnaire for children scores pre-pandemic and during lockdown

	Pre-pandemic, mean ± SD scores or n (%)	During lockdown, mean ± SD scores or n (%)	Δ	p value
Restrained eating				
All patients (n = 59)	59.5±32.6	63.4±33.8	+3.9	0.39
High scores	24 (41)	29 (49)		0.38
Average scores	23 (39)	21 (36)		
Low scores	12 (20)	9 (15)		
Emotional eating				
All patients (n = 57*)	58.0±32.8	67.2±32.9	+9.2	0.11
High scores	20 (35)	27 (47)		0.20
Average scores	27 (47)	24 (41)		
Low scores	10 (18)	6 (10)		
External eating				
All patients (n = 59)	68.2±31.5	68.5±28.4	+0.3	0.57
High scores	31 (53)	26 (44)		0.36
Average scores	24 (41)	29 (49)		
Low scores	4 (7)	4 (7)		

SD, standard deviation. * Subscore missing at baseline for n = 2 patients.

questionnaire (all p values >0.05 , online suppl. Table 3). On group level, all scores remained unchanged over time (all p values >0.05 , Table 3). No effect of sex was found on changes in restrained, emotional, or external eating (all p values >0.05). The majority of children with high scores on restrained eating (21/29, 72%), emotional eating (15/27, 56%), or external eating (24/26, 92%) during lockdown already had high scores pre-pandemic.

When looking into subgroups, 20 (34%) children reported an increase of ≥ 10 percentiles in restrained eating versus 10 (17%) a decrease ($p = 0.07$). Baseline characteristics were not associated with changes in restrained eating (all p values >0.05). Fifteen (26%) children reported an increase of ≥ 10 percentiles in emotional eating versus 10 (18%) a decrease ($p = 0.32$). Children for whom ≥ 10 percentiles increase in emotional eating was reported more often had pre-existent psychosocial problems (73% vs. 30%, $p = 0.049$) and on average were older, although this was not statistically significant (11.3 vs. 9.1 years, $p = 0.32$). Fourteen (24%) children reported an increase of ≥ 10 percentiles in external eating versus 19 (32%) a decrease ($p = 0.38$). Children for whom ≥ 10 percentiles increase was reported were younger, although this was not statistically significant (9.7 vs. 11.3 years, $p = 0.42$).

Qualitative Results – Eating Behaviors

An increased demand for food by the child was reported for 21/75 (28%) children. Most of these children lived in urban areas (20/21, 95%, $p = 0.033$), were <10 years old

(19/21, 90%, $p < 0.001$), and showed signs of insatiable behavior (17/21, 81%, $p < 0.001$). These children on average had a slightly lower SES z-score, although this was not statistically significant (mean -0.4 SDS, $p = 0.24$). An increased demand for food was associated with higher external eating scores (mean 85.7 vs. 62.6, $p < 0.001$) during lockdown. Most parents attributed the increased demand to loss of daily structure and loss of delimited lunch box portion sizes due to school closings. Other reported reasons were increased stress, eating out of boredom, and food-seeking behavior. Consequently, many parents had to put more effort to maintain control over their child's eating behavior. In some families, this led to increased conflicts.

Fifteen (20%) families reported no changes in eating behaviors, mostly because they already had strict eating schemes due to previous dietary and/or pedagogic support. Moreover, eleven families reported improved eating behavior during lockdown, mostly due to decreased external eating stimuli, although their external eating scores did not differ significantly (mean 75.4 vs. 67.3, $p = 0.43$).

Theme 2: Changes in Physical Activities and Screen Time during Lockdown Dutch PA Questionnaire

The PA questionnaire was completed by 55/83 (66%) families during lockdown. Their children's baseline characteristics did not differ from those who did not complete the questionnaire (all p values >0.05 , online suppl. Table

Table 4. Time spent on physical activities and screen time pre-pandemic and during lockdown

	Pre-pandemic, mean ± SD	During lockdown, mean ± SD	Δ	p value
<i>PA (h/wk)</i>				
All patients (n = 55)	9.1±6.7	7.2±7.6	-1.9	0.02
Patients who fulfil Dutch PA guidelines				
Pre-pandemic and during lockdown (n = 21)	14.2±5.8	13.3±5.6	-0.9	0.42
Neither pre-pandemic nor during lockdown (n = 17)	2.8±1.7	0.7±0.9	-2.1	0.001
Pre-pandemic but <i>not</i> during lockdown (n = 11)	12.6±4.0	2.0±2.4	-10.6	0.003
During lockdown but <i>not</i> pre-pandemic (n = 6)	3.3±1.2	14.0±8.5	+10.7	0.03
<i>Screen time (h/wk)</i>				
All patients (n = 54)	18.2±12.9	18.0±11.7	-0.2	0.65
Patients who fulfil AAP recommendations for screen time				
Pre-pandemic and during lockdown (n = 11)	8.0±4.0	6.5±3.9	-1.5	0.33
Neither pre-pandemic nor during lockdown (n = 24)	26.4±12.5	24.4±9.7	-2.0	0.42
Pre-pandemic but <i>not</i> during lockdown (n = 11)	7.0±3.63	20.7±10.0	+13.7	0.003
During lockdown but <i>not</i> pre-pandemic (n = 8)	23.0±10.1	7.8±4.7	-15.2	0.01

Bold values are significant. SD, standard deviation; AAP, American Academy of Pediatrics; PA, physical activity.

Table 5. Pediatric quality of life inventory scores pre-pandemic and during lockdown

	Pre-pandemic, mean ± SD scores or n (%)	During lockdown, mean ± SD scores or n (%)	Δ	p value
<i>Physical functioning</i>				
All patients (n = 49)	63.5±24.8	66.3±23.1	+2.8	0.12
Low scores (<p60)	24 (49)	21 (43)		0.45
<i>Emotional functioning</i>				
All patients (n = 49)	58.4±20.6	60.1±22.3	+1.7	0.45
Low scores (<p60)	23 (47)	26 (53)		0.55
<i>Social functioning</i>				
All patients (n = 49)	63.9±22.9	67.7±23.7	+3.8	0.12
Low scores (<p60)	20 (41)	15 (31)		0.18
<i>Educational functioning</i>				
All patients (n = 48)	62.7±18.3	66.1±21.9	+3.4	0.32
Low scores (<p60)	18 (38)	18 (38)		1.00
<i>Total scores</i>				
All patients (n = 48)	62.4±18.3	65.4±18.6	+3.0	0.06
Low scores (<p60)	23 (49)	20 (42)		0.51

SD, standard deviation.

4). On group level, mean weekly PA time decreased significantly and mean weekly (noneducational) screen time did not change (*p* values 0.02 and 0.65, respectively, Table 4). No effect of sex was found on changes in weekly PA time (*p* = 0.66). With regard to weekly screen time, girls showed an increase from 15.2 ± 9.9 h to 18.6 ± 11.9 h during lockdown, whereas boys showed a decrease from

20.9 ± 12.6 h to 17.3 ± 11.7 h during lockdown (*p* = 0.003). Thirty-two (58%) children fulfilled the WHO recommendations pre-pandemic (Table 4), similar to 49% of children in the Dutch general population (*p* = 0.33). This did not change significantly during lockdown (27/55, 49%, *p* = 0.33 vs. pre-pandemic). Children who fulfilled WHO recommendations during lockdown were younger (9.2

vs. 13.2 years, $p = 0.002$) and more often (21/27, 78%, $p = 0.004$) already fulfilled the recommendations pre-pandemic. During lockdown, 19/55 (35%) children adhered to the American Academy of Pediatrics screen time recommendations, similar to 22/55 (40%) pre-pandemic ($p = 0.65$).

Qualitative Results – Physical Activity

Many families (42/75, 56%) reported a decrease of their child's PA during lockdown. Often (36/75, 48%), family members tried to motivate their children into PA, which succeeded in two-third of families. Reasons for not succeeding were anxiety for COVID-19 infection in children and/or parents to leave the house and preference of child to perform PA with peers rather than parents. Reasons for succeeding were use of online videos, performing PA together with family members, parents having more time to spend on PA with their children, and parents arranging outside play dates with peers.

A minority of children (11/75, 15%) reported no change in PA during lockdown. Another subgroup (7/75, 9%) reported increased PA due to playing outside more often. Some families bought sports equipment to enhance possibilities, such as a punching ball or trampoline.

Theme 3: Changes in Emotional Well-Being and Family Dynamics during Lockdown

Pediatric Quality of Life Questionnaire

The PedsQL was completed by 49/83 (59%) families during lockdown, which included more often families with a child with psychosocial problems (67% vs. 38%, $p = 0.009$) or autism (24% vs. 6%, $p = 0.026$, online suppl. Table 5). On group level, mean sub- and total scores improved slightly during lockdown, although not statistically significant (all p values >0.05 , Table 5). No effect of sex was found on changes in mean sub- and total scores (all p values >0.05). Most children with low total scores during lockdown had low scores pre-pandemic (17/20, 85%). The children with low scores during lockdown more often had pre-existent psychosocial problems (85% vs. 54%, $p = 0.023$) or autism (45% vs. 11%, $p = 0.007$). Eleven (23%) children reported an increase of ≥ 10 percentiles of total score versus 6 (13%) a decrease of ≥ 10 percentiles ($p = 0.23$). This was unrelated to baseline characteristics (all p values >0.05).

During lockdown, total scores were not associated with time spent on PA, screen time, or restrained eating (all p values >0.05), but were negatively associated with emotional eating ($\beta = -0.28$, $SE = 0.72$, $p < 0.001$) and external eating ($\beta = -0.29$, $SE = 0.90$, $p = 0.002$).

Qualitative Results – Emotional Well-Being and Family Dynamics

During lockdown, 46/75 (61%) parents reported deteriorated emotional well-being of their child and worsened family dynamics. The most frequently experienced negative emotions were anger ($n = 27$, 36%), boredom ($n = 25$, 33%), and anxiety ($n = 24$, 32%), mostly related to conflicts due to being at home together all the time. Other reasons were increased conflicts regarding eating behavior, loss of predictability of daily structure, missing social contacts with friends, family, and/or teachers, and the limited possibilities in daily activities. Several parents reported difficulties with the increased demand of combining working from home themselves with all different parenting roles: having to organize homeschooling, motivate their children to engage in PA, and control their eating behavior. These pedagogical demands compromised their adherence to the lifestyle advices that they had received from health care professionals pre-pandemic.

Fourteen (19%) families reported positive changes in family dynamics. The increased family time, with more space for their children's emotions and needs, led to better understanding of each other. Two families mentioned that the temporary pause of therapies with health care professionals enabled them to unwind and 4 families (5%) reported less stress due to school closures.

Theme 4: Impact of Lockdown on Daily Structure of Children

Qualitative Results – Daily Structure of Children

All children had to cope with changes in daily structure, and 33/75 (44%) had difficulties adapting. Most frequently, sleeping patterns were disturbed. Families that experienced no difficulties in adapting had pre-existent or newly implemented strict daily schedules in place to help their children to keep the normal structure of school weeks as much as possible.

Discussion

To our knowledge, this is the first study to report the impact of COVID-19-related lockdown measures on eating styles and behaviors, PA, screen time, and HRQoL in children and adolescents with severe obesity. Our quantitative analyses showed that on group level, the time spent on PA decreased significantly. In half of the population, mean time spent on PA decreased to ≤ 2 h/week. When zooming in on subgroups, children with pre-existent psychosocial problems more often showed increased

emotional eating. In addition, the lowest HRQoL scores during lockdown were seen in children with pre-pandemic high scores on external or emotional eating or pre-existent psychosocial problems. Our qualitative analyses revealed an increased demand for food by predominantly younger children with signs of insatiable behavior and/or higher external eating scores. Moreover, a majority of parents reported deteriorated emotional well-being of their child and worsened family dynamics during the lockdown.

To date, one Italian study in 41 children with obesity investigated the impact of COVID-19 lockdown on time spent on PA (as reported by parents during a telephone interview) and found a decreased PA (-2.3 h/week), which is similar to the -1.9 h/week decrease in our study [16]. When zooming in on our study population during lockdown, children who managed to adhere to PA guidelines during lockdown were significantly younger (9.2 vs. 13.2 years) and more often adhered to PA guidelines pre-pandemic. In line with recent findings, encouragement from parents or peers seemed important [2, 4, 5, 32]. Moreover, in half of our population, mean time spent on PA decreased dramatically to ≤ 2 h/week, which was often attributed to COVID-19-related anxiety, as we ourselves as well as a recent US study reported recently [15, 33]. This alarming lack of PA puts these children at risk for negative mental health effects and weight gain [33–35].

Contrary to our expectations, we did not identify statistically significant changes in emotional eating or external eating on group level during lockdown. Moreover, most children with high scores during lockdown already had high scores pre-pandemic. Notably, our study population has higher DEBQ-C scores pre-pandemic as can be expected in a population with severe obesity [12]. These pre-pandemic eating styles as well as pre-existent insatiable behavior seemed the most important predictors of high emotional and external eating scores during lockdown. Of note, we did not investigate whether eating styles correlate directly to food intake, but high scores on external or emotional eating may put children at risk for weight gain. To date, one Saudi-Arabian study reported prevalence of high emotional eating in healthy young women (12% vs. 47% in our population) and found a positive association with BMI and perceived stress [36]. In our study, children with increased emotional eating scores during lockdown significantly more often had pre-existent psychosocial problems. Moreover, adhering to pre-pandemic strict daily schedules was reported to help in minimizing the experienced impact of COVID-19 lockdown on children's eating behaviors.

HRQoL in children with obesity is known to be diminished and is associated with severity of the obesity and older age [13, 14]. In our study, only 13% reported a decrease versus 23% an increase of ≥ 10 percentiles in PedsQL scores. However, PedsQL scores were considerably lower compared to another cohort of children with obesity pre-pandemic (mean total score 65.4 vs. 75.5, respectively) [14]. We identified one other study that measured HRQoL using the PedsQL during lockdown in children from the general population, which reported an almost 15 points higher mean total score compared to our population [37]. Accordingly, the absence of a further decline in mean total PedsQL score in our population could be explained by a "ceiling" effect. The lower PedsQL scores in our study might also have been caused by the characteristics of our academic patient population, which included a relatively large proportion of children with intellectual disability, autism, and/or psychosocial problems. Indeed, our drop-out analyses revealed that the PedsQL questionnaire was more often completed by families whose children had autism and/or pre-existent psychosocial problems, and these children significantly more often showed low HRQoL scores during lockdown compared to children without these characteristics. Interestingly, we did not find an association between HRQoL and PA or screen time, although other studies have suggested a protective effect of PA on the mental health impact of the COVID-19 pandemic in children [33, 35, 37–39]. We did find a strong negative association between HRQoL scores and emotional and external eating during lockdown.

Several studies have underlined the importance of healthy family dynamics during lockdown [5, 39–41]. In our population, families who reported improved dynamics attributed this to increased family time and more space for each other's emotions. Moreover, having enough physical space at home and having the financial possibility to buy, for example, sports equipment was beneficial. A substantial part of families reported increased tensions and difficulties with juggling between competing parenting roles during lockdown. In our clinical experience pre-pandemic, parents of children with obesity already have to put substantial effort in managing healthy lifestyle choices for their children. The additional parenting roles, remote working, and possible job insecurities associated with the COVID-19 pandemic can therefore put an extra strain on parents of children with severe obesity. Broadly in line with our results, recent general population studies found similar mental and social health complaints in families during lockdown. These were as-

sociated with family characteristics such as living in single-parent families, having less space at home, having multiple siblings, having pre-existent medical problems in the family, and changes in parental working conditions [40, 42, 43]. Moreover, increased parental COVID-19-related stress was found to be associated with non-nutritive use of food and snacks, such as emotional and instrumental feeding [44]. These studies together with ours, highlight the importance of evaluating the need for parental support, especially in families with the above-mentioned risk factors. Although we and others did not find a statistically significant effect of SES z-score on our outcomes on group level [7], our qualitative data suggest that children from families with lower SES might have more challenges to face. Moreover, the COVID-19 lockdown measures, especially school closures, have been shown to exacerbate existing inequalities, e.g., children's risk of psychosocial or mental problems [37], or food insecurity [45].

Based on our study, we recommend a proactive approach in specific patient subgroups to minimize negative effects of lockdown, e.g., by offering individualized adjustments to patient- and family-specific medical support, together with other involved health care professionals. First, children who already were at risk pre-pandemic, e.g., due to psychosocial problems, insatiable behavior, high emotional or external eating, or not fulfilling WHO PA recommendations, show the worst outcomes during lockdown. Second, COVID-19-related anxiety, when present, seems to influence PA [15]. Third, adolescents seem to be at risk for increased emotional eating and decreased PA, whereas younger, i.e., prepubertal, children more often show increased external eating.

Strengths and Limitations

A strength of our study is the evaluation of multiple lifestyle behaviors and well-being that are known to have reciprocal interactions, in a unique population of children with severe obesity. Furthermore, we compared validated questionnaire data longitudinally, enabling us to identify the children who improved or deteriorated during lockdown. Our mixed-methods design provided insights in the reasons why children succeeded or failed in maintaining a healthy lifestyle. It should be noted that we did not use transcriptions of the telephone interviews. However, all relevant information was documented comprehensively in the medical records using an extensive pre-defined format. This study was performed within the first 2 months of the first COVID-19-related lockdown in the Netherlands, providing us the unique opportunity to

investigate the acute impact of these unforeseen circumstances. As children's and families' lifestyle behaviors, well-being, and attitudes toward the lockdown measures may have changed since, follow-up studies are needed. Another limitation is that we did not record whether questionnaires were completed by children or their parents, which might have influenced reported behaviors. Our study was designed to compare lifestyle factors and well-being in children with severe obesity pre-pandemic and during COVID-19 lockdown. Therefore, we did not include an additional control group of children without obesity.

Conclusion

In conclusion, our mixed-methods study shows differing responses to COVID-19-related lockdown measures in children and adolescents with severe obesity. Quantitative analyses revealed that on group level, PA declined, whereas noneducational screen time, eating styles, and HRQoL did not change significantly. Qualitative analyses showed that a minority of families kept adhering to strict schedules and reported no changes or improved lifestyle behaviors, whereas a substantial part of families reported a deterioration in PA, eating behaviors and HRQoL. Children with pre-existent psychosocial problems, insatiable behavior, or pre-existent high external or emotional eating were most at risk for the negative effects on lifestyle behaviors and well-being. These children need to be targeted by health care professionals to minimize short- and long-term negative physical and mental health consequences.

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Statement of Ethics

This study was approved by the Medical Ethics Committee of the Erasmus University Medical Center (Erasmus MC), Rotterdam, The Netherlands, approval number MEC-2012-257. In accordance with Dutch law, all caregivers of children ≤ 16 years gave written informed consent; additionally, children aged ≥ 12 years gave their written informed consent and children aged ≤ 12 years gave their oral assent.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

M.S.W. and O.A. took part in the conceptualization, data curation, formal analysis, investigation, methodology, project administration, validation, visualization, writing the original draft, and verifying the underlying data. E.v.d.E. was involved in the conceptualization, data curation, formal analysis, investigation, method-

ology, validation, visualization, writing, reviewing and editing, and verifying the underlying data. J.H., A.E.B., L.K. took part in the conceptualization, investigation, methodology, writing, reviewing and editing. E.F.C.v.R. and E.L.T.v.d.A. participated in conceptualization, funding acquisition, investigation, methodology, resources, software, supervision, validation, visualization, and writing, reviewing and editing of the manuscript. B.v.d.V. took part in the conceptualization, data curation, formal analysis, investigation, methodology, project administration, resources, software, supervision, validation, visualization, writing, reviewing and editing, and verifying the underlying data.

Data Availability Statement

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants but are available from the Data sharing committee (CGG Steering Committee, Dr. E.L.T. van den Akker, centrumgezondgewicht@erasmusmc.nl) upon reasonable request.

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