

Weighing in on COVID-19: The impact of the pandemic on children and adolescents with obesity participating in a weight management program

Barkha P. Patel¹ | Thrmiga Sathiyamoorthy² | Mohana Giruparajah¹ |
Alene Toulany^{2,3,4,5} | Jill K. Hamilton^{1,2,4} 

¹Division of Endocrinology, The Hospital for Sick Children, Toronto, Ontario, Canada

²Temerty Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada

³Division of Adolescent Medicine, The Hospital for Sick Children, Toronto, Ontario, Canada

⁴Child Health Evaluative Sciences, SickKids Research Institute, Toronto, Ontario, Canada

⁵Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Ontario, Canada

Correspondence

Jill K. Hamilton, Division of Endocrinology, The Hospital for Sick Children, 555 University Avenue, Toronto, ON M5G 1X8, Canada.
Email: jill.hamilton@sickkids.ca

Funding information

Lunenfeld Studentship

Summary

Background: COVID-19 mitigation measures, including closures of schools and recreational facilities and alterations in eating behaviours and physical activity, may impact weight.

Objective: To examine changes in body weight and body mass index (BMI) in children and adolescents with obesity participating in an obesity treatment program before and during the COVID-19 pandemic in Ontario, Canada.

Methods: Body weight and BMI at baseline and 6 months were recorded for the 'historic' cohort (females = 34, males = 21) before the pandemic (November 1, 2018, to March 18, 2020) and for the 'pandemic' cohort (females = 30, males = 30) during the pandemic (March 19, 2020 to July 31, 2021). Analyses were adjusted for baseline weight/BMI, age, and ON-Marg score, a measure of the social determinants of health.

Results: In males, body weight (98.29 versus 89.28 kg, $p < 0.001$) and BMI (36.46 versus 34.85 kg/m², $p = 0.027$) were greater in the pandemic compared with historic cohort. In females, body weight ($p = 0.769$) and BMI ($p = 0.548$) were not different between the two cohorts.

Conclusion: The COVID-19 pandemic may have diminished the health impacts of a weight management program, particularly in males, leading to increased body weight and BMI.

KEYWORDS

adolescents, children, COVID-19, obesity, weight gain

1 | INTRODUCTION

On March 11, 2020, the World Health Organization (WHO) declared COVID-19 (a coronavirus) a global pandemic.^{1,2} Compared with previous pandemics (e.g., H1N1 influenza in 2009), COVID-19 resulted in unprecedented and severe public-health measures over a prolonged period of time.³ International jurisdictions, including Canada, instituted several measures to curb the spread of coronavirus, including stay-at-home orders, social distancing measures, restriction of in-person

schooling, and closure of playgrounds, recreational facilities, and other non-essential businesses and services.⁴ Despite the necessity of these public-health measures, they imposed serious disruptions to the health and well-being of people of all ages. The pandemic led to dramatic lifestyle behaviour changes, such as an increase in food shopping, takeout meals,⁵ and increased sedentary activities (e.g., sleeping longer, greater screen time, and decreases in physical activity due to reduced movements outside of the house).⁶⁻⁹ Moreover, social isolation contributed to an increase in sedentary activities further complicating existing

unhealthy eating habits and significantly reducing opportunities for physical activity for individuals who have overweight or obesity.

Few studies have explored the impact of the pandemic and corresponding lock-down measures on changes in body weight and obesity.¹⁰ In 2016, the WHO estimated that approximately 340 million children and adolescents (5–19 years old) had overweight or obesity.¹¹ Additionally, the United States (U.S.) expected 1.27 million new childhood obesity cases by March 2021, citing school closures as an important contributor to significant weight gain.⁹ A 2021 study by Lange et al. showed that within a large US-based cohort of individuals (2–19 years of age), the rate of body mass index (BMI) increase approximately doubled during the pandemic compared with a pre-pandemic period.¹⁰ Of note, youth who had overweight or obesity before the pandemic, as well as younger school-aged children, experienced the largest increases in BMI. Improving health outcomes in children and adolescents during the COVID-19 pandemic is critical, as obesity remains a prominent risk factor for severe COVID-19 with increased mortality,¹² in addition to its associated co-morbidities.¹³ Also, since in-person visits to see a doctor have been mostly replaced by virtual health care,¹⁴ many children and adolescents participating in weight management programs have had interruptions to their in-person medical care during the COVID-19 pandemic that may have impacted their weight management.

COVID-19 has also disproportionately impacted disadvantaged families. Negative impacts include loss of income and additional expenses (e.g., childcare, home internet),¹⁵ loss of education and school-based supports (e.g., connection to services, subsidized nutritional meals),¹⁶ and a general decline in mental well-being.¹⁷ The potential negative effects of the COVID-19 pandemic response in children and adolescents are exacerbated in those living in poverty,¹⁸ with behavioural health needs, in foster care or at risk of maltreatment, and with complex medical needs.^{19,20} It is important to consider the impact of the pandemic on paediatric obesity outcomes to understand how these factors influence weight management.

Given the significant disruptions from the COVID-19 pandemic and its associated repercussions, it is critical to consider the impact of the pandemic on child and adolescent weight trajectories. The objective of the current study was to examine changes in body weight and BMI in children and adolescents with obesity participating in an interdisciplinary obesity treatment program before and during the COVID-19 pandemic in Ontario, Canada. We hypothesized that weight and BMI will be greater during compared with before the pandemic and may differentially impact boys and girls.

2 | METHODS

2.1 | Patient population

This study was conducted at the Hospital for Sick Children (SickKids), the largest academic and paediatric tertiary referral center in Canada. This observational study recruited patients from the SickKids Team Obesity Management Program (STOMP) between November 2018

and July 2021. STOMP is a 2-year multidisciplinary treatment program that engages with children and adolescents (1–18 years of age) living with severe and complex obesity, and their families. In practice, severe and complex obesity is defined as having a BMI percentile greater than or equal to the 99th percentile for age and sex, or if the patient has significant weight-related comorbidities and a BMI greater than or equal to the 95th percentile for age and sex.²¹ Patients and families are offered standardized education and nutritional, physical, medical, and mental health supports through individual and group sessions.²² The STOMP medical visits with a physician occur at baseline, 1 month, 3 months, and then every month for a 2-year period. At these medical visits, patients may see other allied health professionals, including nurses, dietitians, social workers, and psychologists, if necessary. There are also follow-up appointments with the allied health professionals which occur weekly for the first 8 weeks. Patients attend group education classes of 2 h duration running weekly for 8 weeks. Following this they regularly meet with allied health professionals every 2 weeks for 9 months. This equates to approximately 70–100 h of contact. During the second year of the program, the sessions are individualized, and contact is approximately 40–50 h. All appointments are scheduled for 1 h. During the COVID-19 lockdown, appointments were virtual; however, the level of care provided to patients remained similar to the standard of care previously provided.

The study was approved by the Research Ethics Board at SickKids. Written consent was obtained directly from all adolescents aged 13 years and older, and from parents in the study. For all younger patients, written informed consent was obtained from the parent.

2.2 | Data collection

Data from participants were collected during two time frames: (1) pre-COVID-19 (i.e., 'historic' cohort; November 1, 2018 to March 18, 2020) and (2) during the COVID-19 pandemic (i.e., 'pandemic' cohort; March 19, 2020 to July 31, 2021). These two cohorts were independent because participants can only enrol in STOMP once. The time frame for data collection was equal for both cohorts (1 year, 4 months). Demographic characteristics (i.e., age, sex,) were collected at baseline visits in both the historic and pandemic cohorts. Because STOMP is a 2-year program, participants' height (m), weight (kg) and BMI (kg/m^2) are determined at baseline, 6, 12 and 24 months. In this study, however, the baseline and 6-month visit data for each participant were selected for analysis to allow comparisons before and during the pandemic for the largest sample of participants. After 6 months, visits have been delayed or conducted virtually during the pandemic, and home weights were not often measured. All baseline and 6 month data for height and weight for the historic cohort were measured in-person by trained staff using a stadiometer and/or a digital scale while in light clothing and without shoes. Similarly, in the pandemic cohort, all baseline height and weight were measured in-person; however, at the 6 month visit five females self-reported their height and weight. In addition to BMI, age- and sex-specific BMI percentiles were calculated using WHO growth charts.²¹

As a covariate, the Ontario Marginalization Index (ON-Marg) was used as an area-level measure of the social determinants of health using patient postal codes. This census-based index was developed to examine levels of marginalization across residential areas in Ontario, Canada, and has been validated across time and geographic areas.²³ The ON-Marg represents the average of four social determinants of health dimensions measured in quintiles. Quintiles ranged from 1 to 5, with the lowest quintile (Q1) representing the least marginalized and the highest quintile (Q5) representing the most marginalized. The index has four dimensions including residential instability (i.e., housing status, home ownership, etc.), material deprivation (i.e., education, unemployment, income, etc.), ethnic concentration (i.e., recent immigrants, visible minorities, etc.) and dependency (i.e., participation in the labor force).²³

2.3 | Statistical analysis

Statistical analyses were conducted using the Statistical Package for the Social Sciences software (SPSS version 21, Chicago, IL, USA). Potential differences in baseline characteristics were examined using independent *t*-tests between males in the historic versus pandemic cohort and between females in the historic versus pandemic cohort. An analysis of covariance (ANCOVA) was used to examine the effect of cohort (historic versus pandemic) on body weight and BMI at 6 months separately in males and females, adjusting for baseline weight/BMI, age and ON-Marg score. We conducted a secondary analysis using an ANCOVA to examine the effect of cohort and age group (e.g., 2- to 5-year-olds, 6- to 11-year-olds and 12- to 18-year-olds) on body weight and BMI at

6 months separately in males and females, adjusting for baseline weight/BMI and ON-Marg score. Data are presented as means \pm standard error (SE) unless otherwise indicated. Significance was considered at $p < 0.05$.

3 | RESULTS

3.1 | Patient demographics

A total of 115 children and adolescents (1–18 years old) participated in the study. There were 55 in the historic cohort and 60 in the pandemic cohort. At baseline, no significant differences were observed between males or females in the historic versus pandemic cohorts in terms of ages, body weights, BMIs, BMI-Z scores, health dimensions, and ON-Marg scores at baseline ($p > 0.05$, Table 1).

3.2 | Body weight at 6 months between historic and pandemic cohorts

In males, after adjusting for age ($p = 0.605$), ON-Marg score ($p = 0.817$), and baseline body weight ($p < 0.001$), body weight was significantly greater in the pandemic compared with historic cohort (98.29 vs. 89.28 kg, $p < 0.001$, Figure 1). However, in females, body weight was not significantly different in the pandemic compared with historic cohort (88.33 vs. 87.83 kg, $p = 0.769$), after adjusting for age ($p = 0.497$), ON-Marg score ($p = 0.745$) and baseline body weight ($p < 0.001$, Figure 1).

Furthermore, including age group in the secondary analysis did not alter the findings. In males, after adjusting for ON-Marg score

TABLE 1 Participant baseline characteristics^a

Cohort	Males (n = 51)		Females (n = 64)	
	Historic (n = 21)	Pandemic (n = 30)	Historic (n = 34)	Pandemic (n = 30)
Age (years)	11.79 \pm 5.18	12.26 \pm 3.60	13.58 \pm 4.45	11.54 \pm 4.62
Weight (kg)	81.83 \pm 41.37	97.60 \pm 33.09	90.68 \pm 34.01	80.48 \pm 37.98
Height (m)	1.51 \pm 0.27	1.60 \pm 0.21	1.53 \pm 0.19	1.49 \pm 0.26
BMI (kg/m ²)	32.55 \pm 8.78	36.51 \pm 7.23	37.35 \pm 9.66	33.85 \pm 9.77
BMI-Z score	3.75 \pm 1.04	4.32 \pm 1.44	3.93 \pm 1.20	3.71 \pm 1.66
Residential Instability score ^b	3.76 \pm 1.67	3.50 \pm 1.59	3.50 \pm 1.44	3.60 \pm 1.45
Material deprivation score ^c	3.43 \pm 1.66	3.30 \pm 1.74	3.21 \pm 1.55	3.33 \pm 1.60
Ethnic concentration score ^d	4.19 \pm 0.87	4.20 \pm 1.03	4.09 \pm 1.11	4.30 \pm 1.06
Dependency score ^e	1.95 \pm 1.24	2.00 \pm 1.05	2.47 \pm 1.42	2.30 \pm 1.37
ON-Marg score ^f	3.33 \pm 0.89	3.25 \pm 0.98	3.32 \pm 0.86	3.38 \pm 0.86

Note: No significant differences were observed within males and females in each cohort.

^aData are presented as means \pm standard deviation.

^bResidential instability (i.e., 1 = least unstable, 5 = most unstable).

^cMaterial deprivation (i.e., 1 = least deprived, 5 = most deprived).

^dDependency (i.e., 1 = least dependent, 5 = most dependent).

^eEthnic concentration (i.e., 1 = least ethnically concentrated, 5 = most ethnically concentrated).

^fAverage of four quintile scores.

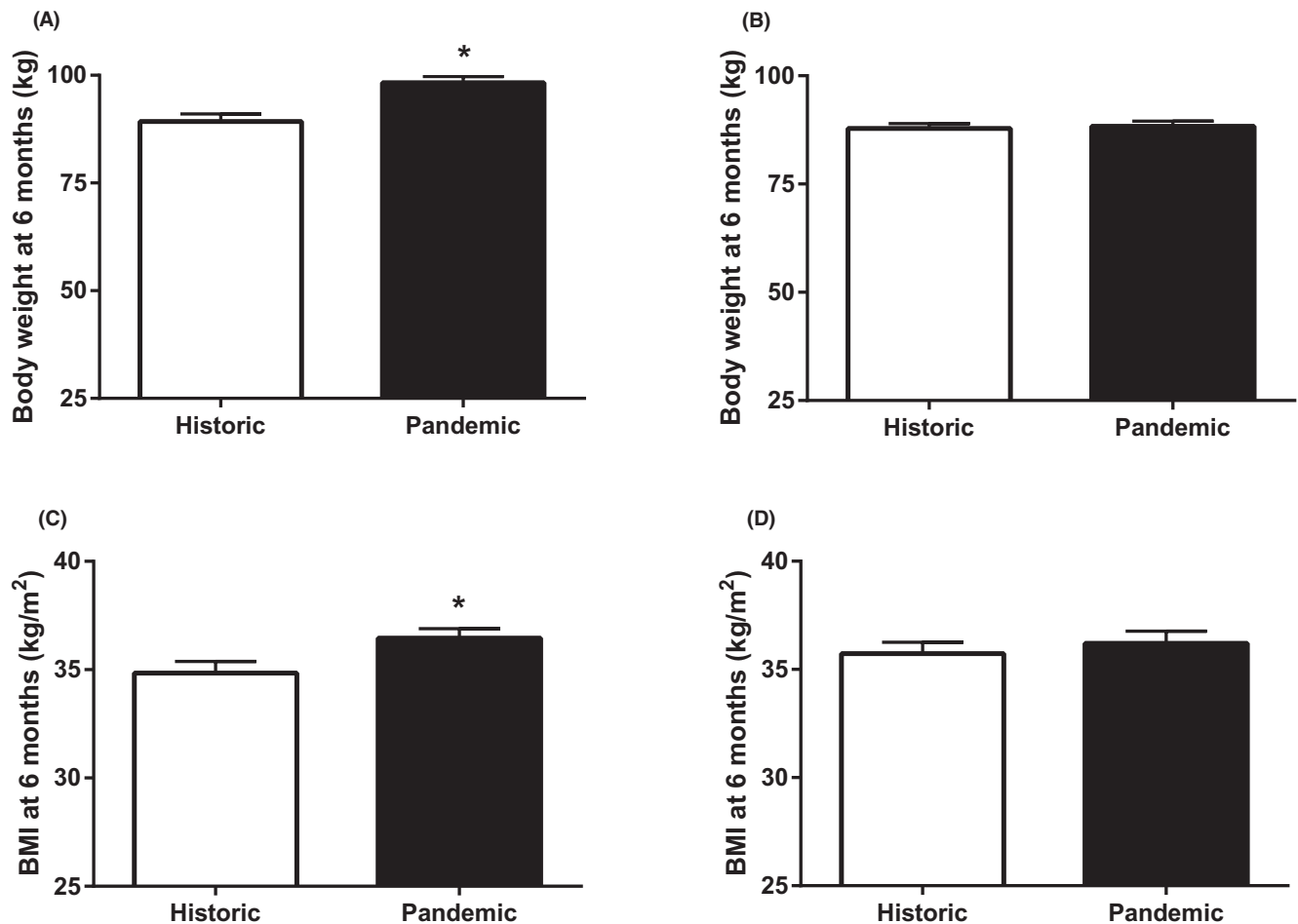


FIGURE 1 (A–D) Body weight at 6 months in males (A) and females (B), and BMI at 6 months in males (C) and females (D) before (“Historic”) and during the COVID-19 pandemic (“Pandemic”). ANCOVAs were used to examine the effect of cohort (historic versus pandemic) at 6 months on body weight means and BMI means separately in males and females, adjusting for baseline weight/BMI, age, and ON-Marg score. Data are means \pm SE; Historic: Males, $n = 21$; females, $n = 34$; Pandemic: males, $n = 30$; females, $n = 30$. *Significantly different from historic, $p < 0.05$

($p = 0.803$) and baseline body weight ($p < 0.001$), body weight was significantly greater in the pandemic compared with historic cohort (95.44 versus 87.27 kg, $p < 0.001$), but not affected by age group ($p = 0.171$) or an interaction between cohort and age group ($p = 0.787$). In females, after adjusting for ON-Marg score ($p = 0.491$) and baseline body weight ($p < 0.001$), body weight was not significantly different in the pandemic compared with historic cohort (88.06 versus 87.87, kg, $p = 0.932$) and was not affected by age group ($p = 0.260$) or an interaction between cohort and age ($p = 0.910$).

3.3 | BMI at 6 months between historic and pandemic cohorts

In males, after adjusting for age ($p = 0.916$), ON-Marg score ($p = 0.120$), and baseline BMI ($p < 0.001$), BMI was significantly greater in the pandemic compared with historic cohort (36.46 versus 34.85 kg/m², $p = 0.027$, Figure 1). However, in females, BMI was not significantly different in the pandemic compared with historic cohort (36.20 versus

35.73 kg/m², $p = 0.548$), after adjusting for age ($p = 0.401$), ON-Marg score ($p = 0.595$) and baseline BMI ($p < 0.001$, Figure 1).

Furthermore, including age group in the secondary analysis slightly altered the findings for males, but not females. In males, after adjusting for ON-Marg score ($p = 0.121$) and baseline BMI ($p < 0.001$), BMI was not significantly greater in the pandemic compared with historic cohort (36.33 versus 34.63 kg/m², $p = 0.073$), and was not affected by age group ($p = 0.862$) or an interaction between cohort and age group ($p = 0.800$). In females, after adjusting for ON-Marg score ($p = 0.419$) and baseline BMI ($p < 0.001$), BMI was not significantly different in the pandemic compared with historic cohort (36.29 versus 35.94 kg/m², $p = 0.742$), and was not affected by age group ($p = 0.500$) or an interaction between cohort and age ($p = 0.780$).

4 | DISCUSSION

This research adds to the growing literature examining weight gain during the COVID-19 pandemic, but with a focus on Canadian

children and adolescents living with obesity. The results of this observational study support our hypothesis that the pandemic has an impact on weight in children and adolescents attending an obesity management program, which differs based on sex. Males had a greater increase in weight, whereas females' weight did not significantly change during the pandemic, despite participation in a weight management program. These findings may suggest an increase in paediatric obesity due to the pandemic. When males and females were grouped by age, weight-related outcomes were mostly consistent, despite the decrease in power resulting from categorizing a continuous variable into groups.

Our data demonstrates that changes in weight and BMI were atypical during the pandemic. These results are aligned with a large U.S. cohort of 432 302 people aged 2–19 years with outpatient visits, which found that those with overweight and obesity and younger school-aged children had the largest increases in BMI during the pandemic compared with the pre-pandemic period.¹⁰ However, sex differences were not discussed. Our results show that sex is a determining factor of weight gain during a global pandemic. For instance, body weight in males after 6 months of lockdown was ~10.1% greater than the body weight of males measured at 6 months during the prepandemic period. It is important to highlight that the pandemic cohorts were followed during the first 6 months of the pandemic. This period had the highest lockdown restrictions, with schools, for example, closed until September 2020,²⁴ and in-person clinic visits drastically reduced. Although not significant, body weight in females after 6 months in the pandemic cohort was only 0.57% greater than the historic cohort. Our findings are consistent with another study which also report a weight-percentile rise after the COVID-19 lockdown in males compared with females, who showed no change.²⁵

There are several lines of evidence that may account for the sex differences. This may be explained by the different interactions of sex with metabolic health and behavioural patterns (e.g., active lifestyle, sedentary time, sleep patterns).²⁶ Ruiz-Roso et al. reported that male adolescents were more active compared with females prior to the pandemic. However, both groups' inactivity significantly increased during April to May 2020.²⁷ Moreover, the impact of the lockdown on physical activity was reported by a Canadian study measuring Fitbit step counts in children aged 9–16 years with congenital heart disease. They found that during the early phase of the pandemic, there was a statistically significant reduction of 21–24% in step counts.²⁸

Another possible explanation is related to differences in dietary habits and nutrition. Pietrobelli et al. reported that the number of meals eaten per day increased significantly more in male adolescent participants than females (1.64 versus 0.58 meals) during lockdown.²⁹ Furthermore, adolescents' increased weight gain was associated with increased consumption of fried foods, sweets, and sugary drinks during the pandemic, while an increase in BMI was associated with a reduction in vegetable, fruit, and legume intake; however, no sex differences were reported.^{30,31} To further contextualize sex differences on adolescents' dietary trends, a multi-national study from Italy, Spain, Chile, Colombia, and Brazil found that females significantly increased

their intake of vegetables and fruits compared with males during the pandemic.³²

Lastly, there may be an interaction between atypical eating habits, sex, and mental health. A study investigating the early impact of the pandemic in patients with self-reported eating disorders in the U.S. and the Netherlands showed that food restriction in Anorexia Nervosa and binge eating in Bulimia Nervosa and Binge Eating Disorder were worsened.³³ Although the age range of these participants (16 and more than 60 years old) did not exclusively examine children and adolescents and the sample was predominantly female (96%), this suggests that individuals with atypical eating behaviours may be more vulnerable for relapse during the pandemic.³³ Moreover, a recent study in Ontario, Canada, demonstrated that acute care visits for eating disorders among children and adolescents increased significantly after the onset of the COVID-19 pandemic and remained well above expected levels during the first 10 months of the pandemic.³⁴ Disruption to structured days as a result of closures of childcare centres, schools, recreational facilities, and playgrounds may have consequences on families due to disruptions in daily routines, which is normally a protective factor for both physical and mental health.³⁵ Few studies have examined this interaction among children and adolescents to make conclusive claims.

This study adds to the literature as the first Canadian study to examine weight and BMI over time for patients enrolled in an obesity management program during the COVID-19 pandemic. Nevertheless, there are several limitations. First, the sample size was relatively small and only baseline and 6 month data were analysed. However, because participants were already enrolled in an obesity management program, follow-up appointments were easily attained and there was no loss-to-follow up. Second, the generalizability of these results is difficult due to the varying degrees of public health measures enacted in different jurisdictions (i.e., outside of Toronto, ON). In line with this, marginalized communities were significantly affected by the disruptions associated with the pandemic³⁶; however, we did not find a significant effect of ON-Marg index on weight and BMI. Future studies should assess this measure in larger populations, as other reports have discussed that lower income families reported economic problems such as losing wages due to child care responsibilities and expenses due to sudden school closures.³⁷ Finally, because this was an observational study, several factors were not reported or measured. For example, documentation reporting physical activity, dietary patterns, and family environment must be considered and likely play a role in the observed differences in weight gain between males and females.

Notwithstanding these limitations, our findings have important implications. It is critical that policy makers consider the indirect impacts the pandemic mitigation strategies have had on child weight gain and associated co-morbidities. There is an increased need for treatment of paediatric obesity post-pandemic given the changes in weight we observed. In fact, the American Academy of Paediatrics recommends the assessment of BMI in every future paediatric visit to identify and intervene on weight gain during the pandemic.³⁸ Interventions should also include nutrition and physical activity counselling not only for patients but the whole family. Given what is known so far

about the negative impacts of pandemic mitigation measures, it is recommended that access to low-cost, subsidized recreational programs (that allow for increased physical activity), enhanced social supports, access to nutritionally balanced meals, and health care must be provided.

In conclusion, our findings reveal that the pandemic may have diminished the positive effects that a weight management program could have in children achieving weight loss, more evidently in males. This suggests more resources and interventions will be required to treat obesity in children and adolescents in a post-pandemic era.

AUTHOR CONTRIBUTIONS

Concept and design: Thrmiga Sathiyamoorthy, Barkha P. Patel, Jill K. Hamilton. Acquisition, analysis, or interpretation of data: Barkha P. Patel, Alene Toulany, Jill K. Hamilton, Thrmiga Sathiyamoorthy. Drafting of the manuscript: Thrmiga Sathiyamoorthy, Barkha P. Patel. Critical revision of the manuscript for important intellectual content: Thrmiga Sathiyamoorthy, Barkha P. Patel, Jill K. Hamilton, Alene Toulany, Mohana Giruparajah. Statistical analysis: Barkha P. Patel. Obtained funding: Jill K. Hamilton. Administrative, technical or material support: Mohana Giruparajah. Supervision: Barkha P. Patel, Jill K. Hamilton.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

ORCID

Jill K. Hamilton  <https://orcid.org/0000-0002-1958-2800>

REFERENCES

- World Health Organization. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19—11 March 2020*; 2021. Accessed October 6, 2021. <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19--11-march-2020>
- Centers for Disease Control and Prevention. *Basics of COVID-19 CDC*; 2021. Accessed October 6, 2021. <https://www.cdc.gov/coronavirus/2019-ncov/your-health/about-covid-19/basics-covid-19.html>
- Stevenson E, Barrios L, Cordell R, et al. Pandemic influenza planning: addressing the needs of children. *Am J Public Health*. 2009;99(suppl 2):S255-S260. doi:10.2105/AJPH.2009.159970
- McCormack GR, Doyle-Baker PK, Petersen JA, Ghoneim D. Perceived anxiety and physical activity behaviour changes during the early stages of COVID-19 restrictions in community-dwelling adults in Canada: a cross-sectional study. *BMJ Open*. 2021;11(8):e050550.
- Khan MAB, Smith JEM. "Covibesity," a new pandemic. *Obes Med*. 2020;19:100282.
- Mattioli AV, Pinti M, Farinetti A, Nasi M. Obesity risk during collective quarantine for the COVID-19 epidemic. *Obes Med*. 2020;20:100263.
- Cuschieri S, Grech S. COVID-19: a one-way ticket to a global childhood obesity crisis? *J Diabetes Metab Disord*. 2020;19(2):2027-2030.
- Storz MA. The COVID-19 pandemic: an unprecedented tragedy in the battle against childhood obesity. *Clin Exp Pediatr*. 2020;63(12):477-482.
- An R. Projecting the impact of the coronavirus disease-2019 pandemic on childhood obesity in the United States: a microsimulation model. *J Sport Heal Sci*. 2020;9(4):302-312.
- Lange SJ. *Longitudinal Trends in Body Mass Index Before and During the COVID-19 Pandemic Among Persons Aged 2–19 Years—United States, 2018–2020*. Vol 70. Centers for Disease Control MMWR Office; 2021. doi:10.15585/MMWR.MM7037A3
- World Health Organization. *Obesity and Overweight*; 2021. Accessed October 6, 2021. <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- Kassir R. Risk of COVID-19 for patients with obesity. *Obes Rev*. 2020;21(6):e13034.
- Bornstein SR, Dalan R, Hopkins D, Mingrone G, Boehm BO. Endocrine and metabolic link to coronavirus infection. *Nat Rev Endocrinol*. 2020;16(6):297-298.
- Canadian Medical Association Poll. *What Canadians Think About COVID-19 & Virtual Health Care*; 2020. Accessed October 6, 2021. <https://www.cma.ca/sites/default/files/pdf/virtual-care/cma-virtual-care-public-poll-june-2020-e.pdf>
- Mimoun E, Ben Ari A, Margalit D. Psychological aspects of employment instability during the COVID-19 pandemic. *Psychol Trauma Theory Res Pract Policy*. 2020;12(suppl 1):S183-S185.
- Underwood P, Brown N, Te Riele K, et al. *Learning at Home During COVID-19: Effects on Vulnerable Young Australians Independent Rapid Response Report*; 2020. Accessed October 6, 2021. https://www.utas.edu.au/_data/assets/pdf_file/0008/1324268/Learning-at-home-during-COVID-19-updated.pdf
- Xie X, Xue Q, Zhou Y, et al. Mental health status among children in home confinement during the coronavirus disease 2019 outbreak in Hubei Province, China. *JAMA Pediatr*. 2020;174(9):898-900.
- Van Lancker W, Parolin Z. COVID-19, school closures, and child poverty: a social crisis in the making. *Lancet Public Heal*. 2020;5(5):e243-e244.
- Wong CA, Ming D, Maslow G, Gifford EJ. Mitigating the impacts of the COVID-19 pandemic response on at-risk children. *Pediatrics*. 2020;146(1):e20200973.
- Sistovaris M, Fallon B, Miller S, et al. *Fact Sheet: Child Welfare and Pandemics*. Policy Bench, Fraser Mustard Institute for Human Development, University of Toronto; 2020. Accessed October 6, 2021. https://cwpr.ca/sites/default/files/publications/Child%20Welfare%20and%20Pandemics%20Information%20Sheet_ENGLISH.pdf
- Dietitians of Canada; Canadian Paediatric Society; College of Family Physicians of Canada; Community Health Nurses Association. The use of growth charts for assessing and monitoring growth in Canadian infants and children. *Can J Diet Pract Res*. 2004;65(1):22-32.
- Luca P, Dettmer E, Khoury M, et al. Adolescents with severe obesity: outcomes of participation in an intensive obesity management programme. *Pediatr Obes*. 2015;10(4):275-282.
- Matheson FI, Moineddin R, Dunn JR, Creatore MI, Gozdyra P, Glazier RH. *Ontario Marginalization User Guide*; 2006. Accessed October 8, 2021. http://www.torontohealthprofiles.ca/onmarg/userguide_data/ON-Marg_user_guide_1.0_FINAL_MAY2012.pdf
- Nielsen K. *A timeline of COVID-19 in Ontario* | *Globalnews.ca*; 2020. Accessed October 6, 2021. <https://globalnews.ca/news/6859636/ontario-coronavirus-timeline/>
- Vinker-Shuster M, Grossman ES, Yeshayahu Y. Increased weight gain of children during the COVID-19 lockdown. *Isr Med Assoc J*. 2021;23(4):219-222.
- Agostinis-Sobrinho C, Gómez-Martínez S, Nova E, et al. Lifestyle patterns and endocrine, metabolic, and immunological biomarkers in European adolescents: the HELENA study. *Pediatr Diabetes*. 2019;20(1):23-31.
- Ruiz-Roso MB, de Carvalho PP, Matilla-Escalante DC, et al. Changes of physical activity and ultra-processed food consumption in adolescents from different countries during Covid-19 pandemic: an observational study. *Nutrients*. 2020;12(8):2289.
- Hemphill NM, Kuan MTY, Harris KC. Reduced physical activity during COVID-19 pandemic in children with congenital heart disease. *Can J Cardiol*. 2020;36(7):1130-1134.

29. Pietrobelli A, Pecoraro L, Ferruzzi A, et al. Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in Verona, Italy: a longitudinal study. *Obesity*. 2020;28(8):1382-1385.
30. Allabadi H, Dabis J, Aghabekian V, Khader A, Khammash U. Impact of COVID-19 lockdown on dietary and lifestyle behaviours among adolescents in Palestine. *Dynam Hum Heal*. 2020;7:2170.
31. Sidor A, Rzymiski P. Dietary choices and habits during COVID-19 lockdown: experience from Poland. *Nutrients*. 2020;12(6):1657.
32. Ruiz-Roso MB, de Carvalho PP, Mantilla-Escalante DC, et al. Covid-19 confinement and changes of adolescent's dietary trends in Italy, Spain, Chile, Colombia and Brazil. *Nutrients*. 2020;12(6):1807.
33. Termorshuizen JD, Watson HJ, Thornton LM, et al. Early impact of COVID-19 on individuals with self-reported eating disorders: a survey of ~1000 individuals in the United States and The Netherlands. *Int J Eat Disord*. 2020;53(11):1780-1790.
34. Toulany A, Kurdyak P, Guttman A, et al. Acute care visits for eating disorders among children and adolescents after the onset of the COVID-19 pandemic. *J Adolesc Heal*. 2021;22:42-47. doi:10.1016/j.jadohealth.2021.09.025
35. Brazendale K, Beets MW, Weaver RG, et al. Understanding differences between summer vs. school obesogenic behaviors of children: the structured days hypothesis. *Int J Behav Nutr Phys Act*. 2017;14(1):1-14.
36. Kantamneni N. The impact of the COVID-19 pandemic on marginalized populations in the United States: a research agenda. *J Vocat Behav*. 2020;119:103439.
37. Public Health Ontario. *Negative Impacts of Community-Based Public Health Measures During a Pandemic (e.g., COVID-19) on Children and Families Key Findings*; 2020. Accessed October 6, 2021. <https://www.publichealthontario.ca/-/media/documents/ncov/cong/2020/06/covid-19-negative-impacts-public-health-pandemic-families.pdf?la=en>
38. American Academy of Pediatrics. *Supporting Healthy Nutrition and Physical Activity During the COVID-19 Pandemic*; 2021. Accessed October 6, 2021. <https://www.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/clinical-guidance/supporting-healthy-nutrition-and-physical-activity-during-the-covid-19-pandemic/>

How to cite this article: Patel BP, Sathiyamoorthy T, Giruparajah M, Toulany A, Hamilton JK. Weighing in on COVID-19: The impact of the pandemic on children and adolescents with obesity participating in a weight management program. *Pediatric Obesity*. 2022;e12948. doi:10.1111/ijpo.12948