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## Original Research

# Perceived changes in lifestyle behaviours and in mental health and wellbeing of elementary school children during the first COVID-19 lockdown in Canada



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## ABSTRACT

**Objectives:** The closure of schools to prevent the spread of COVID-19 prompted concerns of deteriorating lifestyle behaviours, mental health, and wellbeing of children, particularly those in socioeconomically disadvantaged settings. We assessed changes in lifestyle behaviours (physical activity, screen time, eating habits and bed/wake-up times), mental health and wellbeing during the first lockdown in Spring 2020 as perceived by school children from disadvantaged settings, and examined determinants of these changes. **Study design:** Cross-sectional study.

**Methods:** We surveyed 1095 grade 4 to 6 students (age 9–12 years) from 20 schools in socioeconomically disadvantaged communities in northern Canada. Students reported on changes in lifestyle behaviours, mental health and wellbeing during the lockdown. Determinants of these perceived changes were examined in multivariable regression models.

**Results:** A majority of students reported declines in physical activity, having late bed/wake-up times, and modest improvements in mental health and wellbeing. Many students reported increases rather than decreases in screen time and snacking. Positive attitudes toward being active, eating healthy, going to sleep on time and being healthy were strongly associated with maintaining healthy lifestyle behaviours during the lockdown. Positive attitudes toward active and healthy living and healthy lifestyle behaviours were associated with maintaining positive mental health and wellbeing during the lockdown.

**Conclusions:** The considerable changes in lifestyle behaviors, superimposed on the pre-existing burden of unhealthy lifestyle behaviours, put this generation of children at increased risk for future chronic disease. Findings call for effective health promotion of active and healthy lifestyles to benefit both physical and mental health.

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## Introduction

The COVID-19 pandemic, declared by the World Health Organization on March 11, 2020,<sup>1</sup> resulted in the implementation of drastic public health measures that affected large populations of school-aged children.<sup>2,3</sup> While effective at reducing the viral spread, these measures prompted concerns regarding children's

lifestyle behaviours (physical activity, screen time, eating habits and sleep patterns) and mental health and wellbeing.<sup>4</sup>

Healthy lifestyles, mental health and wellbeing are essential for physical, social and emotional development of children.<sup>5</sup> Unhealthy lifestyles and psychological problems at a young age may be difficult to reverse and will track into adulthood,<sup>6–9</sup> thereby predisposing children to a range of chronic diseases and mental illness later in life.<sup>10</sup> A recent survey of Canadian parents revealed that only 4.8% of children (5–11 years) and 0.6% of adolescents (12–17 years old) adhered to physical activity and sedentary behaviour recommendations during the early pandemic period, although 71.1% were meeting sleep recommendations.<sup>11</sup> In addition, some

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emerging studies suggest, albeit not consistently, that mental health declined among children during the first COVID-19 lockdown.<sup>12–14</sup>

The health and wellbeing of socioeconomically disadvantaged children during the pandemic is of particular concern.<sup>15</sup> The prevalence of poor lifestyles and mental illness is already high among these children, and studies report on low adherence to lifestyle recommendations during the lockdown in socioeconomically disadvantaged settings.<sup>16</sup> In addition, the pandemic-caused stressors (household food insecurity, parental job loss,<sup>17</sup> disruptive family dynamics<sup>18</sup>) may disproportionately affect the physical and mental health of vulnerable children. To date, existing evidence has come predominantly from online surveys in convenience samples of parents rather than children, and children's perspectives on their lifestyle behaviours, mental health and wellbeing have not yet been heard. Among elementary school children residing in socioeconomically disadvantaged communities, we (1) examined the perceived changes in lifestyle behaviours, mental health and wellbeing and (2) assessed the role of attitudes toward active and healthy living and other determinants of these changes.

## Methods

During in-person learning in November–December 2020 and January–February 2021, we invited 1340 students in grades 4 to 6 from 20 schools located in British Columbia, Alberta, Manitoba, and Northwest Territories to participate in the survey. All 20 schools are part of the Alberta Project Promoting healthy Living for Everyone (APPLE) in Schools project – an innovative, internationally recognized, not-for-profit health promotion program targeting children from socioeconomically disadvantaged communities. Grounded in a Comprehensive School Health approach, the program promotes healthy lifestyle behaviours, mental health and wellbeing by transforming the school's culture to “make the healthy choice the easy choice”.<sup>19,20</sup>

Data were collected in school during regular class time, with research assistants prompting the survey questions projected on the whiteboard through Zoom. A total of 1095 students completed the survey, with the participation rate of 81.6%. The Health Research Ethics Board of the University of Alberta (Pro00061528) and participating school boards approved all the procedures.

As part of the pandemic response in Canada, in-school learning in all participating schools (among others) was suspended mid-March 2020. Although school buildings were closed, online learning continued for the duration of the 2019/2020 school year. Grade K-6 students were permitted to attend in-person classes when the participating schools re-opened in September 2020 with enhanced public health measures in place (e.g. cohorting, masking, physical distancing)<sup>21–23</sup> and an early and extended Christmas break.

Students were asked to compare their activity levels during the Spring 2020 lockdown with their activity levels before this lockdown with respect to 24 common physical activities derived from the PAQ-C.<sup>24</sup> Response categories were adapted to reflect changes in activity levels, as perceived by the students, during the COVID-19 lockdown. Response categories (Less than/About the same/More than before schools got closed) were assigned a score of ‘-1’, ‘0’ and ‘1’, averaged and dichotomized using ‘0’ as the cut-off value, with lower values indicating less physical activity during the lockdown, and ‘0’ and above more physical activity. The same response categories were provided for the questions about perceived changes in time spent playing video games and using a cellphone, and in the number of meals and snacks. With respect to sleep, students reported their wake-up time and bedtime on weekdays. In accordance with the Canadian 24-h Movement Guidelines for children

and youth,<sup>25</sup> we coded responses for weekday wake-up time after 10:00 am or bedtime after 11:00 pm as having late bed/wake-up times. The surveys included 11 questions related to mental health and wellbeing (details described in our previous work<sup>26</sup>), with response categories adapted to capture perceived changes during the lockdown (More/About the same/Less than before schools got closed). The response categories were assigned a score of ‘-1’, ‘0’ and ‘1’ for positively stated items and reverse coded for negatively stated items. The cumulative score was created and dichotomized using ‘0’ as the cut-off value, with values above ‘0’ representing better mental health and wellbeing, and between ‘-12’ and ‘0’ (inclusive) worse mental health and wellbeing during the lockdown.

Attitudes toward active and healthy living were assessed by a series of questions: “How much do you care about being healthy? Being physically active? Eating healthy foods? Going to sleep on time?” The response categories were ‘very much’, ‘quite a lot’, ‘a little bit’, and ‘not at all.’ We considered these attitudes as potential determinants of changes in lifestyle behaviours, mental health and wellbeing based on their utility to help prioritize future prevention intervention efforts. Given existing differences in lifestyle behaviours by gender, grade,<sup>27</sup> race/ethnicity, and socioeconomic status,<sup>28</sup> we considered the student's gender (girl, boy), grade level (4, 5, 6), languages spoken (English only, English and Indigenous language(s), and English and other language(s)), region of residence (rural, small population centre, medium, and large population centre<sup>29</sup>) as potential confounders. In addition, we adjusted for social and material deprivation indices that were derived from Canada Census 2016 data based on postal codes of APPLE Schools included in the analysis (detailed description of and procedures for calculating these indices can be found elsewhere<sup>30</sup>). Higher quintiles for both indices indicate more deprived areas.<sup>31,32</sup> Finally, we considered the length of time since school reopening in September 2020 (<3 months, ≥3 months) as a confounder to account for the possibility that student's lifestyle behaviours and mental health and wellbeing three or more months after reopening could have returned to the pre-pandemic levels.

## Statistical analyses

First, multivariable logistic regression models were used to examine the association of the attitudes toward being healthy with perceived changes in physical activity, playing video games, cellphone use, maintaining and adopting good meal and snack routines, not having late bed/wake-up times, and maintaining positive mental health and wellbeing while adjusting for potential confounders. Gender-stratified exploratory factor analysis with varimax (orthogonal) rotation was employed to extract latent factors that maximized the explained variance. After examination of the scree plot and based on the Kaiser criterion (i.e. eigenvalue >1), three clusters were identified separately for girls and boys to reflect gender differences in clustering of the responses (Table S1). Factor scores were then calculated for each of the clusters using the Bartlett's test of sphericity,<sup>33</sup> dichotomized and considered as outcomes in the multivariable logistic regression models. Before analyses, missing values were imputed for lifestyle behaviors and mental health and wellbeing based on ‘multivariate imputation by chain equation (MICE)’.<sup>34</sup> Approximately 80% of students provided responses to each of the 20 questions (11 questions on mental health and wellbeing, five on screen time, two on eating habits, and two on sleep), and 90% completed at least 19 of the items. Data from 31 students who did not respond to 10 or more of the 20 questions were excluded from analyses. Fixed effects regression modeling was applied instead of mixed effects models since the intra-class correlation was below 0.02 for all models.<sup>35</sup> In addition, we

considered changes in lifestyle behaviours as potential correlates of changes in mental health and wellbeing.

### Results

Table 1 shows the characteristics of the 1095 participants and their schools. There were more girls (n = 557) than boys (n = 538) and more grade 6 (n = 400) relative to grade 4 (n = 312) and 5 (n = 383) students participating. Twenty percent of students reported speaking one or more Indigenous languages and 11% speaking another language in addition to English. In terms of students' attitudes toward active and healthy living, the majority of girls and boys cared 'very much' or 'quite a lot' about being healthy, physically active and eating healthy, although less than half reported they cared about good sleep.

About two-thirds of girls and boys (62% and 64%, respectively) recalled their physical activity levels to be lower during the lockdown than before the lockdown (Fig. 1). Almost two-thirds of boys (64%) reported they spent more time playing video games during the lockdown, whereas about one-quarter (24%) reported this to be about the same and 12% spent less time playing video games during the lockdown. Almost half the girls (46%) and more than a third of boys (38%) reported using a cellphone more, 23% and 27% of girls and boys reported using it less than before, and the rest of the

students reported no change. Almost half of girls (48%) and 37% of boys reported snacking more than 14% and 16% of girls and boys who reported snacking less during the lockdown. Sixty-eight percent of girls and 67% of boys reported late bed/wake-up times (Fig. 1).

While 44% and 31% of girls and boys perceived, on average, their mental health and wellbeing to be worse, the majority perceived their mental health and wellbeing to be better during the lockdown (Fig. 1). However, responses to the individual questions were mixed (Fig. 2). For example, 35% of girls and 27% of boys indicated they felt lonely more often compared to 33% and 41% of girls and boys who felt lonely less often during the lockdown than before the schools got closed. Thirty-two percent of students reported feeling lonely the same as before the lockdown. Almost half of girls (48%) and 36% of boys indicated they were more bored than 22% and 33% of girls and boys reporting they were less bored during the lockdown than before the schools got closed. At the same time, most of girls (47%) and boys (58%) reported enjoying their time at home more than before the lockdown, while the rest enjoyed their time at home less and about the same (Fig. 2).

Students who cared about being physically active were more likely to report no increases in time playing video games and using a cellphone and were more likely to maintain positive mental health (Table 2). Similarly, those who cared about eating

**Table 1**  
Characteristics of students and schools that participated in the study, Canada, 2020/21.

Student Characteristics	Girls (n = 557)	Boys (n = 538)	Total (n = 1095)
	n (%)	n (%)	n (%)
<b>Grade Level</b>			
Grade 4	161 (29)	151 (28)	312 (28)
Grade 5	180 (32)	203 (38)	383 (35)
Grade 6	216 (39)	184 (34)	400 (37)
<b>Attitudes toward being healthy</b>			
Care <sup>a</sup> about being healthy	486 (87)	460 (85)	926 (86)
Care <sup>a</sup> about being physically active	429 (77)	409 (76)	838 (77)
Care <sup>a</sup> about eating healthy	416 (75)	376 (69)	792 (72)
Care <sup>a</sup> about good sleep	268 (49)	235 (44)	503 (46)
<b>Language(s) spoken</b>			
English only	387 (69)	374 (70)	761 (69)
English and Indigenous	109 (20)	110 (20)	219 (20)
English and other	61 (11)	54 (10)	115 (11)
<b>School characteristics</b>	<b>Schools (n = 20)</b>		<b>Students (n = 1095)</b>
	n (%)		n (%)
<b>Time since reopening</b>			
≤3 months	13 (65)		672 (61)
>3 months	7 (35)		423 (39)
<b>Region of residence<sup>b</sup></b>			
Rural	8 (40)		165 (15)
Small PC	7 (35)		583 (53)
Medium PC	2 (10)		188 (17)
Large PC	3 (15)		159 (15)
<b>Material deprivation quintile</b>			
1 (least deprived)	2 (10)		66 (6)
2	4 (20)		222 (20)
3	5 (25)		447 (41)
4	5 (25)		291 (27)
5 (most deprived)	4 (20)		69 (6)
<b>Social deprivation quintile</b>			
1 (least deprived)	5 (25)		224 (20)
2	6 (30)		402 (37)
3	4 (20)		197 (18)
4	3 (15)		164 (15)
5 (most deprived)	2 (10)		108 (10)

PC: population centre.

<sup>a</sup> Percent of students who responded 'very much' or 'quite a lot'.

<sup>b</sup> Rural refers to a community with <1000 population, small PC to 1000–29,999 population, medium PC to 30,000–99,999, large PC refers to population of 100,000 or more.<sup>29</sup>

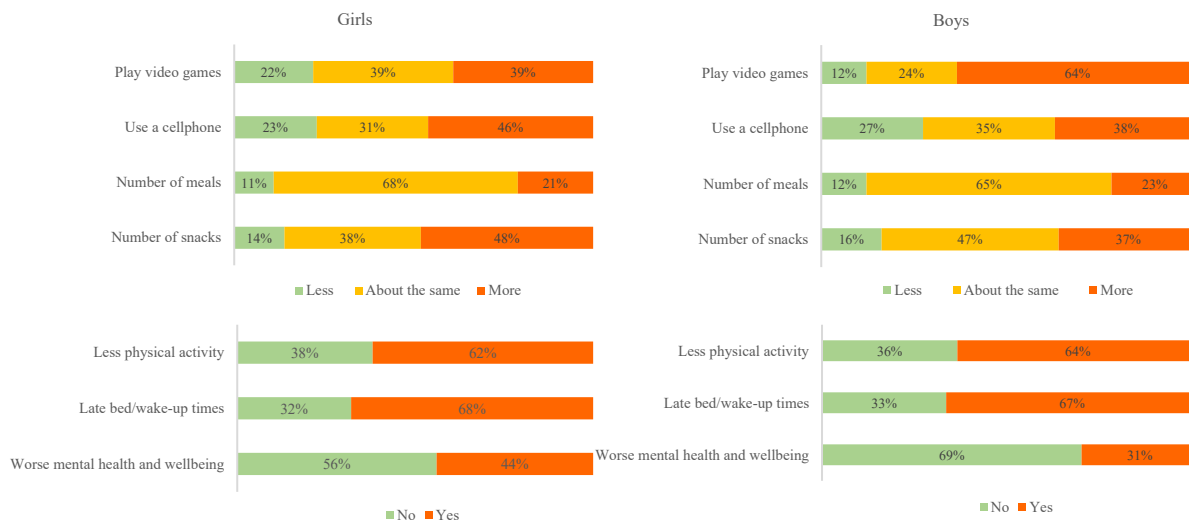


Fig. 1. Changes in physical activity, time playing video games, time using the cellphones, meal and snack frequency, bed/wake-up times, and mental health and wellbeing during vs before the lockdown.

healthy were more likely to report no increases in snacking during the lockdown and were likely to consume same amount or fewer snacks, while those who cared about their sleep and being healthy were less likely to report late bed/wake-up times during the lockdown. Gender-stratified associations are presented in Tables S2 and S3.

Tables 3 and 4 report on the associations of changes in lifestyle behaviours with changes in mental health and wellbeing in girls and boys, respectively. Girls who were more physically active during than before the lockdown were less likely to experience ‘internalizing and functioning problems, tiredness and loneliness’ and more likely to have a ‘positive outlook on future and time during lockdown’ relative to those who were less physically active (Table 3). In girls, spending less or the same amount of time playing video games was associated with a higher likelihood of maintaining

positive mental health and wellbeing during the lockdown and being bored and lonely. In addition, having more meals was associated with having a ‘positive outlook on future and time during the lockdown’. Similar to girls, boys who were physically active during the lockdown were more likely to have a ‘positive outlook on future and time during the lockdown’. Boys who reported having more meals and fewer snacks were more likely to experience positive mental health and wellbeing during the lockdown (Table 4).

Discussion

The present study reported on changes in the lifestyle behaviours and mental health and wellbeing, as perceived by elementary school-aged children living in socioeconomically disadvantaged communities, during the Spring 2020 COVID-19 lockdown.

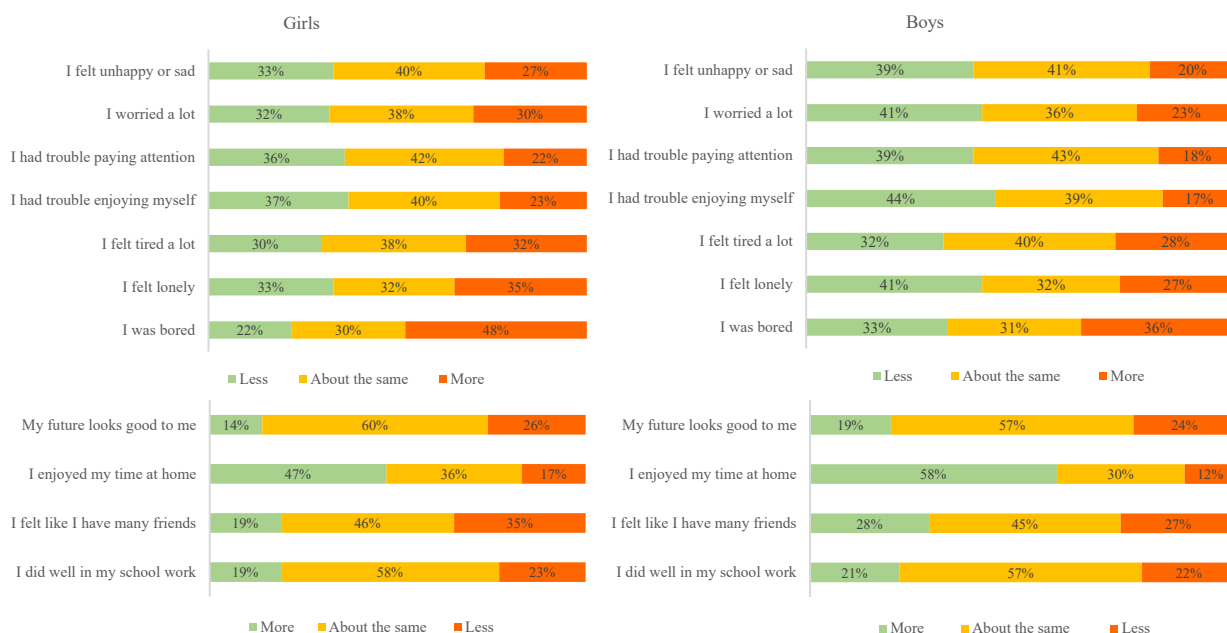


Fig. 2. Changes in mental health and wellbeing during vs before the lockdown.

**Table 2**  
Associations<sup>a</sup> of attitudes toward active and healthy living with changes in physical activity, sedentary behaviours, healthy eating, sleep, mental health and wellbeing during vs before the lockdown, Canada, 2020/21.

	More physical activity (vs less)	Same/less time playing video games (vs more)	Same/less time on cell phone (vs more)	Same/more meals (vs less)	Same/fewer snacks (vs more)	No late bed/wake-up times (vs late)	Better mental health and wellbeing (vs worse)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Care about being healthy</b>							
A little/not at all	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Very much/quite a lot	1.12 (0.72, 1.78)	1.20 (0.77, 1.87)	0.94 (0.61, 1.42)	1.39 (0.70, 2.65)	0.83 (0.53, 1.28)	1.69 (1.13, 2.51)	1.13 (0.71, 1.79)
<b>Care about being active</b>							
A little/not at all	Ref	Ref	Ref				Ref
Very much/quite a lot	1.18 (0.83, 1.68)	2.12 (1.5, 3.00)	1.86 (1.35, 2.59)				1.39 (1.06, 1.82)
<b>Care about eating healthy</b>							
A little/not at all				Ref	Ref		Ref
Very much/quite a lot				0.67 (0.39, 1.12)	1.44 (1.05, 1.98)		1.29 (0.91, 1.81)
<b>Care about good sleep</b>							
A little/not at all						Ref	Ref
Very much/quite a lot						2.15 (1.63, 2.84)	0.85 (0.60, 1.19)

OR: odds ratio; 95% CI: 95% confidence interval; Ref: reference category.

<sup>a</sup> All estimates are adjusted for the student characteristics (gender, grade level, language(s) spoken) and school/community characteristics (social deprivation, material deprivation, region of residence, and time since reopening of schools).

Children reported to be less physically active, to spend more time playing video games (boys) and using cellphones (girls), and to snack more. The majority of students reported having late bed or wake-up times on weekdays during the lockdown. In contrast, the majority of students found their mental health and wellbeing to be better during the lockdown. Moreover, positive attitudes toward being active, eating healthy, going to sleep on time and being healthy were strongly associated with maintaining healthy lifestyle behaviours during the lockdown. Last, positive attitudes were also associated with maintaining positive mental health and wellbeing during the lockdown.

Several studies reported on a considerable disengagement in physical activity during the lockdown.<sup>36–40</sup> While this appears true for most of our respondents, it is noteworthy that changes for the better were reported by more than one-third of girls and boys. In a study of lifestyle behaviours in Irish adolescents (12–18 years old) during the first lockdown,<sup>41</sup> 20% and 30% of students reported

exercising more and about the same, respectively, than 50% exercising less than pre-pandemic. The majority of boys and girls reported an increase in time playing video games and using cellphones, respectively. The decrease in physical activity combined with an increase in screen time is concerning. However, in the context of the pandemic where physical distancing is paramount, and multiple and repeat lockdowns are enforced; sedentary activities that involve peer/social interaction might have favourable effects on emotional wellbeing because students might use video gaming to connect with peers.<sup>42</sup> Health promotion messages should seek a balance between encouraging active lifestyles while affording children the opportunities for social interaction through online mediums, particularly those that encourage physical activity (e.g. exergaming).

Participants reported snacking more during the lockdown, which is consistent with emerging literature.<sup>43,44</sup> Despite the substantial increase in the consumption of processed foods since

**Table 3**  
Associations of changes in lifestyle behaviours with changes in mental health and wellbeing and its subgrouping during vs before the lockdown among girls, Canada, 2020/21.

	Better mental health and wellbeing (vs worse)	Internalizing and functioning problems, tired and lonely (vs not)	Positive outlook (vs not)	Bored and lonely (vs not)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Physical activity</b>				
Less than before	Ref	Ref	Ref	Ref
More than before	0.66 (0.45, 0.97)	0.52 (0.36, 0.76)	1.69 (1.13, 2.55)	0.81 (0.55, 1.18)
<b>Video games</b>				
Less than/same as before	1.61 (1.09, 2.37)	1.25 (0.85, 1.83)	1.16 (0.78, 1.72)	1.54 (1.04, 2.27)
More than before	Ref	Ref	Ref	Ref
<b>Cellphone use</b>				
Less than/same as before	1.18 (0.8, 1.73)	1.01 (0.69, 1.47)	1.47 (0.99, 2.18)	1.86 (1.27, 2.73)
More than before	Ref	Ref	Ref	Ref
<b>Number of meals</b>				
Less than/same as before	Ref	Ref	Ref	Ref
More than before	1.66 (0.93, 2.99)	1.02 (0.57, 1.81)	1.78 (1, 3.18)	1.42 (0.79, 2.58)
<b>Number of snacks</b>				
Less than/same as before	1.32 (0.9, 1.94)	1.3 (0.89, 1.89)	1.19 (0.81, 1.77)	1.06 (0.72, 1.54)
More than before	Ref	Ref	Ref	Ref
<b>Late bed/wake-up times</b>				
No	Ref	Ref	Ref	Ref
Yes	0.74 (0.5, 1.09)	0.77 (0.52, 1.14)	0.83 (0.56, 1.24)	0.67 (0.45, 0.99)

OR: odds ratio; 95% CI: 95% confidence interval; Ref: reference category.

All estimates are adjusted for the following student characteristics (grade level, language(s) spoken) and school/community characteristics (social deprivation, material deprivation, region of residence, and time since reopening of schools).

**Table 4**  
Associations of changes in lifestyle behaviours with changes in mental health and wellbeing and its subgrouping during vs before the lockdown among boys, Canada, 2020/21.

	Better mental health and wellbeing (vs worse)	Bored, tired and lonely (vs not)	Internalizing and functioning problems (vs not)	Positive outlook (vs not)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
<b>Physical activity</b>				
Less than before	Ref	Ref	Ref	Ref
More than before	1.18 (0.77, 1.82)	1.05 (0.71, 1.54)	0.69 (0.47, 1.02)	2.06 (1.39, 3.06)
<b>Video games</b>				
Less than/same as before	0.82 (0.53, 1.27)	0.86 (0.57, 1.29)	1.04 (0.7, 1.56)	0.65 (0.43, 0.97)
More than before	Ref	Ref	Ref	Ref
<b>Cellphone use</b>				
Less than/same as before	1.2 (0.78, 1.85)	1.2 (0.81, 1.78)	1.08 (0.73, 1.59)	0.8 (0.54, 1.19)
More than before	Ref	Ref	Ref	Ref
<b>Number of meals</b>				
Less than/same as before	Ref	Ref	Ref	Ref
More than before	1.92 (1.08, 3.39)	1.38 (0.8, 2.39)	1.11 (0.64, 1.92)	0.9 (0.52, 1.57)
<b>Number of snacks</b>				
Less than/same as before	1.83 (1.2, 2.78)	1.31 (0.9, 1.92)	1.22 (0.83, 1.78)	1.08 (0.73, 1.59)
More than before	Ref	Ref	Ref	Ref
<b>Late bed/wake-up times</b>				
No	Ref	Ref	Ref	Ref
Yes	1.44 (0.93, 2.26)	1.16 (0.78, 1.73)	1.04 (0.71, 1.55)	1.11 (0.75, 1.66)

OR: odds ratio; 95% CI: 95% confidence interval; Ref: reference category. All estimates are adjusted for the following student characteristics (grade level, language(s) spoken) and school/community characteristics (social deprivation, material deprivation, region of residence, and time since reopening of schools).

the start of the pandemic,<sup>45</sup> there are also reports that many families used the lockdown as an opportunity to steer their eating habits toward healthier options.<sup>46</sup> This underlines the importance of the health promotion initiatives focusing on healthy eating habits in the family setting.

Our findings of late bed/wake-up times during the lockdown are consistent with emerging literature,<sup>47</sup> but are not necessarily alarming. Most schools provided flexible school hours during the lockdown, and a shift toward later bedtime among children was shown to be accompanied by longer sleep duration, improved sleep quality and less daytime sleepiness during the lockdown.<sup>48</sup> Adopting a flexible school time schedule during the lockdown may help ensure children meet the recommended number of hours of sleep.<sup>49</sup>

Evidence on the impact of the COVID-19 pandemic on mental health and wellbeing in children is equivocal, and our study also reports mixed findings. While some children reported their mental health and wellbeing to worsen during the lockdown, most students reported positive changes. These results are seemingly not consistent with studies showing modest adverse impact of the pandemic on children and youth's mental health and wellbeing.<sup>50,51</sup> For example, in a survey of 166 grade 4 students in South Korea, Choi et al.<sup>52</sup> reported an increase in stress levels along with unchanged life satisfaction, underscoring the importance of high quality parent–child relationship in supporting children's mental health and wellbeing during the pandemic. Cultural and contextual factors, such as resiliency in small communities in Canada,<sup>53,54</sup> may also underlie the findings in the current study. All participating schools are part of the APPLE Schools program that takes a Comprehensive School Health approach to promoting healthy lifestyle behaviours and mental wellness. Pre-pandemic research had shown that this program was effective in increasing physical activity levels,<sup>55–57</sup> reducing screen time, improving vegetables and fruit consumption, and preventing excess body weight.<sup>58</sup> APPLE Schools continued the delivery of their programming when school buildings were closed, connecting directly with students and parents, sharing resource/activities promoting healthy lifestyle, distributing exercise equipment, providing healthy food hampers,

offering online activities (e.g. guided meditations), support from mental health therapists, among others. These activities could have helped students to weather the adverse effects of the lockdown, particularly on mental health and wellbeing given the emphasis of the APPLE Schools programming on promotion of mental health and wellbeing. Moreover, APPLE Schools programming also targets the attitudes of students. In this study, we revealed that students with positive attitudes toward active and healthy living, were more likely to maintain healthy lifestyle behaviors and mental health and wellbeing.

Most of the emerging literature on lifestyle behaviours and mental health and wellbeing of children is based on parental reports, while our study gathered information directly from students. Grade 4 to 6 students have appropriate literacy level to complete surveys and may be better at responding to questions on changes in lifestyle behaviours and mental health and wellbeing than their parents.<sup>59</sup> Another strength of this study is a very high response rate achieved by providing flexibility to teachers in scheduling the survey administration and coordinating on the day when most of the students were available. However, there are several limitations, including the cross-sectional design of the study. Longitudinal studies are required to study long-term health impacts that might result from the negative lifestyle changes associated with the pandemic-related public health measures.<sup>60</sup> Particular attention should be paid to socioeconomically disadvantaged groups and communities because the pandemic has exacerbated pre-existing inequalities, with evidence emerging that a range of adversities (e.g. financial burden, access to basic necessities) are maintained over time.<sup>61</sup> In addition, the surveys were administered several months after the lockdown, which may have affected participants' recall of the changes in lifestyle behaviours and mental health and wellbeing.

**Conclusion**

This study in the general population of elementary school–aged children from socioeconomically disadvantaged communities demonstrated considerable changes in physical activity, screen

time, eating habits and bed/wake-up times, albeit modest changes in mental health and wellbeing. Considering multiple and repeat lockdowns and the negative changes in lifestyles observed in this study population despite the ongoing APPLE Schools programming, investments in health promotion are critical to avoid a cascade of negative health consequences in the decades ahead.

## Author statements

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### Ethical approval

The Health Research Ethics Board of the University of Alberta (Pro00061528) and participating school boards approved all the procedures.

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### Competing interests

The authors have no real or perceived competing interests to disclose.

### Authors' contributions

All listed authors contributed to study design, drafted and revised the article, and gave their final approval of the version submitted for publication. KM and PJV conceptualized the study and methodology, and secured funding and resources. MKAK, KM, and PJV developed a statistical analysis plan, and MKAK conducted all data analyses. JD and PJV accessed and verified the data and wrote the original draft. All authors reviewed and approved the final manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2021.10.007>.

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