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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

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ABSTRACT

Objectives The COVID-19 pandemic changed daily routines, including physical activity, which could influence physical and mental health. In our study, we describe physical activity and sedentary behaviour patterns in relation to the pandemic and estimate associations between anxiety and physical activity and sedentary behaviour in community-dwelling adults.

Design Cross-sectional study.

Setting Calgary, Alberta, Canada.

Participants Between April and June 2020, a random sample of 1124 adults (≥18 years) completed an online questionnaire.

Primary and secondary outcomes The online questionnaire captured current walking, moderate intensity, vigorous intensity and total physical activity and sedentary behaviour (ie, sitting and leisure-based screen time), perceived relative changes in physical activity, sedentary and social behaviours since the pandemic, perceived seriousness and anxiety related to COVID-19, and sociodemographic characteristics. Differences in sociodemographic characteristics, perceived relative change in behaviour and current physical activity and sedentary behaviour were compared between adults with low and high anxiety.

Results Our sample (n=1047) included more females (60.3%) and fewer older adults (19.2%). Most participants (88.4%) considered COVID-19 as extremely or very serious and one-third (32.9%) felt extremely or very anxious. We found no differences (p>0.05) in current physical activity or sedentary behaviour by anxiety level. The largest perceived change in behaviours included social distancing, driving motor vehicles, use of screen-based devices, watching television and interactions with neighbours. We found anxiety-related differences (p<0.05) in perceived changes in various behaviours.

Conclusions Changes in physical activity, sedentary behaviour and social behaviour occurred soon after the COVID-19 pandemic was declared, and some of these changes differed among those with low and high anxiety.

BACKGROUND

In late 2019, the world became aware of a new and emerging virus, and on 11 March

Strengths and limitations of this study

► Our study captured perceived changes in physical activity, sedentary and social behaviours as a result of the COVID-19 pandemic public health emergency response.

► An online questionnaire was administered to a random sample of adults within the first 3 months of the WHO's declaration of the COVID-19 pandemic.

► Perceived changes in physical activity, sedentary and social behaviour since COVID-19 were examined in relation to a single-item measure of COVID-19 related anxiety.

► Perceived changes in physical activity, sedentary and social behaviour measured within the first 3 months of the pandemic may not reflect current or future behaviours as the COVID-19 pandemic continues.

► Despite retrospectively capturing change in behaviour since the COVID-19 pandemic, causality cannot be inferred based on the cross-sectional study design.

2020, the WHO assessed COVID-19 as a pandemic.[1] To reduce disease transmission, many countries, including Canada,[2] implemented public health emergency orders that included the closures of educational and daycare facilities, non-essential businesses, and private and public recreation facilities (eg, playgrounds, outdoor exercise equipment and sports courts and fields). The Government of Canada developed several guidelines on social and physical distancing to slow the spread of COVID-19, including suggestions to work from home whenever possible.[3] Despite the need for a rapid public health response to the COVID-19 crisis, the imposed restrictions on mobility, physical distancing and social interaction have impacted health.[4]

Anxiety is a risk factor for poor cardiovascular health[5] and lower quality of life.[6] The stress of rapidly adapting to new work, leisure, child-minding, school schedules and personal economic pressures have likely contributed to anxiety during the pandemic.[7–10] The rapid transmission, high mortality rate and perceived risk of infection from COVID-19 in addition to social distancing, lockdowns and masking requirements have all contributed to anxiety levels.[11–14] A study of seven middle-income Asian countries found being of younger age, not in a relationship, being in contact with people who contracted COVID-19 and worries about COVID-19 were risk factors of adverse mental health, while being male, having children, staying with six or more people, employment, higher perceived likelihood of surviving COVID-19, less exposure to health information, hand hygiene practices and mask wearing were protective factors against adverse mental health.[15] A recent meta-analysis estimated that almost two-thirds of adults from Asian and European countries reported abnormal anxiety during the early stages of the pandemic.[16] In Canada, Dozois[17] found a fourfold increase in the prevalence from 4% to 16% in self-reported high or extreme anxiety among adults due to the pandemic.

Regular physical activity has been associated with a reduction in anxiety and is a recommended treatment for mild to moderate depression.[18] Physical activity could improve mental health during the COVID-19 pandemic.[19] Regular physical activity can reduce the risk of chronic health conditions including cardiovascular diseases, diabetes, hypertension, overweight or obesity, depression and anxiety, and certain types of cancers.[20] Notably, decreases in physical activity and physical movement can result in immediate reductions in aerobic capacity,[21 22] lean muscle tissue[21 23 24] and increased fatigue.[25] Moreover, physical activity can strengthen the immune system[26 27] and reduce inflammation from conditions associated with cardiovascular disease, obesity and diabetes.[28] Regardless of age, underlying health conditions can increase an adult's susceptibility to COVID-19, often resulting in serious and prolonged hospitalisation.[29–31]

Aligned with COVID-19 specific physical activity recommendations elsewhere,[32] the current Canadian public health guidelines advise individuals to be active by going outside while staying close to home and maintaining physical distancing from others outside of one's household.[3] Evidence on the effects of the COVID-19 pandemic on physical activity is emerging.[33–39] In the UK, Robinson et al[35] found that since the COVID-19 lockdown, 40% of adults reported exercising less, 34% reported being less physically active and 73% reported spending more time sitting. The researchers also found that previous psychiatric diagnosis was associated with perceived decreases in physical activity. Furthermore, those who perceived their mental health had declined since the COVID-19 lockdown undertook fewer metabolic equivalent (MET) minutes of physical activity per week.[35] In the USA, the attenuation in physical activity during COVID-19 was greater for those achieving recommended levels of physical activity prior to the implementation of public health restrictions (eg, social isolation, social distancing and stay-at-home orders).[34] Moreover, those who no longer met the physical activity recommendations during the COVID-19 pandemic had stronger depressive symptoms and stress.[34] In Canada, Lesser and Nienhuis[40] found that compared with previously active adults, a higher proportion of previously inactive adults decreased their physical activity during COVID-19.

Given these unprecedented times, it is important to investigate the extent to which the COVID-19 pandemic has affected health and physical activity among Canadian adults. The aims of this study were twofold: (1) to describe physical activity and sedentary behaviour patterns among adults in relation to the pandemic public health emergency response and (2) to estimate associations between anxiety related to COVID-19 and physical activity and sedentary behaviour patterns in community-dwelling adults.

METHODS
Study and sample design
The study and sample design has been described elsewhere.[37] Briefly, in April 2020, we sent a recruitment postcard with a link to an online questionnaire to a random sample of 25 000 north central Calgary households (Alberta, Canada). The timing of the survey coincided with the pandemic declaration[1] and the Government of Alberta's declared province-wide state of public health emergency (17 March–15 June 2020). The public health measures included no social gatherings, temporary business closures and capacity reductions, province-wide mask requirements and working from home. The public health measures prohibited attendance at public recreational facilities and private entertainment facilities (eg, gyms, swimming pools, arenas, community centres, playgrounds, skateboard parks but not golf courses and outdoor shooting ranges). The public health measures also prohibited indoor and outdoor private or public gatherings of more than 15 people (minimum of 2 m apart) but allowed members of the same household to gather at indoor and outdoor locations.

Eligible participants required internet access, resided in north central Calgary, were aged 18 years or older and had a current email address for receiving correspondence from the research team. All participants provided written informed consent prior to gaining access to the online questionnaire. After completing the questionnaire, participants received a pass to a local recreation facility and were entered into a prize draw to win one of two $500 VISA gift cards. One adult per household completed the online questionnaire (n=1124).

Measures

COVID-19 related anxiety

One item, adapted from a previous pandemic study on perceived risks,[41] captured participants anxiety. Specifically, participants were asked 'How anxious are you as a result of the current COVID-19/Coronavirus situation?' (response options: *extremely anxious, very anxious, somewhat anxious* or *not anxious at all*). Due to the skewed distribution in responses, we collapsed responses into two categories (high anxiety (extremely or very anxious) and low anxiety (somewhat or not at all anxious)).

Seriousness of COVID-19

Also adapted from a previous study,[41] one item asked participants to what extent they felt the current COVID-19/coronavirus situation was serious (ie, response options: *extremely serious problem, a very serious problem, a somewhat serious problem,* or *not a serious problem*). Similarly, due to the skewed distribution in responses, we collapsed responses into two categories (ie, extreme or very serious and somewhat or not serious).

Current physical activity

Three items from the International Physical Activity Questionnaire (IPAQ - Short Form) captured physical activity during the last 7 days.[42 43] Participants reported the number of days per week they undertook vigorous physical activity (VPA), moderate physical activity (MPA) and walking for at least 10 min at a time. Participants then reported their usual time per day for these activities. We estimated weekly minutes of physical activity by multiplying the number of days by the minutes per day undertaking each physical activity. Established IPAQ procedures were implemented to minimise over-reporting of physical activity minutes.[44] In addition, we estimated total weekly relative energy expenditure (METs) based on IPAQ procedures[42 44] (total MET minutes per week = [VPA minutes × 8] + [MPA minutes × 4] + [walking minutes × 3.3]).

Current sedentary behaviour

Usual time sitting per day (eg, at work, home, doing coursework and during leisure) during the last 7 days was measured using an item from the IPAQ-Short Form.[42] Participants also reported their average time per day during the last 7 days watching television or using other screen-based electronic devices (eg, for video or computer games, DVD/movies, internet and email) outside the workplace.[45]

Perceived relative behaviour change related to COVID-19

On a five-point scale (*a lot less frequently, a little less frequently, about the same, a little more frequently* or *a lot more frequently*), participants reported their perceived relative change in indoor and outdoor physical activity, walking in the neighbourhood alone or with family members, walking to stores, cafes or shops, sedentary behaviours (television viewing, gaming and use of screen-based devices), driving a motor vehicle, using public transit, visiting parks, using pathways, social interactions with neighbours and others, and social distancing, since the onset of the pandemic. Similar items have been used previously to capture change in physical activity behaviour due to COVID-19 in Canada[36 37] and elsewhere.[35]

Sociodemographic characteristics

Captured sociodemographic characteristics included age (18–35, 36–60 or ≥60 years), sex (male or female), highest education completed (high school of less, trade/diploma/some university, bachelor degree or graduate degree), annual gross household income (≤$79 999, $80 000 to $119 999, ≥$120 000 or don't know/refused to answer), marital status (married/common law or other), children <18 years of age in the household (yes or no), employment status (working full-time, working part-time, not employed, student/homemaker, retired or other), ethnicity (Caucasian, Chinese, Asian other, non-Asian other and multiple ethnicities) and dog ownership (owns dog or no dog).

Statistical analysis

A complete case analysis was undertaken given the small proportion of missing cases (6.8%). Pearson's χ^2 estimated the sociodemographic differences among those reporting COVID-19 as extremely/very serious and among those reporting high anxiety related to COVID-19. Independent t-tests estimated the differences in perceived relative change in physical activities, sedentary behaviours and social behaviours between those reporting low versus high anxiety related to COVID-19.

Sociodemographic-adjusted (marginal) means for weekly frequency (days/week) in walking, MPA, and VPA and total MET minutes per week, non-workplace screen-based minutes per day and total sitting minutes per day were estimated and compared between the low and high COVID-19 anxiety groups using generalised linear models (normal distribution and identity link function). Among those reporting participation on at least 1 day per week, covariate-adjusted means for weekly minutes of walking, MPA and VPA were also estimated and compared between the low and high COVID-19 anxiety groups using generalised linear models (gamma distribution and identity link function). The 95% CIs for the marginal means were estimated.

We compared differences in current total weekly physical activity and total daily sitting by perceived relative change in social distancing (no change or decrease vs increase; independent t-tests) and time outdoors (no change vs decrease vs increase; Welch's Analysis of Variance with least significant difference pairwise comparisons) since COVID-19, as these changes reflect compliance with the enacted public health restrictions. Statistical significance for all tests was set at an alpha level of p<0.05. The analysis was undertaken using IBM Statistical Package for Social Sciences V.24.

Table 1 Sample profile and reporting of seriousness and anxiety related to COVID-19 (n=1047)

	Category	% Sample	% Extremely/very serious	% High anxiety
Age (years)	18–35	40.0	85.7*	34.1
	36–60	40.8	88.8	33.0
	≥60	19.2	93.5	29.9
Sex	Female	60.3	90.2*	31.7
	Male	39.7	85.8	33.6
Education	Completed high school or less	13.6	85.9	41.5*
	Completed trade, diploma, some university	30.3	89.3	35.0
	Completed bachelor degree	41.3	88.7	28.2
	Completed graduate degree	14.9	88.5	33.3
Annual gross household income	0–$79 999	22.3	92.7	39.9*
	$80 000–$119 999	23.1	85.1	35.1
	≥$120 000	34.6	87.6	26.8
	Don't know/refuse to answer	20.1	89.0	32.9
Employment status	Working full-time	48.9	87.3*	28.3*
	Working part-time	11.7	82.0	29.5
	Not employed	11.7	90.2	51.6
	Student/homemaker	9.0	89.4	36.2
	Retired	13.4	93.6	26.4
	Other	5.4	94.7	50.9
Ethnicity	Caucasian	64.4	86.8	29.2*
	Chinese	11.9	93.6	35.2
	Asian other	8.7	94.5	47.3
	Non-Asian other	8.1	88.2	40.0
	Multiple ethnicities	6.9	87.5	36.1
Children <18 years in household	Yes	45.9	85.0*	36.2*
	No	54.1	91.3	30.0
Relationship status	Married/common law	73.4	87.8	31.6
	Other	26.6	90.3	36.3
Dog ownership	Owns dog	31.7	88.3	30.4
	No dog	68.3	88.5	34.0

High anxiety includes those who reported feeling extremely or very anxious about COVID-19.
*P<.05. Statistically significant between categories within sociodemographic variable using Pearson's χ^2.

RESULTS
Sample characteristics
Our data collection (14 April–8 June 2020) coincided with the first 3 months of the declared state of public health emergency. The analytical sample included a complete data set of 1047 participants. The sample included mostly young to middle-aged adults, females, those completing bachelor or graduate degrees, households with incomes of ≥$80 000/year, full-time or part-time workers, Caucasians, household with no children, those married or in common law relationships and households without a dog (table 1).

The distribution in sociodemographic characteristics for the analytical sample and excluded cases were similar (p>0.05) for sex, age, household income, educational attainment, relationship status and dog ownership (results not shown). However, compared with the analytical sample, excluded cases included a higher proportion (p<0.05) of Caucasians (88.3%), households with a child at home (80%), homemakers or students (17.4%) and a lower proportion of retirees (4.3%), part-time workers (0%) and those unemployed (30.4%).

Seriousness of COVID-19 by sociodemographic characteristics
Most participants (88.4%) considered the COVID-19 situation as extremely or very serious (table 1). Compared with the analytical sample, a similar proportion (p=0.51) of excluded cases considered the COVID-19 as extremely

or very serious (93.8%). Compared with their counterparts, a significantly (p<0.05) higher proportion of adults ≥60 years of age (93.5%), females (90.2%), retirees (93.6%) or other employment status (94.7%), and households with no children (91.3%) reported COVID-19 as extremely or very serious (table 1).

COVID-19 related anxiety by sociodemographic characteristics

Approximately one-third of participants (32.9%) reported feeling extremely or very anxious about COVID-19 (table 1). Compared with the analytical sample, excluded cases were more likely (p<0.05) to report feeling very or extremely anxious (51.9%). Compared with their counterparts, a significantly (p<0.05) higher proportion of those with high school or less education (41.5%), a household income <$80 000/year (39.9%), the unemployed (51.6%) or other employment status (50.9%), non-Chinese Asian (47.3%) and households with children (36.2%) reported feeling very or extremely anxious about COVID-19 (table 1).

Perceived relative change in physical activity, sedentary and social behaviours since COVID-19 pandemic by anxiety

On average, the largest perceived change in behaviours since the declaration of the pandemic included undertaking social distancing (increased), driving motor vehicles (decreased), using screen-based devices (increased), watching television (increased) and in-person interactions with neighbours (decreased) (table 2). Compared with those reporting less anxiety, those feeling very or extremely anxious about COVID-19, on average, perceived their physical activity with family (3.25 vs 3.07), time outdoors (3.16 vs 2.96) and use of pathways (3.20 vs 2.96) had increased in frequency (p<0.05) (table 2). In addition, perceived driving a motor vehicle decreased to a greater extent among those feeling very or extremely anxious about COVID-19 (1.65 vs 1.84, p<0.05). Perceived sedentary behaviour had increased since the pandemic; however, this change was larger (p<0.05) among those feeling very or extremely anxious (ie, watching television: 3.71 vs 3.95, playing video games: 3.21 vs 3.43 and using screen-based devices: 3.85 vs 4.03) (table 2).

Table 2 Perceived relative change in physical activity, sedentary behaviour and social behaviour since COVID-19 pandemic declaration by anxiety

Behaviour	All participants (n=1047) Mean (SD) (rank)	Low COVID-19 related anxiety (n=703) Mean (SD)	High COVID-19 related anxiety (n=344) Mean (SD)	P value
Physically active in home	3.71 (1.10)[6]	3.69 (1.05)	3.75 (1.17)	0.479
Physically active outdoors alone	2.99 (1.13)[17]	3.04 (1.07)	2.90 (1.23)	0.066
Physically active outdoors with family	3.19 (1.21)[14]	3.25 (1.18)	3.07 (1.27)	0.025*
Walk in neighbourhood alone	3.28 (1.20)[13]	3.31 (1.11)	3.21 (1.36)	0.228
Walk in neighbourhood with family	3.42 (1.29)[10]	3.45 (1.25)	3.32 (1.38)	0.128
Walk to store, café or shop	2.39 (1.16)[8]	2.43 (1.14)	2.30 (1.22)	0.097
Visit parks	2.68 (1.29)[11]	2.71 (1.25)	2.62 (1.38)	0.274
Spend time outdoors	3.09 (1.26)[16]	3.16 (1.20)	2.96 (1.37)	0.025*
Use pathways	3.12 (1.28)[15]	3.20 (1.22)	2.96 (1.38)	0.006*
In-person interaction with neighbours	2.26 (1.13)[5]	2.26 (1.13)	2.24 (1.14)	0.740
In-person interaction with others	2.30 (1.18)[7]	2.32 (1.18)	2.25 (1.15)	0.356
Undertake social distancing	4.77 (0.61)[1]	4.77 (0.59)	4.77 (0.66)	0.927
Drive motor vehicle	1.71 (1.06)[2]	1.65 (1.00)	1.84 (1.16)	0.010*
Use public transit	2.49 (0.88)[9]	2.52 (0.86)	2.42 (0.92)	0.073
Watching television	3.79 (0.93)[4]	3.71 (0.88)	3.95 (1.00)	<0.001*
Playing video games	3.28 (0.74)[12]	3.21 (0.66)	3.43 (0.87)	<0.001*
Use screen-based devices	3.91 (0.88)[3]	3.85 (0.85)	4.03 (0.93)	0.002*

Rank based on absolute difference relative to 'no change' since COVID-19 pandemic declaration.
Behaviour change item response scale: 1=a lot less frequently, 2=a little less frequently, 3=no change, 4=a little more frequently, 5=a lot more frequently.
High anxiety includes those who reported feeling extremely or very anxious about COVID-19.
Low anxiety includes those who reported feeling somewhat or not at all anxious about COVID-19.
*P<.05 (two tailed) based on independent t-test.

Table 3 Differences in current physical activity and sedentary behaviour by COVID-19 related anxiety

Behaviour	N	Total sample Mean (SD)†	COVID-19 anxiety	
			Low anxiety Marginal mean (95% CI)	High anxiety Marginal mean (95% CI)
Walking days per week	1047	4.41 (2.35)	4.58 (4.20 to 4.77)	4.37 (4.06 to 4.68)
Walking minutes per week	965	221.82 (202.50)	243.21 (218.53 to 267.88)	231.47 (204.99 to 257.94)
MPA days per week	1047	2.96 (2.34)	3.03 (2.74 to 3.32)	2.81 (2.50 to 3.12)
MPA minutes per week	793	170.93 (192.95)	183.60 (161.62 to 205.58)	183.70 (158.88 to 208.55)
VPA days per week	1047	2.52 (2.21)	2.58 (2.30 to 2.86)	2.53 (2.23 to 2.83)
VPA minutes per week	716	173.55 (157.64)	199.47 (175.67 to 223.27)	200.80 (175.42 to 226.19)
Total MET minutes per week	1047	2142.03 (1653.00)	2244.12 (1990.37 to 2497.86)	2137.63 (1865.73 to 2409.54)
Non-workplace screen-based minutes per day	1047	195.89 (166.79)	203.10 (182.24 to 223.79)	217.26 (194.99 to 239.52)
Total sitting minutes per day	1047	329.08 (221.30)	296.23 (268.80 to 323.65)	291.57 (261.19 to 320.96)

Total MET minutes per week=walking min (× 3.3 METs)+MPA min (× 4 METs)+VPA min (× 8 METs).
High anxiety includes those who reported feeling extremely or very anxious about COVID-19.
Low anxiety includes those who reported feeling somewhat or not at all anxious about COVID-19.
Marginal means adjusted for age, sex, education, income, employment status, ethnicity, marital status, dog ownership and predicted at mean value of covariates.
*P<.05 for difference in marginal means between low and high anxiety.
†Total sample means not adjusted for covariates.
MPA, moderate intensity physical activity (excluding walking); PA, physical activity; VPA, vigorous intensity physical activity.

Differences in current physical activity and sedentary behaviour by COVID-19 anxiety

Adjusting for sociodemographic characteristics, we found no significant differences (p<0.05) in current weekly physical activity (frequency, duration and relative energy expenditure) or daily sedentary behaviour (duration) between those reporting low versus high anxiety (table 3).

Difference in current physical activity and sedentary behaviour by perceived change in social distancing and time outdoors since COVID-19

Most participants (94.5%) perceived they had increased social distancing during the pandemic. We found no significant differences (p>0.05) in current mean total weekly physical activity nor mean daily total sitting by change in social distancing (perceived no change or decrease=2349.98 vs increase=2130.72 MET minutes/week, and perceived no change or decrease=281.11 vs increase=331.67 minutes/day, respectively) (table 4). Overall, 41.3% perceived their time outdoors had increased since COVID-19, while similar proportions perceived no change (29.8%) or a decrease (28.9%) in time outdoors. Compared with adults who perceived their time outdoors had decreased, those perceiving no change or an increase, on average, reported significantly (p<0.05) more total weekly physical activity (perceived decrease=1685.21 vs no change=2314.24 and increase=2338.05 MET min/week) and less daily sitting (perceived decrease=363.61 vs no change=326.87 and increase=306.45 min/day) (table 5).

DISCUSSION

Congruent with findings elsewhere,[35] we found that participants perceived their sedentary behaviour had increased due to COVID-19. Consistent with other findings,[33–35] we also found that participants perceived changes in their physical activity due to COVID-19 and that these changes differed by anxiety related to COVID-19. Others have reported differences in perceived change in physical activity between those with and without pre-existing psychiatric conditions during the pandemic.[35] We did not find any significant anxiety-related differences in current amounts of physical activity or sedentary behaviour.

Table 4 Differences in current physical activity and sedentary behaviour by change in social distancing since COVID-19

Behaviour	Perceived change in social distancing	
	Decrease or no change (n=54) Mean SD	Increase (n=993) Mean (SD)
Total MET minutes per week	2349.98 (3072.70)	2130.72 (1940.24)
Non-workplace screen-based minutes per day	175.93 (167.64)	196.98 (166.75)
Total sitting minutes per day	281.11 (242.48)	331.67 (219.92)

*P<.05 for difference by perceived change in social distancing.

Table 5 Differences in current physical activity and sedentary behaviour by change in time outdoors since COVID-19

Behaviour	Perceived change in time outdoors		
	Decrease (n=303) Mean (SD)	No change (n=312) Mean (SD)	Increase (n=432) Mean (SD)
Total MET minutes per week*	1685.21 (1875.42)[ab]	2314.24 (1956,60)[a]	2338.05 (2097.07)[b]
Non-workplace screen-based minutes per day*	229.52 (198.75)[ab]	198.36 (164.62)[ac]	170.52 (137.24)[bc]
Total sitting minutes per day*	363.61 (233.07)[ab]	326.87 (226.69)[a]	306.45 (205.79)[b]

Columns with same superscript ([a,b,c]) indicate a significant difference (p<0.05; least significant difference pairwise comparisons) in behaviour by perceived change in time outdoors since COVID-19.
*P<.05 for difference by perceived change in time spent outdoors (Analysis of Variance; Welch Robust Test of Equality of Means).

The majority of Canadians (70%) are concerned about the impact of COVID-19 on the Canadian and world population's health.[46] We found most participants reported COVID-19 as extremely or very serious (88%). We also found a higher proportion of older adults, females, retirees and households with no children reported COVID-19 as extremely or very serious relative to other groups. These differences might reflect that some groups (eg, older adults) are at higher risk of serious health complications due to COVID-19.[47 48] Despite males having a higher risk of developing more serious health complications from COVID-19,[47 48] speculatively, females may consider the COVID-19 situation more serious due the rapid changes in daily routines (eg, closures of schools an daycare facilities, balancing at home work and child-minding). While we did not examine differences in perceived seriousness of COVID-19 based on pre-existing health conditions, Ramage-Morin and Polsky[46] found higher concern associated with COVID-19 among those with existing health conditions.

Anxiety levels reported in Canada[17] and elsewhere[16] have worsened in only a short period of time since the COVID-19 pandemic began. We found almost one-third of participants reported very high or extreme anxiety related to COVID-19 within the first 3 months of the pandemic. This is of concern given that high anxiety negatively impacts health,[5 6] and the pandemic is still ongoing. Compared with other groups, higher proportions of those with low education, low household incomes, unemployed, non-Chinese Asians and with children reported very high or extreme anxiety related to COVID-19. Other studies have reported associations between sociodemographic characteristics and anxiety during the early stages of the pandemic.[49 50] Congruent with our findings, cohabitating, having children and having lower of income have been associated with higher anxiety during COVID-19 in European studues[49 50]; however, in Asian countries having no children at home, being single or separated, having higher education and being younger adult (<30 years) have been associated with adverse mental health during COVID-19.[15] We did not find higher anxiety among older adults that might reflect our potentially healthier sample. Notably, the effects of age on anxiety during COVID-19 reported elsewhere appears to be mixed.[15 50]

Higher anxiety levels reported in our study and elsewhere might reflect the stress of individuals and families rapidly adapting to new daily schedules, economic pressures, or concerns about contracting or transmitting COVID-19.[7–12] Canadian governments and health authorities have provided online resources to combat mental health conditions due to the pandemic[51 52]; however, individual, environmental and policy approaches that target the determinants of these conditions are needed.[53 54]

Encouraging people to be more physically active, even under a state of public health emergency, is important for supporting health.[32 55] Canadians are being advised to be active by going outside while staying close to home and maintaining physical distancing.[3] Approximately 95% of our sample reported increasing their social distancing behaviour since COVID-19 suggesting high compliance with physical distancing restrictions. Perceived change in social distancing as well as interactions with others was similar regardless of anxiety levels. Nevertheless, almost 29% of participants perceived their time outdoors had decreased since the pandemic despite the Canadian government recommending people be active outdoors. Notably, those with high anxiety decreased time outdoors while those with low anxiety increased time outdoors. These trends were also found for pathway use. While we did not find differences in current physical activity and sedentary behaviour by level of anxiety, those who perceived their outdoor time had decreased accumulated less physical activity and more sitting compared with those who increased or did not change their outdoor time. Adults with higher anxiety should be encouraged to spend more time outdoors during the pandemic as it could provide mental health benefits via opportunities for physical activity[18] and connections with nature.[40 56]

Increases in sedentary behaviour corresponding with COVID-19 restrictions have been found.[35] We found, on average, participants reported sitting approximately 6 hours per day and spending just over 3 hours per day on recreational screen-based activity aligned with the maximum of 8 hours of sedentary and 3 hours of screen time per day promoted by the adult Canadian 24 hour Movement Guidelines.[57] Alarmingly, participants reported perceived increases in sedentary behaviour (eg, watching television, play video games and use of

screen-based devices) during the pandemic. Despite no differences in current sitting or leisure-based screen time, the perceived changes in sedentary behaviour were more pronounced among those with higher anxiety. The public health emergency restrictions that encouraged people to perform their usually daily tasks at home (eg, working and schooling) might have inadvertently provided more opportunity for home-based sedentary behaviour. Physical activity recommendations specific to COVID-19 exist, yet these recommendations do not explicitly address sedentary behaviour.[3 32] Recommending and providing more opportunities for outdoor activity and implementing multilevel interventions that target sedentary behaviour in the home setting[58 59] could reduce sitting during the pandemic.

We did not have comparison pre-COVID-19 physical activity data; however, the majority of our sample (78.8%) was moderately active (ie, ≥600 MET minutes per week)[44] despite the pandemic. This level of physical activity might be considered high given that other studies have reported decreases in physical activity due to COVID-19.[33–35 38] We cannot conclude if any changes in total accumulated physical activity have occurred due to the pandemic; however, our findings might suggest some changes in behaviour have supported the maintenance or increases in physical activity (eg, being physically active at home and walking in the neighbourhood either along or with family). It is possible that some adults in our sample increased while others decreased their physical activity[40] or that others substituted their physical activities with those that could be safely undertaken under the pandemic restrictions.[39] While the goal of encouraging adults to accumulate health-enhancing physical activity has not changed,[60] strategies now need to adapt to the current restrictions (and opportunities) that have emerged during the pandemic.[61 62]

Our study has several limitations. Despite including a measure of perceived behaviour change, causality cannot be inferred from our study. Our study represents the relationships between physical activity, sedentary behaviour and anxiety captured within the first 3 months of the pandemic. Given the ongoing public health restrictions, the emergence of second and third waves of increased infection rates, and the launch of the COVID-19 vaccine programme across Canada, our findings may not generalise to the current situation. Given the lack of available prepandemic data for our sample, we are unable to rule-out the potential effects of pre-existing anxiety, psychopathologies or health conditions on levels of COVID-19 related anxiety during the early stages of the pandemic.

The self-report measures of physical activity and anxiety included in our study may be subject to social desirability and reporting bias. Our survey included a single-item (global) measure of COVID-19 related anxiety; however, this may not have fully captured the anxiety experienced during the pandemic and in particular anxiety experienced in relation to specific life events (eg, job loss,

illness or death of a family member or friend and isolation from family and friends). The higher levels of education and income of participants, the low response rate and sampling of households from north central Calgary communities may also limit the generalisability of our findings.

CONCLUSIONS

The COVID-19 pandemic had immediate impacts on physical activity and sedentary behaviour. Encouraging adults, and in particular those with high anxiety, to be physically active outdoors while maintaining physical distancing could support the accumulation of physical activity during the pandemic. The pandemic has further highlighted the importance of encouraging physical activity and discouraging sedentary behaviour in general as a means of promoting health and well-being in the community. To inform future public health strategies, more research is needed to better understand how people have adapted their daily routines to maintain their physical activity levels during the pandemic. In addition to promoting physical activity and discouraging sedentary behaviour, interventions that directly address the increased anxiety associated with infectious disease pandemics are also needed.

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REFERENCES

1 WHO. WHO Director-General's opening remarks at the media briefing on COVID-19, 2020. Available: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020 [Accessed 29 Apr 2020].
2 Detsky AS, Bogoch II. COVID-19 in Canada: experience and response. *JAMA* 2020;324:743–4.
3 Government of Canada. Physical distancing: how to slow the spread of COVID-19, 2020. Available: https://www.canada.ca/en/public-health/services/publications/diseases-conditions/social-distancing.html [Accessed 14 Jan 2021].
4 Arora T, Grey I. Health behaviour changes during COVID-19 and the potential consequences: a mini-review. *J Health Psychol* 2020;25:1155–63.
5 Tully PJ, Cosh SM, Baune BT. A review of the affects of worry and generalized anxiety disorder upon cardiovascular health and coronary heart disease. *Psychol Health Med* 2013;18:627–44.
6 Olatunji BO, Cisler JM, Tolin DF. Quality of life in the anxiety disorders: a meta-analytic review. *Clin Psychol Rev* 2007;27:572–81.
7 Fegert JM, Vitiello B, Plener PL, *et al*. Challenges and burden of the coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: a narrative review to highlight clinical and research needs in the acute phase and the long return to normality. *Child Adolesc Psychiatry Ment Health* 2020;14.
8 Pfefferbaum B, North CS. Mental health and the Covid-19 pandemic. *N Engl J Med* 2020;383:510–2.
9 Park CL, Russell BS, Fendrich M, *et al*. Americans' COVID-19 stress, coping, and adherence to CDC guidelines. *J Gen Intern Med* 2020;35:2296–303.
10 Mann FD, Krueger RF, Vohs KD. Personal economic anxiety in response to COVID-19. *Pers Individ Dif* 2020;167:110233.
11 Malesza M, Kaczmarek MC. Predictors of anxiety during the COVID-19 pandemic in Poland. *Pers Individ Dif* 2021;170:110419.
12 Banerjee D, Rai M. Social isolation in Covid-19: the impact of loneliness. *Int J Soc Psychiatry* 2020;66:525–7.
13 Benke C, Autenrieth LK, Asselmann E, *et al*. Lockdown, quarantine measures, and social distancing: associations with depression, anxiety and distress at the beginning of the COVID-19 pandemic among adults from Germany. *Psychiatry Res* 2020;293:113462.
14 Wang C, Chudzicka-Czupała A, Grabowski D, *et al*. The association between physical and mental health and face mask use during the COVID-19 pandemic: a comparison of two countries with different views and practices. *Front Psychiatry* 2020;11:569981.
15 Wang C, Tee M, Roy AE, *et al*. The impact of COVID-19 pandemic on physical and mental health of Asians: a study of seven middle-income countries in Asia. *PLoS One* 2021;16:e0246824.
16 Salari N, Hosseinian-Far A, Jalali R, *et al*. Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis. *Global Health* 2020;16:57.
17 Dozois DJA, Mental Health Research Canada. Anxiety and depression in Canada during the COVID-19 pandemic: a national survey. *Canadian Psychology/Psychologie canadienne* 2020;62:136–42.
18 Ravindran AV, Balneaves LG, Faulkner G, *et al*. Canadian network for mood and anxiety treatments (CANMAT) 2016 clinical guidelines for the management of adults with major depressive disorder: section 5. complementary and alternative medicine treatments. *Can J Psychiatry* 2016;61:576–87.
19 Hu S, Tucker L, Wu C, *et al*. Beneficial effects of exercise on depression and anxiety during the Covid-19 pandemic: a narrative review. *Front Psychiatry* 2020;11:587557.
20 Warburton DER, Bredin SSD. Health benefits of physical activity: a systematic review of current systematic reviews. *Curr Opin Cardiol* 2017;32:541–56.
21 Lippi G, Henry BM, Sanchis-Gomar F. Physical inactivity and cardiovascular disease at the time of coronavirus disease 2019 (COVID-19). *Eur J Prev Cardiol* 2020;27:906–8.
22 Mujika I, Padilla S. Detraining: loss of training-induced physiological and performance adaptations. Part II: long term insufficient training stimulus. *Sports Med* 2000;30:145–54.
23 Mujika I, Padilla S. Muscular characteristics of detraining in humans. *Med Sci Sports Exerc* 2001;33:1297–303.
24 Bowden Davies KA, Pickles S, Sprung VS, *et al*. Reduced physical activity in young and older adults: metabolic and musculoskeletal implications. *Ther Adv Endocrinol Metab* 2019;10:204201881988882.
25 Glass JM, Lyden AK, Petzke F, *et al*. The effect of brief exercise cessation on pain, fatigue, and mood symptom development in healthy, fit individuals. *J Psychosom Res* 2004;57:391–8.
26 Nieman DC, Wentz LM. The compelling link between physical activity and the body's defense system. *J Sport Health Sci* 2019;8:201–17.
27 Nieman DC. Coronavirus disease-2019: a tocsin to our aging, unfit, corpulent, and immunodeficient Society. *J Sport Health Sci* 2020;9:293–301.
28 Hojman P. Exercise protects from cancer through regulation of immune function and inflammation. *Biochem Soc Trans* 2017;45:905–11.
29 Petrakis D, Margină D, Tsarouhas K, *et al*. Obesity - a risk factor for increased COVID-19 prevalence, severity and lethality (Review). *Mol Med Rep* 2020;22:9–19.
30 CDC COVID-19 Response Team. Preliminary Estimates of the Prevalence of Selected Underlying Health Conditions Among Patients with Coronavirus Disease 2019 - United States, February 12-March 28, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:382–6.
31 Hu Y, Sun J, Dai Z, *et al*. Prevalence and severity of corona virus disease 2019 (COVID-19): a systematic review and meta-analysis. *J Clin Virol* 2020;127:104371.
32 Polero P, Rebollo-Seco C, Adsuar JC, *et al*. Physical activity recommendations during COVID-19: narrative review. *Int J Environ Res Public Health* 2021;18:65.
33 Tison GH, Avram R, Kuhar P, *et al*. Worldwide effect of COVID-19 on physical activity: a descriptive study. *Ann Intern Med* 2020;173:767–70.
34 Meyer J, McDowell C, Lansing J, *et al*. Changes in physical activity and sedentary behavior in response to COVID-19 and their associations with mental health in 3052 us adults. *Int J Environ Res Public Health* 2020;17:6469.
35 Robinson E, Boyland E, Chisholm A, *et al*. Obesity, eating behavior and physical activity during COVID-19 lockdown: a study of UK adults. *Appetite* 2021;156:104853.
36 Moore SA, Faulkner G, Rhodes RE, *et al*. Impact of the COVID-19 virus outbreak on movement and play behaviours of Canadian children and youth: a national survey. *Int J Behav Nutr Phys Act* 2020;17:85.
37 McCormack GR, Doyle-Baker PK, Petersen JA, *et al*. Parent anxiety and perceptions of their child's physical activity and sedentary behaviour during the COVID-19 pandemic in Canada. *Prev Med Rep* 2020;20:101275.
38 Liu X, Kakade M, Fuller CJ, *et al*. Depression after exposure to stressful events: lessons learned from the severe acute respiratory syndrome epidemic. *Compr Psychiatry* 2012;53:15–23.
39 Cheval B, Sivaramakrishnan H, Maltagliati S, *et al*. Relationships between changes in self-reported physical activity, sedentary behaviour and health during the coronavirus (COVID-19) pandemic in France and Switzerland. *J Sports Sci* 2021;39:1–6.
40 Lesser IA, Nienhuis CP. The impact of COVID-19 on physical activity behavior and well-being of Canadians. *Int J Environ Res Public Health* 2020;17:3899.
41 Van D, McLaws M-L, Crimmins J, *et al*. University life and pandemic influenza: attitudes and intended behaviour of staff and students towards pandemic (H1N1) 2009. *BMC Public Health* 2010;10:130.
42 Bauman A, Bull F, Chey T, *et al*. The International prevalence study on physical activity: results from 20 countries. *Int J Behav Nutr Phys Act* 2009;6:21.
43 Craig CL, Marshall AL, Sjöström M, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;35:1381–95.
44 IPAQ. Guidelines for data processing and analysis of the International physical activity Questionnaire-Short and long forms, 2005. Available: http://www.ipaq.ki.se [Accessed 11 Jan 2020].
45 McCormack GR, Mardinger C. Neighbourhood urban form and individual-level correlates of leisure-based screen time in Canadian adults. *BMJ Open* 2015;5:e009418.
46 Ramage-Morin PL, Polsky JY. Health-related concerns and precautions during the COVID-19 pandemic: a comparison of Canadians with and without underlying health conditions. *Health Rep* 2020;31:3–8.
47 Zheng Z, Peng F, Xu B, *et al*. Risk factors of critical & mortal COVID-19 cases: A systematic literature review and meta-analysis. *J Infect* 2020;81:e16–25.

48 Rozenfeld Y, Beam J, Maier H, *et al*. A model of disparities: risk factors associated with COVID-19 infection. *Int J Equity Health* 2020;19:126.

49 Malesza M, Kaczmarek MC. Predictors of anxiety during the COVID-19 pandemic in Poland. *Pers Individ Dif* 2021;170:110419.

50 Hyland P, Shevlin M, McBride O, *et al*. Anxiety and depression in the Republic of Ireland during the COVID-19 pandemic. *Acta Psychiatr Scand* 2020;142:249–56.

51 Alberta Health Services. Taking charge of what you can: a COVID-19 toolkit, 2021. Available: https://www.albertahealthservices.ca/assets/info/ppih/if-ppih-covid-19-mental-health-toolkit.pdf [Accessed 27 Jan 2021].

52 Government of Canada. Wellness together Canada, 2021. Available: https://ca.portal.gs/ [Accessed 27 Jan 2021].

53 Stokols D. Translating social ecological theory into guidelines for community health promotion. *Am J Health Promot* 1996;10:282–98.

54 Myer RA, Moore HB. Crisis in context theory: an ecological model. *J Couns Dev* 2006;84:139–47.

55 Ricci F, Izzicupo P, Moscucci F, *et al*. Recommendations for physical inactivity and sedentary behavior during the coronavirus disease (COVID-19) pandemic. *Front Public Health* 2020;8.

56 Lawton E, Brymer E, Clough P, *et al*. The relationship between the physical activity environment, nature relatedness, anxiety, and the psychological well-being benefits of regular Exercisers. *Front Psychol* 2017;8:1058.

57 Ross R, Chaput J-P, Giangregorio LM, *et al*. Canadian 24-hour movement guidelines for adults aged 18-64 years and adults aged 65 years or older: an integration of physical activity, sedentary behaviour, and sleep. *Appl Physiol Nutr Metab* 2020;45:S57–102.

58 Owen N, Sugiyama T, Eakin EE, *et al*. Adults' sedentary behavior determinants and interventions. *Am J Prev Med* 2011;41:189–96.

59 Prince SA, Saunders TJ, Gresty K, *et al*. A comparison of the effectiveness of physical activity and sedentary behaviour interventions in reducing sedentary time in adults: a systematic review and meta-analysis of controlled trials. *Obes Rev* 2014;15:905–19.

60 Ding D, Mutrie N, Bauman A, *et al*. Physical activity guidelines 2020: comprehensive and inclusive recommendations to activate populations. *Lancet* 2020;396:1780–2.

61 Hammami A, Harrabi B, Mohr M. Physical activity and coronavirus disease 2019 (COVID-19): specific recommendations for home-based physical training. *Manag Sport Leis* 2020;4:1–6.

62 Chtourou H, Trabelsi K, H'mida C, *et al*. Staying physically active during the quarantine and Self-Isolation period for controlling and mitigating the COVID-19 pandemic: a systematic overview of the literature. *Front Psychol* 2020;11:1708.