



Parent anxiety and perceptions of their child's physical activity and sedentary behaviour during the COVID-19 pandemic in Canada

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ABSTRACT

The public health emergency response to the COVID-19 virus has involved physical distancing strategies to reduce person-to-person transmission. Pandemics, including COVID-19, may influence changes to physical activity and sedentary behaviours among children. However, the role of parent anxiety related to COVID-19 on children's physical activity and sedentary behaviours has yet to be explored. The purpose of this study was to examine the associations between parent COVID-19 anxiety and physical activity and sedentary behaviours among school-aged children (5–17 years) and; to describe these behaviour patterns among school-aged children in relation to the COVID-19 public health emergency response. Between April and June 2020, a random sample of adults (Calgary, Canada) completed an online questionnaire. This sample included 345 parents of at least one school-aged child (80.5% aged 5 to 11 years and 54.9% male). Approximately one-third of parents (35.7%) reported being extremely or very anxious about COVID-19. During this period, most children increased television watching (58.8%), computing or gaming (56.4%), and use of screen-based devices (75.9%). Not surprisingly, given the mandated closure of playgrounds, approximately one-half of children decreased playing at the park (52.7%) and in public spaces (53.7%). Children's physical activity at home either increased (48.8%) or remained unchanged (32.9%). Children of more anxious parents had fewer visits to the park and were more likely to spend ≥ 2 h/day computing or gaming compared with children of less anxious parents. Strategies to counteract the unintended consequences of the COVID-19 public health measures on parent and child wellbeing are needed.

1. Background

Globally, the coronavirus disease (COVID-19) pandemic has resulted in over 37 million total confirmed cases and more than 1 million related deaths, while in Canada there have been at least 170,000 cases and 9000 related deaths (World Health Organization. Coronavirus disease, 2019). COVID-19, caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), primarily targets the human respiratory system (Rothan and Byrareddy, 2020). COVID-19 is highly transmissible from person-to-person spread via direct contact or via droplets from the coughing or sneezing of an infected individual (Moore et al., 2020). COVID-19 symptoms include systemic (i.e., fever, fatigue, headache, dry cough, acute cardiac injury, hemoptysis, hypoxemia, diarrhoea) and respiratory disorders (i.e., rhinorrhoea, sore throat, sneezing, pneumonia,

acute respiratory distress syndrome) (Rothan and Byrareddy, 2020; Guo et al., 2020). Previous studies have found that these physical symptoms are associated with depression (Wang et al., 2020), anxiety (Tee et al., 2020) and stress (Le et al., 2020). All age groups are at risk of COVID-19, however, older adults (Guo et al., 2020; Li et al., 2020) and those with underlying health conditions (Guo et al., 2020) are more likely to develop severe symptoms.

The public health emergency response to the COVID-19 pandemic in Canada, like many other developed western countries, included measures to reduce person-to-person transmission of the virus. The measures, which were implemented across all Canadian provinces (including Alberta) comprised of forced closures of educational and daycare facilities, non-essential businesses, and private and public recreation facilities (e.g., playgrounds, outdoor exercise equipment, and

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sports courts and fields). Individuals and families were advised to take personal steps to reduce virus transmission including practicing physical distancing (i.e., avoiding crowded places, avoiding common greetings, limiting contact with high-risk individuals, and maintaining a distance of 2-metres from others), forgoing international travel, and self-quarantining if they experienced symptoms (Government of Alberta. Help prevent the spread. <https://www.alberta.ca/prevent-the-spread.aspx> [accessed April 15, 2020]). Without public health emergency responses to contain virus transmission, the population of infected individuals would have doubled every two days (Cheng and Shan, 2020). However, the stress of managing new work, leisure, child-minding, school, and other family routines, financial pressures, the fear of vulnerable family members and friends contracting COVID-19, and the global panic during the pandemic has likely led to increased stress and anxiety for some parents (Fegert et al., 2020; Pfefferbaum and North, 2020; Park et al., 2020). Studies have demonstrated that abnormal levels of anxiety were experienced during the COVID-19 outbreak in approximately two-thirds of Chinese adults (Huang and Zhao, 2020; Wang et al., 2020). Notably, there is a lack of evidence investigating the impact of COVID-19 on the mental health of children and parents (Tran et al., 2020).

The public health emergency response to slow COVID-19 transmission was necessary; however, the measures have interrupted daily routines, including physical activity (PA) patterns (Chen et al., 2020). From the few existing studies, there is evidence demonstrating public health epidemic and pandemic responses can affect PA (Balanza-Martinez et al., 2020; Lau et al., 2003; Tan et al., 2004). Lui et al. (Lau et al., 2003) undertook telephone interviews in Hong Kong during the 2003 Severe Acute Respiratory Syndrome (SARS) outbreak and found 51% of adults perceived high risk of SARS transmission when using public transportation while 12% perceived high risk for walking in the street. They also found 46% of adults avoided going outside and 24% avoided using public transportation (Lau et al., 2003). Tan et al. (Tan et al., 2004) found that during the 2003 SARS outbreak in Wuhan (China) most adults reduced their outdoor activities (71%) but paradoxically half of adult's increased their physical activities (53%). More time spent outdoors is associated with more PA and less sedentary behaviour (SB) (Beyer et al., 2018) and public transportation use contributes to overall PA (Rissel et al., 2012).

Few studies have investigated the impact of infectious disease epidemics and pandemics on children's play, PA and SB (Xiang et al., 2020; Moore et al., 2020). Notably, among children (6–17 years) from Shanghai (China), Xiang et al. (Xiang et al., 2020) found an absolute reduction of 42% in the proportion of children achieving at least 60 min per day of moderate to vigorous PA (MVPA) and over a 28-hour increase in leisure screen time during the COVID-19 pandemic. Prior to the COVID-19 pandemic one-third of Canadian children were achieving at least 60-minutes of MVPA per day (Colley et al., 2017). However, reductions in PA (e.g., neighbourhood walking and biking, outside PA and sports, outside play) and increases in SB (e.g., television or screen time) in Canadian children (5–17 years) as a result of the COVID-19 pandemic have recently been identified (Moore et al., 2020).

Among children, changes in PA in a few weeks to months can lead to cardiorespiratory, metabolic, and musculoskeletal changes (Janssen and LeBlanc, 2010; Baquet et al., 2003). In children, regular MVPA is associated with better lipid profiles, reduced risk of metabolic syndrome, more favourable body composition and bone mineral density, and improved mental health (Janssen and LeBlanc, 2010). Higher levels of PA and fitness in children are also associated with improved cognitive function and academic performance (Donnelly et al., 2016; Biddle and Asare, 2011; Poitras et al., 2016). Active school transportation is positively associated with PA and can provide cardiovascular benefits (Larouche et al., 2018). Moreover, among children, higher levels of SB (e.g., watching television and screen-time), independent of PA levels, may be adversely associated with body composition, cardiovascular and metabolic health, and psychosocial health (Tremblay et al., 2010; de

Rezende et al., 2014). Given the effects of PA and SB on children's health, studies investigating the COVID-19 pandemic on these behaviours are needed.

While the influence of parent anxiety on children's PA during pandemics is yet to be directly explored, there is evidence that parental anxieties related to social and environmental factors (e.g., fear, safety, and risk) can impact their child's PA (O'Connor and Brown, 2013; Weir et al., 2006). Thus, parent anxiety related to the COVID-19 pandemic could further influence their child's PA and SBs. The aims of this study were two-fold: 1) to estimate the associations between parent COVID-19 anxiety and PA and SBs among school-aged children (5–17 years), and; 2) to describe PA and SB patterns among school-aged children in relation to the COVID-19 public health emergency response.

2. Methods

2.1. Study and sample design

The University of Calgary Conjoint Human Research Ethics Board approved the study (REB19-1910). Between April and June 2020 (spring), after the World Health Organization announced COVID-19 as a pandemic (WHO, 2020), we conducted a cross-sectional survey with adults to capture baseline PA, SB, play, parks use, social connections, and program awareness as part of a larger evaluation of a local charitable enterprise's (Vivo) PA and play intervention (Vivo Play Project) implemented in north central Calgary communities (Canada). Due to the timing of the survey, we also included items capturing perceived anxiety and seriousness of COVID-19 and behaviour changes since the onset of the pandemic. We mailed two recruitment postcards (1 week apart) to a simple random sample of 25,000 households with equal chance of selection across 14 adjacent communities. Based on 2016 national and civic census data, compared with city of Calgary overall, the sampled communities, on average, had lower median household incomes (\$107,841 vs. \$125,737), higher proportions of immigrants (37% vs. 31%), families with children at home (66% vs. 62%), and visible minorities – non-Caucasian in race or non-white in colour and not aboriginal (48% vs. 36%) – and similar levels of education (14% not completing high school diploma and 60% completing post-secondary) and unemployment (9%) (The City of Calgary, 2020). The postcard invited one adult per household to complete an online questionnaire (hosted by Qualtrics) which included study information and a consent form. Eligible participants were required to: 1) have internet access; 2) reside in north central Calgary; 3) be at least 18 years of age; 4) have a current email address (for future study correspondence), and 5) provide informed consent. Participants who completed the questionnaire received a pass to a local recreation facility (\$30 value) and entered a draw to win a \$500 gift card.

A total of 1124 adults completed the questionnaire with an approximate 5% response rate. This low return response rate likely reflects the lower response rates generally associated with online surveys relative to other survey types (Fan and Yan, 2010). The response rate might also have been impacted by the questionnaires being available only in English and online (internet access required), and by the atypical conditions (e.g., physical distancing, self-isolation, quarantine, fear, and anxiety) associated with COVID-19 during the recruitment. Among the adults who completed the questionnaire, 345 were parents of at least one school-aged child. The study focused on parents who provided complete data (n = 328).

2.2. Data collection

Parent's proxy-reported PA, SB and sociodemographic characteristics for their school-aged children. In the case of more than one school-aged child at home, the parent reported for the child with the next birthday. Data presented herein were captured between April 14 and May 27, 2020.

2.3. Variables

2.3.1. Parent anxiety

One item captured parent's level of anxiety associated with the COVID-19 pandemic (extremely anxious, very anxious, somewhat anxious, and not anxious at all). This item was adapted from another study used to measure anxiety during the 2009 H₁N₁ pandemic (Van et al., 2010). We recoded responses into two categories (high anxiety [extremely or very anxious] versus low anxiety [somewhat or not at all anxious]) to address the skewed distribution in responses to this item and to aid in the interpretation of results.

2.3.2. Perceived change in child's physical activity and sedentary behaviour

On a 5-point scale (a lot less frequently, a little less frequently, about the same, a little more frequently, and a lot more frequently) parents reported their child's change in indoor and outdoor PA, SB (television viewing, gaming, and use of screen-based devices), playing at the park and in public spaces, as well as spending time indoors and outdoors with friends since the COVID-19 pandemic. We collapsed responses into three categories (perceived decrease, no change in behaviour, or increase in behaviour). We included those behaviours that might change due to the local public health response to COVID-19 including physical distancing and the closure of recreational facilities, parks, and playgrounds. Similar items have been used elsewhere with Canadian adults (Moore et al., 2020).

2.3.3. Child physical activity

One item captured the child's current level of PA. Parents reported the number of days during the past week that their child was moderate-to-vigorously active for a total of 60-minutes. Parent reports of their child's weekly participation, frequency, and duration of PA demonstrate acceptable reliability (Telford et al., 2004). Child self-reports of PA using a similar item have also demonstrated acceptable reliability and validity (Scott et al., 2015). To accrue optimal health benefits, the current Canadian PA guidelines recommend children (5–17 years) accumulate ≥60-minutes of MVPA daily (Tremblay et al., 2016). Parents also reported the number of days over the past week their child engaged in play (any type of fun or enjoyable activity chosen by the child excluding sedentary screen-based activities) and number of days in the past month visiting a park.

2.3.4. Child sedentary behaviour

Three items captured the child's SB. Parents reported the average number of hours per day (during past 30 days), their child spent: 1) watching television or videos; 2) used the computer and played video games, and; 3) screen-based electronic devices other than a computer or television. Parent reporting of children's SB has been used elsewhere (Telford et al., 2004; Arundell et al., 2019; Salmon et al., 2006). We dichotomized each sedentary activity to reflect the children's SB recommendations included in Canada's 24-hour movement guidelines (<2 h/day) (Tremblay et al., 2016).

2.3.5. Sociodemographic characteristics (covariates)

Parent sociodemographic characteristics reported in this study include age, sex, highest education, annual gross household income, marital status, number of dependents in the household, employment status, ethnicity, and dog ownership. Parents also reported their child's sex and age.

2.4. Statistical analysis

We estimated descriptive statistics (means, standard deviations, and frequencies) for sociodemographic, and PA, play, SB, and anxiety variables. We used Fisher's exact chi-square to estimate statistically significant differences in perceived change in child's behaviour since the pandemic by level of parent COVID-19 anxiety (high versus low).

Covariate-adjusted multiple linear regression estimated the differences in the child's mean days per week of MVPA and play, and days per month visiting a park by parent low and high anxiety. Multiple binary logistic regression estimated the odds ratios (OR) for the association between child SBs in the past 30-days and parent high versus low COVID-19 anxiety. We estimated 95 percent confidence intervals (95CI) for the linear and logistic regression models. Statistical significance was set at an alpha level of $p < .05$. The analysis was undertaken using IBM Statistical Package for Social Sciences (SPSS version 24).

3. Results

3.1. Sociodemographic characteristics

The mean age of parents reporting on behalf of their children was 42.6 years and the mean number of children <18 years of age per household was just under 2 years old. (Table 1). The majority of parents were female (67.1%), completed university (58.2%), worked full-time (53.7%), Caucasian (56.4%), married or in a common-law relationship (82.6%), and did not own a dog (67.7%). Approximately, one-third of parents reported being extremely or very anxious about COVID-19 (35.7%) (Table 1). Among children whose behaviour was reported, most were 5–11 years of age (80.5%) and male (54.9%).

3.2. Parent perceived levels of physical activity, park visits, and sedentary behaviour

Children on average, achieved ≥60 min of MVPA on 3.48 ± 2.41 days/week (18.3% with no MVPA days), spent 4.52 ± 2.75 days playing during the past week (16.5% with no play days), and visited a park on 4.85 ± 6.39 days during the past month (34.5% with no park visits). The

Table 1
Sample characteristics (n = 328).

	Category	Estimate
Parent or household characteristics		
Age in years [mean ± SD]		42.6 ± 8.8
Sex [%]	Female	67.1
Education [%]	Completed high school or less	14.9
	Completed trade, diploma, or some university	26.8
	Completed bachelor degree	40.5
	Completed graduate degree	17.7
Annual Gross Household Income [%]	0 to \$79,999	19.2
	\$80,000 to \$119,999	22.3
	\$120,000 or more	37.8
Employment Status [%]	Don't know/Refuse to answer	20.7
	Working full-time	53.7
	Working part-time	16.8
	Not employed	13.7
	Student/Homemaker/retired/other	15.9
Ethnicity [%]	Caucasian	56.4
	Chinese	11.3
	Asian other	13.7
	Non-Asian Other or multiple ethnicities	18.6
Children <18 years in household [mean ± SD]		
Relationship status [%]	Married/common law	82.6
Dog ownership [%]	Owns dog	32.3
Anxiety due to COVID-19 [%]	High	35.7
Child characteristics		
Age [%]	5 to 11 years	80.5
	12 to 17 years	19.5
Age in years [mean ± SD]		10.8 ± 4.0
Sex [%]	Female	45.1
SD: Standard deviation		

majority of children spent ≥ 2 h/day watching television (74.1%), using a computer or gaming (63.7%), and using screen-based devices (60.7%).

3.3. Parent perceived change child physical activity and sedentary behaviour frequency

A high proportion of parents perceived that their child's PA at home increased (48.8%) or remained unchanged (32.9%) since the pandemic (Table 2). A similar proportion of parents perceived their child's PA outdoors either increased (38.7%) or decreased (39%) during this same time. Approximately half of parents perceived decreases in their child's play at the park (52.7%) and in public spaces (53.7%) while only 15.5% and 9.5% of parents reported increases in these same behaviours, respectively during the pandemic.

Notably, over half of all parents perceived increases in their child's SBs during the pandemic including watching television (58.8%), playing video games (56.4%), and using screen-based devices (75.9%) (Table 2). Only 2–3% of parents reported decreases in these same behaviours during the pandemic. Over two-thirds of parents perceived the amount of time their child spent with friends outdoors (70.7%) and indoors (71.3%) decreased during the pandemic with only 5.8% and 6.4% of parents, respectively, reporting an increase in these behaviours.

Table 2

Comparison of parent anxiety by parent-reported perceived behaviour change since the COVID-19 pandemic (n = 328).

Perceived change in child's frequency of behaviour		% overall	% among parents reporting low anxiety (n = 211)	% among parents reporting high anxiety (n = 117)
Physically active in home	Increased	48.8	52.6	41.9
	No change	32.9	33.2	32.5
	Decreased	18.3	14.2 ^a	25.6 ^a
Physically active outdoors	Increased	38.7	41.2	34.2
	No change	22.3	25.6	16.2
	Decreased	39	33.2 ^a	49.6 ^a
Watching television	Increased	58.8	54.0 ^a	67.5 ^a
	No change	38.4	43.6 ^b	29.1 ^b
	Decreased	2.7	2.4	3.4
Playing video games	Increased	56.4	49.8 ^a	68.4 ^a
	No change	40.9	47.9 ^b	28.2 ^b
	Decreased	2.7	2.4	3.4
Using screen-based devices	Increased	75.9	73.5	80.3
	No change	22	23.7	18.8
	Decreased	2.1	2.8	0.9
Playing at park	Increased	15.5	17.5	12
	No change	31.7	30.3	34.2
	Decreased	52.7	52.1	53.8
Playing at other public spaces	Increased	9.5	10.4	7.7
	No change	36.9	39.3	32.5
	Decreased	53.7	50.2	59.8
Spending time with friends outdoors	Increased	5.8	6.2	5.1
	No change	23.5	21.3	27.4
	Decreased	70.7	72.5	67.5
Spending time with friends indoors	Increased	6.4	6.6	6
	No change	22.3	18.5 ^a	29.1 ^a
	Decreased	71.3	74.9	65

Same superscript indicates significant difference (two-tailed $p < .05$) for categorical outcomes within COVID-19 behaviour change based on Fishers exact chi-square test with z-tests for pairwise differences in proportions.

Low anxiety includes participants reporting being somewhat or not at all anxious due to COVID-19. High anxiety includes participants reporting being extremely or very anxious due to COVID-19.

3.4. Children's physical activity and sedentary behaviour and parent COVID-19 anxiety

Parent perceived changes in their child's PA and SBs were associated with parent COVID-19 anxiety (Table 2). Compared with low anxiety parents, a higher proportion of high anxiety parents reported decreases in their child's PA in the home (25.6% vs. 14.2%, $p < .05$) and outdoors (49.6% vs. 33.2%). Compared with low anxiety parents, a higher proportion of high anxiety parents reported increases in their child's television watching (67.5% vs. 54.0%, $p < .05$) and computer use and video games (68.4% vs. 49.8%, $p < .05$) (Table 2).

Adjusting for covariates, compared with parents with low COVID-19 anxiety, parents with high anxiety reported their children visited parks on fewer days during the past month (5.42 vs. 3.00 days, $p < .05$) (Table 3). Count of days per week achieving ≥ 60 min of MVPA or days playing did not significantly differ for children of low versus high anxiety parents. There was no significant associations between parent anxiety and their child's participation in television watching or device use, however, adjusting for covariates, children of high anxious parents were more likely than children of low anxious parents to participate in ≥ 2 h/day of computer use or video gaming (OR 1.78, 95CI 1.02, 3.11) (Table 3).

4. Discussion

Our findings demonstrate that the COVID-19 public health emergency response measures likely affected children's PA and SB within the first two-to-three months of the WHO-declared pandemic. Other studies have also reported the COVID-19 outbreak negatively affected PA and SBs among children (Xiang et al., 2020). Our findings suggest that child PA at home increased, while PA in public locations decreased. Alarmingly, we found increases in participation in SB (watching television, computing or video gaming, and other screen-based devices) among children. Notably, we also found that higher parent anxiety related to COVID-19 might have exacerbated the reductions in PA (at home and outdoor PA) and increases in SB among children during the early stages of COVID-19 pandemic.

In much of Canada, the COVID-19 public health emergency response included physical distancing measures to reduce gatherings, particularly among non-immediate family members, and the closure of schools, parks and playgrounds, recreational and sport facilities, and malls where people, including children may accumulate PA. Our findings suggest that for the majority of children, playing at the park and in public spaces, and spending time with friends indoors and outdoors remained unchanged or decreased in response to the COVID-19 pandemic, which may reflect compliance with physical distancing measures. Evidence elsewhere suggests that most adults comply with health authority recommendations to reduce the spread of COVID-19 (Park et al., 2020). Similar to the Canadian national PA data collected 1-month after the WHO declared the COVID-19 pandemic (Moore et al., 2020), we also found children accumulated 60-minutes of MVPA on approximately only 3 days/week. Consistent with other studies, our findings also suggest higher levels of SB among children during the COVID-19 pandemic (Moore et al., 2020). Moreover, our findings regarding parent perceived change in children's specific PAs and SBs support the national data (Moore et al., 2020), suggesting reductions in the former and increases in the latter during the COVID-19 pandemic. We found a higher level of participation in PA in the home, which indirectly corresponds with the slight increase in frequency of inside play observed in the national data (Moore et al., 2020) during COVID-19.

Our findings demonstrated that approximately one-half of children decreased their visits to parks and other public spaces, and over two-thirds of children had decreased time spent with friends indoors and outdoors. In the US, children spent more time being physically active (e. g., play, unstructured activity, and walking) at locations close to home (indoors or neighbourhood streets) during the early stages versus before

Table 3

Comparison of parent-reported child participation in physical activity, play, and sedentary behaviour by parent anxiety related to the COVID-19 pandemic (n = 328).

N	Days per week of MVPA Marginal mean (95CI)	Days per week playing Marginal mean (95CI)	Days per month visiting a park Marginal mean (95CI)	≥2 h per day watching television/videos OR (95CI)	≥2 h per day using computer or gaming OR (95CI)	≥2 h per day using screen- based devices OR (95CI)
Low	211 3.09 (2.56, 3.62)	3.40 (2.88, 3.92)	5.42 (4.08, 6.76)	1	1	1
High	117 2.59 (2.01, 3.17)	2.97 (2.40, 3.54)	3.00 (1.54, 4.47)*	1.47 (0.83, 2.61)	1.78 (1.02, 3.11)*	1.04 (0.62, 1.73)

Low anxiety includes participants reporting being somewhat or not at all anxious due to COVID-19. High anxiety includes participants reporting being extremely or very anxious due to COVID-19. Adjusted for child gender, parent gender, child age, parent age, gross annual household income, parent employment status, parent education, parent ethnicity, marital status, number of children in household, and dog ownership. OR: Odds ratio estimated from binary logistic regression. Marginal mean estimated from linear regression model.

95CI: 95 percent confidence interval. *p < .05

the COVID-19 pandemic (Dunton et al., 2020). Friends are important for children's PA (Maturro and Cunningham, 2013; Sawka et al., 2013) as well as for their social and emotional development (Newcomb and Bagwell, 1995). While our findings suggest children may be spending less time with other children physically (which may result in less PA), we cannot rule out that children are not replacing this behaviour with online socializing (via social media). Higher social media use was identified among Canadian children 1-month following the COVID-19 pandemic declaration (Moore et al., 2020). Public health and school strategies might facilitate meaningful social interactions among children during pandemics.

This study provides novel insights about the impact of parent anxiety on children's PA and SBs. Notably, approximately one-third of parents reported high anxiety related to COVID-19. Anxiety can negatively influence cardiovascular health (Tully et al., 2013) and quality of life (Olaturunji et al., 2007). Our findings suggest that a significant proportion of our sample might be at risk of poor health, especially if their high anxiety remains elevated for an extended time. Our findings show that high levels of parent anxiety might affect their children's PA and SB. In particular, children of parents reporting high COVID-19 anxiety visited parks less frequently in the past month relative to children of parents reporting less anxiety. Children of parents reporting high anxiety were also more likely to spend at least 2 h computing or gaming. Parents with high COVID-19 anxiety may be more likely to follow public health physical distancing measures during pandemics and/or they are more likely to restrict their child's play in public spaces, such as parks, out of fear for their child's or family's health. Despite these findings, achievement of the recommended amount of MVPA were similar between children of low and high anxiety parents but on average less than the recommended level (7-days/week) (Tremblay et al., 2016). Encouraging children in Canada to meet the recommended levels of PA and SB guidelines is already challenging and the COVID-19 pandemic has made this task more difficult. Public health professionals, recreational practitioners, school administrators, and parents should find creative ways of encouraging children to be physically active and reduce SB while complying with public health pandemic response measures. Our findings also highlight the need for public health strategies that address parent anxiety during epidemics and pandemics (Brooks et al., 2020). Increasing access to cognitive behavioural and mindfulness based therapy video conference sessions may relieve anxiety and stress for parents struggling to cope during the pandemic (Ho et al., 2020).

We acknowledge that our study has some limitations. The cross-sectional design does not allow us to infer temporality. Our study also represents a snap-shot of the levels of and associations between parent anxiety, and children's PA and SB in the first two-to-three months of the COVID-19 pandemic as public health emergency response measures were implemented and daily life drastically interrupted. Behaviour patterns as well as anxiety levels could change during the course of the pandemic. Children's PA and SB and parent anxiety were self-reported thus social desirability bias, over-reporting bias, and recall errors are possible. Despite evidence suggesting some differences in terms of the

impact of COVID-19 on PA by age (Moore et al., 2020) our sample size did not allow age-stratification of results. The higher levels of education and income of participants, the low response rate, and sampling of households from north central Calgary communities may limit the generalizability of our findings however, our pattern of findings reflect those of a recent national survey (Moore et al., 2020). We adapted and administered a single-item anxiety measure used during previous pandemics (Van et al., 2010) however, multi-construct questionnaires, such as the Depression, Anxiety, and Stress Scale (DASS-21) (Lovibond and Lovibond, 1995) might provide a more comprehensive perspective of mental health during the COVID-19 pandemic (Elbay et al., 2020; Mazza et al., 2020). Notably, while COVID-19 anxiety was associated with children's SB and lowered park use, we cannot rule out the contributions of parent anxiety unrelated to COVID-19 affecting their children's behaviour.

The COVID-19 pandemic has affected the PA and SBs of children and influenced the ways in which children interact socially. Parent anxiety related to COVID-19 appears to be associated with PA and SB of their children, with higher parent anxiety leading to fewer visits to parks and more computing and gaming. Ongoing research and surveillance of PA and SB among children and parent anxiety during the pandemic can inform responsive multi-level strategies to support health and wellbeing of children and parents.

CRediT authorship contribution statement

Gavin R. McCormack: . : Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Patricia K. Doyle-Baker:** . : Conceptualization, Methodology, Writing - original draft, Writing - review & editing. **Jennie A. Petersen:** Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Dalia Ghoneim:** Investigation, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Author contributions

GRM, PKDB, and JAP conceived and designed the study. JAP and DG coordinated the study and data collection. GRM and JAP undertook the data analysis. All authors interpreted the results and drafted the manuscript. All authors approved the final manuscript.

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