Correlates of Perceived Physical Activity Transitions during the COVID-19 Pandemic among Canadian Adults

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Background: The purpose of this study was to explore socio-ecological predictors of moderate to vigorous physical activity (MVPA) as a result of the COVD-19 pandemic restrictions. **Method:** A representative sample of 1,055 English-speaking Canadians (18+ years) completed measures of MVPA during the COVID-19 restrictions and reflecting on MVPA prior to these restrictions, as well as demographics, COVID-19-related cognitions and behavior (i.e. perceived threat, social distancing), psychological factors (e.g. personality traits, habit, identity, strategic planning), social factors (e.g. dependent children, co-habitation), home environment affordances (exercise equipment, programming) and the neighborhood environment (e.g. access to outdoor recreation, neighborhood safety). **Results:** Participants perceived that they had decreased weekly MVPA ($p < .01$) and the availability of home equipment and strategic planning were critical predictors ($p < .01$). Profiles by MVPA guidelines, however, showed that 58 per cent of the sample had not changed and 6 per cent had increased MVPA. Identity was the critical predictor of the different MVPA profiles, followed by habit, extraversion, availability of home equipment, and the age of the participant ($p < .01$). **Conclusion:** Pandemic restrictions have affected the MVPA of many Canadians, and variables across the socio-ecological spectrum explain who has been able to maintain MVPA during this unprecedented time.

Keywords: habit, home environment, identity, personality, planning

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INTRODUCTION

COVID-19 was classified as a worldwide pandemic on 11 March 2020 (World Health Organization, 2020). COVID-19 is caused by a coronavirus (SARS-CoV-2) which can result in acute respiratory distress in humans and is transmitted through respiratory droplets and contact routes (Xu, Shi, & Wang, 2020). As of this writing, there have been over 15,000,000 cases of COVID-19 and over 600,000 deaths worldwide (Johns Hopkins University, 2020). The devastating effects of the COVID-19 outbreak have led to significant changes in daily life. Canada has reported over 113,000 cases and nearly 9,000 deaths (Johns Hopkins University, 2020); thus, like many countries, Canada put restrictions into place to require physical distancing (two meters away from others) and has eliminated community and social gatherings and interactions, with a general instruction to "stay home" (Government of Canada, 2020a, 2020b).

This order was based on best-practice public health guidelines for reducing the spread of respiratory viruses (Jefferson et al., 2011); yet, the consequences have affected how people engage in recreation, and the relative composition of daily physical activity behaviors. For example, Fitbit's presentation of its users noted a 5 per cent to 20 per cent reduction in total steps across the globe during the early stages of the pandemic (Fitbit Inc., 2020). Early pre-print research has replicated this general finding in China (Qin et al., 2020), the United States (Dunton, Wang, Do, & Courtney, 2020; Meyer et al., 2020), and Europe (Cheval et al., 2020). Furthermore, higher intensity physical activity, and those individuals with physical activity profiles commensurate with international guidelines (World Health Organization, 2012), appear to be particularly compromised (Cheval et al., 2020; Meyer et al., 2020). These findings are concerning because regular moderate to vigorous intensity physical activity (MVPA) is essential for mental and physical health (Rhodes, Bredin, Janssen, Warburton, & Bauman, 2017); yet, it was plagued by low participation rates even before the COVID-19 pandemic (Guthold, Stevens, Riley, & Bull, 2018).

As a result (or in anticipation) of the physical activity decline, the media, health organisations, and academics have run copious editorials and commentaries attempting to assist in physical activity promotion during the pandemic (e.g. American College of Sports Medicine, 2020; Hanson et al., 2020; Jiménez-Pavón, Carbonell-Baeza, & Lavie, 2020; Washington Post, 2020). This is a helpful body of literature, yet is stands to reason that promotion recommendations be assisted by an evidence base, which is currently lacking. Indeed, our literature review identified only one study that has focused on correlates of physical activity changes during COVID-19 (Dunton et al., 2020). This study focused on demographic correlates and showed that those who were unemployed were more likely to be affected by decreases in physical activity. The purpose of this study was to explore a broad socio-ecological

(Stokols, 1992) scope of predictors that could conceivably affect changes in MVPA as a result of the pandemic restrictions among a representative sample in English Canada.

Specifically, the objectives of this study were to (1) replicate the change in MVPA findings from China, Europe, and the United States, within a Canadian sample, (2) explore correlates of current MVPA and shifts in MVPA after the COVID-19 restrictions had been in place for nearly two months, and (3) predict the stability of the MVPA profiles (e.g. inactive throughout, active throughout, those who were active but became inactive) as a result of the COVID-19 pandemic restrictions. We employed demographic (e.g. employment, income, education), SARS-CoV-2-related (social distancing, perceived threat of the virus), personality (e.g. neuroticism, conscientiousness), psychological factors specific to physical activity (identity, habit, planning, affective attitude), social situation (dependent children, other people in the home, dog ownership), home-environment (home equipment, physical activity programming), and neighborhood (recreation convenience, infrastructure quality, aesthetics, and safety) variables as predictors.

Based on prior research (e.g. Meyer et al., 2020; Qin et al., 2020) we hypothesised that Canadians would show an overall decrease in MVPA since the pandemic restrictions, yet there would likely be a small group who have increased MVPA. We also hypothesised that a portion of our sample would report remaining active at recommended guidelines at the same level throughout the pandemic restrictions and another group of people would report being regularly active at MVPA recommendations prior to the restrictions, suffering some set-backs early during the restriction changes, but who have now resumed regular MVPA. Most of the predictor variables chosen for this study are established correlates of sustained MVPA (Bauman et al., 2012; Carraro & Gaudreau, 2013; Christian et al., 2018; Karmeniemi, Lankila, Ikaheimo, Koivumaa-Honkanen, & Korpelainen, 2018; Kaushal & Rhodes, 2014; Kwasnicka, Dombrowski, White, & Sniehotta, 2016; Rhodes, 2017; Rhodes & Boudreau, 2017; Rhodes & Quinlan, 2015); thus, any and all of these could explain MVPA changes. Still, we hypothesised that access to/ownership of home exercise equipment and a strong physical activity identity would emerge among the key correlates. Specifically, the COVID-19 pandemic restrictions dramatically reduced facility-based opportunities for MVPA so home-based opportunities seem like an extraordinary necessity. Further, identity is proposed as a reflexive motivational system in the face of discrepant feedback information (Burke, 2006; Burke & Stets, 2009). Thus, those with strong physical activity identities would experience an enormous desire to enact improvised MVPA behaviors in order to reduce the dissonance of their identity standard and their situation (Rhodes, Kaushal, & Quinlan, 2016).

METHOD

Participants and Procedures

A cross-sectional sample of 1,230 participants responded to the survey. We excluded surveys that had more than 30 per cent of missing data and took less than 5 min to complete. The average time to complete the survey was 19 min. Overall, 1,055 participants were included in the final sample of Canadian adults, aged 18+ years, where data was collected from 1 May to 7 May 2020. Participants were recruited through a third-party market research company, Maru/Blue. Maru/Blue has a consumer online database of 120,000 Canadian panellists. Panel participants are recruited through a variety of online and offline methods and receive small cash incentives and prize opportunities after completing surveys. For this survey, each participant received 100 points (the equivalent of $1 CAD). The panel is generally comparable with the Canadian census in terms of age, gender, region, income, employment, and language spoken (Statistics Canada, 2019). This sampling strategy is routinely employed by national organisations given their ability to rapidly recruit large, representative Canadian samples. Ethical approval was obtained for this research by the University of Victoria Human Research Ethics Board (#20-0187) and informed consent was obtained from all participants prior to answering the survey.

Measures

Outcomes. MVPA was measured using a modified Godin Leisure-Time Questionnaire (Godin, Jobin, & Bouillon, 1986; Godin & Shephard, 1985). Both weekly frequency and duration of PA were provided with an open-ended assessment and the multiplicative (frequency × duration) sum of moderate and vigorous intensity minutes were used as the estimate of weekly MVPA (Courneya, Jones, Rhodes, & Blanchard, 2004). Two times of MVPA were assessed with this instrument. The first assessment asked participants to retrospectively consider their average physical activity based on a typical week just before the government ordered physical or social distancing in their area due to the COVID-19 (coronavirus) pandemic. The second assessment asked participants to consider their current average physical activity based on a typical week after the government ordered physical or social distancing in their area due to the COVID- 19 (coronavirus) pandemic.

We also assessed MVPA transition at public health guideline levels due to the COVID- 19 pandemic with a modified stage questionnaire (Reed, Velicer, Prochaska, Rossi, & Marcus, 1997) created for this study. Guideline messaging of at least a 150 min per week of moderate to vigorous intensity physical activity in bouts of 10 min or more was used as the definition of regular physical activity

(Tremblay et al., 2011). Exemplars of vigorous (running, jogging, hockey, football, soccer, squash, basketball, cross-country skiing, judo, roller skating, vigorous swimming, and vigorous long-distance bicycling) and moderate (fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, and popular and folk dancing) intensity were further provided to assist participants in recall. Participants were then asked to select one scenario that best represented their MVPA: (1) currently inactive, and was not active regularly before the COVID-19 (coronavirus) pandemic; (2) active regularly before the COVID-19 (coronavirus) pandemic, but not regularly active currently; (3) active regularly before the COVID-19 (coronavirus) pandemic, at some point during the pandemic was not active regularly, but now active regularly again; (4) currently active, and was active before the COVID-19 (coronavirus) pandemic; (5) not active regularly before the COVID-19 (coronavirus) pandemic, but active now.

Predictors. *Demographics* were measured using validated self-report instrumentation from prior research (Benoit, McCarthy, & Jansson, 2015) and commensurate with Statistics Canada (Statistics Canada, 2019). *COVID-19* social distancing behavior was assessed using an instrument validated during SARS (Lau, Yang, Tsui, & Kim, 2003; Leung et al., 2003). The measure included five items, measured on a scale from (1) never to (4) always, and asked about non-essential travel, greeting behavior, group gathering behavior, limiting contact with people who are high risk, and maintaining two meters distance from others outside the home. The instrument showed adequate internal consistency ($\alpha = .74$). Threat of the SARS-CoV-2 virus was measured using instrumentation adapted from the extended parallel process constructs (perceived susceptibility, perceived severity) (Witte, 1992). These included four items on 7-point Likert scales from (1) strongly disagree to (7) strongly agree. The items asked about beliefs that COVID-19 is severe, serious, whether the participant is at risk, and whether the participant believes they could contract it. Internal consistency was acceptable ($\alpha = .82$).

Psychological factors included established personality trait correlates of MVPA (i.e. agreeableness and openness were not measured because they have no reliable association with MVPA; Rhodes & Boudreau, 2017; Rhodes & Pfaeffli, 2012) and selected constructs of multi-process action control (M-PAC) (Rhodes, 2017). Personality was measured using select items from the NEO Five-Factor Inventory (Costa & McCrae, 1992). Questions are answered on a 5-point Likert scale from "strongly disagree" to "strongly agree". For the analysis, we included the Neuroticism scale (i.e. tendency to be anxious, pessimistic, vulnerable; $\alpha = .89$) and Saucier's (1998) sub-scales of extraversion-activity (i.e. tendency to be energetic, talkative, and live a fast-paced lifestyle; $\alpha = .72$) and conscientiousness-goal-striving (i.e. tendency to be ambitious, dutiful, and goal-driven; $\alpha = .73$). For the selected M-PAC constructs, the measures were first contextualised as regular MVPA before

COVID-19 using the same definition outline in the outcome measures above. We included a three-item measure of affective judgments (Rhodes, Fiala, & Conner, 2009) (i.e. regular PA was enjoyable, pleasant, exciting) on a 7-point Likert scale from (1) strongly disagree to (7) strongly agree (α = .94). Assessment of habit used the self-reported automaticity index (e.g. "Regular MVPA was something I did automatically"; Gardner, Abraham, Lally, & De Bruijn, 2012), on a Likert scale from (1) strongly disagree to (5) strongly agree (α = .93). Identity was measured using the role identity sub-scale (e.g. "When I described myself to others, I usually included my involvement in MVPA"; Wilson & Muon, 2008) of the exercise identity scale (Anderson & Cychosz, 1994) on a Likert scale from (1) strongly disagree to (5) strongly agree (α = .92). Finally, behavioral regulation was assessed by the Executive Function Index sub-scale of strategic planning (i.e. propensity to prepare a plan, anticipate consequences, and use strategies to execute it) (Spinella, 2005). The measure includes seven items, answered on a 5-point scale from (1) not at all to (5) very much (α = .72).

Social factors included study-created single items that assessed whether the participant was caring for dependent children in the home, whether the participant lived with other people, and whether the participant owned a dog.

Home environment questions. Based on the home exercise environment affordances measure developed by Sallis et al. (Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997) this measure was scored as a dichotomous metric, where having access to any of the following provisions was counted as having home equipment (treadmill, exercise bike, weights/resistance band) or exercise programming (smartphone exercise apps, exergames, work out videos, virtual personal trainer, virtual workout groups).

Neighborhood environment was assessed by items from the Neighbourhood Environment Walkability Scale (NEWS) (Saelens, Sallis, Black, & Chen, 2002) and the International Physical Activity Prevalence Study Environmental Survey Module (IPAPSEM) (IPAQ, 2004). These chosen items highlight Alfonzo's (Alfonzo, 2005) hierarchy of land-mix use, aesthetics, crime, and walking infrastructure quality as key characteristics. Land-mix use was assessed with the item: "My neighborhood has several free or low-cost recreation facilities, such as parks, walking trails, bike paths, and recreation centers". Walking infrastructure quality was measured by the item: "There are well-maintained sidewalks on most of the streets in my neighborhood", and neighborhood aesthetics was measured using the item: "There are many attractive natural sights in my neighborhood (such as landscaping, views...)." Finally, safety was measured with the item: "There is a high crime rate in my neighborhood." All items were answered using a 4-point Likert scale from strongly disagree (1) to strongly agree (4) which is similar between the NEWS and IPAPSEM measures.

Statistical Analysis

Normality of all variables was checked to determine whether any transformations were required. We followed a procedure where skewness and kurtosis was first checked, followed by conversion to z-scores if skewness was over 2.0 and/or kurtosis was over 3.0 (Kim, 2013). Z-scores > 3.29 were considered outliers, and subsequently shrunk to the next highest score in the distribution (Tabachnick & Fidell, 1996). Uncorrected and corrected variables were also examined in supplementary analyses to explore and comment upon any differences in the findings. Following the descriptive analyses, we examined the association of all predictor variables with pre-COVID-19 MVPA, during COVID-19 MVPA, and the unstandardised residual of during COVID-19 MVPA regressed on pre-COVID-19 MVPA using point-biserial and Pearson correlations. This was followed by ordinary least squares regression analyses, to provide estimates of the variables in multivariate prediction equations. However, because of the large number of predictor variables, a data-reduction strategy was employed for multivariate estimation. Specifically, only statistically significant predictors in the bivariate analyses were entered into the multivariate equations.

For assessment of the predictors of MVPA behavior profiles across the COVID-19 pandemic we used chi-square (categorical variables) and univariate analysis of variance (continuous variables) followed by post-hoc tests to examine which groups were different from each another. Similar to the analyses noted above, we used discriminant function analysis to predict multivariate membership among the five possible groupings, when a predictor variable had a significant univariate relationship. Alpha was set at $p < .01$. Given the large sample size, effect sizes were estimated to aid in the interpretation of the inferential statistics results. Specifically, $r = .10$ was considered the minimum recommended effect size for the social sciences based on Cohen's (1992) recommendations. All analyses were performed using SPSS (IBM, 2011).

RESULTS

Characteristics of Respondents

Characteristics of the sample can be found in Table 1. Respondents had a mean age of 48.82 ($SD = 16.66$), and an equal gender representation (51% female; 0.6% did not identify as male or female). The sample was mainly white (83%), and just under half were university educated and employed full-time. Nearly a quarter of the sample lived alone, 29 per cent reported being responsible for dependent children in their household, and 28 per cent were dog owners. Over two-thirds of the sample were from an urban neighborhood, and the overall proportions of respondents were representative of Canadian provinces with the

TABLE 1
Demographic, and Physical Activity Profile (*N* = 1055)

Characteristic	*M (SD)*	N (%)
Geographic representation		
Atlantic		131 (8.10)
Quebec		56 (5.40)
Ontario		485 (46.80)
Prairies		237(22.85)
British Columbia		175 (16.90)
Demographic profile		
Age	48.82 (16.66)	
Gender, female		536 (51.00)
Ethnicity		
White		869 (82.80)
Chinese		66 (6.30)
Mixed background		29 (2.80)
Aboriginal, Metis, Inuit, North American Indian		11 (1.00)
South Asian		30 (2.90)
Black		10 (1.00)
South-East Asian		10 (1.00)
Other		22 (2.10)
Education		
Elementary/Middle school		15 (1.40)
High school		216 (20.60)
College/Technical		306 (29.10)
University		358 (34.10)
Advanced degree		156 (14.80)
Annual household income		
Under $60,000		358 (34.90)
$61,000 to $99,999		314 (29.70)
$100,000–$159,999		262 (25.50)
$160,000+		93 (9.00)
Employment status		
Full-time (35+ h wk)		507 (48.20)
Part-time (20–35 h wk)		125 (11.90)
Student		35 (3.30)
Homemaker		57 (5.40)
Not reported		17 (1.60)
Unemployed		311 (29.60)
# Children in the home	1.54 (1.03)	
# People in the household	2.36 (1.28)	
Neighborhood		
City		726 (69.10)
Town/Village		142 (23.10)
Countryside		82 (7.80)
Dog owner?, yes		296 (28.10)
Meeting MVPA guidelines		396 (37.50)

*MVPA = moderate to vigorous physical activity

exemption of Quebec (see Table 1). Finally, 37.5 per cent of respondents reported current MVPA during the COVID-19 pandemic as commensurate with international guidelines (i.e. 150 min or more per week), which is much lower than the 60 per cent prevalence reported prior to these restrictions (Colley, Butler, Garriguet, Prince, & Roberts, 2018).

Handling Normality Assumptions

Prior to conducting the main analyses, preliminary analyses showed that both current MVPA and MVPA pre-COVID-19 pandemic were kurtotic (i.e. values $\geq$ 3). Therefore, outliers (no more than five respondents on each variable) were reduced to the next highest value (Tabachnick & Fidell, 1996), which reduced all kurtosis below 2.00. The outliers were from extremely high MVPA scores (> 900 min per week).

Pre-COVID-19 and Current Pandemic MVPA Comparisons

Moderate to vigorous physical activity minutes before COVID-19 ($M = 201.38$; $SD = 223.76$) were significantly higher (paired $t = 9.50$, $p < .01$; M change = 46.68, 95% CI 37.05, 56.32) than MVPA minutes reported during the COVID-19 restrictions ($M = 154.70$; $SD = 200.40$). This finding was nearly identical in the MVPA variables uncorrected for outliers (Mean change = 46.92, 95% CI 35.60, 58.24). Correlates of pre-COVID-19 MVPA, MVPA during the COVID-19 lockdown, and change in MVPA between the two assessments are presented in Table 2. Briefly, pre-COVID-19 MVPA minutes were positively associated ($p < .01$) with activity-extraversion, affective judgments, habit, and identity in the medium-large range (Cohen, 1992) and income, education, employment status, goal striving-conscientiousness, strategic planning, dog ownership, and availability of home PA equipment in the small effect size range (Cohen, 1992). In addition, age had a negative association with pre-COVID-19 MVPA in the small effect size range. The multivariate regression equation for these predictors was significant ($F_{15,988} = 31.14$, $p < .01$), explaining 32 per cent of the variance in pre-COVID-19 MVPA. Identity ($\beta = .35$), activity-extraversion ($\beta = .16$), and dog ownership ($\beta = .10$) were the independent predictors of the equation ($p < .01$). There were no differences in the findings with the MVPA variable that was uncorrected for outliers.

Moderate to vigorous physical activity minutes during the pandemic were also positively associated ($p < .01$) with activity-extraversion, affective judgments, habit, and identity in the medium range (Cohen, 1992) and income, education, employment status, goal striving, strategic planning, dog ownership, availability of home PA equipment, and home PA programming in the small effect size range (Cohen, 1992). In addition, social distancing had a negative association

TABLE 2
Predictors of Pre-COVID-19, Current Pandemic MVPA, and Change in MVPA

	MVPA before the pandemic	Multivariate association β	MVPA during quarantine r	Multivariate association β	Δ MVPA r	Multivariate association β
Demographics						
Gender (1 = male, 2 = female)	−.08*	−.02	−.02		.06	
Age (yrs)	−.11*	−.06	−.09*	.00	−.01	
Race (1 = other, 2 = white)	.03		.04		.02	
Urban	.03		.00		−.03	
Income	.10*	−.03	.11*	−.03	.05	
Education	.14*	.04	.11*	.03	.02	
Employment status	.10*	−.02	.10*	−.01	.03	
COVID-19 related						
Social distancing	−.07		−.10*	−.04	−.07	
Perceived threat	−.07		−.09*	−.05	−.06	
Psychological factors						
Neuroticism	−.05		−.07		−.05	
Activity (Extraversion)	.42*	.16*	.38*	.19*	.12*	.09*
Goal striving (Conscientiousness)	.16*	−.03	.18*	−.04	.09*	−.01
Affective judgments	.41*	.06	.29*	−.06	−.02	
Strategic planning	.14*	−.01	.19*	.09*	.13*	.10*
Habit	.42*	.07	.32*	.05	.03	
Identity	.53*	.35*	.42*	.28*	.06	
Social factors						
Living alone	−.01	.10*	−.03		−.03	
Dependent children	.05		.08		.06	
Dog owners	.15*		.14*	.10*	.05	
Home environment						
Home equipment	.09*	.02	.17*	.09*	.15*	.12*

TABLE 2 *(CONTINUED)*

	MVPA before the pandemic	Multivariate association β	MVPA during quarantine r	Multivariate association β	Δ MVPA r	Multivariate association β
Home PA programming	.12*	.03	.10*	.05	.02	
Neighborhood environment						
Proximity to parks, trails	.05	.02	.03		–.01	
Local infrastructure quality	.07		.06		.02	
Local aesthetics	.09*		.07		.02	
Neighborhood safety	.08		.05		–.01	

Note: MVPA = moderate and vigorous intensity physical activity minutes. *p < .01.

with MVPA in the small effect size range (Cohen, 1992) during the pandemic lockdown. The multivariate regression equation for these predictors was significant ($F_{15,989} = 20.45$, $p < .01$), explaining 34 per cent of the variance in MVPA. Identity ($\beta = .28$), activity-extraversion ($\beta = .19$), and dog ownership ($\beta = .10$) again were the independent predictors of the equation ($p < .01$), all in the small effect size range (Cohen, 1992). When comparing these findings with the uncorrected for outliers MVPA variable, there were no differences in the multivariate analysis, but the COVID-19 variables (threat, social distancing) had slightly smaller coefficients in the bivariate analyses ($r = -.07$ each $p < .05$ compared to $r = -.09/-.10$ $p < .01$).

Finally, change in MVPA minutes from before to during the pandemic was positively associated ($p < .01$) with activity-extraversion, strategic planning, and availability of home PA equipment all in the small effect size range (Cohen, 1992). The multivariate regression equation was significant ($F_{4,1021} = 10.61$, $p < .01$), explaining 4 per cent of the variance in MVPA change. Strategic planning ($\beta = .10$) and availability of home PA equipment ($\beta = .12$) were the independent predictors of the equation ($p < .01$), both in the small effect size range (Cohen, 1992). There were no differences in the findings when using the MVPA variable that was uncorrected for outliers.

Understanding Transitions in Meeting MVPA Guidelines across the COVID-19 Pandemic

A sub-total of 1,037 of our 1,055 participants answered the adapted stage algorithm that asked about their transitions in meeting MVPA guidelines (World Health Organization, 2012) from before COVID-19 to the present. Of these respondents, 274 (26%) reported being consistently inactive (not active before COVID-19 and not active at present), 209 (20%) indicated that they had an unsuccessful transition (active before, but inactive currently), 64 (6%) marked that they were adopters (not active before but active currently), 158 (15%) noted they had a breach and repair situation where they were active before, had an inactivity period during the initial lockdown transition, yet they are now regularly active, and 332 (32%) suggested they have always been active throughout (ever active).

Correlates of these five distinct inactive, unsuccessful transition, adopter, breach and repair, and ever active profiles of are detailed in Table 3. Among the potential demographic correlates, only age and education distinguished the groups ($p < .01$). Post-hoc tests showed that the groups that transitioned in some fashion during the COVID-19 pandemic (i.e. adopters, unsuccessful transition, breach and repair) were younger than the groups marked by staying the same across time (i.e. inactive, ever active). For education, post-hoc tests showed that the inactive group had less formal education than the ever active and breach and repair groups.

TABLE 3
Predictors of MVPA Guideline Transitions during the COVID-19 Pandemic Restrictions

	Inactive (n = 274; 26%)	Unsuccessful Transition (n = 209; 20%)	Adopters (n = 64; 6%)	Breach and Repair (n = 158; 15%)	Ever Active (n = 332; 32%)	F/χ^2	η^2	Post-Hoc	Correlation with Discriminant Function
Demographics									
% female	52.4	44.9	63.5	51.3	52.6	7.45			
Age (yrs)	51.28 (16.74)	47.45 (17.32)	42.27 (14.08)	46.46 (16.85)	49.64 (49.63)	5.23*	.02	UT,BR, AD<IA; AD<EA	−.10
% white	81.7	80.6	82.2	81.5	85.2	2.49			
% urban	67.4	76.4	68.8	73.4	65.3	9.14			
Income	4.44 (2.44)	4.84 (2.51)	4.82 (2.45)	5.11 (2.32)	4.93 (2.58)	2.25	.00		
Education	3.17 (0.99)	3.40 (1.03)	3.47 (1.02)	3.56 (1.04)	3.51 (0.99)	5.59*	.02	IA<EA, BR	.07
% Employed	55.3	61.1	68.8	64.6	59.5	6.04			
COVID-19 related									
Social distancing	3.76 (0.71)	3.75 (0.35)	3.76 (0.36)	3.76 (0.34)	3.75 (0.32)	0.20	.00		
Perceived threat	5.83 (1.12)	5.72 (1.11)	5.77 (1.03)	5.77 (1.05)	5.56 (1.09)	2.53	.01		
Psychological factors									
Neuroticism	2.88 (0.89)	2.92 (0.81)	2.83 (0.77)	2.83 (0.73)	2.54 (0.82)	9.69*	.04	EA<AD,BR,IA, UT	−.06
Activity (Extraversion)	2.37 (0.73)	2.85 (0.72)	2.80 (0.71)	2.92 (0.71)	3.02 (0.72)	33.23*	.12	IA<all; UT<EA	.14
Goal striving (Conscientiousness)	3.41 (0.65)	3.59 (0.64)	3.67 (0.70)	3.58 (0.62)	3.80 (0.61)	14.27*	.05	IA<all; UT, BR<EA	.03
Affective judgments	4.01 (1.44)	5.39 (1.22)	4.28 (1.55)	5.56 (1.03)	5.47 (1.15)	72.55*	.22	IA, AD<UT,EA, BR	.08
Strategic planning	3.52 (0.62)	3.61 (0.65)	3.76 (0.57)	3.73 (0.55)	3.85 (0.55)	13.18*	.05	IA<BR,AD,EA; UT<EA	−.06
Habit	2.47 (1.07)	3.48 (0.87)	2.57 (1.01)	3.50 (0.84)	3.83 (0.79)	99.00*	.28	IA,AD<UT, BR<EA	.26
Identity	2.06 (0.96)	3.43 (0.89)	2.36 (0.97)	3.53 (0.87)	3.84 (0.86)	172.97*	.40	IA<AD<UT,BR<EA	.81

TABLE 3 *(CONTINUED)*

	Inactive (n = 274; 26%)	Unsuccessful Transition (n = 209; 20%)	Adopters (n = 64; 6%)	Breach and Repair (n = 158; 15%)	Ever Active (n = 332; 32%)	F/χ^2	η^2	Post-Hoc	Correlation with Discriminant Function
Social factors									
% Living alone	24.8	21.1	18.8	18.4	26.2	5.43		EA,IA,UT<AD	-.07
% Dependent Children	26.3	28.2	46.9	34.2	25.9	14.57*			
% Dog owners	24.5	27.8	23.4	25.9	32.8	6.56			
Home environment									
% with home equipment	43.1	45.9	64.1	66.5	66.3	50.08*		IA,UT<AD,EA,BR	.17
% with home PA programming	55.8	64.8	65.6	73.4	61.1	14.15*		IA,EA<BR	.02
Neighborhood environment									
Parks, trails	3.10 (0.86)	3.13 (0.85)	3.20 (0.82)	3.29 (0.78)	3.12 (0.95)	1.38	.01		
Infrastructure quality	2.97 (1.04)	3.12 (0.95)	3.05 (1.09)	3.23 (0.86)	3.16 (0.97)	2.20	.01		
Aesthetics	2.85 (0.86)	2.91 (0.91)	3.00 (0.89)	3.01 (0.83)	2.95 (0.89)	1.00	.00		
Safety	1.63 (0.77)	1.63 (0.81)	1.59 (0.79)	1.70 (0.89)	1.50 (0.75)	2.20	.01		

Note: Inactive (IA) = not active before COVID-19 and not active at present. Unsuccessful transition (UT) = active before, but inactive currently. Activity Breach and Repair (BR) = active before and active now after a period of inactivity during the shift. Ever Active (EA) = active before and all throughout. Adopters (AD) = Not active before but active currently. *p < .01.

SARS-CoV-2-related constructs (perceived threat, social distancing) were not related to group membership ($p > .01$), but there were several psychological constructs that could distinguish among the groups ($p < .01$). The ever active group was less neurotic than all other groups. By contrast, the inactive group reported lower activity-extraversion and goal-striving conscientiousness compared to all other groups, and the ever active group also had higher activity-extraversion and goal-striving-conscientiousness than the unsuccessful transition group. The two groups that were inactive pre-COVID-19 (inactive, adopter) were distinguished as having lower affective judgments about MVPA compared to the three groups that were active pre-COVID-19 (unsuccessful transition, breach and repair, ever active). The inactive group reported lower strategic planning than the breach and repair, adopter, and ever active groups, while the unsuccessful transition group also reported lower strategic planning than the ever active group. The two groups that were inactive pre-COVID-19 (inactive, adopter groups) were distinguished as having lower habit strength than all other groups, and the ever active group reported higher habit strength than any other group. Finally, identity sequentially distinguished the inactive from adopters, and unsuccessful transition, breach and repair from ever active, with each division reporting a consecutively greater MVPA identity.

Of the social variables, only the presence of dependent children distinguished the five groups ($p < .01$). Specifically, those who adopted MVPA during the COVID-19 lockdown were more likely to have dependent children compared to all other groups. No neighborhood environment variables distinguished the groupings ($p > .01$), but both home environment variables predicted group membership ($p < .01$). Specifically, the inactive and unsuccessful transition groups reported owning less PA home equipment compared to the adopters, breach and repair, and ever active groups. The breach and repair group also reported more PA home programming compared to both the inactive and ever active groups.

For the multivariate model, the discriminant analysis identified one clear significant discriminant function that distinguished among the five groups with a large effect size [Wilks' $\lambda = .51$; canonical $r = .65$, $\chi^2 = (48) = 686.81$, $p < .01$]. Identity had a large association with this discriminant function ($r = .81$), while age ($r = -.11$), activity-extraversion ($r = .14$), habit ($r = .26$), and the availability of home equipment ($r = .17$) had small associations (Cohen, 1992).

DISCUSSION

Regular MVPA is effective to support mental and physical health across the lifespan (Rebar et al., 2015; Rhodes et al., 2017; Warburton & Bredin, 2017), so a focus on physical activity promotion during and after the COVID pandemic is important, especially when initial reports show a considerable decline (Fitbit

Inc., 2020). Promotion recommendations are assisted by an evidence base, and an understanding of the correlates of MVPA during the COVID-19 pandemic is an important first step so that interventions can target key factors affecting current behavior and behavioral declines. This study is one of the first to explore a broad socio-ecological (Stokols, 1992) scope of predictors of MVPA as a result of the pandemic restrictions. Our findings assist in understanding why some people changed their MVPA when compared to others.

Early peer-reviewed COVID-19 research has shown MVPA decreases in China (Qin et al., 2020), the United States (Dunton et al., 2020; Meyer et al., 2020), and Europe (Cheval et al., 2020). Based on this prior research, we hypothesised that Canadians would also show an overall decrease in MVPA since the pandemic restrictions. This hypothesis was supported. Our findings showed that study participants perceived that they had decreased 47 min of MVPA per week on average (effect size $d = .21$), which is comparable to past research in other nations thus far. The difference is meaningful and substantiates the actions of media and health organisations that are providing physical activity messaging information to assist people during this unprecedented public health crisis.

Our analysis of correlates of MVPA during the COVID-19 restrictions showed that there were key variables at nearly all levels of the socio-ecological model (Sniehotta et al., 2017). Demographics of age (negative association), income, education, and employment (positive associations), personality traits of conscientiousness and extraversion (positive association), psychological constructs of affective judgments, strategic planning, identity, and habit (positive association), household composition in terms of dog ownership, home physical activity equipment, and home physical activity programming (positive association) were all significant correlates of MVPA during the COVID-19 pandemic. All of these factors are generally reliable correlates of MVPA (Bauman et al., 2012; Carraro & Gaudreau, 2013; Christian et al., 2018; Kaushal & Rhodes, 2014; Rebar et al., 2016; Rhodes & Boudreau, 2017; Rhodes et al., 2017; Rhodes et al., 2009; Rhodes et al., 2016) so it is not surprising that they are also correlates of MVPA during the COVID-19 restrictions. Unique to this situation, however, social distancing behavior was also a significant correlate of MVPA (negative association), suggesting that engaging in the recommended measures from their local and federal government may have impacted individuals' MVPA. From this result, we suggest that physical activity messaging alongside social distancing messaging may be helpful as a form of problem solving for how people can achieve both of these recommendations (Hall, Laddu, Phillips, Lavie, & Arena, 2020; Middleton, Simpson, Bettger, & Bowden, 2020; Torous, Myrick, Rauseo-Ricupero, & Firth, 2020).

The more important and interesting objective of our study, however, was to explore the predictors of changes in MVPA as a result of the pandemic restrictions. To do this, we used two MVPA assessments. One was the residual

variation between pre-COVID-19 MVPA and current MVPA during the lockdown. This variable represents the general deviations in MVPA as a result of COVID-19, perceived by the sample. The other approach we included was an assessment of profiles in meeting MVPA public health guidelines (World Health Organization, 2012) as a result of the COVID-19 pandemic restrictions. Using this approach, we hypothesised that there would likely be a more complicated profile than just a general decline. We hypothesised that any of the predictor variables chosen for the study could explain these changes in MVPA because all are established correlates (Bauman et al., 2012; Carraro & Gaudreau, 2013; Christian et al., 2018; Karmeniemi et al., 2018; Kaushal & Rhodes, 2014; Kwasnicka et al., 2016; Rhodes, 2017; Rhodes & Boudreau, 2017; Rhodes & Quinlan, 2015). Still, we specifically hypothesised that home exercise equipment and a strong physical activity identity would emerge among the key predictors. This was theorised because the COVID-19 restrictions dramatically reduced facility-based opportunities for MVPA, thus necessitating the means of home activity (Kaushal & Rhodes, 2014). COVID-19 also radically changed regular lifestyle routines that would test identity-behavior reflexive actions (Burke & Stets, 2009).

Our findings for simple changes in MVPA had some support for these hypotheses. The availability of home equipment emerged as a key predictor of positive change in MVPA alongside strategic planning. Our profiles in meeting MVPA public health guidelines (World Health Organization, 2012) fully supported our hypotheses. Specifically, 26 per cent of the sample reported being consistently inactive, and 32 per cent suggested that they have always been active throughout the pandemic, amounting to 58 per cent of the sample suggesting that they had not changed their behavior around public health guidelines. By contrast, 20 per cent indicated that they had an unsuccessful transition (active before, but inactive currently), 6 per cent marked that they were adopters (not active before but active currently), and 15 per cent noted that they had a breach and repair situation where they were active before, had an inactivity period during the initial lockdown transition, yet they are now regularly active. Multivariate analyses of these different groupings highlighted that identity was the critical predictor, followed by the strength of physical activity habits, activity-extraversion, the availability of home equipment, and the age of the participant (negative association).

Taken together, the results support key theoretical principles that attempt to explain how some people maintain behavior in disruptive and difficult conditions and allow for practical applications to assist in MVPA continuation. For example, the availability of home physical activity equipment was a reliable correlate of both methods of analysing MVPA change. Opportunity to enact MVPA is a construct that resides in several theoretical models (e.g. Bandura, 1998; Michie, van Stralen, & West, 2011; Rhodes, 2017; Rhodes, Blanchard, & Matheson, 2006; Sallis & Owen, 1997) and highlights the importance of infrastructure and

equipment independent of motivation or capability/self-efficacy. The results of our analyses provide evidence that people who had home equipment were able to weather the storm and maintain MVPA. Indeed, in post-hoc analyses, we showed that the presence of home equipment was a critical marker of the breach and repair group, who presumably had disruptions to their MVPA routines, but found a way to get back to regular activity. The practical suggestion from this finding is to improve home equipment affordances where possible and to provide advice about makeshift or inexpensive home physical activity in challenging circumstances (Amri Hammami, Harrabi, Mohr, & Krustrup, 2020).

Personality traits are less amenable to change but are among the most reliable constructs to distinguish life transitions (Soto, 2019), so it is not surprising that activity-extraversion (propensity for an energetic, fast-paced lifestyle), goal-striving-conscientiousness (tendency to achieve, and work toward goals), and neuroticism (propensity to experience vulnerability, affect) each had some evidence as a correlate of MVPA profiles during the COVID-19 restrictions. The results indicate potential "at risk" personalities that may benefit from targeted intervention (Rhodes & Boudreau, 2017). Other psychological factors such as identity, planning/self-regulation, and habit are all established constructs that predict health behavior maintenance (Kwasnicka et al., 2016). These select constructs feature prominently in M-PAC (Rhodes, 2017), which advances from traditional social cognitive models that include reflective motivational constructs (e.g. attitudes, perceptions of control, forming of intentions) to also include regulatory (tactics used to manage behavioral enactment) and reflexive (learned associations triggered through circumstances or stimuli) constructs that are proposed to influence MVPA continuation. As noted previously, identity represents a self-standard, and people enact behaviors aligned with this self-standard to ameliorate dissonance (Rhodes et al., 2016). Physical activity identity is tied closely to one's ability to self-regulate (Strachan, Perras, Forneris, & Stadig, 2017) and the evidence from this study supports this theorising. It seems likely that those participants with a strong identity would have experienced an enormous desire to enact improvised MVPA behaviors in order to stay congruent with their identity standard. Physical activity identity promotion research is in its infancy, with relatively undeveloped behavior change techniques (McEwan et al., 2019). While there are some theories that can assist in identity formation (e.g. Burke, 2006; Deci & Ryan, 1985; Kendzierski & Morganstein, 2009), sustained research is needed to explicate exactly what techniques are most effective.

Habit is where behaviors are performed based on previously learned cue–behavior associations (Rhodes & Rebar, 2018). While the COVID-19 restrictions likely disrupted many of these cues, certain factors like time of day (Schumacher, Thomas, Raynor, Rhodes, & Bond, 2020) may have still created a strong impulse (Gardner, 2015) to enact MVPA; further, those with home exercise routines (and home equipment) would likely have remained unaffected by the COVID-19 restrictions and engaged in MVPA based on this strong habit

response. Like identity, habit formation research is a growing evidence-base at present. Habit formation ultimately has one critical behavior change technique, which is behavioral repetition within the same context (Gardner & Rebar, 2019). While it is recognised that other motivational techniques are likely needed to instill the behavioral repetition to even achieve a habit (Gardner & Rebar, 2019; Rebar, Gardner, & Verplanken, 2020; Rhodes, 2017), we recommend that habit forming techniques be included in MVPA messaging, particularly among those who are seeking assistance in sustaining the behavior.

Planning has been a well-studied construct in physical activity and is a hallmark construct of action control theories (i.e. theories that explain the intention–behavior gap) (Rhodes & Yao, 2015). Planning can be trained as a skill (Allan, Sniehotta, & Johnston, 2013), but it also has a cognitive component that aligns with one's executive functioning (Garcia-Barrera, 2019; Jurado & Rosselli, 2007). In our study, we measured the latter, because MVPA plans were likely to change dramatically during COVID-19 restrictions and it was one's strategic planning in the identification and organisation of the steps and elements needed to achieve a specific goal (Packwood, Hodgetts, & Tremblay, 2011), such as effectively engaging in an MVPA program during the dynamic COVID-19 times. We recommend that strategies for planning be incorporated into MVPA messaging. Specifically, and given the current changing environment, targeting the type of planning that relies more heavily on adapting to shifting contingencies and barriers, such as coping planning, may prove the best effects (Rhodes, Grant, & De Bruijn, in press).

Finally, older participants generally showed less MVPA and positive behavioral adaptations during COVID-19. In part, we speculate this may have been because COVID-19 is more dangerous to older, particularly compromised, populations (Government of Canada, 2020a) and thus older adults were simply being more cautious about MVPA to minimise exposure. The finding highlights potential value in a targeted approach to assisting older adults in maintaining MVPA during this pandemic, with messaging focusing on what activities to do, how to be safe and perform MVPA, and various tips and strategies focused on older adult activities (Amri Hammami et al., 2020; Jiménez-Pavón et al., 2020; Middleton et al., 2020).

Despite the large national sample, the innovative research questions, and the theoretical and applied strengths of this paper, there are limitations to this research. First, the design is cross-sectional and thus all analyses of change are based on retrospective interpretations of our participants. Asking participants to recall MVPA is more accurate than light intensity activities (Matthews, Moore, George, Sampson, & Bowles, 2012), and a five-week retrospective assessment during a very unusual moment in history is likely to have considerable validity compared to much longer recall durations (Matthews et al., 2018); still, this is a noteworthy limitation of the findings. The MVPA measures are also self-report and thus subject to further recall biases. Given that our instruments were

accessible only in English, our sampling was reflective of English Canada but did not have full representation in Quebec, which has been compromised severely by COVID-19 cases and may have added further value to the results. We also included a limited array of social variables as predictors in our study. Further exploration of social support and various social norms (injunctive, moral, descriptive) may prove interesting for a more refined understanding of key social-level correlates of MVPA during the COVID-19 restrictions. Finally, while our sample clearly includes heterogeneity among MVPA practices, and inactivity that is even higher than national averages pre-COVID-19 (ParticipACTION, 2019), our questionnaire did not include health indicators, so factors like body mass index and chronic health conditions are unknown.

In summary, the COVD-19 pandemic restrictions have affected engagement in recreation, and daily MVPA. There has clearly been a downward shift in MVPA as a result of the restrictions, yet over half of the Canadians sampled did not perceive the shifts to alter their behavior around international public health guidelines. Psychological theory pertaining to behavioral maintenance (Kwasnicka et al., 2016; Rhodes, 2017) explained the general pattern of results. Identity was the critical predictor, followed by the strength of physical activity habits, strategic planning, and the availability of home equipment. Interventions and messaging focusing on these critical factors may assist in restoring MVPA and preventing further decline.

CONFLICTS OF INTEREST

The authors have no conflicts of interest relevant to this article to disclose.

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